Acknowledgement

Given its mission in the field of international cooperation in science and technology and with the aim of introducing some of the country's technological capabilities and S & T diplomacy development, the Center for International S & T Cooperation (CISTC) has prepared the present book on Feb. 2019. It contains several sections including history and background, policies and strategies, capacities and capabilities (human resources, scientific productivity, products and achievements), and authorities in different technology areas. The present book is an updated version of "Science and Technology in Iran: A Brief Review" which has already been prepared on Aug. 2017.

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- Digital Economy and Smart Technology Development Council
- Technology Development Council of Water, Drought, Erosion & Environment
- Soft Technology Development Council
- Technology Development Council for Space and Advanced Transportation
- Energy Technology Development Council
- Pardis Technology Park
- Knowledge-Based Firms

SCIENCE AND TECHNOLOGY IN IRAN: A BRIEF REVIEW

IRAN 2019

Contents

1 Iran at a Glance

Abu Rayhan al-Biruni (973-1050 C.E.) is one of the major figures of Islamic Mathematics. He contributed to Astronomy, Mathematics, Physics, Medicine and History.

Iran at a Glance

Iran, Cradle of Civilization

The Islamic Republic of Iran enjoys a rich and lavish history and boasts one of the world's oldest civilizations. Iran is located in southwest Asia, in the Middle East and is the 18th largest country by area in the world, spanning from as far north as Armenia or Turkmenistan to as far south as the Persian Gulf. The country's size and position have historically made it a strategic bridge for east-west and north-south trade routes which indicates its potential to be a regional hub for commerce and an attractive tourist destination.

Iran is one of the rare countries in the world which enjoys four distinctive seasons. In the north, the evergreen forests draw a parallel line to the beautiful serene waters of the Caspian Sea which makes the country's climate most pleasant. In the south, Iran borders the Persian Gulf with gorgeous and appealing palm trees and a hot and humid climate. To the east of Iran, one can find hot desserts with running sand and starry nights. On west, this vast land is endowed with mountains high in the sky catching the eye of every visitor.

Iran has an abundance of various tourist attractions, from the ski slopes within a short car ride of Tehran to the 2,500-year-old ruins of the Achaemenid Empire at Persepolis and the harmonious gardens of the Bagh-e-Eram Palace in Shiraz, just to name a few. Iran is home to 19 UNESCO World Heritage sites -more than Greece- plus a rugged coastline on the Caspian Sea that makes it one of the best countries for hiking, 20 mountain resorts for winter sports, beaches on the Persian Gulf, and the holy shrine (Imam Reza) in Mashhad.

Iran's economy in 2017, with GDP of nearly $439.5 billion, was the second largest economy in the Middle East and North Africa (MENA) region. It also has the second largest population of the region with an estimated 80.277 million people in 2016. Persian is the official language and Islam is the official religion of the country.

The country has a wealth of natural resources, including the first and fourth natural gas reserves and oil reserves, respectively, with the least economic dependence on oil incomes among oil-rich countries in the MENA. Iran is well-positioned to exercise a significant influence in basic materials sectors; especially cement, stone, and steel. The country is already the top cement exporter in the world and the largest cement producer in the Middle East. Iran is a net exporter of electricity to its neighbors and has an ample mineral wealth, including large cooper, lead, and zinc reserves. Iran's pistachios, saffron and of course caviar have brought great fame for its agriculture. It also produces a wide range of crops and is among the top five producers of eggplant, onions, and a range of fruits including quince, figs, and watermelons.

Science, Technology and Innovation in Iran at a glance

Enrolment in and Graduation from Tertiary Education in Iran

	2005-2006	2015-2016
Students	2,389,867	4,348,383
Graduates	340,246	859,697
PhD Students	19,237	193,206

Scientific Publications

	2005	2011	2015	2017
Iran's share in Scientific Publications in the Middle East	14.8%	32.4%	28.6%	30.8%
Rank in the Middle East	3	1	1	1
Iran's share in Scientific Publications in the World	0.4%	1.5%	1.5%	1.85%
Rank in the world	34	17	16	16

Gender Balance in Higher Education

46.1% 53.9%

2015-2016
High level of gender equality in both secondary and tertiary education compared to other countries in the Middle East

The Number of Universities in Iran

Public Universities — 149
Public Medical Universities — 57
Islamic Azad University — 567
Private Universities — 329

Knowledge-Based Firms

52 (2014) → 4068 (Feb. 2019)

The Number of supported KBFs has increased from 52 in March 2014 to 4068 in Feb. 2019. They account for around 136,000 jobs and $9.5 billion in revenue.

The Number of S&T parks in Iran

1 (2002) → 43 (2017)

The Number of Incubators in Iran

136 (2013) → 192 (2017)

Companies Located in S&T Parks and Incubators

2012 → 2518
2013 → 3000
2014 → 3400
2015 → 3650
2016 → 4475

Innovation and Prosperity Fund (as of Dec. 2017)

2117	$395 million
Approved projects	Total support

Technology-Based Exports ($ billions)

High- and Medium High-Tech exports

1.5 (2004) → 7 (2009) → 12.1 (2014)

Knowledge-Based Products Exported by S&T Parks and Incubators ($ millions)

2012 → 0.7
2013 → 14.1
2014 → 50.5
2015 → 214.6
2016 → 231.4

National Policy Documents on Science, Technology and Innovation (STI)

The governance model for the innovation system is inspired by the policy documents. These include the 2005 document, Vision 2025, drafted by the Expanding Discernment Council of the System (EDCS), the 2011 NMPSE (National Master Plan for Science and Education; also commonly called the Comprehensive Scientific Road Map), and other important policy documents listed in table 1. Together, these serve to guide the national STI policy agenda, with stipulated objectives, milestones and processes for implementation. Here, some of the overall policies on science and technology advised by the Supreme Leader and the National Policy for a Resilient Economy are presented, respectively.

Table 1
Key Policy Documents of Iran' s STI

Policy Measures/Documents	Year Approved
Comprehensive Document of International Scientific Relations of IRI	2018
The 5-Year Development Plan (FYDPs) (containing STI-related articles)	The 6th FYDP approved in 2017
The Development Plans' Permanent Regulations Act	2016
Regulations of the Technology Annex and the Development of Internal Capabilities in the International Contracts and National Plans	2016
Removing Production Barriers Act	2015
Amendments to Government Financial Regulations Act	2015
National Policy for S&T	2014
National Policy for a Resilient Economy	2014
Act of Maximum Use of Production and Services to Satisfy the Country's Needs and Enhance them in Exports	2012
National Master Plan for Science and Education (NMPSE) (Iran Comprehensive Scientific Road Map)	2011
Law for Supporting Knowledge-Based Firms	2010
Act on Patents, Industrial Designs and Commercial Signs	2006
Vision 2025 Document: 20-year Vision Plan	2005
Law for Establishment of Ministry of Science, Research and Technology (MSRT)	2004
Foreign Investment Promotion and Protection Act	2002

Main National Policies on STI

• Local content and technology transfer policies

"The Maximum Utilization of Local Capabilities" law (MULC) and the "Technology Annex" are two policy measures aimed at increasing local content in Iran. The former was originally enacted in 1996 and revised in 2012. The latter, which was approved in September 2016 after nearly two years of discussion, parallels efforts to aid the development of knowledge-based products. It applies to those international contracts (including, inter alia, inward foreign investment and technology licensing) to which the Government is a party or for which the Government is providing support for building domestic firm-level STI capabilities. Its main purpose is to ensure that contracts, including purchase of technologies, are accompanied by collaboration with the foreign firm(s) to contribute to local learning and promote other spillovers.

The Technology Annex seeks to leverage international contracts to foster STI capacity-building and is aligned with – indeed complementary to – the MULC law. The law aims at enhancing local firms' capabilities in terms of R&D, design and engineering, to be stipulated in international infrastructure and industrial contracts. The general regulations and requirements in each contract are similar to the Technology Annex. The MULC law requires at least a 51 percent share of inputs by local parties in international contracts, with respect not only to raw materials and construction, but also to technology and skills. Effective industrial development will depend on how industrial policy is designed and implemented, keeping in mind the need to ensure sufficient transparency to avoid capture of policymakers by vested interests.

Key objectives of the national policy on science and technology promulgated by the Supreme Leader in September 2014 are as follows:

- Continuous scientific strives to get the authority of science and technology in the world with an emphasis on:
  - Developing science and innovation and theorizing;
  - Promoting global position in science and technology and becoming the scientific and technological hub in the Muslim world;
  - Developing basic science and fundamental research;
  - Achieving advanced science and technology through special policymaking and planning.

- Optimizing performance and structure of the education and research system in an effort to achieve the objectives specified in the Vision 2025 Document in line with scientific development with an emphasis on:
  - Knowledge management and integration of strategic policymaking, planning and monitoring in science and technology domains and continuous promotion of the S&T indices and updating comprehensive scientific roadmap given global and regional scientific and technical developments;
  - Supporting establishment and expansion of science and technology parks and districts;
  - Identifying elites, developing exceptional talents, and retaining and attracting human capital;
  - Increasing research expenditure to at least 4% of GDP by the end of 1404 with a focus on optimal resources utilization and productivity promotion.

- Improving the relationship between higher education, research and technology systems and other strategic sectors with an emphasis on:
  - Increasing the share of science and technology in the national income and economy, and improving national strength and efficiency;
  - Providing monetary and non-monetary support for idea-to-product process and increasing the share of high technology products and services and domestic technology in GDP as much as 50%;
  - Developing and strengthening national and international communication networks between universities, research centers and the domestic and foreign technology development and innovation enterprises, as well as improving institutional cooperation in public levels given priorities of the Islamic countries.

- Developing active, constructive and inspiring cooperation in the field of science and technology with other countries and accredited scientific and technical centers throughout the world and the region, especially in the Islamic world along with strengthening the independence of the country, with an emphasis on:
  - Developing industries and services based on modern sciences and technologies and providing support for manufacturing and export of knowledge-based and indigenous technological products especially in priority areas through improving export and import performance in the country;
  - Taking necessary measures for technology transfer and acquiring knowledge to design and manufacture products in the country employing the capacity of the national market in consuming imported products;
  - Taking benefit of the scientific and technical capabilities of the Iranian expatriates and attracting prominent researchers and experts from other countries, especially the Islamic countries;
  - Achieving authority in evaluating scientific contributions and providing opportunities for uptaking national and international research results, particularly from the Islamic world.

Comprehensive Document of International Scientific Relations of IRI

The “Comprehensive Document of the International Scientific Relations of IRI” was approved at meeting No. 805, dated March, 6, 2018 by the Supreme Council of Cultural Revolution.

The most important macro-level objectives:

- Realizing active scientific diplomacy for acquiring new knowledge and emerging technologies in the required and prioritized fields;
- Coordinated and coherent use of scientific capacities of the country to promote science and technology in other aligned societies and countries;
- Promoting, disseminating, and transferring the country’s scientific and technological achievements with a focus on the national interests and macro-level policies of the country.

The most important strategies:

- Creating coordination and synergy between the related bodies and coherent policymaking with a view to developing international scientific cooperation;
- Developing transnational networks among scientists, students, academic researchers, research centers, S&T parks, and KBFs at home and abroad;
- Intelligent development of scientific relations with other countries focused on comparative advantages of the country.

The most important measures:

- Strengthening and exploiting the capacity of the embassies and other active entities in the international arena for intelligent development of an international scientific relation system;
- Developing scientific and technological product/ service markets, especially the knowledge-based ones, in the target countries via purposeful diplomacy;
- Developing international scientific cooperation through holding educational courses, projects, research centers and KBFs.

The Center for International Science and Technology Cooperation (CISTC) as the functional wing of the Vice-Presidency for Science and Technology is responsible for implementing this document.

National Policy for a Resilient Economy: Technology and Innovation as the Key Factors of Economic Growth

The National Policy for a Resilient Economy has been promulgated by the Supreme Leader in February 2014 to push forward the policy agenda on local capabilities through adoption of a more outward-oriented development policy approach. Some of the main goals of the Resilient Economy are:

- Providing necessary conditions and harnessing all facilities and financial resources as well as scientific and human capital to develop entrepreneurship;
- Creating a highly knowledge-based economy, implementing the NMPSE, and improving the NIS to increase proportion and production of knowledge-based products and exports;
- Improving the financial system of the country to support the influential parts of the national economy, such as S&T;
- Increasing exports of innovative and technological goods and services with an emphasis on their added value;
- Developing economic free zones in order to foster advanced technologies; and
- Expanding the discourse on the Resilient Economy, particularly in scientific, educational and media circles.

In order to implement the Resilient Economy policy, the government established a dedicated secretariat in mid-2015. The Supreme Economy Council (SEC) had already been selected in mid-2014, as the main body which approves Resilient Economy plans and projects. In this line, the secretariat approved 27 national plans, 10 of which are relevant to STI considering the national priorities:

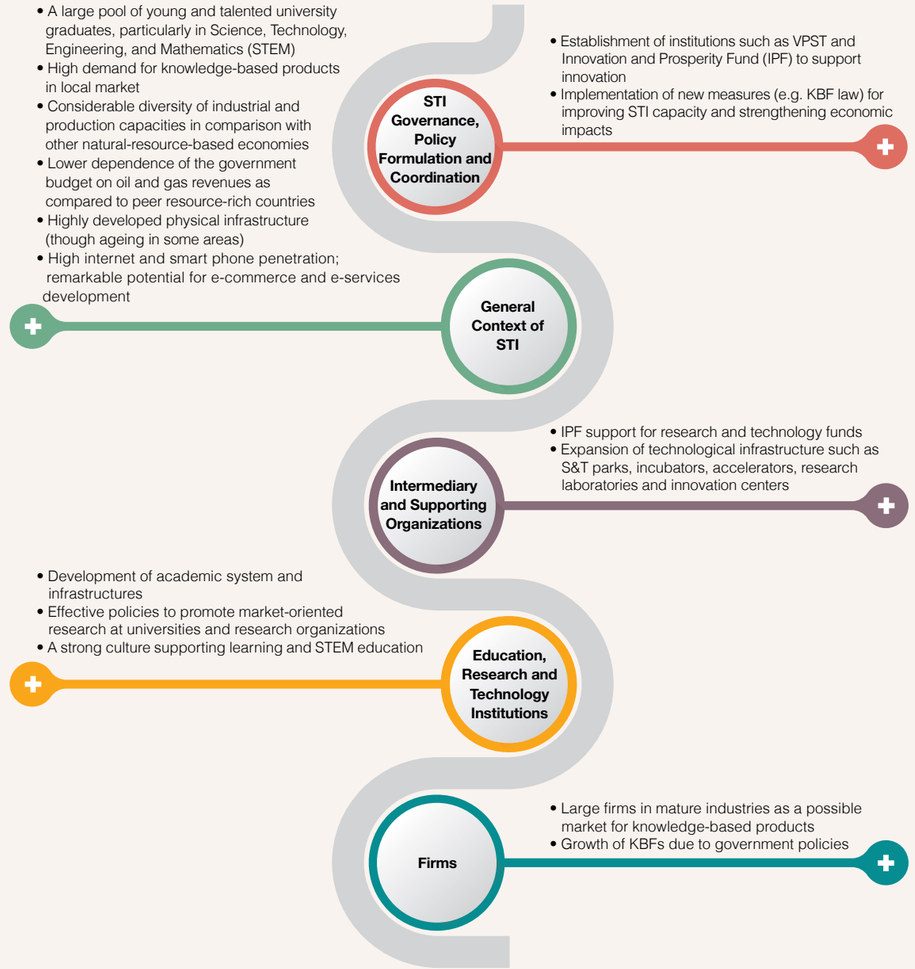
- Designing, organizing, implementing and monitoring the package of production and employment in 2018;
- Designing, organizing, implementing, and monitoring the supporting package of non-oil export development;
- Producing and broadcasting special programs by IRIB (Islamic Republic of Iran Broadcasting) aimed at removing barriers to manufacturing, encouraging investors, promoting domestic consumption and strengthening the resistance economy discourse;
- Developing knowledge products market;
- Providing support for development of indigenous content and creating digital businesses on the platform of the National Information Network;
- Designing, organizing, implementing and monitoring the package for promoting business environment in 2018;
- Design and implementation of a mechanism for obligating Iran's foreign import partners (in selected fields) to transfer part of their production chain to the country;
- Providing support for creation and development of private specialized export companies;
- Providing support for Iranian cultural, artistic, and media products focused on developing domestic market and export;
- Designing and implementing the water crisis transition program.

As transition to KBE is a collective effort, it requires engagement of different bodies, particularly the Ministry of Industry, Mine and Trade (MIMT) and MSRT. In this line, the Vice-Presidency for Science and Technology (VPST), as the main body for overseeing transition to KBE, is in charge of two important projects, broken down into two action plans:

- Developing technological interactions with the world economy and exporting knowledge-based goods and services through:
  - Creating 4068 supported Knowledge-Based Firms (KBFs) taking advantage of the facilities provided under the Law for Supporting Knowledge-Based Firms;
  - Designing and implementing pro-market policies to promote development of knowledge-based ecosystem in selected sectors (e.g. aerospace, biotechnology and nanotechnology, ICT, environment and O&G);
  - Creating and promoting development of markets, and using KBFs' capacities to provide at least 15 percent of the required local material and equipment; and
  - Promoting development of financing mechanisms (e.g. Venture Capital Funds (VCFs) and collateral) and insurance for knowledge-based production;

- Strengthening manufacture of innovative products through:
  - Developing infrastructures for export of knowledge-based products; and
  - Designing a holistic system for technology transfer and an implementation plan.

Iran's Strengths/ Opportunities in Transitioning to Knowledge-Based Economy



Source: UNCTAD





Science and Technology Statistics

According to the 20-year Vision document, achieving the first place in science and technology in the region in terms of realization of the knowledge-based economy with an emphasis on software movements and scientific productions and acquisition of advanced knowledge and capability of producing science and technology are the most important goals in science and technology domains. Here, the descriptive and quantitative data on science and technology trends in Iran within the recent years are presented.

• Number of Higher Education Students by Gender and Educational Level

Totally 4348383 students were studying in Iranian universities in 2016, of whom 46.5% were woman, showing a better gender balance in Iran than in other comparable countries of the region. Figure 1 depicts the distribution trends in different educational levels.

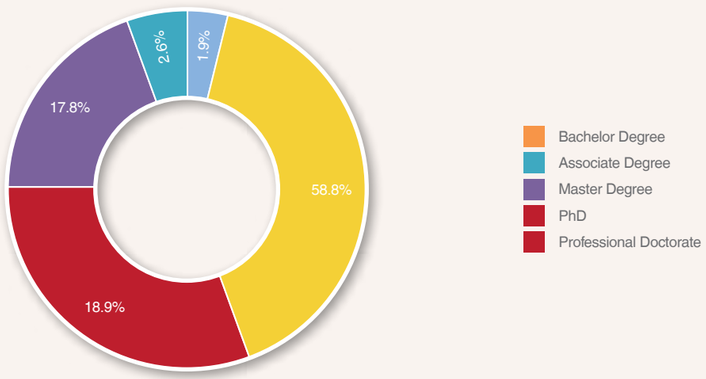


Figure 1: *Students in Higher Education by Educational Level, 2015-2016*

• Iran's Contributions to Regional and Global Scientific Publications

Iran's share in scientific publications worldwide has been growing over the past two decades, from 0.07 percent in 1996 to 1.85 percent in 2017 (fig. 2). Likewise, its share in total regional scientific publications increased from 3.5 percent in 1996 to 31.8 percent in 2017. Joint publications by Iranian authors and foreign collaborators accounted for around 22.23 percent. A major reason for these improvements is the increasing importance given to scientific publications, research, promotion of university professors through awarding grants to them, and granting awards to the graduate students and pursuing their admissions to accredited universities.

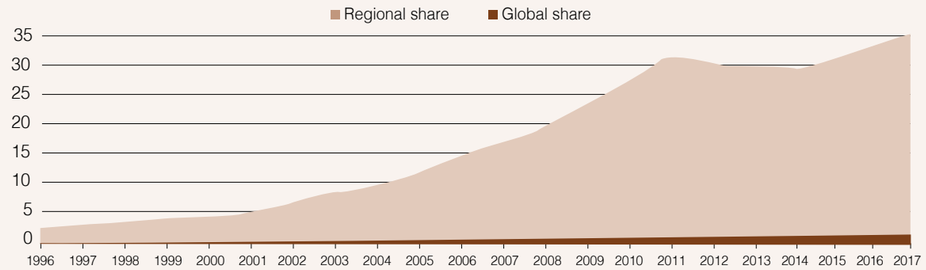


Figure 2: *Proportion of Iran's Scientific Publications in Total Regional and Global Publications, 1996–2017 (%)*
Source: Scimago database (accessed in September 2016) at http://www.scimagojr.com/.

• Universities

The government has sought to expand the higher education system including universities as the main strategy to improve its human capital. Figure 3 shows various categories of universities in the country. It should be noted that University of Applied Sciences and Technology specialized in vocational training (1011 branches); Technical and Vocational University (168 branches); Payame Noor University providing distance learning programs (531 branches); and Farhangiyan University offering teacher education and human resources development for the Ministry of Education (103 branches) are among universities operating under the supervision of MSRT.

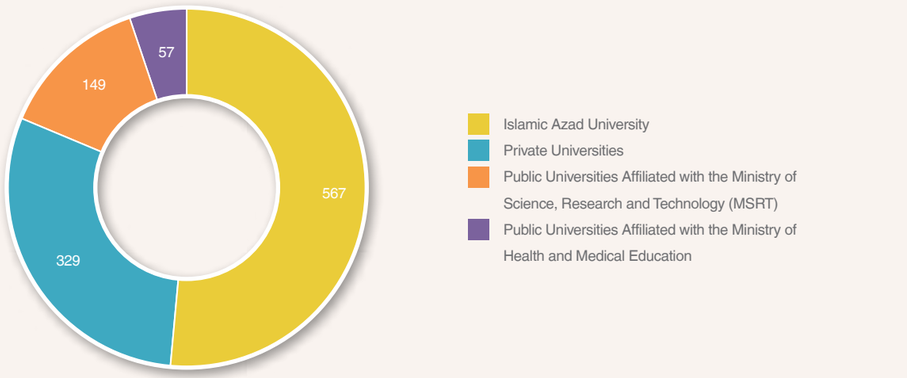


Figure 3: *The Number of Iranian Universities, 2016*

Source: Institute of Research and Planning in Higher Education (IRPHE) (2016)

• Science and Technology Parks

At the moment there are a total of 43 active Science and Technology (S&T) Parks across the country. Figure 4 shows the growth trend of S&T parks in Iran during 2002- 2017.

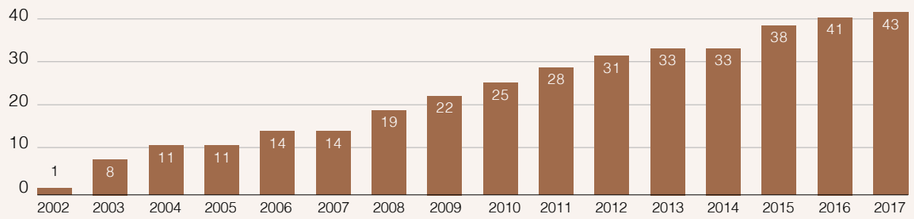


Figure 4: *Growth in the Number of S&T Parks during 2002-2017*

Source: MSRT, www.msrt.ir/fa/techno/Files/.

• Incubators

In 2017, there were 192 active incubators across the country. Figure 5 represents the growth trend of incubators in Iran during 2013-2017.

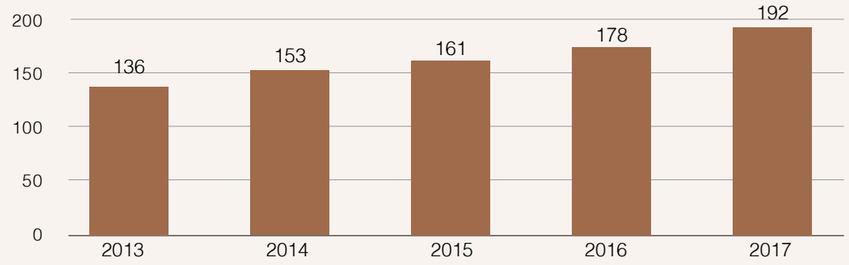


Figure 5: *Growth in the Number of Incubators during 2013-2017*

Source: MSRT (2016)

• Laboratories

Laboratories have been increased dramatically in number over the past few years, from 3500 in 2013 to 12,594 since September 2016 (figure 6).

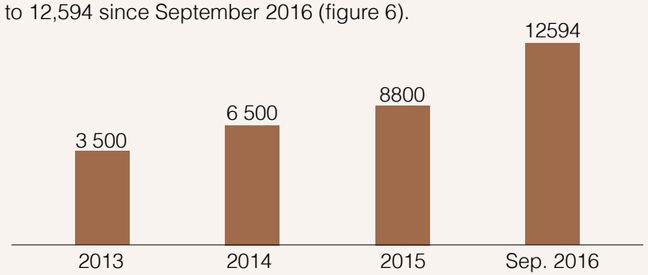


Figure 6: *The Number of Laboratories Affiliated with MSRT, 2013–2016*

Source: MSRT (2016)

• Research Institutes

In Iran, there are 686 research institutes. Figure 7 shows different categories of such institutes.

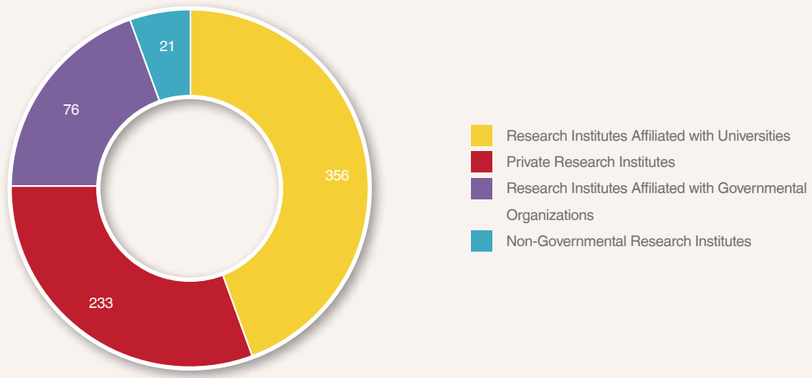


Figure 7: *The Number of Research Institutes in Iran*

• Knowledge-Based Firms

After approval of the law on supporting Knowledge-Based Firms (KBFs) in 2010 and its implementation in 2013, various supportive mechanisms were developed for KBFs. Subsequent years witnessed a rapid growth of KBFs, from 52 in March 2014 to 4,068 in Feb. 2019. They created more than 136,000 jobs and $9.5 billion in revenue.

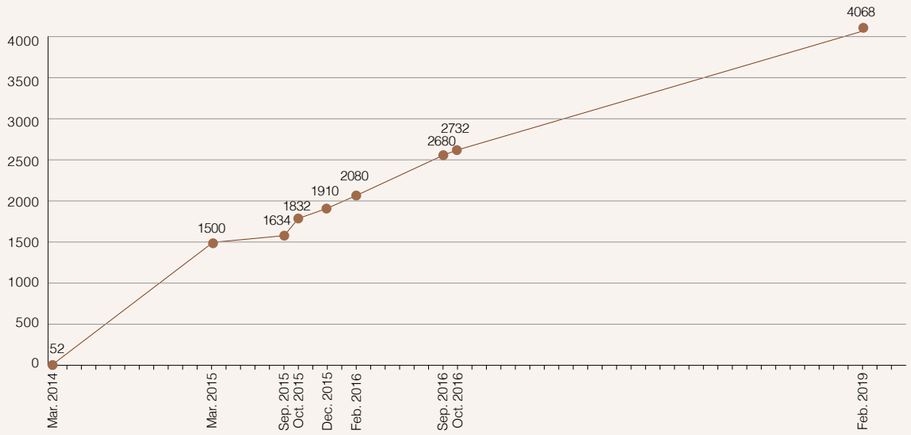


Figure 8: *The Number of Knowledge-Based Firms (2014–2019)*

Source: VPST; http://daneshbonyan.isti.ir/

Science and Technology Key Players

Iran's S&T system is marked by a variety of key players operating at different levels. Here, a brief overview of some key bodies is explained as follows:

• Supreme Council of Cultural Revolution

The Supreme Council of Cultural Revolution (SCCR) was established in 1984 upon official closure of universities. SCCR is the highest policymaking and legislative body for all stages of pre-university and academic education. Its resolutions do not require parliament's approval and become law automatically. Members of the SCCR include heads of the three powers of state, Minister of Education; Minister of Science, Research and Technology; and Minister of Health and Medical Education, as well as several cultural experts. Ministry of Education is responsible for all stages of pre-university education. Within the MSRT, technology development falls under a separate Vice-Ministry.

The vast scope of mission of the council includes all fields related to culture and science throughout the country. The council, then, is responsible for providing and approving principles, objectives, policies and programs related to the scientific and cultural issues, providing the cultural engineering map of the country and updating this map, formulating map of science, providing a plan to develop the educational system of the country, directing and reorganizing macro-management in cultural, educational, research and media organizations, and presenting efficient strategies for each field.

• Vice-Presidency for Science and Technology

The Vice-Presidency for Science and Technology (VPST) was established in 2007 to oversee innovation policy. It thus fulfills an important horizontal mandate to engage all relevant parties in supporting innovation as part of its oversight of innovation policy. Various powerful line ministries are provided with extensive resources earmarked for research and innovation within their specific realms of responsibility. The VPST's role in the innovation system as coordinator of innovation policy is of critical importance; it helps to establish a "whole-of-government" (or government-wide) approach characterized by effective cross-ministry collaboration on innovation policy. As one of the vice-presidential offices, it reports directly to the President and paves the ground for greater consistency and closer collaboration among various actors throughout the NIS. The VPST is also expected to link the governance and operational levels of the innovation system. Nowadays, this office is actively engaged in implementing innovation policy programs, coordinates the initiatives of innovation activities, and takes the ground for active presence of innovative firms, business and economic innovations, and design of innovation policy instruments.

The VPST has about 350 staff members in-house, plus consultants and experts based in other organizations to look after various tasks. The VPST does not necessarily try to pursue all tasks in-house; rather, for many activities it relies on the organizations with whom it collaborates. The main internal hierarchy of the VPST includes four deputies responsible for policy making and strategic assessment, innovation and commercialization of technology, management development and resources and international science and technology cooperation. In addition, it has two special units, namely, the office of KBFs and the Pardis Technology Park (PTP) located just outside the capital, Tehran. PTP is considered to be the most pioneering technology park in the country which supports hi-tech companies to increase their competitiveness in the international markets.

• The Center for International Science and Technology Cooperation

The Center for International Science and Technology Cooperation (CISTC) was established in 2017 through merger of the Deputy for International Affairs and Technology Transfer affiliated

to the Vice-Presidency for Science and Technology and the International Affairs Office of the National Elite Foundation.
As it has been already mentioned, CISTC is assigned to implement the Comprehensive Document of the International Scientific Relations of IRI introduced by the Supreme Council of Cultural Revolution to the Vice-presidency for Science and Technology in 2018. Developing cooperation and constructive interactions with other countries, international scientific and technological entities and foreign experts in line with achieving a leading position in the knowledge economy is considered to be the main mission of this center.
Promoting scientific partnerships and developing human resources by taking advantage of the capacity of foreign experts especially Iranian diaspora and brain circulation, expanding technological cooperation and exchange by using capacities of the international/foreign companies and entities in the field of technology development and exchange, and developing knowledge-based businesses through using the capacity of the international markets and facilitating entry of domestic KBFs as well as technology companies to such markets are among the main strategies of CISTC.

• Ministry of Science, Research and Technology

The Ministry of Science, Research and Technology (MSRT) is the main state ministry involved in higher education, science, research and technology. MSRT mandates to:
- Provide support and encourage universities and research institutes (public/private);
- Develop basic and applied research;
- Provide support for S&T parks and incubators;
- Focus on fields such as Engineering, Basic Sciences, Art, Humanities and Agriculture;
- Promote and support research through funding, human resource development and providing the necessary research facilities;
- Facilitate knowledge and innovation development in all scopes of science and technology including indigenous knowledge;
- Contribute to life quality improvement;
- Provide services to research community especially at higher education and research institutions.

In addition, MSRT is paying particular attention to implementing diplomacy of science and technology, traffic of academic collaborations, developing, strengthening, and improving national and international science and technology cooperation with its foreign partners including overseas universities and science and technology institutions.
In addition, there are other public or private institutions with related functions including the Ministry of Education which is responsible for primary and secondary education, the Ministry of Health and Medical Education, and other scientific and technological institutions affiliated with other public or private institutions in the country.

• Iran High-Tech Laboratory Network

The Iran High-Tech Laboratory Network (called LabsNet) was established in 2014 by the Vice-Presidency for Science and Technology with the aim of presenting laboratory services to the university and industrial researchers. Initially, this network started its activities in the field of nanotechnology in 2004 and then it was commissioned to expand its activities in other areas.
LabsNet missions include improving quality of the high-tech laboratory services by standardization of laboratory activities, improving laboratory technicians' knowledge base through organizing training courses and experience-sharing sessions, and facilitating industrial and academic researches' access to laboratory services.
Currently, LabsNet serves more than 461 public and private laboratories and 10,000 laboratory equipment located in 60 cities covering all provinces of the country.

Geographical Distribution of Laboratory Network

It should be noted that 70% of laboratories are placed on universities and research centers. Figure 9 displays laboratories affiliated to High-tech laboratory network.

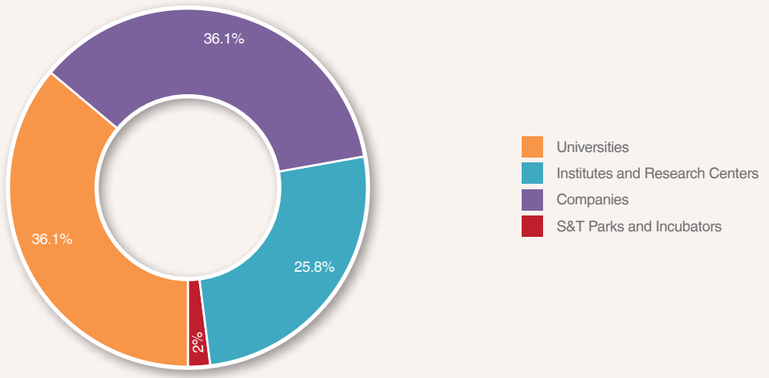


Figure 9: *Laboratories Affiliated to High-tech Laboratory Network*

LabsNet also covers a wide range of fields in high technology laboratory services such as Nano, Bio, Energy, Cognitive, Stem Cells, ICT, Herbal, Fabs, etc. Also, it boasts:
- More than 531 High-Tech Instrument Experts;
- More than 44 ISO/IEC17025 Accredited Labs;

- More than 2,186,000 lab services provided per year; and
- More than 68,000 customers (national and international) per year.

LabsNet provides its members with a unique opportunity to share their capabilities, experiences and knowledge through the network and also creates funding opportunities for the renovation and/or standardization of facilities at member laboratories through funds offered by the Vice-Presidency for Science and Technology.
LabsNet maintains a variety of international collaborations including laboratory services, interlaboratory comparisons, training, standardization, renovation and other projects of mutual interest.

• Center for Progress and Development of Iran

Since its establishment in 1984, the Center for Progress and Development of Iran (CPDI) has always tried to identify bottlenecks and neglected affairs in the progress of Iran, especially in the field of high technology, and to contribute to the advancement of these affairs in the country. This role is being played by informing and creating a discourse on the country's key opportunities and threats for progress, and participating in operational actions in order to actively engage with them (such as prototyping and modeling, institution-building, policy-making, and mechanism design).
CPDI believes that the progress of the country will not be achieved, unless a consensus takes place between various stakeholders in the country, and the opportunities for international cooperation are properly exploited. For this reason, CPDI- as a consultant and facilitator- has a close relationship with all stakeholders, including executive agencies, universities and research institutes, private companies, specialists and scientists. This center also tries to identify international cooperation opportunities and establish constructive and continuous interactions with different countries and institutions.
Achieving these goals requires an agile and flexible organizational structure. Accordingly, CPDI, with the help of young elites in an ad-hoc structure, organizes emerging groups focused on various fields of progress to take special missions on the path to progress of the country. At present, the main focus of these groups is on the following axes:

- Identifying and monitoring emerging issues with great potential to create transformation, and trying to involve the country in such areas in a timely manner;
- Identifying opportunities and threats facing the country in resilient economy and knowledge-based economy, and trying to find effective ways of dealing with them;
- Monitoring and identifying management mechanisms and soft technologies, and trying to benchmark the successful ones and localize them.

• Innovation and Prosperity Fund

The Innovation and Prosperity Fund was established directly under the President in 2011 for the purpose of supporting KBFs both financially and non-financially. Since March 2017, it has funded 2117 projects with total turnover of $395 million. Moreover, high and medium-high-tech exports have dramatically increased from $1.5 billion in 2004 to $12.1 billion in 2014, which followed by turning the total trade balance positive in 2016.

• Iran National Science Foundation

The Iran National Science Foundation (INSF) was founded in 2003 by approval of Iran's Supreme Council of Cultural Revolution. For more than a decade, INSF has taken meaningful actions to provide a variety of support programs to Iranian researchers and scientists so that the gap

between science and industry is bridged and the Iranian people can directly touch the impact of scientific development on their life quality. Currently, more than 70 percent of the faculty members and researchers from different universities and research institutes across the country are involved in various activities and projects defined by INSF.
The major activities of the foundation include providing support for innovation center development, research projects, and international patent application; holding scientific events, post-doctoral and short-term visit programs; and granting various research awards.

• National Elites Foundation

The National Elites Foundation was set up in 2004 with the aim of providing the innovators and leaders in science with financial and intellectual support. The organization offers different kinds of support to its members including scientific, monetary/non-monetary incentives such as granting low-interest or gratuitous loans, supplying any sources or laboratory facilities scarce in the country, involving the members with in-demand/priority national projects, assisting the members to commercialize their innovations or move them to the policy level, as well as providing them with other similar support services and networking opportunities.
In December 2013, a new department was created within the foundation, called the Deputy of International Affairs. It aims to harness talent of non-resident Iranians to improve domestic capacity in S&T and take advantage of experience of the diaspora. The foundation tailors its services to four different groups: Iranian PhD graduates from the world's top universities, Iranian professors teaching in the world's top universities, Iranian experts and managers heading the world's top scientific centers and companies in technological fields, and -last but not least- non-resident Iranian investors and entrepreneurs with successful experiences. The eligibility criteria were revised in 2014 to include groups and individuals based on their research expertise, experience, and academic performance.

• Pardis Technology Park

The Pardis Technology Park (PTP), as the most pioneering S&T park in the country, was established in 2005 under supervision of the Vice-Presidency for Science and Technology. PTP has been designed to commercialize technology achievements and create appropriate conditions for technology growth and hi-tech companies development through provision of high-end services; strengthening competitive advantage; and providing access to technology incubators, spin-off

processes, and expert labor. It also meets the requirements of getting linked to the actual and potential global markets.

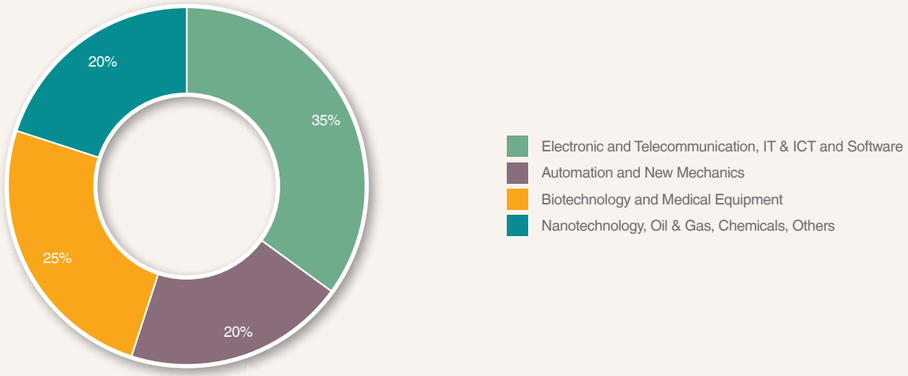


Figure 10: *Combination of PTP Companies*

In May 2018 around 255 hi-tech companies were operating in PTP. These companies have been rigidly selected out of more than 1500 membership applications. The above figure represents technology combination of member companies.

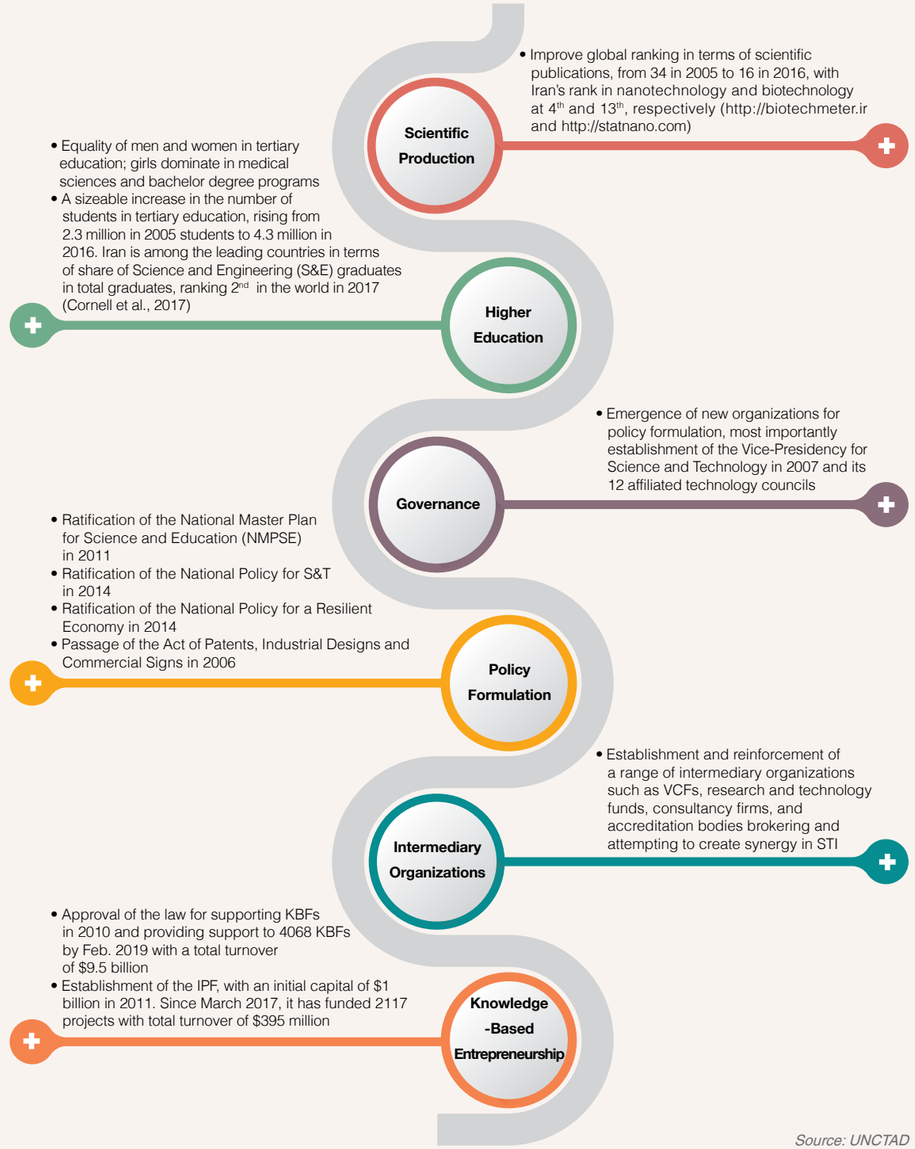
• Innovation Acceleration Center

The Innovation Acceleration Center began its work in 2014 under supervision of the Pardis Technology Park (PTP) with the primary mission of entrepreneurship ecosystem reinforcement and start-ups growth acceleration in the country. Both the government and the private sector have collaborated and shared their equipment and experiences in order to empower entrepreneurship ecosystem.
Besides holding different entrepreneurship events, the center is responsible for establishing different accelerators as an effective measure to empower the startups and educate young entrepreneurs. Innovation Acceleration Center is looking forward to establishing co-working spaces for young entrepreneurs in order to build new teams and found new startups through collaborating with the startup community and the private sector.

• Iranian Venture Capital Association

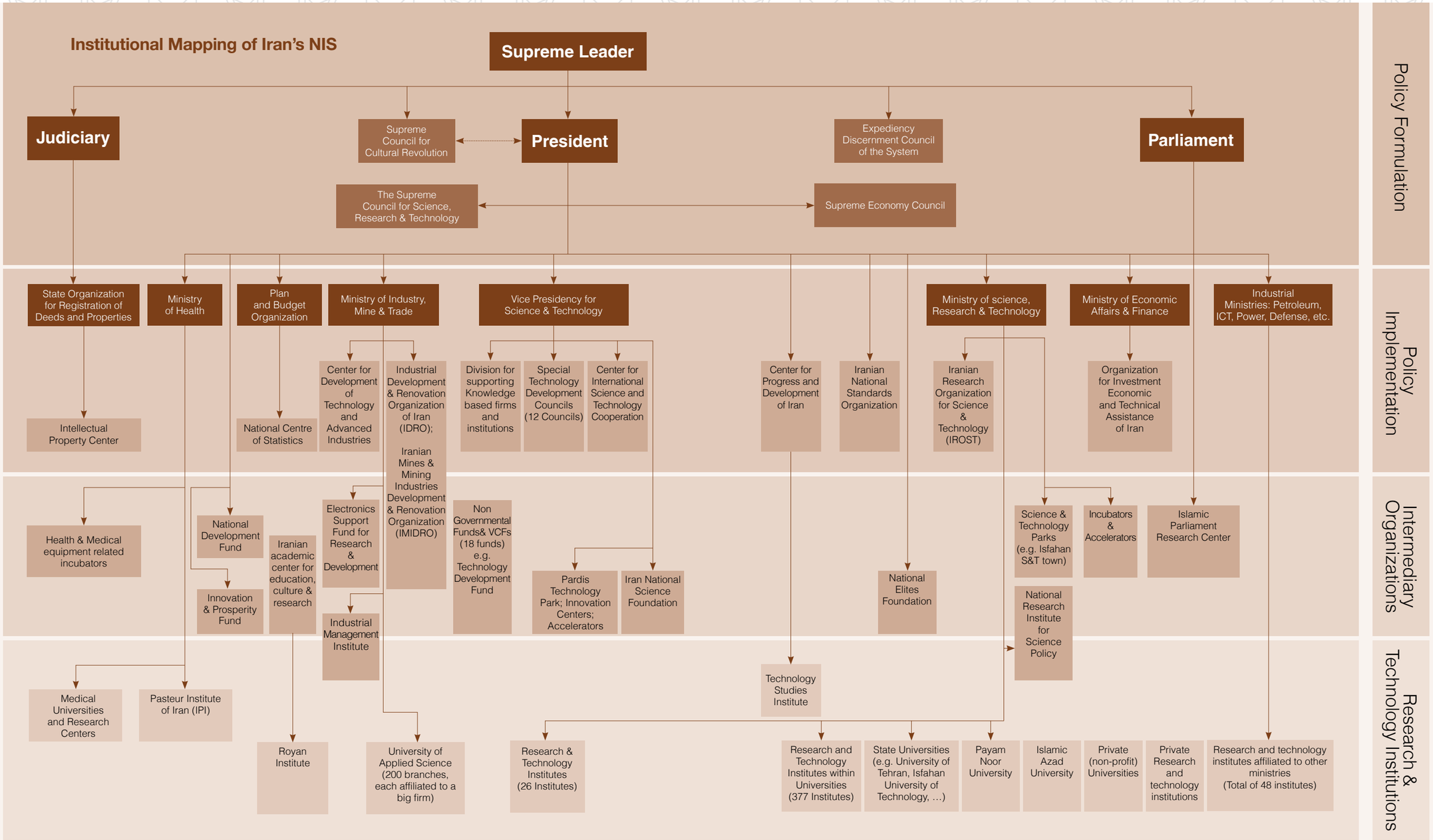
The Iranian Venture Capital Association (IRVC) founded in 2012, is a non-governmental organization representing Iran's venture capital and angel investor sectors as well as accelerators and S&T funding organizations. More than 80% of Iranian VCs and accelerators are IRVC members.
Thanks to large network of investors and inventors, IRVC provides the accurate data and transparency on Iranian market to help investors make fact-based decisions on bringing in their own capital, innovation or expertise to the market.
By building a solid structure of active financing institutions, VCs and entrepreneurs in Iran, IRVC promotes professional investment in startups and new technology-based firms.

Main Trends and Changes in Iran's General Context of NIS during 2005-2015



Source: UNCTAD

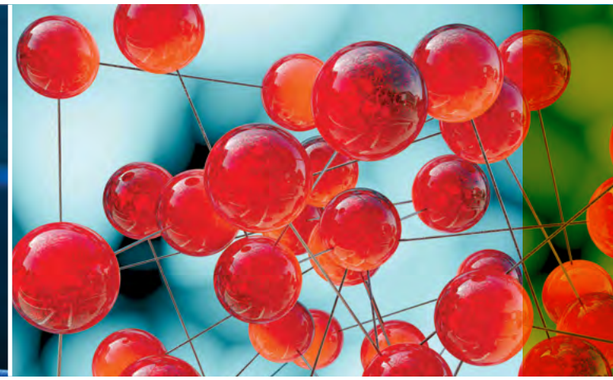
Institutional Mapping of Iran's NIS



Source: UNCTAD

2 Nanotechnology

Nanotechnology



I. History and Background

Islamic Republic of Iran has adopted a comprehensive approach in nanotechnology development aiming at creating wealth relying on this emerging technology. As a result, Iran has been able to achieve a sizable share in local and international markets. Timely entrance into the field accompanied with a focus on an endogenous development model in science and technology development has also prepared the grounds for actualization of this objective. Nanotechnology has had, and will have a great impact on all industries worldwide through improving the existing products and creating new ones. Contribution to the global advancements in this field is possible for Iranian scientists through enhancing their technological knowledge, being focused, and continuing their efforts.

Policymaking for nanotechnology development in Iran was initiated in 2001. Iran Nanotechnology Innovation Council (INIC) was established in 2003 to ensure coordination and synergy among all institutions and agencies involved in nanotechnology development. In August 2005, “Future Strategy Plan”(ten -year strategy for nanotechnology development in Iran 2005-15) was approved by the government. With the implementation of the future strategy plan and its three supplementary phases until 2018, Iran was ranked fourth in the world in nano-science production and nowadays, this industry enjoys over 29 thousand researchers. On the other hand, more than 460 thousand students are trained in nanotechnology development. Also,181 companies produce 447 nanotechnology-related products and equipment. 65 companies are also providing business development services to diffuse nanotechnology into industry.

After the implementation of the “Future Strategy Plan”, the second plan for ten-year nanotechnology development (2015-25) was prepared in 2015 and operated since the second half of the same year.

II. Policies and Strategies

Nanotechnology development policymaking and planning is focused on designing a practical and applicable model. In this line, it is tried to provide the structured programs for all rings of the value chain from science and technology development towards commercialization and market development. In addition, operational programs are continuously kept up-to-date based on contingencies and requirements of different time periods.

Some of the programs implemented during the past decade are as follows:

- Networking more than 81 research laboratories from academia and private sector in the form of Nanotechnology Laboratory Network. In this network over 1660 advanced laboratory services were provided to researchers and engineers;
- Hosting more than 100 nanotechnology startups in incubators and technology parks;
- Hosting technology development service providers in the Tech-Market Services Institute (Corridor);
- Creating student laboratories network (TAVANA network) containing 66 labs located in student research institutes across the country;
- Supporting intellectual property service provider companies;
- Establishing the Expert Committee on Food and Drug Administration to assess nanohealth products including pharmaceuticals, medical equipment, cosmetics and hygiene products, foodstuff, and beverages.

Some nanotechnology achievements in priority areas including health, water and environment, energy, and construction are as follows:

- Karun river water treatment to produce drinking water;
- Removing heavy metals from water;
- Sugarcane industry wastewater treatment plants;
- Producing industrial power plant filters to improve productivity in power industry;
- Producing nano-medicine, especially anti-retroviral ones;
- Producing materials and equipment used in construction industry such as concretes, paints, pipes, and resistant plastics.

III. Capacities and Capabilities

A. Human Resources

According to a study conducted in 2000 on the country’s human resource status, the number of researchers involved in nanotechnology was not more than a dozen and just eight papers were published in a year. After the formation of Iran Nanotechnology Initiative Council, nanotechnology sector witnessed a dramatic increase in the number of researchers, publication of more than 29000 ISI articles, and involvement of 2600 active faculty members.

Also, during the last decade, 263 universities or research centers have been involved in the field of nanotechnology.

Ferdowsi University of Mashhad | Iran University of Science & Technology | Shahid Beheshti University | University of Tehran

University of Mazandaran | Sharif University of Technology | University of Kashan | Amirkabir University of Technology

University of Gilan | Zabol University | Alzahra University | Shiraz University

Some Universities Involved in Nano-science and Nanotechnology

B. Scientific Productivity

Iranian universities and research institutes conducted over 3700 nanotechnology-related doctoral dissertations and more than 16,200 master's theses (see figure 1).

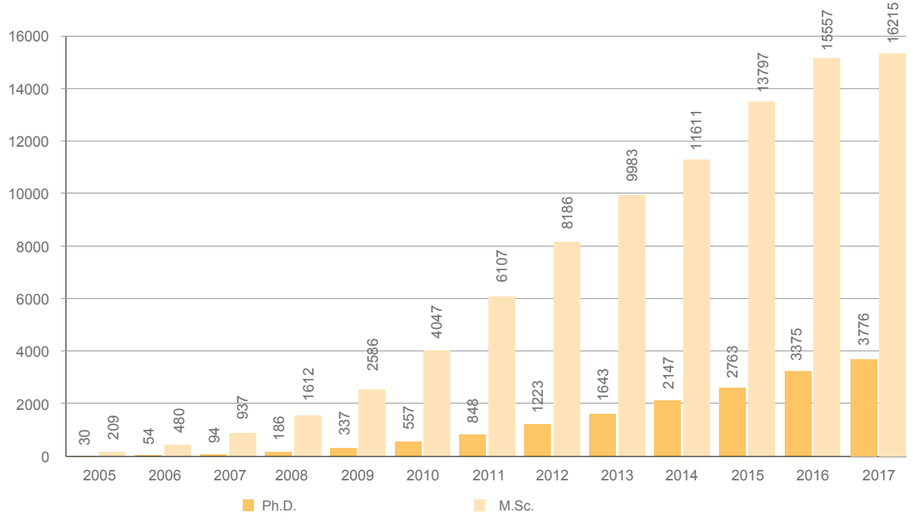


Figure 1: *Iranian Nanotechnology Graduates per year (Jun. 2018)*

Figure 2 displays the number of articles published by contribution of Iranian researchers in the Web of Science ISI database from 2001-2017.

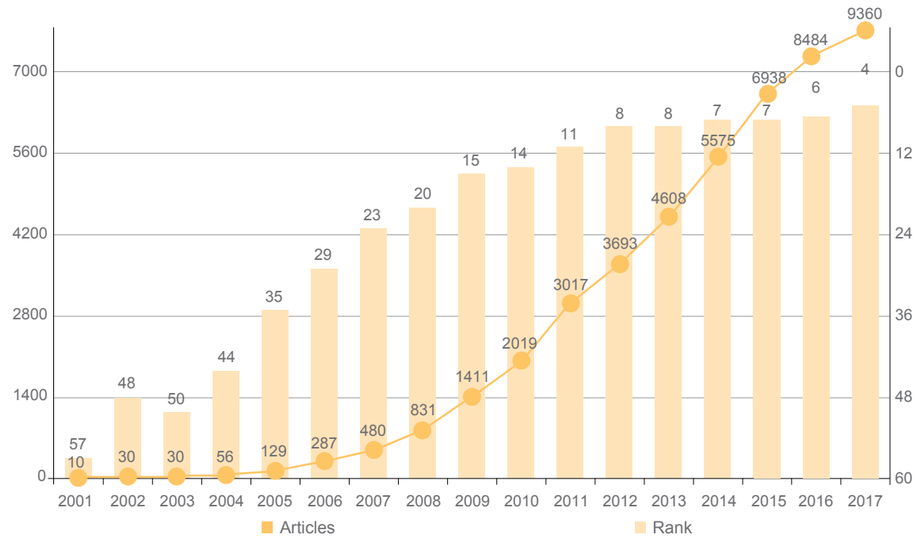


Figure 2: *The Number & Rank of Iranian Nanotechnology ISI Articles in the World (2001-2017)*

Table 1

The Number & Rank of 30 Top Countries in Nanotechnology ISI Articles (2017)

Rank	Country	Number of Articles	Rank	Country	Number of Articles
1	China	59198	16	Brazil	2948
2	USA	52281	17	Saudi Arabia	2921
3	India	13324	18	Poland	2582
4	Iran	9360	19	Singapore	2386
5	South Korea	9213	20	Turkey	2323
6	Germany	8836	21	Swiss	2054
7	Japan	7691	22	Malaysia	1924
8	France	6002	23	Egypt	1892
9	United Kingdom	5801	24	Sweden	1877
10	Russia	5328	25	Netherlands	1778
11	Spain	4553	26	Pakistan	1728
12	Italy	4482	27	Belgium	1400
13	Australia	3924	28	Mexico	1361
14	Canada	3570	29	Czech Republic	1228
15	Taiwan	3111	30	Portugal	1114

Source: statnano.com

C. Some Achievements

The below chart shows the increasing trend of Nano-based products developed in Iran in the past 8 years.

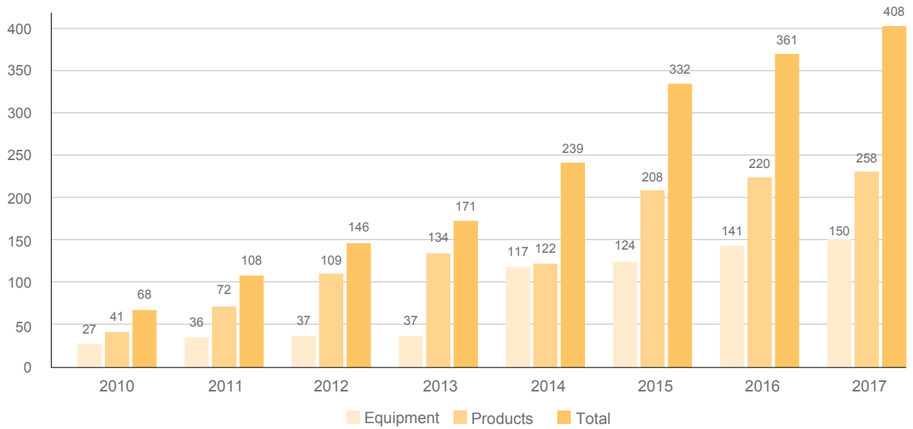


Figure 3: *Nanotechnology Products and Equipment*

Here, some leading products and equipment are introduced as follows:

• Electro Spinning Unit (Nano Fiber Production)

Applications of electro spinning units include filtration, ballistic resistant coatings, biomedical, medical prostheses, wound dressing and drug delivery and pharmaceutical compounds. The product advantages compared to other available samples include reliability, user-friendliness, and sustainability, as well as higher accuracy, performance and production rates.

Industrial Equipment for Nanofibers Production Line

• Nano Cavitation System

The device has a unique technology with a variety of applications in the areas of water and wastewater treatment such as water disinfection, removal of chemical contaminants, heavy metals, etc. Cavizone technology works based on advanced oxidation process. This technology has employed ozone injection methods, hydrodynamic cavitation and electrochemical oxidation to kill bacteria and remove biofilm, organic matter and heavy metal oxide from different water and wastewater.

Nano-Masterbatch *Nano Composite Profiles*

When water is in the cycle of cavizone process, the cell walls of bacteria are decomposed and heavy metals are oxidized and prepared for final treatment. Cavizone technology consists of three efficient oxidation processes that introduce an affordable and efficient technology compared to other alternative technologies. These three processes include hydrodynamic nano cavitation, injection of nano-ozone and electrochemical oxidation. Some product highlights are as follows:

- Oxidation without utilization of chemicals;
- Ability to increase capacity in various industrial scales;
- Portability;
- High efficiency;
- Eco-friendly;
- Affordability.

• Nanoliposome Producer

Nanoliposome or submicron bilayer lipid vesicle is a new technology to encapsulate and deliver bioactive agents. Nanoliposomes can enhance the performance of bioactive agents by improving their solubility and bioavailability, in vitro and in vivo stability, as well as preventing their unwanted interactions with other molecules.

Due to their biocompatibility and biodegradability, nanoliposomes can be potentially applied in a vast range of fields including pharmaceutical, food, cosmetics and agricultural industries.

• Rebar Spot Welding Electrode, Welding Nozzles and Copper - Alumina Fittings

These products are made of copper-alumina nanocomposites through cold forging process and are applied to automotive industries, tubing, aerospace and home appliances. Key features of this product are as follows:

- Mechanical strength of low-carbon steel (4 times the pure copper due to homogeneous distribution of aluminum oxide nanoparticles within copper matrix);
- Electrical and thermal conductivity in the range of 82% pure copper to retain these properties at high temperatures;
- Higher durability of parts compared with the similar products.

The material is unique due to the homogeneous distribution of alumina nanoparticles in copper matrix. Due to the stability of these particles at high temperatures, all properties of this material

SinaDoxosome

SinaCurcumin

(unlike other alloys such as Cu- Cr- Zr) are maintained up to 1000 °c while there is no loss of properties. Resistance at high temperatures, lack of phase transitions (structural), competitive price and superior quality are among some advantages of this product compared to other available ones.

• SinaDoxosome (Doxorubicin Hydrochloride Liposome Injection)

SinaDoxosome is a liposomal drug delivery system containing doxorubicin hydrochloride applicable to treat cancers of breast, ovary, AIDS-related Kaposi, leukemia, etc.

Heart attack is one of the dangerous side effects of doxorubicin. Therefore, a 100 nm nanoliposomes is used to reduce its side effects. Nanoliposomes also increase the durability of the drug in the body and leave the immune system intact due to the use of polymer coatings on the surface of the particles.

Product benefits include high efficacy and low side effects, especially, reduced cardiotoxicity compared with doxorubicin hydrochloride usage.

• SinaCurcumin (Soft Gelatin Capsules Containing Curcumin Nanomicelles)

Curcumin (Diferuloylmethane) is a polyphenol of category D Aryl Heptanoid. This substance is the active part of Curcuma Longa, a perennial plant known as turmeric. Generally, anti-oxidant, cancer prevention and anti-inflammatory properties are among the biggest biological effects of turmeric and curcumin. As a potent anti-inflammatory product, it is used in the following conditions:

- Arthritis (osteoarthritis and rheumatoid arthritis);
- Gastrointestinal inflammation (Crohn's disease, gastritis, irritable bowel syndrome and ulcerative colitis);
- Inflammation of the mouth (gingivitis, stomatitis, etc.);
- Inflammation of the skin (psoriasis, eczema and ulcers, etc.);
- Prevention and Reduction of cancers;
- Side effects of chemotherapy and radiotherapy;
- An effective supplement in patients with depression;
- Powerful antioxidants and beneficial supplement for healthy cardiovascular system (anti-platelet aggregation, lowering cholesterol, LDL, etc.);

Welding Nozzle and Copper Alumina

Alumina-Copper Bar

- Improved liver function (fatty liver adjuvant therapy and prevention of progressive liver disease, etc.);
- Treatment and prevention of diabetes complications (diabetic neuropathy and retinopathy, etc.).

Advantages compared to similar products include absolute absorption of curcumin by spherical nanomicelles which increase curcumin solubility in water.

• SinaAmpholish (NanoLiposomal Amphotericin B Topical Gel)

The size of NanoLiposomal amphotericin B is about 100 nm which in cases of *cutaneous leishmaniasis*, after topical application, can pass through the horny layer and reach the macrophages in epidermis and dermis. Since liposomes are foreign particles for body, they will be swallowed by macrophages (which have phagocytic properties). Then, the vesicles fuse with the membrane of lysosomes in macrophages and contents of vesicles are transferred into lysosomes. Inside the lysosomes, the liposomal phospholipids are decomposed in acidic pH of lysosomes by lysosomal hydrolase enzymes and release the drug in the liposome. Thus, the encapsulated highly concentrated drugs in liposomes are released in the vicinity of *Leishmania* and destroy it.

Amphotericin B is the most effective medication to treat fungal and protozoan infections such as *Leishmania*. Therefore, its topical form is used in the following cases:

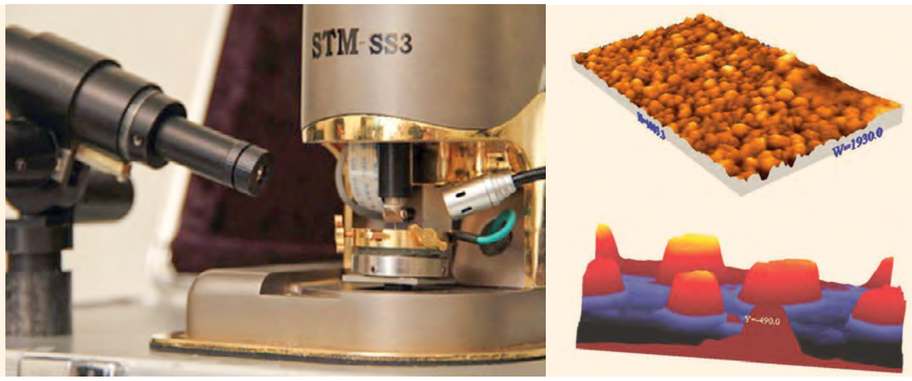
- Treatment of cutaneous *leishmaniasis (cutaneous leishmaniasis)* caused by various species of *Leishmania*;
- Topical chronic recurrent fungal infections such as dermatophytes;

Advantages compared to the similar products include more efficiency (above 90%) compared with conventional treatment and the use of antimony compounds (40%-70%), shorter treatment duration, painless and easier usage compared to the injectable treatment, and fewer side effects compared to systemic treatments.

IV. Authorities

A. Iran Nanotechnology Innovation Council

Iran Nanotechnology Innovation Council (INIC) is responsible to determine and supervise the implementation of the general policies to develop nanotechnology in the country. INIC's main mission is to enable Iran to achieve a proper place among the 15 advanced countries in nanotechnology and



Scanning Tunneling Microscope (STM) & Results

leverage nanotechnology in economic development of the country. By providing facilities, creating market and removing the impeding obstacles, the Iran Nanotechnology Innovation Council aims to pave the road for the private sector activity and generation of wealth in the country. In summary INIC tasks include:

- Setting goals, strategies, macro-scale policies and national initiatives to develop nanotechnology in the country;
- Assigning general tasks to governmental bodies, determining missions for each sector and making coordination among them within the framework of a long term national plan;
- supervising actualization of goals and programs.

Various institutions with defined strategies and working plans follow the targets of INIC as summarized in the next sections.

B. Other Authorities

• Tech-Market Services Institute (Corridor)

The Tech-Market Services Institute (Corridor) was established with the aim of accelerating commercialization process and developing new technologies. The corridor already includes the following sections:

○ Evaluation Department for Nanotechnology Products and Companies

Assessing nanotechnology companies' eligibility, evaluating nanoproducts in terms of stability of the nanomaterial structure and its properties, and granting certificates are among the main missions of this department.

○ Commercialization Service Development Department

This department aims to identify technology development services, expand links with brokers and institutions, and monitor the quality of the provided services.

• Iran Patent Office

Having focused on importance of intellectual property as one of the important infrastructure of technology development, the Intellectual Property Department affiliated to the "Iran Nanotechnology Innovation Council" started its activity in 2005, and since 2014 as the "Iran Patent Office" has undertaken the responsibilities related to the field of intellectual property in all areas of science and technology under supervision of the "Vice-Presidency for Science and Technology".

Desalination Unit (Cap. 5000m³/day)

Nitrate Removal Unit (Cap. 5000m³/day)

Arsenic Removal Unit (Cap. 10,000m³/day)

• Tech-Export Services Corridor

This office supports companies to reach international export markets by providing export development services. It also backs firms by direct supervision on the quality of services provided by specialized firms (brokers) in each field.

• Iran Nanotechnology Standardization Committee

Recognizing the importance and role of standardization in nanotechnology development and commercialization and in line with objectives of the National Nanotechnology Program including wealth creation and life quality improvement, the "Iran Nanotechnology Standardization Committee (INSC)" was established by the Iran Nanotechnology Innovation Council (INIC) in 2006. INSC consists of three specialized working groups and serves as mirror committee of ISO/TC229.

Its main objectives include sustainable, safe and responsible development of nanotechnology while enjoying its benefits and protecting human health and environment. INSC has successfully accomplished to:

- Develop 66 national standards;
- Publish 4 international standards in ISO/TC229;
- Establish Iran Nanosafety Network (INSN);
- Implement National Nanometrology System;
- Promote nanotechnology standardization and nanosafety.

• Iran Nanosafety Network

Focusing on health, safety and environment in the field of nanotechnology and making collaboration platform for researchers and the related institutions, the "Iran Nanosafety Network" was founded to convoke the researchers and their activities in nanosafety within the framework of the network programs. For more information, see www.nanosafety.ir.

• Joint Nanometrology Strategic Committee

This committee was established in close collaboration with the Institute of Standards and Industrial Research of Iran (ISIRI) and they jointly published national nanometrology plan. The National Nanometrology System was implemented to institutionalize dynamic and continuous development of nanometrology and secure national and international credibility in nano-measurements.

C. Companies

There are more than 129 nanotech-based startups and more than 181 companies with nanotechnology product manufacturing activities. The following figures display activity areas of nanotechnology startups and nanotechnology products, respectively.

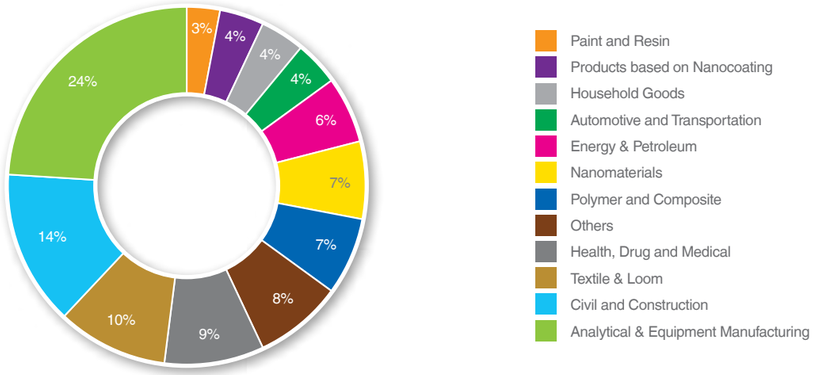


Figure 4: *Activity Areas of Nanotechnology Startups*

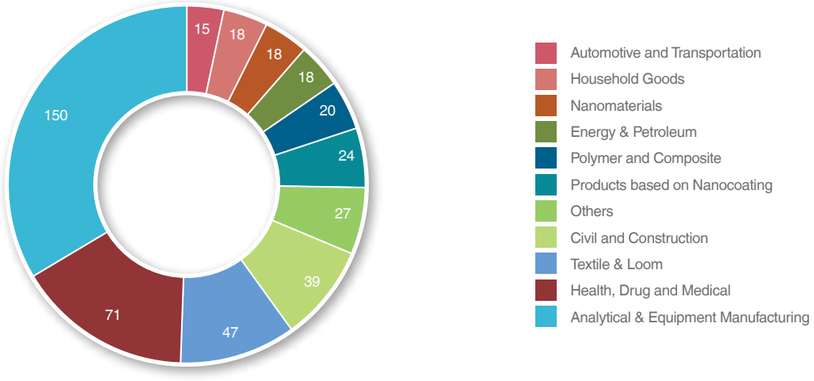


Figure 5: *Nanotechnology Products [Source: nanoproduct.ir (Dec. 2016)]*

V. International Cooperation

Active participation of Iran's nanotechnology companies in credible international exhibitions has paved the way for them to develop technological and commercial interactions with international partners. Currently, several Iranian nanotechnology companies are successfully exporting their knowledge-based products to other countries. On the other hand, active presence of the country in local and regional networks such as Asia Nano Forum (ANF) has made it possible for Iranian companies to collaborate with international nanotechnology community at policymaking and public sector levels. Also, at high decision-making levels, one can refer to bilateral cooperation agreements with countries such as China, Thailand, South Korea and Russia in the areas such as education, standards, certification, joint research and development as well as commercial interactions. The Iran's Nanotechnology Community, led by INIC, fiercely pursues bilateral or multilateral international collaborative initiatives in the following areas:

- Running international cooperation in scientific, educational, technological, and commercial levels as well as standardizing and policymaking;
- Cooperating in nanotechnology training at different levels, joint research and development (R&D), researcher exchange, knowledge and experience exchange, joint standard development, technology transfer, and joint investment with international companies and institutions;
- Making mutual commercial agreements to certify nanotechnology products and facilitate their transactions.

3 Biotechnology

Biotechnology

I. History and Background

Biotechnology is known as one of the state-of-the-art technologies in 21st century and is among the seven key industries which will determine the socioeconomic destiny of communities in the coming decades.

Biotechnology has a long history and is very well-developed in Iran. The history of biotechnology research and academic centers in Iran goes back to a century ago when traditional biotechnology initially was employed to develop medicines and vaccines at the Pasteur Institute of Iran (PII).

The Pasteur Institute, founded in 1921, and the Razi Institute for Serums and Vaccines, founded in 1924, are two well-established centers in Iran for biotechnology research. The Institute of Biochemistry and Biophysics, founded in 1976 and affiliated to the University of Tehran, is also engaged in biological research. The Biotechnology Institute at the Iranian Research Organization for Science and Technology (IROST), founded in 1980, has been actively involved in traditional biotechnology research since its establishment and has gradually shifted its activities to modern biotechnology.

The history of modern biotechnology in Iran dates back to 1980's. The establishment of the National Institute of Genetic Engineering and Biotechnology in 1989 marks a significant point in developing modern methods of biotechnology in the country. With respect to its priority and strategic importance for the Islamic Republic, the Biotechnology Development Council affiliated to the Vice-Presidency for Science and Technology was established in 2008 as the main body for policymaking, planning, executive leadership, coordination and monitoring biotechnological research in the country.

In general, enormous biodiversity in terms of ecosystem, species, and geographical variation; rich natural resources; and unique genetic patterns found in humans, plants, animals, and microorganisms has made obtaining and making use of this vital and transformative technology possible for Iran. Consequently, Iran has made large investments and dramatic progress in biotechnological research, especially over the past decade.

II. Policies and Strategies

Promoting to the first rank in the Middle East and improving Iran's global rank to be placed among the top ten countries in the world by 2025 are the main goals of the Biotechnology Development Council. Major policies and strategies of the sector are as follows:

A. Macro Level Policies

- Promoting national sovereignty and enhancing social welfare;
- Expanding scientific and technological cooperation at national, regional, and international levels;
- Meeting the country's strategic demands for food, public health, environment, and energy;
- Observing the ethical and biosafety principles in accordance with domestic and international regulatory frameworks.

B. Macro Level Strategies

- Maximizing the privatization of biotechnological products;
- Completing and organizing an integrated system for biotechnology management across the country;
- Improving the quality of domestic products with a view to paving the way for entering the international markets;
- Paving the way for making use of the available domestic capacities in Iran and regional countries with a view to expanding the market for domestic biotechnology products;
- Exploiting the biotechnology capabilities as a green industry for environmental protection and restoration;
- Creating the basis for the development of domestic and international partnerships and joint ventures.

III. Capacities and Capabilities

A. Human Resources

Based on the council's latest statistics, about 15,010 biotechnology experts are currently active in the country. The total number of university academic members breaks down as follows: 15 percent instructors, 59 percent assistant professors, 17 percent associate professors and 9 percent full professors. The proportion of faculty members at the level of professorship in biotechnology engineering and medical sciences is respectively higher than that in other groups.

B. Scientific Productivity

In 2017, Iran ranked 13th in the world in terms of the number of published biotechnology articles in the indexed journals (Table 1).

Table 1

Iran's Biotechnology Scientific Productivity Compared to the World (2017)

	Country	Documents		Country	Documents
1	China	7603	9	Italy	1139
2	United States	6561	10	France	1127
3	India	2675	11	Canada	976
4	Germany	2170	12	Brazil	933
5	South Korea	1874	13	Iran	905
6	United Kingdom	1722	14	Australia	901
7	Japan	1582	15	Netherlands	634
8	Spain	1147	16	Switzerland	550

[Source: Scimago]

Also, Iran's share of biotechnology articles in 2015 as compared to the regional countries and the world is 27.22% and 1.27%, respectively (Figure 1).

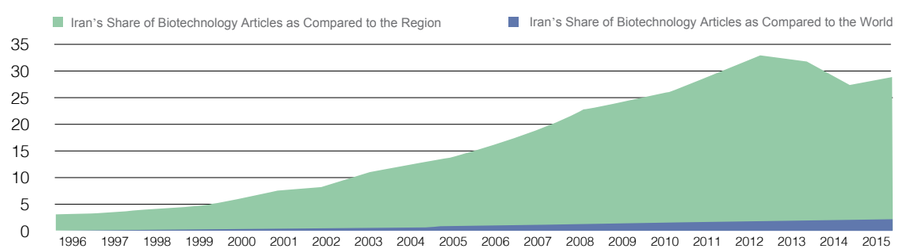


Figure 1: *Iran's Biotechnology Scientific Productivity by Year [Source: Scimago]*

C. Some Achievements

1. Medicine

• Generic name: Trastuzumab

Brand name: Hercease™

Product Information

Hercease™ is a biogeneric form of Trastuzumab which is used to treat breast cancer. It is a recombinant DNA-derived humanized monoclonal antibody that selectively targets the extracellular domain of the human epidermal growth factor receptor 2 (HER2).

Studies indicate that patients with tumors amplification or over-express HER2 have a particularly aggressive form of tumor and a shortened disease-free survival compared to patients with no tumor amplification or over-expression of HER2. HER2 whether over-expression or amplification can be diagnosed using an immunohistochemistry-based (IHC) assessment of fixed tumor blocks or employment of In Situ Hybridization (ISH) technology. The original studies of Trastuzumab showed that it can improve overall survival in late-stage (metastatic) breast cancer from 20.3 to 25.1 months.

• Generic name: Etanercept

Brand name: Altebrel™

Product Information

Etanercept manufacturing is based on expression by a protein recombinant technology using Chinese Hamster Ovary (CHO) cell. This molecule is composed of 934 amino acids weighting 150 KDa and acting as a TNFα Blocker. TNFα is a kind of cytokines which is produced by monocytes and macrophages and increases white cells flow to the swelled areas. Having this property coupled with other related mechanisms, TNFα could increase inflammation. So, Etanercept decreases inflammation responses through inhibiting the mentioned TNFα mechanism which is completely effective in treatment of autoimmune diseases.

Conditions of usage

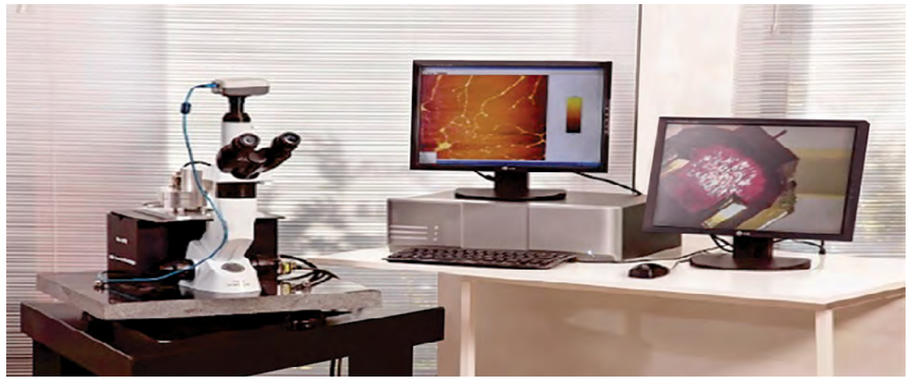
Altebrel™ is a biosimilar product called Etanercept- a generic name. It is used to treat several autoimmune diseases like Rheumatoid Arthritis, Plaque Psoriasis, Psoriatic Arthritis, Spondyloarthritis, Ankylosing Spondylitis and Juvenile Idiopathic.

• **Generic name:** Recombinant Human FVIIa
Brand name: AryoSeven™
Product Information
AryoSeven™ is indicated to treat and prevent bleeding episodes in patients with Hemophilia A or B with inhibitors; acquired hemophilia; congenital factor VII deficiency; and Glanzmann's thrombasthenia.

Product specification (Technical Standards)
AryoSeven™, human activated recombinant blood coagulation factor VII (rFVIIa), is a glycoprotein with 406 amino acids and molecular weight of about 50 KDa which is produced in Baby Hamster Kidney (BHK) cell line via recombinant technology and is highly purified to be acceptable as an injectable human drug. This biologically similar medicine is produced under strict cGMP standards and is currently used by several thousands of patients in different countries.

• **Generic name:** Pegfilgrastim
Brand name: PDlasta®
Product information
PDlasta® is used to reduce the duration of neutropenia (low white blood cell count) and the occurrence of febrile neutropenia (low white blood cell count with a fever) which can be caused by cytotoxic chemotherapy (medicines that destroy rapidly growing cells).
It is used to decrease the incidence of infection (as manifested by febrile neutropenia) in patients with nonmyeloid malignancies receiving myelosuppressive cancer chemotherapy associated with a clinically significant incidence of febrile neutropenia.

• **Generic name:** VitaLact
Product specification (Technical Standards)
Being rich in probiotics, essential vitamins and minerals, it is a perfect product to improve overall immune and energy support. It is also effective to treat digestive disorders and to boost the immune system. The vitamins and minerals help to improve metabolism and general health.
Its advantages compared to the similar ones include: higher count, prebiotics, lower price, strain diversity, product stability, ability of observing the cold chain, and possibility of strain localization for increased effectiveness among Iranians.



• **Generic name:** Interferon β-1a
Brand name: ReciGen®
Product information
ReciGen® (interferon beta-1a) is used to control the progression of Multiple Sclerosis. It is a purified 166 amino acid glycoprotein, with a molecular weight of approximately 22,500 daltons, manufactured through a biotechnological processing of the naturally-occurring interferons by using recombinant DNA technology. It is made up of exactly the same amino acids as the interferon beta found in the human body.

2. Medical Equipment

• **Generic name:** Bio Atomic Force Microscope (Nanoscope)
Brand name: Pajuhesh Ara Atomic Force Microscope
Product specifications (Technical Standards)
Possibility of nanometer-scale imaging from bio samples (bacteria, viruses, DNA, etc.), imaging for samples that cannot be separated from their culture medium, imaging from live nano-scale bio samples in their culture and liquid medium, enjoying fiber microscope up and down in order to view location of sample precisely, using advanced "Stage" to move sample along X and Y axis, having ultra-precise nano scanner, using precise micron operator with negligible mechanical noise, enlarging the received image and re-imaging of the zoom range, and automatic planning to change the parameters of imaging parameters, while scanning are among its specifications.
Its advantages over the foreign counterparts include imaging from both opaque and transparent samples, multifunctionality-13 operating modes on a nano-scope, and rapid imaging up to 30 images per minute.

• **Generic name:** Bio AFM
Brand name: Ara Research Bio AFM
Product specification (Technical Standards)
Integrated with inverted optical microscopes; two independent, closed-loop XY and z scanner; flat and linear XY scan of up to 50 µm × 50 µm with low residual bow; angstrom resolution in Z axis and nano-resolution on X&Y axis; easy sample or tip exchange; easy head removal; direct on-axis optics for high resolution optical viewing; backlash-free sample stage; sample positioning range of 7 mm in X and Y; tight mechanical coupling yields excellent noise performance; and compatible with both reflection and transmission modes.

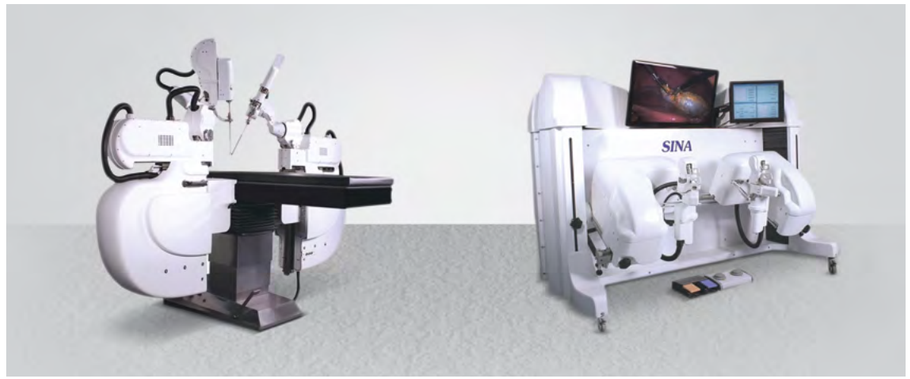
• Generic name: Iranian Gene Gun Completed by Somatic Embryo Induction Devices
Brand name: Kian Gene Gun
Product information
Electromagnetic micro projectile device is made as a wounding agent with the capability of throwing nanoparticles towards cell. The key advantages include user-friendliness, reasonable price, no user fees and consumable parts, precision and high performance. It has been used to produce transgenic organisms (plants, animals, fungi, bacteria, insects etc.).

• Generic name: Monoclonal Antibodies against Human CD Markers
Brand name: Cyto Matin Gene (CMG)
Product information
Monoclonal antibodies can be used to detect the presence of specific antigens on the cell due to their specificity; monoclonal antibodies have become one of the most powerful tools available in the biological sciences. They have wide applications for research, diagnosis and therapy.

• RoboSPECT
Nuclear medicine is a medical specialty that uses radioactive tracers (radiopharmaceuticals) to assess bodily functions and diagnose and treat disease. The most widely used filed in nuclear medicine is cardiac SPECT imaging that provides the information to diagnose the prognosis of coronary artery disease and heart muscle damage following an infarction.
The RoboSPECT, which uses three swivel motors delivering the robotic movements and providing the circular and noncircular SPECT movement, is designed and developed for dedicated cardiac SPECT imaging. Also, the system has Iran MOH production license.

• SERGEOGUIDE II
Currently, “Gamma Probe” is the most popular device for surgeons which is considered as an easy-to-use, small and hand-held tool with the capability of detection and localization of sentinel lymph nodes used not only for breast cancer but also for some cancers in men when detecting sentinel nodes is mandatory. These gamma probe system come in two models SURGEOGUIDE and SURGEOGUIDE II; both meet international standards and have Iran MOH production license.
Some of its clinical applications include:

- Breast cancer;
- Gynecological cancers (cervical, ovarian, uterine, vaginal and vulvar);



- Endocrine cancers (thyroid, parathyroid);
- Urology cancers (prostate, bladder, testicular, kidney and penile).

• SINA
Sina is a complete robotic telesurgery system with force feedback. This system has two main subsystems including master robotic system console at surgeon’s side and slave robotic console at patient’s side with two robots which are installed on the sides of a specific surgery bed. The master robot receives a surgeon’s hand movement and transmits them to the patient’s side slave robots that mimic the movements in a real-time manner.
Main features of master robot console include:

- Ergonomic console base with adjustable 3DOF;
- Two 5DOF back drivable master robot to be manipulated by surgeon’s hand;
- Foot pedals to control the laparoscopic camera and electrocautery.

Main features of slave robot console include:

- Adjustable bed with active 3DOFs;
- Two bed-side 5 DOFs surgery robots;
- Two bed-side passive robots with 3 Cartesian robot motions to adjust active robot’s RCM.

• Generic name: Aneuquick QF PCR Kit
Brand name: KBC Aneuquick QF PCR Kit
Product information
QF-PCR is a novel, fast, cost-effective and reliable molecular technique based on PCR amplification by using fluorescent primers for prenatal 21, 18, 13, X chromosomes and Y aneuploidies diagnosis. DNA extracted from amniotic, chorionic villus samples and blood can be used as the genomic material in this method. In a multiplex assay, specific STR markers are amplified for each chromosome; their peaks represent the number of chromosomes. Since commercial kits are designed for European and American populations, in some cases suspicious results had been seen in Iranian population.
“KBC-Aneuquick” is a novel kit especially designed for Iranian population allele frequencies. This kit has 24 markers which have a wide range of heterozygosity and covers the entire length of each chromosome and critical regions. Markers and their primers were chosen considering the CNVs (Copy Number Variations) and SNPs (Single Nucleotide Mutation) to avoid false-positive or false-negative results.

• DNA Microarray

Nowadays, medicine industry is principally focused on the “Personalized Medicine” as well as “Early Diagnostics”. To achieve either of these goals, the cell genetic content should inevitably be investigated. DNA Microarray is a device that studies presence and/or expression of numerous genes, simultaneously. The DNA microarray system includes a diagnostic chip, a printing robot, and a chip scanner designed and manufactured in the DNA Analysis Laboratory.

Features

Diagnostic Chip

- Equipped with an extra-smooth surface with an average roughness of 1nm;
- Providing a high-affinity substrate for single molecule binding;
- Conducing reliable hybridization reactions.

Printing Robot

- Printing 5-nanoliter droplets of solutions on the chip;
- Moving in 3 perpendicular directions on a course of 0.5m with a 10μm precision.

Chip Scanner

- Detecting fluorescence solutions as dilute as 130 molecules per μm^2.
- Detecting fluorescence dyes in two different channels.

Uses

- Early Diagnosis for cancer and numerous other genetic disorders and diseases;
- Suggesting an optimized path for the physician to prescribe medication for each individual;
- Diagnosing prenatal genetic diseases;
- Detecting contaminations of food and agricultural products.

• Milibioreactor

Milibioreactor determines the oxygen transfer rate (OTR), carbon dioxide transfer rate (CTR), and respiratory quotient (RQ) of microbial, plant, and cell cultures online. The respiration rates (OTR, CTR) are the most accurate measurable variables to quantify the physiological state of fermented cultures.

The advantages of this bioreactor include saving time up to 75%, saving raw materials upto 80%,

and ease of operation. The bioreactor can handle bio-reaction of cells, microorganisms like bacteria, yeast, fungi, animal, and plant cells in research applications such as pharmaceutical laboratory science as well as medicine, foodstaff, environmental, and oil industry. It is also used to determine the optimum operating conditions for biotechnology products (e.g. human proteins, enzymes, and medicine) and to scale up procedure for biotechnology processes.

Direct on-line monitoring of a cell’s metabolism including pH, substrate concentration, nutrient rate (vitamins, phosphorus, and nitrogen), biomass cells, enzymes, and protein production and its effects on the growth of microorganisms and cells are among other functions of this apparatus.

Milibioreactor is also used to study the effects of applying nanoparticles on toxicology of cells and stem cell growth.

Milibioreactor is an appropriate tool to meet FDA’s PAT initiative regarding shaken bioreactors.

3. Agricultural products

• Date palm

Product information

Direct Somatic Embryogenesis (DSE) tissue culture technology is used for the micropropagation of date palms. So far, 15 species of date palm have been integrated in production lines. DSE has been scientifically proven to produce uniform plants with minimum levels of somaclonal variation as compared to other micropropagation methods. Creating new species, proliferation of disease-free seedlings, capability of reproducing throughout the year are among the usages of such product.

• Food Fraud Detection

Food fraud is originated as a way to extend food’s primary ingredients. Food fraud is a growing problem worldwide. According to the World Customs Organization (WCO), food fraud costs $49 billion annually. Moreover, it is deleterious to health.

Polymerase chain reaction (PCR), a DNA-based method, can be used as an alternative method for rapid and accurate detection of DNA’s source in food due to the high stability of DNA compared to RNA.

Now, it is possible to detect food fraud in a wide range of products including processed and raw meat products, canned tuna and the other fish products, dairy products, oil, saffron, pistachio and almond, GMO, and the origin of gelatin derived from different sources (Pastel, Capsule, Jelly powder, etc.).

Features and Advantages
- Sensitive and specific enough to trace small amounts of target DNA;
- Because of high stability in different products, DNA is a key molecule for detection;
- A species-specific method which can be used in fully processed food products;
- A reliable, accurate, and fast system;
- Applicable to a wide range of products.

• Nitro Kara Bio-fertilizer

Nitro Kara is a Nitrogen fixing biofertilizer and it has extremely efficient nitrogen fixing bacteria of *Azorhizobium caulinodans* which is isolated from the nature. *A. caulinodans* is found in soil around plant roots (rhizosphere), root surface and inter cellular spaces of stem and root tissue. When *Azorhizobium* is injected to the plant, under ideal conditions, it multiplies on its host plant and can supply 200-300kg of nitrogen per hectare/season. Moreover, *A. caulinodans* produces growth promoting substances like Indole Acetic Acid (IAA), Gibberellins, and increases root proliferation, plant growth and yield.

Advantages
- Natural and %100 organic;
- Enhancing the crop yields;
- Improving the flavor and scent of crops;
- Organic acids produced by Nitro Kara bacterium increases the dissolution phosphorus and calcium in soil and makes these elements abundantly available to plants;
- Gases produced by Nitro Kara bacteria increases soil porosity, thereby improving flow of air and water in soil;
- Improving the soil quality and root structure;
- Safe for humans, insects, animals and environment;
- More compact for transportation and warehousing, compared to chemical fertilizers.

• PhosphoBARVAR-2 (Phosphate Biofertilizer)

Phosphorus is one of the macro-elements absorbed by plants as water-soluble, free-phosphate ions. As the amount is fixed in soil, phosphate ions is not sufficient for plants.
PhosphoBARVAR-2 biofertilizer is a novel technology which is a safe and effective alternative to chemical phosphate fertilizers. This biofertilizer contains two types of highly efficient phosphate solubilizing bacteria (PSB) that conceal organic acids and phosphatase enzymes which hydrolyze insoluble inorganic and organic phosphate compounds into soluble phosphate ion around roots.

Advantages
- On average 15% increase in yield (about 25% in trees);
- 50-100% reduction in using chemical phosphate fertilizer;
- Excellent for organic farming;
- Reducing fertilizer, transportation and warehousing costs;
- Reducing the environmental hazards of chemical fertilizers;
- Simple application methods;
- Reducing soil-borne diseases;
- Improving soil structure;
- Using only 100-gram package per hectare (1 gram per tree).

• Myco-Root

It is the first formulation of a series of products which is based on the useful properties of beneficial soil Mycorrhizal fungi. This product is an easy-to-use powdery form and supports plants throughout their growing seasons. After using this product, Mycorrhizal fungi colonizes roots and absorbs water and mineral elements more quickly and in greater amounts. As a result, Myco-Root consumption will boost plant growth and resistance to environmental stresses.

Advantages
- Increasing the absorption of mineral elements, growth and plant health;
- Reducing the absorption of harmful elements (Na and Cl);
- Developing flowers and fruits and increasing yield;
- Reducing plant need for water, chemical fertilizers and pesticides;
- Increasing resistance to environmental stresses (drought, salinity, and soil compaction);
- Reducing damage to seedlings and plants during the transition from nursery to the farm;
- Increasing water use efficiency;
- Increasing fertilizer use efficiency;
- Decreasing activity of root pathogens.

Applications
- Field crops;
- Fruit trees;
- Shrubs;
- Ornamental plants;
- Herbs and vegetables;
- Turf grasses and cover crops;
- Some of rangeland plants.

IV. Authorities

A. Biotechnology Development Council

In line with the expansion of biotechnology across the country, the Biotechnology Development Council affiliated to the Vice-Presidency for Science and Technology have always sought to eliminate the barriers of biotechnology advancement by providing biotechnology laboratory equipment and infrastructure and supporting developmental research projects. A number of the Council's objectives include:
- Increasing the contribution of biotechnology products to the GDP;
- Expansion of accessibility and application of biotechnology products and methods to prevent and manage genetic diseases (target diseases include cancer, diabetes, inherited diseases, and MS);
- Increasing the market share of biotechnology products and services to 3 percent of the global biotechnology market by 2015;

- Developing biotechnology research, production and application in fields such as medicine, agriculture, food, health, industries, mining, energy, and environment;
- Setting up biobanks, databases and networks such as the National Plant Gene Bank for microorganisms, human genes and vectors (carriers) in order to record and list the related information.

B. Other Authorities

Currently, there are 25 active biotechnology S&T parks and incubators across the country. Five specialized biotechnology incubators have also been established in Iran. Besides, 527 biotechnology companies have been registered, of which 211 companies are placed in 20 S&T parks and scientific research towns.

The Iranian biotechnology companies produce more than 230 types of biotechnology products. This wide variety of products include recombinant medicine, monoclonal antibodies, organic phosphate and nitrate fertilizers (in both solid and liquid forms), and biotechnology-related equipment. Almost 30 percent of the Iranian biotechnology companies are qualified to export their products. Over 50 types of Iranian biotechnology products are exported to other countries. Currently, 81 universities and 18 research centers and institutes are engaged in biotechnology research and training in Iran. Also, there are 24 specialized research centers conducting biotechnology-related research in the country including 15 research centers affiliated to the Ministry of Science, Research and Technology; 7 research centers affiliated to the Ministry of Health and Medical Education; and 2 research centers affiliated to the Academic Center for Education, Culture and Research (ACECR). Some of the main Iranian biotechnology research centers and institutes with their significant achievements are introduced below.

• National Institute of Genetic Engineering and Biotechnology

The National Institute of Genetic Engineering and Biotechnology (NIGEB) is an affiliated institute to the Ministry of Science, Research and Technology which provides genomic services; conducts quantitative analysis, proteomics-transcriptomics analysis, and cytotoxicity test systems for biomaterials; detects genetically modified organisms (GMO) in food, bioinformatics laboratory; and produces transgenic mice and rat models at the institute's National Center for Transgenic Mouse Research. Table 2 represents some parts of the technical knowledge created in the institute.

Table 2

Technical Knowledge of the Institute

Name	Description	Image
MicAuxin	Certain bacteria can promote plant growth by stimulating the rooting process. This mechanism works through secretion of auxin hormone. MicAuxin facilitates the microbial production of auxin using soil bacteria. This product is used to stimulate rooting in the semi-hardwood olive cuttings and to promote the olive plant growth.	
GAMBIST	The removal of pathogenic strains is a significant step in the treatment of periodontal diseases. Current treatments including antibiotic therapy and common surgeries are associated with several drawbacks. For instance, antibiotic therapy can cause resistant strains. Also, in case of choosing the wrong antibiotics, recurrence of the disease will not be unexpected. Despite having clear benefits, surgeries are also costly and their success depends on controlling the pathogenic bacteria and environmental factors. The probiotic mouthwash solution GAMBIST is an alternative product to treat gum and periodontal diseases. This product lacks the disadvantages of the current treatments and has yielded considerable patient satisfaction.	
Ovafact	Ovafact is a peptide hormone which stimulates synthesis and release of gonadotropin-releasing hormone (GnRH) in fish through interacting with specific receptors. Ovafact is used to increase productivity in different fish families including sturgeons, trouts, common carp, and gold fish.	

• Pasteur Institute of Iran

The Pasteur Institute of Iran (IPI) is an affiliated institute to the Ministry of Health and Medical Education which mainly conducts research, production, education, training, and health-related activities. The IPI was founded in Tehran in 1921 in order to facilitate health services to the public. To commercialize its products and services, two centers have been established in the institute relying on the faculty members' capacities. One of these two centers is a production and research incubator which is home to 60 biotechnology companies in Karaj. The IPI produces a wide variety of products including antigens, antibody diagnostic sera, recombinant products, vaccines, the required injectable solutions by emergency rooms, and diagnostic kits, among other things. Table 3 represents some of the products produced by the Pasteur Institute.

Table 3

Some of the Products Produced by the Institute

Name	Description	Image
Pastopoietin (Recombinant Erythropoietin Alpha)	Pastopoietin has the same biological properties of glycoprotein androgen-binding protein which intensifies the production of red blood cells by stimulating cellular division and differentiation in red blood cell progenitors of bone marrow. It also stimulates the reticulocyte release from bone marrow. This medicine is used to treat anemia associated with chronic renal failure, zidovudine induced anemia in HIV/AIDS patients, chemotherapy-induced anemia in patients with non-myeloid malignancies, and anemia associated with poor clinical outcome in patients undergoing non-cardiovascular surgery.	
Pastokinase (Recombinant Streptokinase)	Streptokinase is used to treat acute coronary artery thrombosis and acute myocardial infarction (AMI) for the lysis of intracoronary thrombi to limit the extent of infarction. Streptokinase is a bacterial protein (beta-hemolytic type C1) which compounds with plasminogen and forms an activator complex with the effect of converting the plasminogen of blood or clotting into plasmin (enzyme lysis of the fibrin).	
Pastoferon Alfa-2b (Human Recombinant Interferon Alfa-2b)	Pastoferon Alfa-2b is obtained from fermentation of manipulated strains of Escherichia coli with plasmid containing 2-b human leukocytes interferon alpha gene. The product contains 1.5 mg of human albumin.	

• Biotechnology Research Institute of the IROST

Established in 1980, Biotechnology Research Institute is one of the seven research centers at the Iranian Research Organization for Science and Technology (IROST). Through two five-year plans, the institute managed to develop a new series of research laboratories and a biotechnology pilot plant. The pilot plant equipment includes fermenters with 15, 75, 750, and 3000 liter capacities which form a complete production line together with the center's centrifuges and dryers.

By collecting an expert team to design and manufacture fermenters, the institute has developed airlift and stirred tank fermenters with a variety of capacities and added them to the pilot plant.

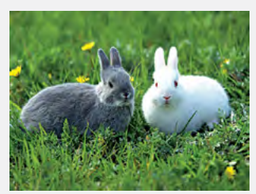
The Biotechnology Institute is also home to the Iranian Center of Industrial and Medical Fungi and Bacteria Collection. Since its establishment in 1980, the center has provided the microorganisms needed by educational, research, and industrial organizations and pharmaceutical factories. Over 2,000 types of microbial samples including different kinds of bacteria, fungi, yeast, and blue-green algae are kept in the center meeting international standards. In 1984, the center became a member of the World Federation for Culture Collections (WFCC). The WFCC has registered the center as the Persian Type Culture Collection and has assigned the code I124 to identify it. As a member of the WFCC, the Iranian Center of Industrial and Medical Fungi and Bacteria Collection is connected with similar centers working under the supervision of this international body.

• Razi Vaccine and Serum Research Institute

Established about 90 years ago, the Razi Vaccine and Serum Research Institute is one of the oldest and most reputed scientific research centers in Iran. The institute is involved in veterinary and biotechnology research. Razi institute is home to the most experienced specialists who work in its six regional branches across the country. The institute is composed of 12 specialized departments and 15 national and reference laboratories. The institute cooperates with the veterinary departments as well as agricultural and natural resources research centers in nearby provinces in order to make accurate and rapid diagnosis of major diseases in livestock, poultry and honey bees. The institute also makes significant contribution to the promotion of new biological products and improvment of the current biotechnology products. Razi institute's laboratory for livestock smallpox is known as a world reference laboratory. The institute produces a variety of vaccines and seroma including human vaccines, livestock and poultry vaccines, parasitic livestock vaccines, fish vaccines, as well as therapeutic sera with medical uses and antibodies. Table 4 contains some of the main products produced by Razi Vaccine and Serum Research Institute.

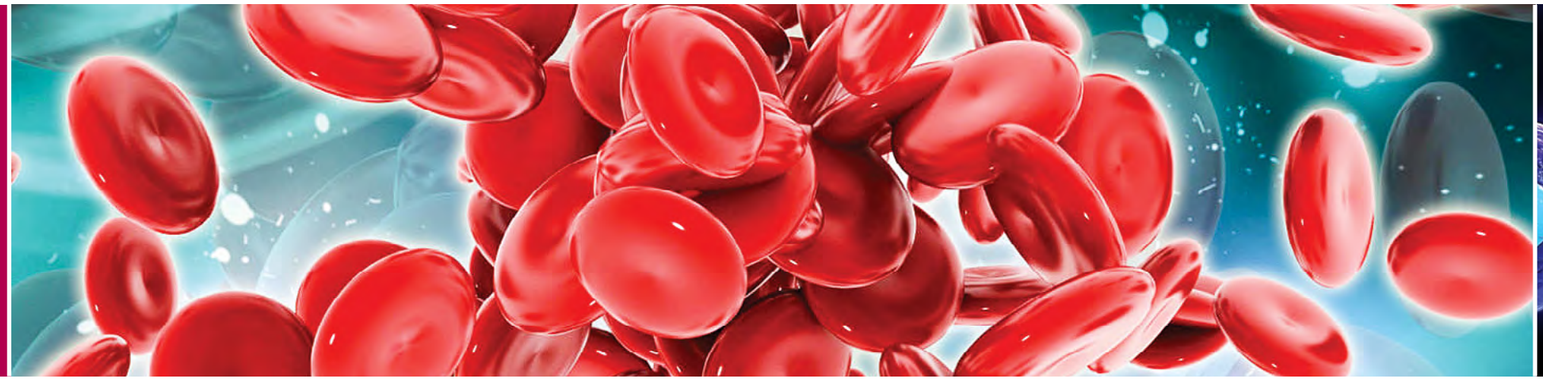
Table 4

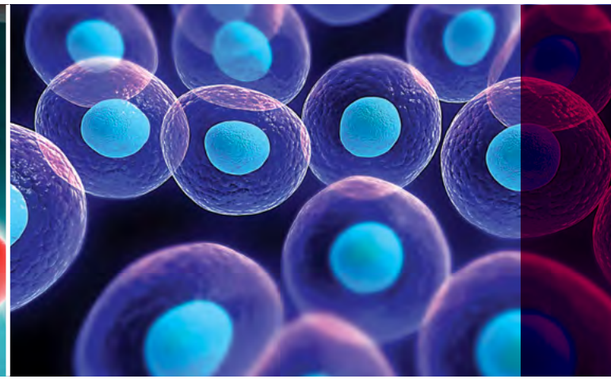
Some of the Main Products Produced by the Institute

Name	Description	Image
Gumboro Vaccine	The Gumboro vaccine contains the intermediate infectious bursal disease virus (Gumboro) inoculated in Specific Pathogen Free (SPF) embryonated chicken eggs. This is a live attenuated vaccine in lyophilized form and is used for immunization against infectious bursal disease (IDB) of Gumboro in local and industrial poultries.	
Therapeutic Sera	The institute produces a variety of therapeutic sera including scorpion and snake antivenoms as well as anti-diphtheria and anti-tetanus antitoxins.	
Laboratory Animals	Razi Vaccine and Serum Research Institute is one of the main producers of laboratory animals in Iran with the primary mission to meet the demands of the institute itself as well as that of other research and academic centers. The institute produces a wide variety of animals including mice (eight types), rats (five types), hamsters (four types), guinea pigs (eight types), and rabbits (one type). These types are different from each other in terms of race and strain. Each type is placed under a different strain. Moreover, each enjoys a specific application in their respective research and experiments.	

4 Stem Cell Technology

Stem Cell Technology





I. History and Background

Stem cell research began in the 1950s, when scientists tried to explore new ways to prevent incurable disorders. However, the advancements made in the field proved that stem cells can also be used for tissue repair in tissue engineering and regenerative medicine as well as treatment of genetic diseases and cancer. Thanks to stem cell sciences, it seems that in the near future the humankind will no longer have concerns about the loss of vital tissues.

The history of stem cell research in Iran goes back to the first hematopoietic stem cell transplantation (HSCT) in 1990s. Since 1994, Iranian researchers have published several papers in stem cell-related fields in high impact journals. By 2004, stem cell studies in Iran were developed to include embryonic stem cell research, which led to derivation of new lines of stem cells in the country. Since early 2005, Iranian researchers have also been engaged in tissue engineering and regenerative medicine. Publishing valuable articles in the credible international journals in these fields has been a continuous trend among Iranian researchers ever since.

The Council for Stem Cell Sciences and Technologies affiliated to the Iranian Vice-Presidency for Science and Technology was established in February 2009 in an effort to accelerate the county's progress in this strategic area and keep pace with other countries. The national document of stem cell sciences and technologies was also approved as part of the country's national comprehensive scientific map in September 2013 at the Supreme Council of the Cultural Revolution.

Iran's headway towards stem cell sciences and regenerative medicine, despite limited investments, reveals the country's enormous capacity for growth in these fields. In terms of published papers in the field of stem cell sciences and regenerative medicine, the Islamic Republic of Iran is ranked first in the Middle East and Islamic countries and second among the East Mediterranean and North African countries.

It is hoped that upon increase in the investments in stem cell research, Iran would be among the world's top 10 countries by 2025 in terms of science and wealth creation in this novel area of research.

II. Policies and Objectives

Major policies and objectives stipulated in the national document of stem cell sciences and technologies are as follows:

A. Macro Level Policies

- To improve efficiency and cost-effectiveness and make optimum use of the resources in the field of stem cell research;
- To enhance self-reliance and employment, and make maximum use of national capacities in this field;
- To mitigate government's domination, strengthen the private sector, and provide support for the qualitative and quantitative development of knowledge-based companies in the country;
- To encourage participation of the private sector, cooperatives, NGOs and foreign investors in the field with an emphasis on interagency coordination and cohesion;
- To adhere to the Islamic philosophical foundations and jurisprudence;
- To observe the ethical, religious, and social principles for further development of the field.

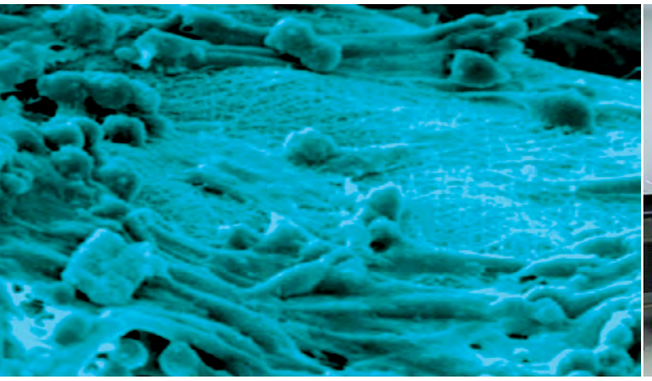
B. Macro Level Objectives

- To encourage self-reliance in production of the basic materials, laboratory equipment and supplies, and laboratory animals and services with a view to meeting at least 50 percent of the domestic demand;
- To enhance national wealth creation through applying stem cells and their products to treat various diseases and access two percent of stem cell market value in the world;
- To achieve national independence in banking the variety of stem cells;
- To involve the private sector in research, technology development and wealth creation while keeping the policymaking and supervisory role of the government in a way that at least 20 percent of the authorized cell treatment centers would be from the private sector;
- To create new knowledge and technologies with a view to ascending to the world's top ten countries in this field in terms of quality and quantity as well as publishing scientific papers in high credible international journals.

III. Capacities and Capabilities

A. Scientific Productivity

Figure 1 shows total number of scientific articles published in international journals by the country of origin of the authors till the end of 2018. Iran ranked 19th in the world with a total number of 9412 scientific papers in the field of stem cell sciences and regenerative medicine including cell therapy, gene therapy, hematopoietic stem cell transplantation, tissue engineering, and biomaterials.



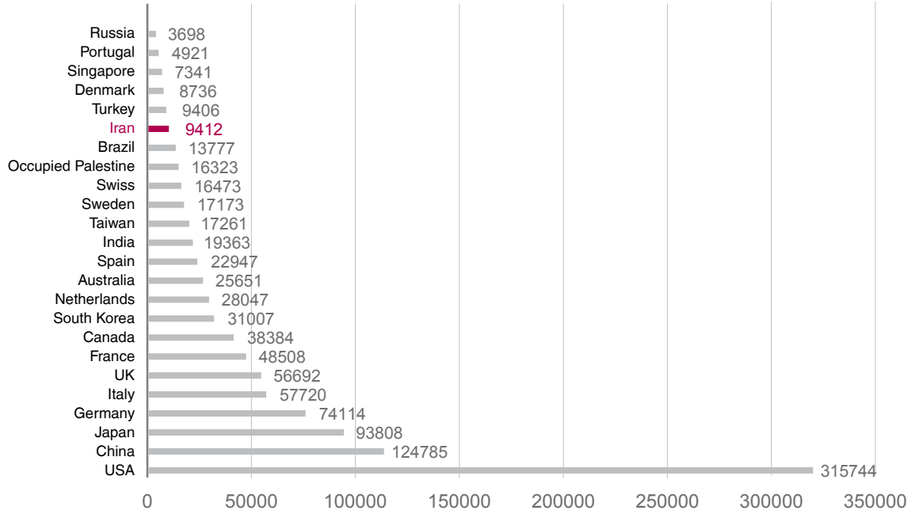


Figure 1: *Ranking of the First 25 Countries in Stem Cell and Regenerative Medicine Publications (Iran Ranked 19th in the World in terms of Published Articles by January 2018 [Source: Scopus, PubMed])*

Figure 2 indicates the number of published papers in the field of stem cell sciences and regenerative medicine focusing on cell therapy, gene therapy, tissue engineering and regenerative medicine only in 2017. According to the statistics, Iran ranked 14th in the world with about 2063 scientific articles in the same year.

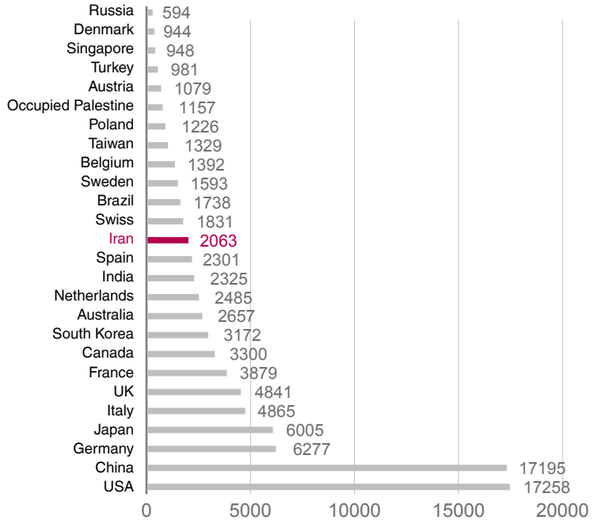


Figure 2: *Ranking of the First 25 Countries in Stem Cell and Regenerative Medicine Publications (Iran Ranked 14th in the World in terms of Published Articles during January to December 2017)*

Figure 3 compares the Middle East and Asia Pacific countries in terms of published papers in different fields of stem cell and regenerative medicine research by the end of 2017. According to the data, Iran ranked 1st in the Middle East and 2nd in the greater Middle East area from eastern Mediterranean to north of Africa with 9412 articles, followed closely by Turkey with 9406 articles.

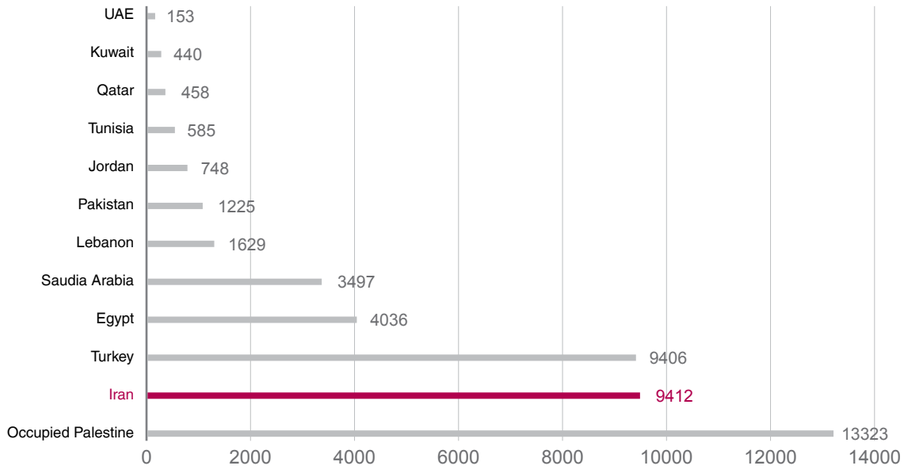
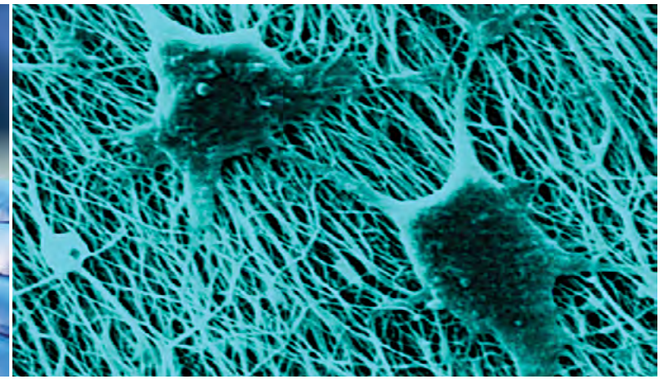


Figure 3: *Ranking of Middle East and Asia Pacific Countries in Stem Cell Sciences and Regenerative Medicine Publications (Iran's Scientific Publications in Comparison with the Regional Countries by the End of 2017 [Source: Scopus, PubMed])*



In the field of stem cell sciences only, Iran has published about 900 research articles, ranking the second country in the region, followed by Turkey with 800 articles.
Figure 4 shows Iran's growth in terms of scientific publications in the field of stem cell sciences, cell therapy, gene therapy, tissue engineering, and regenerative medicine during 2007-17, marking a significant increase in 2013 and 2014 compared to the previous years.

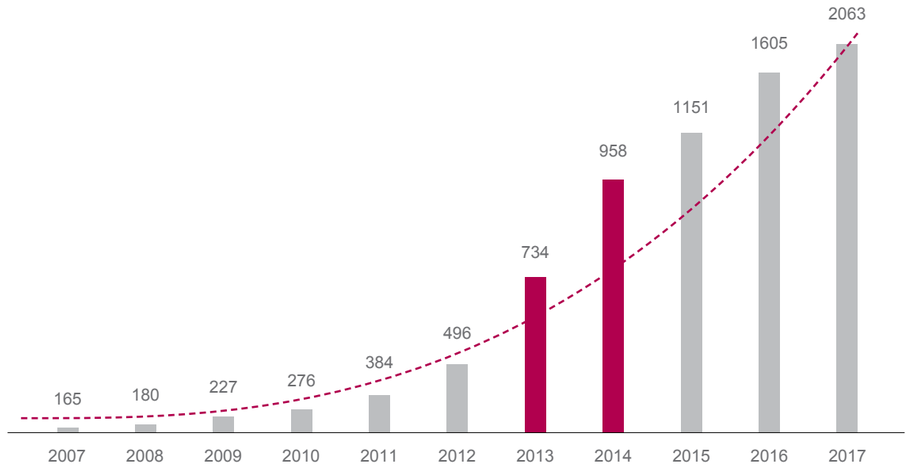


Figure 4: *Growth of Iran's Publications in the Field of Stem Cell Sciences, Cell Therapy, Gene Therapy, Tissue Engineering, and Regenerative Medicine by the End of 2017 [Source: Scopus, PubMed]*

By the end of 2017, the Islamic Republic of Iran has significantly contributed to knowledge production in the region, with a total of 31 percent scientific outputs (figure 5).

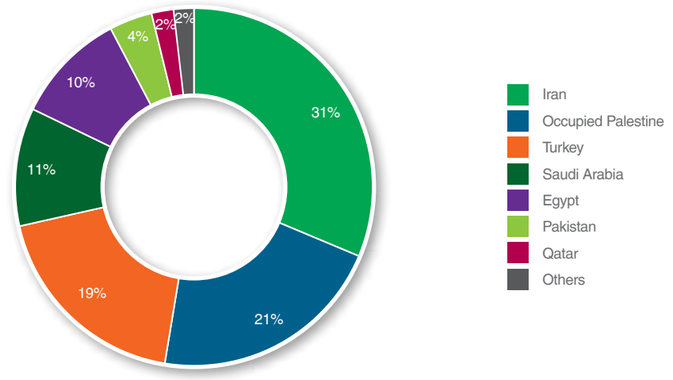


Figure 5: *Knowledge-production in Iran by the end of 2017 in Comparison with the Regional Countries in the Field of Stem Cell Sciences*

B. Human Resources

The growth of human resources in Iran in the field of stem cell sciences is illustrated in the following figures. Figure 6 represents the number of faculty members in the field. A statistical survey on the centers and universities in this field revealed a growing trend in the number of university graduates, as well as master and PhD dissertations in the field of stem cell sciences, regenerative medicine, and tissue engineering as demonstrated in figures 7 and 8.

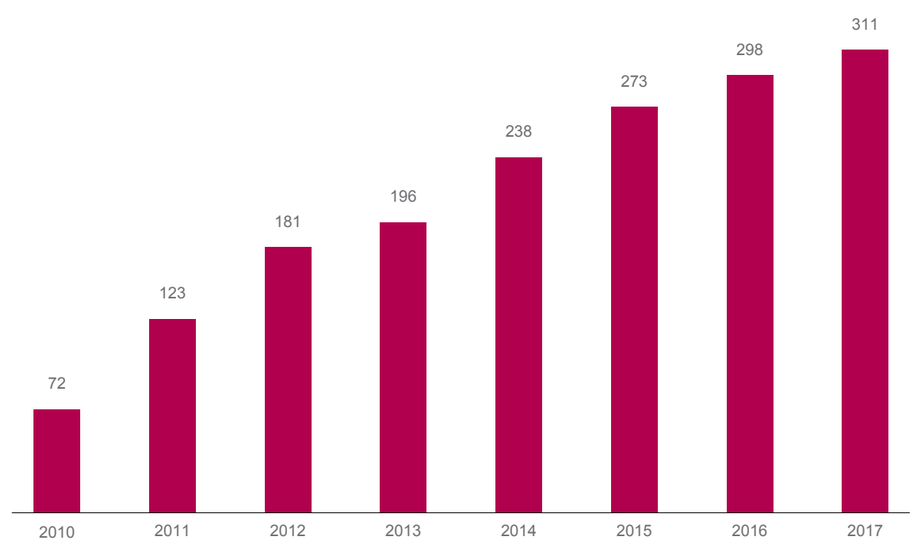


Figure 6: *Faculty Members of Iranian Universities and Research Centers Involved in the Field of Stem Cell Sciences and Regenerative Medicine by the end of 2017*

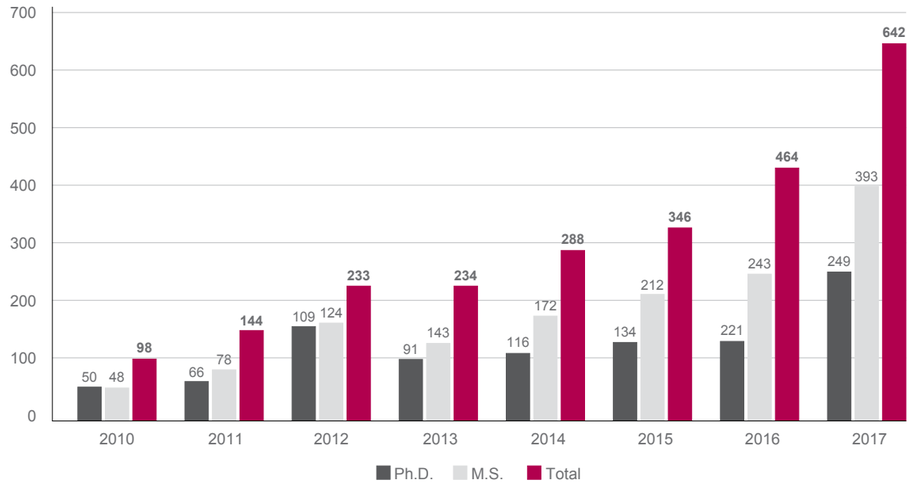


Figure 7: *Total Number of Stem Cell Sciences and Regenerative Medicine Postgraduate Students in Iran during 2010-17*

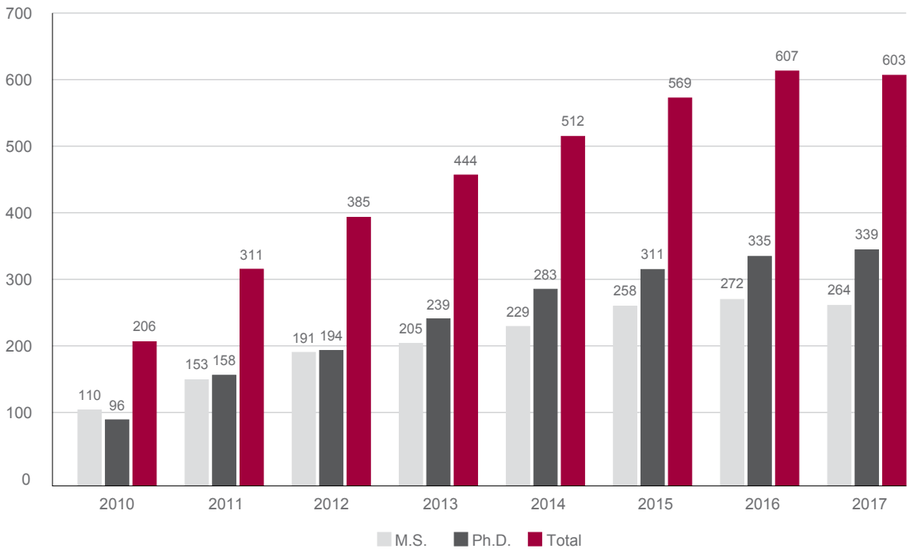


Figure 8: *Human Resources in Iranian Universities and Research Centers Involved in the Field of Stem Cell Sciences and Regenerative Medicine during 2010-17*

C. Clinical Trials

Clinical trials and evaluation of technology projects are considered as important factors to determine the level of advancement in stem cell sciences. In this process, research projects are evaluated and validated before they undergo finalization. In terms of the number of clinical trials in the field of stem cell sciences and cell therapy, Iran ranked the second among the regional countries with 106 registered clinical trials by 2017 (figure 9).

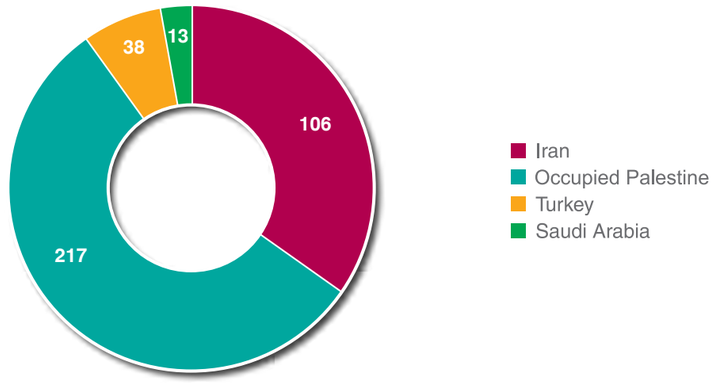


Figure 9: *The Number of Clinical Trials in the Field of Stem Cell Sciences and Cell Therapy in Asia Pacific Region by 2017. [Source: clinicaltrials.gov.]*

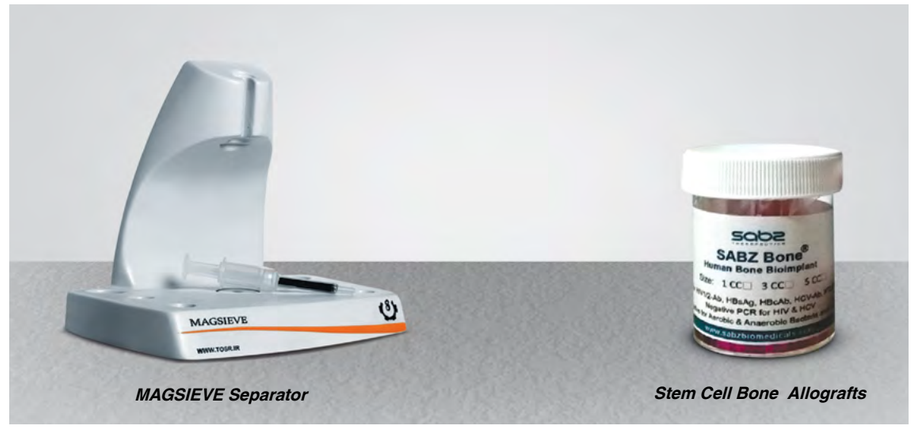
D. Some Achievements

• MAGSIEVE Separator

Magnetic-activated cell sorting (MACS) is an important method to separate stem cell populations. Until recently, two major companies have dominated the production of the technology to perform MACS in the world. However, an Iranian knowledge-based company acquired the technology to produce such equipment and manufacture a device called MAGSIEVE separator, which is as efficient as similar foreign products. The device is meant for clinical use.

• Stem Cell Bone Allografts

A number of Iranian knowledge-based companies produce stem cell bone allografts in different sizes and shapes which are currently used by the hospitals across the country. These structures have orthopaedic applications to treat unhealable broken bones.



MAGSIEVE Separator ***Stem Cell Bone Allografts***

• *IVF Culture Media*

In Vitro Fertilization (IVF) culture media is produced by a domestic knowledge-based company with numerous applications in fertility clinics. The rising number of infertility cases in the country has increased the demand for this product.

• *Antibodies and Immunoassays*

Different kinds of monoclonal and polyclonal antibodies are domestically produced by a number of companies which have made these products available to the market. These antibodies are highly used in stem cell research for separation and identification kits.

IVF Culture Media *Antibodies and Immunoassays*

• *Polymer Scaffolds*

A number of Iranian knowledge-based companies produce synthetic and natural polymer scaffolds in various textures. Stem cell culture and preservation media and buffers are also produced by some domestic companies. Although the raw material for these products is imported, their final production cost is far less than that of similar foreign products. Moreover, these products are continuously produced and supplied to the domestic market due to short expiration date.

Electrospun Scaffolds Made of Multiple Fibers including Polycaprolactone (PCL)

IV. Authorities

A. The Council for Stem Cell Sciences and Technologies

As already mentioned, the Council for Stem Cell Sciences and Technologies affiliated to the Vice-Presidency for Science and Technology was established in February 2009 in order to accelerate the growth of stem cell sciences and technologies in the country to keep pace with other countries in the field. A new team of experts composed of prominent professors, researchers and producers of stem cell sciences in the country was formed in 2005 to provide the infrastructures, devise the comprehensive plan and determine the future goals of this valuable stream of science.
In 2015, numerous measures were taken and implemented in line with the commands stipulated in the comprehensive national document, the most significant of which are as follows:

- Formulating the country's 10-year strategic plan by 2025 in one, five and ten-year subdivisions;
- Absorbing 700 researchers into the council and assigning them to 25 target-oriented expert committees;
- Organizing the biggest national scientific forum in the field of stem cell sciences (the annual festival);
- Setting up associations to develop stem cell sciences and regenerative medicine at provincial universities of medical sciences.

B. Universities

Medical universities across the country are interested in expanding the knowledge related to stem cells in local cities, while research centers affiliated to these universities are in charge of taking care of the research activities. Tehran, Tabriz and Shiraz universities of medical sciences, in collaboration with the Council for Stem Cell Sciences and Technologies, are in the process of establishing a center to conduct research in the field of regenerative medicine. Meanwhile, 19 other medical universities are actively working in the field of stem cell sciences and regenerative medicine. In addition, more than 20 universities affiliated to the Ministry of Science, Research and Technology are cooperating with the universities affiliated to the Ministry of Health and Medical Education in fields such as biomaterials, tissue engineering and equipment manufacturing for regenerative medicine.

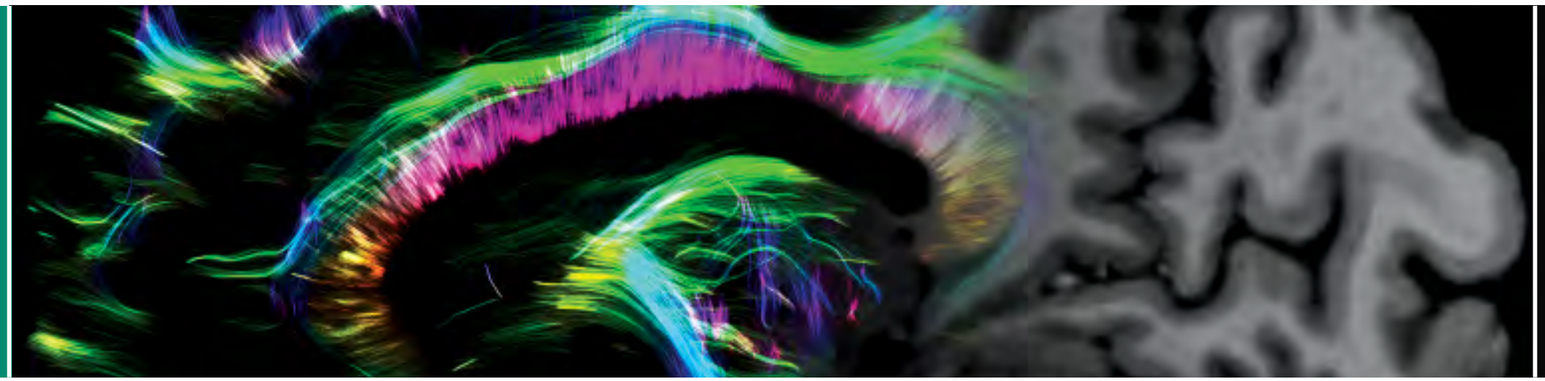
V. International Cooperation

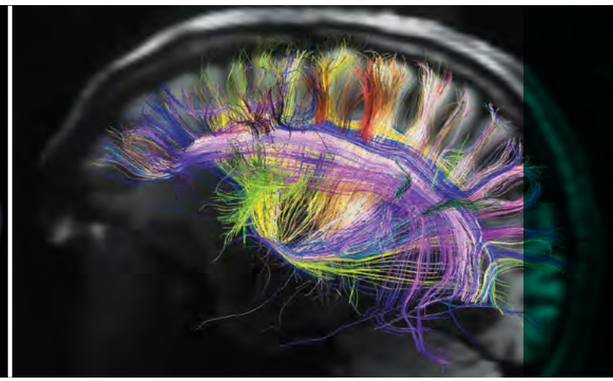
Regarding international cooperation, the Council for Stem Cell Sciences and Technologies is interested in:

- Collaborating with universities, research centers, and companies at the international level to conduct joint clinical trials in stem cell sciences and regenerative medicine;
- Conducting gene therapy studies and clinical trials on genetic disorders such as thalassemia and severe congenital immune deficiencies, etc.;
- Exchanging university professors, students, and experts in the field of cancer cell therapy including CAR T-Cell therapy.

5 Cognitive Sciences

Cognitive Sciences





I. History and Background

Over the last four decades, cognitive sciences and technologies have proved to be extremely fruitful for human; the 1990s was named “The Decade of Brain”. Nations today invest widely on this new realm of knowledge and compete vigorously to gain a more profound understanding of brain mysteries. Cognitive sciences adopt a process-oriented approach. Cognitive scholars see human brain as a complex network that receives, stores and retrieves information. It can manipulate or transfer such information. The processed outputs are speaking or locomotion.

Since late 50s and 60s, cognitive scholars focused on mental representations and the processing thereof. That was how a new interdisciplinary field called “cognitive sciences” emerged.

Starting in 1990s, imaging technologies and studying brain using modern devices have given neuroscience a more significant role in advancement of the cognitive sciences.

Early attempts to introduce cognitive sciences to the Iranian society were made by Dr. Caro Lucas, the well-known professor at the College of Engineering, Tehran University in 1996. Through his great efforts, the “Institute for Intelligent Systems” was founded in the theoretical physics and mathematics center called Institute for Research in Fundamental Sciences (IPM).

In this line, the Institute for Cognitive Studies (ICS) was founded in 1998 as a non-profit institute with the mission to conduct research on cognitive sciences. In 2003, this institute was approved and accredited by the Ministry of Science, Research, and Technology to offer doctoral and master’s degree programs and train students under the title of the Institute for Cognitive Science Studies (ICSS). This institute offers a wide range of doctoral degree programs including cognitive neuroscience (brain and cognition field), cognitive psychology, cognitive linguistics, cognitive modeling, and philosophy of mind and also Master’s degree programs in cognitive psychology and mind, brain and education.

The strategic document for development of cognitive sciences and technologies was approved by the Supreme Council of the Cultural Revolution on October 25, 2011, and under the terms of this document, the Cognitive Sciences and Technologies Council (CSTC) was founded in 2012 under the Vice-Presidency for Science and Technology.

The main objective of CSTC is promoting cognitive sciences and technologies in Iran for wellbeing of all Iranians. This objective is accomplished through formulating policies, supporting scientific activities and technology development, and securing successful implementation of cognitive systems and procedures in different sectors and everyday life. CSTC supports human resource development at the graduate level, research through financial aids for graduate and postgraduate activities, publishing scientific articles in highly-ranked journals, and providing research infrastructures including laboratory facilities and networking. In addition, CSTC supports research projects on human brain mapping for cognitive studies, development of cognitive assessment tests and rehabilitation, cognitive education, cognitive linguistics and its applications nationwide, stem cell research and its applications in cognitive sciences and technologies, development of cognitive games, and brain implant in the country.

II. Objectives and Strategies

Some of the most important objectives and strategies set in the strategic document for development of cognitive sciences and technologies are as follows:

A. Macro Level Objectives

- Producing and developing scientific theories on the functions of mind, studying procedure thereof, its cognitive relation with the brain based on Islamic anthropology principles of the nature of self, mind, and their functions;
- Advancing basic sciences in brain and cognitive studies;
- Achieving and developing methods for growing and enhancing cognitive capabilities and functions;
- Utilizing and developing technologies and tools to be used in brain-computer interfacing and human-machine interaction applications;
- Inventing and developing methods to treat mental disorders and overcoming cognitive disabilities;
- Developing artificial systems inspired by human brain and its cognitive functions;
- Securing the first place in the region and holding scientific authority in cognitive sciences and technologies.

B. Macro Level Strategies

- Conducting interdisciplinary research and academic and seminary co-studies on cognitive sciences and technologies;
- Training the necessary human resources for research and education in cognitive sciences and technologies;
- Theorizing and advancing cognitive sciences and technologies; philosophy of the mind, in particular;

- Strengthening international scientific cooperation and interactions in cognitive sciences and technologies;
- Increasing quality and quantity of scientific and technological production in cognitive sciences and technologies in order to stabilize the scientific position of the country.

III. Capacities and Capabilities

A. Human Resources

As many people contributing to this area are from a range of vastly different disciplines, it is not easy to provide precise statistics on the country's human resources. However, it is possible to produce the estimated statistics of the active researchers based on the number of users registered on the portal of the Cognitive Sciences and Technologies Council (CSTC): The total number of the registered people on the council's portal is 2892, of whom 1432 people are students, 480 graduates, and 980 faculty members.

B. Research Areas Supported by the Council

• Brain Activity Mapping and Recording

Functional MRI: In the recent years, Functional MRI (Magnetic Resonance Imaging), which operates based on hemodynamic response in different areas of brain, is considered as one of the important techniques for studying cognitive activities of the brain. The projects that the council supports in this area include developing tools and analyzing fMRI and combining the optimized structural and functional data aiming to increase spatial precision to make exact diagnosis of the cognitive disorders (such as Alzheimer and Schizophrenia) possible.

fNIRS: Another new non-invasive technique to analyze brain cognitive activities is functional near-infrared spectroscopy (fNIRS) for cerebral cortex. Currently, the council supports studies on new methods for optical imaging of neural signals in order to be used in brain-computer interface (BCI) systems as well as manufacturing portable fNIRS system. Most significant achievements of these projects would be equipping laboratories to study brain networks and timing activities, and manufacturing optical imaging systems to study neural signals and acquire the technical knowledge of brain-computer interface based on optical model. These triple goals play an important role in developing cognitive foundations of the brain activities.

EEG: Electroencephalogram (EEG) is a key device, brain-machine interface, to assess and identify neurophysiological disorders. CSTC supports different projects such as creating local database, determining brain key areas via recorded data, investigating relation of sleep spindles, performing memory tests, and studying brain growth pattern, etc.

ECoG: Electrocorticography (ECoG) records neural activities from the surface of the brain. The ECoG approach is sometimes preferred over its two other counterparts as it provides signals with larger amplitudes and higher temporal and spatial resolution compared with EEG, and can be less invasive than the intra-cortical approach. In this technique, electrodes are directly placed on the exposed surface of the brain. Designing and manufacturing a data recording system and studying the effects of FEF (Frontal Eye Fields) stimulation on the focus of attention are among the projects supported by the council.

• Brain Implants

Brain implant panel of the council has proposed a macro project with the purpose of advancing brain implant in the country. Different parts of the brain implants including stimulating and recording

fNIRS System for Laboratory Application

Brain-computer Interface System

electrodes, stimulating and recording electronic, wireless interfacing for data and power telemetry are among the projects announced by CSTC as the first call for proposal with pre-defined specifications.

• Optogenetics

Optogenetics is a new neural engineering technology and genetic technique that controls a particular population of neurons without affecting the other neurons using light. It is possible to find a mechanism to treat neurological disorders and develop brain-machine interface systems using optogenetics. Controlling nervous system by optogenetics and behavioral and electrophysiological studies using optogenetics are among the projects supported by the council.

• Brain-machine Interface and Neurofeedback

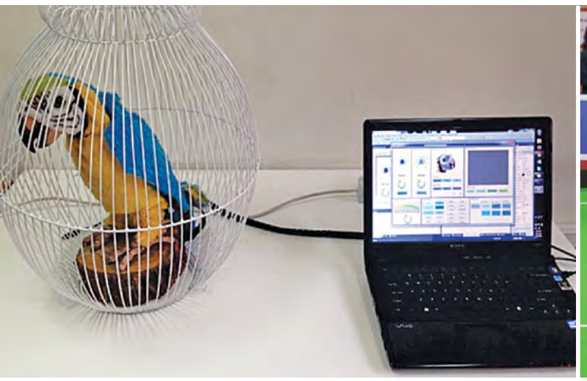
One of the objectives of supporting projects in this area is to build a system including a software by which disabled people with speech difficulties and mobility impairments would be capable of typing. A new generation of neurofeedback systems (second generation) with higher efficiency and faster effect is supported by the council as a research project. The council also supports a project for manufacturing a neurofeedback robot controllable by attention level. It is based on treatment protocols of the Attention-Deficit/Hyperactivity Disorder (ADHD). It is hoped that this robot would be effective in treatment of the ADHD.

• Cognitive Education

Cognitive education is aimed to integrate the findings of the systematic studies in cognitive sciences into education system. Accordingly, the council's cognitive committee has conducted several studies on designing cognitive pattern of education and behavior modifications on its agenda.

• Cognitive Rehabilitation

Cognitive rehabilitation is the process of relearning cognitive skills which have been lost or altered as a result of some brain injury. Robots can help treat patients with such impairments. Designing and manufacturing an internet-controlled robot can improve the internet communications technology in cognitive diagnosis and rehabilitation. Designing and manufacturing robots can also develop their applications in assessment and rehabilitation of cognitive parameters. Accordingly, the council supports projects such as manufacturing a parrot-like robot for rehabilitation of autistic individuals and studying the effect of two humanoid robots as assistant for therapists in treating and educating autistic children.



Parrot-like Robot for Rehabilitation of Autistic Children

Humanoid Robots for Rehabilitation of Autistic Children

• Cognitive Linguistics

Developing clinical language tests to assess language, cognitive, and communication difficulties of the adults with neurocognitive disorders like stroke, dementia and Alzheimer is highly important in diagnosis, rehabilitation, and clinical and basic researches in cognitive sciences and neuroscience. The supported projects are expected to be aiming at localizing the "Western Aphasia Battery-Revised (WAB-R)" test in terms of language, culture, and structure as well as evaluating its assessment criteria and indices for patients with brain injury.

• Cognitive Games

Especially-designed computer games are among useful available tools to increase and improve cognitive capabilities. Hence, the country's capacity and capability in developing computer games and software and the extensive role of cognitive games in enhancing cognitive capabilities of the community are prioritized. The council, in line with this trend, supports the research projects aiming at developing cognitive games and establishing knowledge-based companies in the area of cognitive games.

• Application of Stem Cells in Cognitive Sciences and Technologies

The neurodegenerative disorders are generally characterized by loss of neurons, oligodendrocytes, astrocytes, axons and other cellular communication. Since the foundations for cell therapy are laid, environmental enrichment to protect endangered cells, strengthening endogenous repair mechanisms, and cell transplantation are in focus in modern treatments. Replacement of cells is aimed at finding cells appropriate for pathobiology of disease or their laboratory production.
Currently, stem-cell therapy is advancing and researches are underway to apply stem-cell treatment for neurodegenerative diseases. This new field can have an influential role in treating cognitive diseases through producing healthy functioning cells. Thus, the council's priority is to support the research project on stem cells and their applications in cognitive sciences and technologies.

• Cognitive Assessment Tools

Cognitive assessment is performed by psychology, neurology, or education specialists in order to determine the level of cognitive function of the brain. Cognitive assessment tests may serve a variety of purposes beyond an initial diagnosis. Assessments may be used to guide treatment decisions by identifying an individual's strengths, weaknesses, and needs; design individual treatment programs tailored to these findings; evaluate changing treatment needs; and monitor treatment efficacy. Cognitive assessment tests allows the examiner to avoid subjectivity in traditional examinations by conducting assessments that lead to quantifiable standardized scores, thereby increasing the reliability of the assessment as well as paving the ground for a more sensitive baseline for comparisons across time. So, appropriate application of the existing assessment tools plus development of new tools is considered to be a common need in the modern world. The council in line with its research priorities supports development and standardization of some cognitive assessment tests including aphasia memory and IQ tests.

• Deep Brain Stimulation

Deep Brain Stimulation (DBS) involves implantation of a medical device called neurostimulator which sends electrical signals to specific areas in the brain through implanted electrodes (parts responsible for thinking, planning, and memorizing). Recent studies indicate that DBS can be helpful in treating Parkinson and other tremor disorders plus several mental and nervous system diseases. Today, the credited scientific centers of the world are working on enhancing cognitive skills of the brain through DBS. The council also supports designing and manufacturing a system for deep brain stimulation and several other related projects.

• Transcranial Stimulation

Transcranial stimulation is a non-invasive method that uses a direct or alternating current to stimulate a particular zone in the brain. Primary researches show that it is useful for patients' rehabilitation particularly post-stroke, addiction, and psychological disorders such as depression and for treatment of Parkinson's disease, tinnitus, and migraine. This method is also used in identifying functions of different zones in the brain. The technique in combination with other brain mapping techniques can be used to study issues such as time and location of the brain activities, flexibility and connections of the neural circuits, and involvement of a brain zone in a cognitive task. Therefore, advances in this field can have numerous implications for neuroscience and the related fields while opening promising horizons to treat brain injuries. The council then supports the related projects such as studying long-term impact of transcranial direct current stimulation (tDCS) to reduce drug craving in methamphetamine consumers as well as designing and manufacturing a system to treat Parkinson's disease.

• Cognitive Approach in Addiction Studies

Significant growth in cognitive sciences and technologies over the recent years has provided unique opportunities to develop effective packages of interventions in substance abuse prevention, treatment, and rehabilitation. The council thus supports the pioneering groups in the related research projects. It also supports projects employing different cognitive approaches in behavioral, electrophysiologic, and rehabilitating dimensions.

• Electrophysiology in Small Animals and Primates

Electrophysiology is the study of electrical activities in biological cells and tissues. Using this technique, voltage changes and electrical activity can be measured on a wide variety of scales from single ion channels to a whole organ. Nowadays, cognitive sciences use this technique to study different dimensions of the neurons such as their molecular, cellular, structural and functional aspects. This technique is also useful in studies on different laboratory models like the primates (e.g. monkeys) and small animals (e.g. rats). The council supports projects that use this valuable technique in their studies. These projects study different cognitive processes such as memory and learning, synoptic plasticity, punishment/reward-based decision making, attention, and the changes in these processes caused by cognitive disorders such as Alzheimer, autism, or addiction.

IV. Authorities

Research centers and universities conducting research on cognitive sciences and technologies include: School of Cognitive Sciences, the Institute for Research in Fundamental Sciences (IPM); the Institute for Cognitive Science Studies (non-profit); Research Institute for Cognitive and Brain Sciences, Shahid Beheshti University; Faculty of Psychology and Educational Sciences, Tabriz University; Faculty of Psychology and Educational Sciences (ICBS), Ferdowsi University of Mashhad; Faculty of Psychology and Educational Sciences, Kurdistan University; Faculty of Psychology and Educational Sciences, Semnan University; Neuroscience Research Center, Kerman University of Medical Sciences; and Faculty of Psychology and Educational Sciences, Azarbaijan Shahid Madani University.

V. International Cooperation

Giving mutual visits to cognitive research centers in Iran and Russia, CSTC and Kurchatov Institute signed an MoU in order to increase their mutual collaborations.

To increase the country's interactions with Switzerland in cognitive sciences and technologies, the council has negotiated with professors at the Zurich University. Moreover, the follow-up measures have already resulted in some co-supervised PhD theses.

Several negotiations have been conducted between Iran and Brazil on mutual cooperation on cognitive sciences and technologies followed by an MoU for co-projects and student/professor exchange between the countries.

Iran's efforts to ensure international cooperation on cognitive sciences and technologies have not been limited to the mentioned countries. The country has accomplished to sign a number of MoUs with the leading research centers in South Korea, Germany, and China as well.

6 Medicinal Plants and Traditional Medicine

Medicinal Plants and Traditional Medicine

I. History and Background

Given the growing interest in the use of natural products of medicinal and food industries in the global healthcare debates, Iranian people, officials, and industries have increasingly considered the benefits of medicinal herbs and significance of integrating traditional medicine into modern healthcare system and supporting the field. Iran enjoys 8000 herb species and 2500 species with medicinal properties and applications as spice, fragrance, and cosmetics. It has a rich heritage of traditional medicine with over 14000 reference books and elegant works such as Avicenna's Canon of Medicine and Book of Healing, Al-Razi's Al-Havi, and Zakhireh-i Kharazmshahi. Hence, the urgency of extensive fundamental measures for developing this area is quite obvious. Recognizing the importance of medicinal plants and traditional medicine and in line with global trend, the Islamic Republic of Iran has launched a range of systematic measures for better exploitation of this realm.

II. Policies and Objectives

Major policies and objectives for development of medicinal plants based on the national document of medicinal plants and traditional medicine and other upstream documents are as follows:

A. Macro Level Policies

- Reviewing, reforming, simplifying, and updating the related laws, regulations, and standards in this area;
- Organizing and determining the borders of traditional medicine in health, education, and research system;
- Developing international scientific and technological cooperation in this area;
- Developing and organizing services including producing, distributing, marketing, exporting and commercializing scientific and technological achievements in medicinal plants;
- Providing effective support for fundamental, developmental, and applied research priorities in this area.

B. Macro Level Objectives

- Gaining 20% of pharmaceutical market value of the country by approved products with a herbal medicine origin and natural products. Gaining 10% of health market value by products produced based on traditional medicine principles and 2% of pharmaceutical market value by approved products with herbal origin;
- Gaining 4% of pharmaceutical market value by products produced based on principles of traditional medicine including six essential health principles of Iranian traditional medicine[1];
- Increasing export of medicinal herbs, medicinal herbal-based products and herbal products to join the top 10 countries;
- Gaining 3% of world science production in the field of medicinal herbs and medicinal herbal-based products;
- Obtaining 1% of the world patents in the field of medicinal herbs and the related products;
- Registering and supporting all types of endemic and/or endangered species of medicinal plants through national conservation systems;
- Decreasing formal and informal harvesting on public lands to 200,000 hectares in Vision 2025;
- Increasing the areas under cultivation of medicinal plants and fragrant plants to 500,000 hectares in Vision 2025;
- Improving insurance coverage rate to 30% out of pocket expenses in the field of traditional medicine;
- Improving society's health through developing traditional medicine and enjoying a holistic attitude and principles of health care;
- Gaining the first rank of the region in terms of meeting health and medical needs in the traditional medicine area and increasing export of services, technical knowledge, and natural and herbal products up to 20% of the country's export in the field of medical services;
- Increasing annual patent applications in the scope of traditional medicine products up to 50 patents in 2025.

III. Capacities and Capabilities

A. Human Resources

I.R. Iran has successfully accomplished to increase the number of workforces in the field of medicinal plants and traditional medicine since 2008; this includes significant increase in the number of faculty members, research scholars, students and vocational trainees of the traditional medicine, traditional pharmacy and all related fields of study. Iran has already created a number of entrepreneurial packages since the foundation of the committee and intends to rise the number of such packages to 45 items in 2018 (See table 1).

1. "life environment", "food", "spiritual status", "physical activity", "sleeping and awaking", "excretion and retention"

Table 1

The Number of Human Resources in Medicinal Plants and Traditional Medicine in 2015

Topic	Index	2018
Education and Human Resources	Academic Board in Iranian Medicine's Area	98
	PhD Students of Iranian Medicine's Area	49
	PhD Graduates of Iranian Medicine's Area	150
	PhD Graduates of Medicinal Plants Area	1350
	Students of all Degrees in Medicinal Plants	5650
	Published Articles in Related Area in Scopus Database	1200
	Entrepreneurial Packages	40

B. Current Status

- Developing over 100 knowledge-based enterprises in medicinal plants, herbal medicines, natural products, and traditional medicines;
- Manufacturing and commercializing more than 480 knowledge-intensive products of natural human and animal origin;
- Developing over 400 enterprises in the areas of herbal medicines, natural products and traditional medicines;
- Improving licensing and manufacturing of natural human and animal products and medicines up to 3400 items;
- Enriching scientific production in medicinal plants including 3800 research articles indexed in Scopus's Web of Knowledge;
- Promoting Iran's scientific production rank in medicinal plants up to 15th;
- Increasing the number of traditional medicine and traditional pharmacy colleges to 8 ones;
- Implementing 5 stages of the comprehensive plan including identification, comparison, emendation, translation, and compilation of written medical works including traditional medicine texts.
- Recruiting more than 100 faculty members in traditional medicine colleges and admission of over 500 students in different programs of traditional medicine and traditional pharmacy;
- Establishing over 20 healthcare centers for traditional medicine by early 2016;
- Admitting over 6000 students in the related fields of medicinal plants in all levels (undergraduate, graduate, postgraduate);
- Improving and developing gene bank of endemic or endangered medicinal plant species and conserving 1400 herbal species;
- Completing studies of commercial domestication and cultivation of over 70 species and varieties of medicinal plants;
- Preparing master atlas of medicinal plants for recording the benefits of plants and conserving plant species at a scale of 1:250,000 in the country;
- Identifying and registering information related to phytopathology and distribution of 2300 species of the country's flora;
- Compiling 20 entrepreneurial packages for medicinal plants and natural products;
- Compiling job standards including 134 job titles in 7 main parts of the value chain.

C. Some Achievements

A. Achievements

- Development of over 100 knowledge enterprises involving in herbal medicines, natural products and traditional medicine;
- Development of more than 400 companies involving in herbal medicines, natural products and traditional medicine;
- Increasing export of herbal medicines, and natural, herbal and traditional products; annually amounting to $750 million;
- Creation of more than 500 jobs in the knowledge enterprises located at the S&T parks and incubators;
- Production and commercialization of more than 500 natural, animal-based and medicinal products;
- Production and commercialization of more than 2369 herbal medicines and natural products, all registered in Iran;
- Production and commercialization of 990 traditional medicines, all registered in Iran;
- Production of 55 veterinary supplements and medicines to control diseases in livestock, poultry and aquaculture in the country;
- Production of 357 registered extracts and essences in the country;
- Identification of 2300 plant species with medicinal properties and recording their phytology and distribution pattern in Iran;
- Development of a gene bank and revival of various species of endemic or extinct medicinal herbs and conservation of 1550 medicinal species;
- Completion of researches on domestication of 170 species of indigenous and endemic plants in Iran;
- Standardization of 120 species of medicinal plants, natural products and related industries;
- Development of industrial- scale cultivation of medicinal plants with economic value including barberry, damask roses, saffron and jujube in 150,000 hectares of land;
- Expansion of the comprehensive atlas and dispersion map for medicinal plants to include 27 provinces in order to protect and record the benefits of the plant species;
- Admission of over 5,600 students in the fields related to medicinal plants at all levels;
- Increase in the number of Iranian PhD students in the field of Iranian traditional medicine up to 170 in 2017;
- Development and promotion of scientific status of 8 faculties, 17 medical departments, 8 departments of pharmacy and 8 medical history courses in the medical universities of the country;
- Restoration of the written heritage of Iranian medicine including over 2000 titles of books and treatises, of which 200 books have been restored and edited.
- Construction of 20 Iranian traditional medical clinics with Iranian Islamic architecture in 20 medical universities of the country;
- Pilot integration of the traditional medical services into mainstream health care system in 9 medical universities of the country.

B. Some Products

• Avishit Barij Solution

Avishit Barij Solution which consists of thyme essential oil is provided for treatment and prevention of fungal infections of farmed fish, particularly fish eggs. This herbal combination is a good alternative to chemical compounds with many environmental and human risks.
Avishit Barij should be used for prevention, control, and treatment of fungal contamination of eggs in rainbow trout and sturgeon at a dose of 50 ppm for 1 hour after gastrulation.

• Varrocide

Varrocide is an herbal-based anti-varroa drug with anti-parasitic properties. Varrocide is a 100% herbal drug which contains active ingredients of thyme, lavender, and some other medicinal plants. Its most important active ingredients are phenolic compounds such as thymol, carvacrol, and linalool.
Since both Varrocide and food of honey bees have herbal origins, this drug is of great significance for honey quality and food hygiene. It has also no side effects for human and bees.

• SaffroMood

SaffroMood, an herbal anti-depressant, is a gelatin capsule containing 150 mg dried standardized extract of saffron (quantified by input) mixed with vitamin B6. Passing successful clinical trials, SaffroMood is now commercially produced.
Using this Iranian study, a French company produced Saframyl antidepressant for the first time in 2008 which has been registered in the European Pharmacopoeia and introduced to the pharmaceutical market.

• Calendula Officinalis

Calendula ointment contains 1.5% calendula officinalis extract and is used for treatment of skin lesions such as allergic dermatitis, prevention and relief of skin irritation due to radiation treatment, skin injuries including scratches, cuts, and dry and cracked skin, prevention and treatment of sunburn, and alleviation of the itch and inflammation from insect bite.

• Recubizul® Shampoo

Know.Tech.Phar. Pharmaceutical Co., in compliance with documentations available in scientific sources, primarily took step to produce Recubizul ointment, and finally the formulation and production of Recubizul® Shampoo was realized with the usage of effective ingredients of German chamomile flowers. In addition, the effective ingredients of calendula flowers (with scientific name Calendula officinalis) have been used in this shampoo to obtain an agreeable scent and anti-inflammatory effect.
Recubizul® Shampoo can be used for cases of inflammation such as eczema, hives, urine-burn in babies, all other types of spread and non-spread inflammation on the head and body, and superficial wounds and burns on body. It also provides care for sensitive and inflammatory skin.

• Dentol

Dentol is a dental drop formulated based on studies on an Iranian endemic plant (Savory of Khuzestan). Dentol contains 10% carvacrol effective in relieving pain and eliminating infection of decayed teeth. This drug is very fast acting and has been internationally marketed.

• Livergol

Each coated Livergol tablet contains dried milk thistle (Silybum marianum) formulated in two dosages of 70 and 140 mg Silymarin. Livergol is used for protection of liver inducing bile, treatment of acute and chronic hepatitis, fatty liver, and cirrhosis. Moreover, it reduces toxicities of anticancer drugs.

• Opiucough

Opiucough is an herbal-based anti-cough syrup containing compounds purified from noscapine, sundew (drosera), licorice, eucalyptus, and peppermint. It is administered in treating dry and productive coughs, improving breathing, and reducing lower respiratory tract problems.

• Aftogel

Aftogel oral patch contains standardized extract of licorice root (Glycyrrhiza glabra L.). Aftogel contains 18.0 mg pyrogal-based polyphenols. It is used for treatment of stomatitis, thrush and mouth sores, and chemotherapy-induced oral mucositis. This drug is patented in Iran and U.S.A as well.

• Urtica ZB

Urtica syrup is formulated using active ingredient of urtica dioica. Urtica is prescribed in treatment of kidney stones, reduction of inflation and urinary tract infections.

IV. Authorities

A. National Council for Science & Technology Development of Medicinal & Aromatic Plants and Traditional Medicine

The National Council for Science & Technology Development of Medicinal & Aromatic Plants and Traditional Medicine was established in 2008 by the Vice-Presidency for Science and Technology. This committee, as the coordinating and integrating unit for all players in medicinal plants and traditional medicine of the country, is designed to realize cross organizational collaboration and interaction of all stakeholders so that pre-defined targets would be fulfilled. The “National Document of Medicinal Plants and Traditional Medicine” prepared based on a 20-year-vision plan and the comprehensive scientific map of the country, and was presented to the steering committee of the comprehensive scientific map in the Supreme Council for Cultural Revolution (SCCR), that was accordingly ratified and proclaimed by the council in 2013. More than 300 scholars, managers, and players in the area have participated in preparing this document.

B. Other Authorities

A variety of actors from different parts of the government, policymakers, and non-governmental organizations somehow influential in advancement of science and technology of medicinal plants and traditional medicine are actively collaborating with the Committee for Development of Science and Technology of Medicinal Plants and Traditional Medicine. Some of these authorities and actors include:

The General Office for Monitoring and Evaluation of Natural Products and Supplements associated with Food and Drug Administration; Deputy for Traditional Medicine associated with Ministry of Health and Medical Education; Institute of Medicinal Plants of Jihad University (ACECR); Ministry of Agriculture and its affiliated organizations and institutions; Directorate General of Food, Medicine, and Hygiene Industries of Ministry of Industry, Mine and Trade; Technical and Vocational Training Organization; Ministry of Cooperatives, Labor and Social Welfare; the National Network of Research and Technology of Medicinal Plants; Life Sciences Department associated with Presidential Center for Progress and Development; and Deputy for Research and Technology of Ministry of Science, Research and Technology.

Moreover, around 120 universities, scientific and research institutions and organizations of science and technology of medicinal plants and traditional medicine contribute to the development of this area.

V. International Cooperation

International cooperation can be persuaded in the following fields:

- To develop medicinal plant and natural product export as well as science and technology transfer required for advancement of this area;
- To coordinate mutual visits to industrial companies in the most advanced countries in this area;
- To transfer know-how and the required equipment to improve quality of the knowledge-based products;
- To develop co-branding and international standards to facilitate export development;
- To sign international agreements in an attempt to establish technology commercialization offices in the target countries.

7 Information and Communication Technology

Information and Communication Technology

I. History and Background

Given the effects of Information and Communication Technology (ICT) on various economic and social sectors in the country, policymaking and coordination charter of several supreme councils were established within different periods. The High Council of Informatics affiliated to the Plan and Budget Organization (PBO) was the first one established in 1980. Ministry of Industry, Mine and Trade as the stakeholder of manufacturing sector and Ministry of Post, Telegraph and Telephone as the stakeholder of infrastructure were two original actors in Information, Communications and Electro-electronic Sector. With ICT development and its growing effects on different sectors, tasks and responsibilities were apportioned nationwide and in process, Digital Economy and Smart Technology Development Council affiliated to the Vice-Presidency for Science and Technology was established in 2000 in an attempt to develop and promote the related technologies, help knowledge-based businesses and promote knowledge.

The council contributes to commercialization of domestic science and technologies, alongside science production in the universities and businesses involved in the sector.

In addition to developing ICT infrastructure and applications, development of this technology, by focusing on production development in this sector as a dynamic and effective industry in the country progress, may lead to an increase in productivity of all economic and manufacturing sectors.

II. Policies and Strategies

Major ICT policies and strategies are stipulated in the following upstream documents:

- Sixth Development Plan: Articles 67, 68, and 69;
- 20-Year Vision Document: Policy No. 9;
- Strategic Plan for Modern Industry Development (Ministry of Industry, Mine &Trade, 2001);
- Development and Use of Information and Communication Technology Plan- TAKFA (High Council of Informatics- 2002);
- Information Cyberspace Security Document- AFTAA (High Council of AFTAA -2005);
- E-Commerce Document- META (Ministry of Industry, Mine &Trade, 2005).
- Comprehensive IT System (2007).
- The Public Services Management Act
- E-government Roadmap (Ministry of ICT)
- The 6th Plan's Major Policies

III. Capacities and Capabilities

A. Current Status

The following tables and figures show the current status of information and communication technology in Iran and its comparison with neighboring countries.

Table 1

ICT Indicators– Public Access to ICT

Indicator	Unit	2010 status (5th plan)	Last Status	Reference Date	NSO[1]	Reference Period (month)
International Internet Bandwidth	Gbps	64.3	10746251024	March 20, 2018	TIC	3
International Internet Bandwidth per Internet User	Kbps per user	1091 bps	24.5	Sep. 22, 2018	ITC	3
Domestic Internet Bandwidth	Mbps	–	69632000	March 20, 2018	TIC	3
Percentage of the Population Covered by Cellular Network	%	–	96.5	March 20, 2018	CRA	3
Mobile Cellular Telephone Subscribers per 100 Population	%	73.7	108.98	March 20, 2018	CRA	3
The Proportion of Households with Access to Computer by Urban and Rural Regions	%	22.3	61.39	March 20, 2017	ITC	3
The Proportion of Households with Access to Internet by Urban/Rural Regions and Type of Services	%	26.5	62.21	March 20, 2017	ITC	3

1. National Statistics Organizations: All the public agencies collecting official statistics

Table 2

ICT Indicators - Development of ICT Infrastructures

Indicator	Unit	Expected Status at the End of the 5th Plan	Performance Status at the End of 2013	NSO	Realization Rate (%)
Proportion of Households with access to National Information Networks and Broadband Internet (minimum speed: 512 Kbps)	%	60	38	Statistical Center of Iran	63
International Internet Bandwidth	Gbps	500	124	Telecommunications Infrastructure Company (TIC)	25
Domestic Internet Bandwidth	Gbps	2000	844	TIC	42
Per Capita Shared Capacity	Kbps per Individual	832	260	Communications Regulatory Authority	31
The Number of Active Domestic Data Centers	Center	40	18	Information Technology Organization	45

Table 3

ICT Indicators – IT Economy

Indicator	Unit	Expected Status at the End of the 5th Plan	2013 Performance	NSO	Realization Rate (%)
Ratio of Exports of IT Products and Services to Total Non-Oil Exports	%	1.5	0.146	MIMT*	10
Ratio of Imports of IT Products and Services to Total Imports	%	10.4	6.3	MIMT	61
Share of CT Value-added in Total Value-added	%	_	1.58	MIMT	_
Share of IT Value-added in Total Value-added	%	_	0.54	MIMT	_

** Ministry of Industry, Mine and Trade*

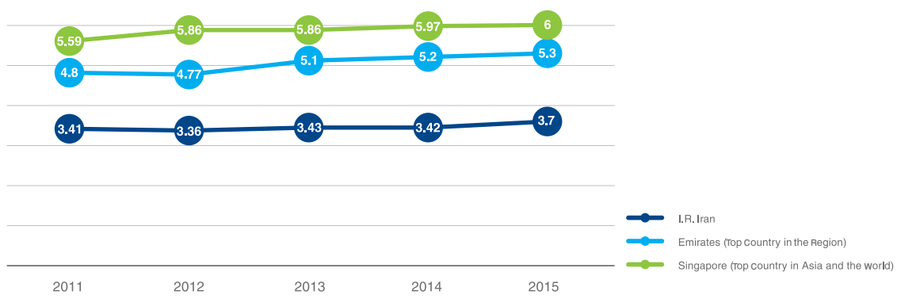


Figure 1: *Network Readiness Index; Comparison of Iran's Growth Trends and Top Countries in 2011-2015*

Source: Information Technology Organization (Monitoring System)

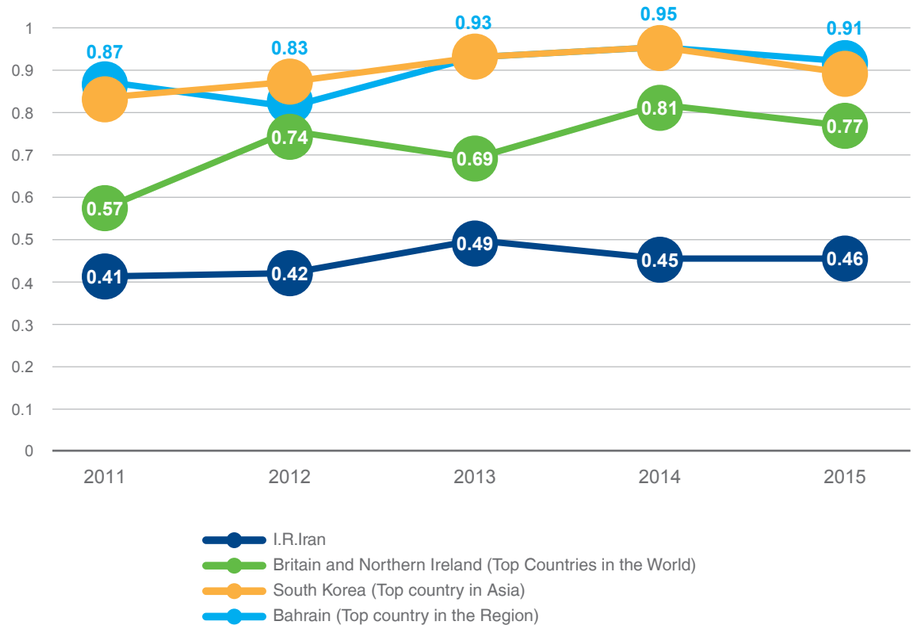


Figure 2: *E-Government Index; Comparison of Iran's Growth Trends and Top Countries in 2011-2015*

Source: Information Technology Organization (Monitoring System)

B. Human Resources

About 17 percent of students, namely 740,000 students (except for students in universities affiliated to Ministry of Health and Medical Education), are studying ICT related fields, according to student statistics in 2014-2015.

The number and proportion of students in different levels of ICT are presented in Table 4 and Figure 3.

Table 4

The Number of ICT Students in the Academic Year 2014-2015

Level	Number
A.S.	203.291
B.S.	488.454
M.S.	46.199
Ph.D.	3144
Total	741.088

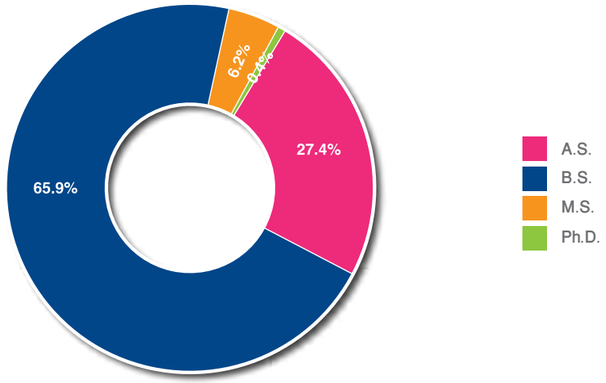


Figure 3: *Proportions of ICT Students in the Academic Year 2014-2015*

In 2015, the number of ICT graduates was about 1,870,000 out of a total of 6,900,000 graduates looking for job (Figure 4).

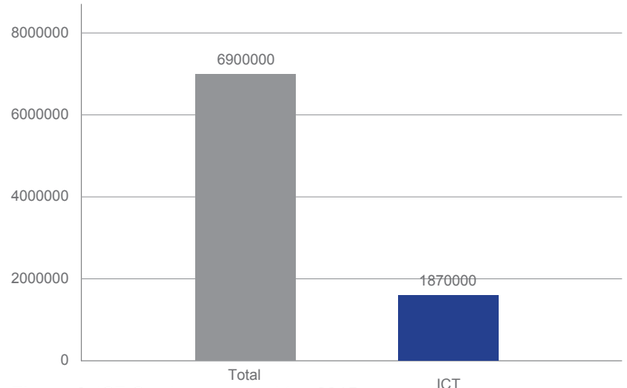


Figure 4: *ICT Graduates up to May 2015*

In 2014, 20% of ICT workforces were working in the public sector and 80% in the private sector, which totally amounted to about 117,000.

Table 5

Total Number of Human Resources Working in ICT by the End of 2014

Sector	Number
Public Sector	23591
CT Private Sector	45550
IT Private Sector	48000
Total	117,141

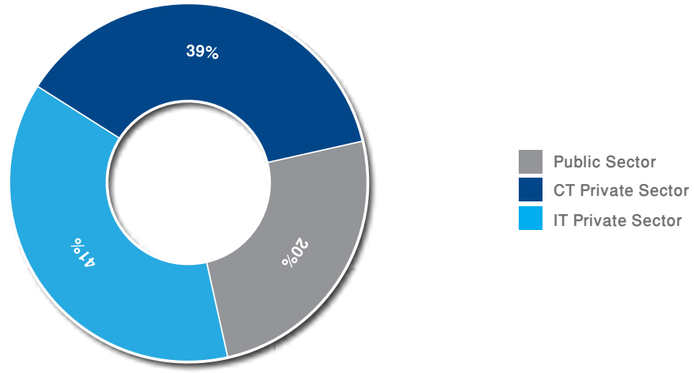


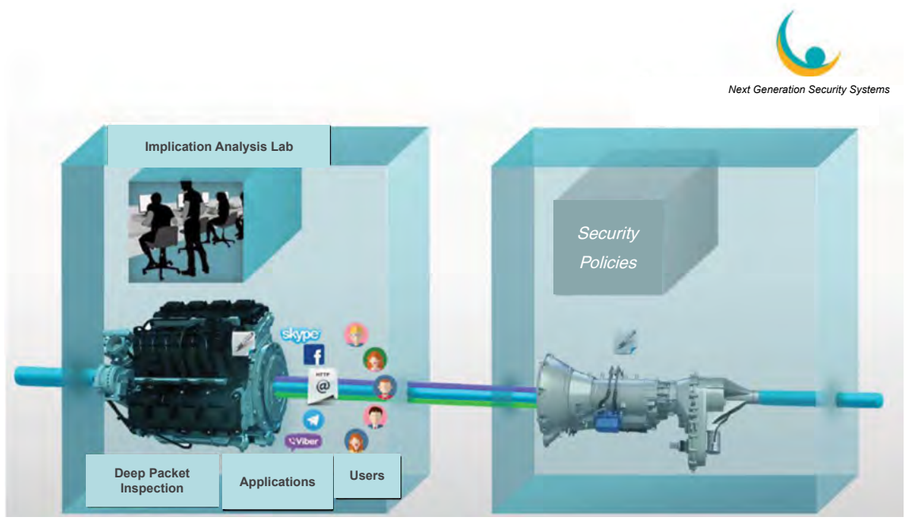
Figure 5: *Proportion of Human Resources Working in ICT Sector by the End of 2014*

C. Some Achievements

• Next Generation Security Systems Technology-SANA

This plan aims to develop the infrastructures required to produce next generation security products such as firewalls. Precision-inspection packages and high quality processing are necessary in such technologies. SANA provides these capabilities in the form of a complete set of hardware and software products. This plan includes the following themes:

- SANA-PA: Next generation security systems for filtering (NG Filtering)
- SANA-TN: Next generation security systems for intrusion detection (NG IDPS)
- SANA-HEFAZ: Next generation security systems for firewall (NG FW)

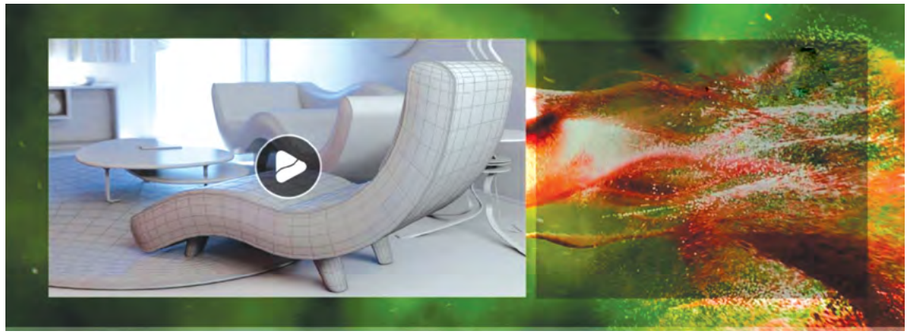


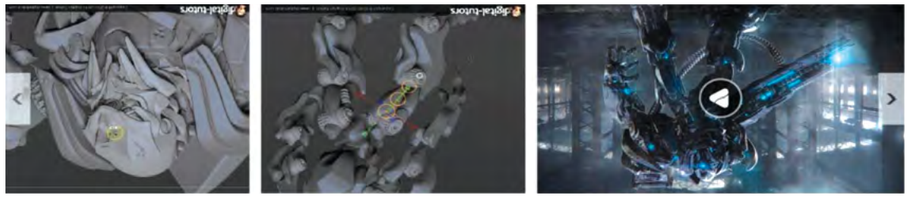
Schematic Design of Next Generation Security Systems

• The Package for Promoting National Computer Games Industry

This package includes several projects to promote and develop national computer games industry focusing on the following topics:

- Digital distribution network of games;
- Cloud gaming;
- Quality control lab and computer games testing;
- Specialized virtual training for game development;
- Developing three games by a large company through supporting 9 startups;
- Developing 8 small casual and mobile games in cities of Tehran, Saqez, and Kashan;
- Developing a big mythology-based game for PCs and mobile phones.





Some Examples of Computer Games Software in Production Stage

• Supporting Big-Data Plans

Analysis of rapidly growing and diverse data involves employing new tools and methods. Organizations should benefit from experts, appropriate infrastructures and the required tools for data storage, extraction, processing and analysis, so that they could elicit appropriate information from these data.

These plans include the following parts:

- Training experts in data science; these experts who are familiar with businesses and concepts of big data help to analyze and implement big data systems;
- Preparing hardware infrastructures including data centers, storage equipment, servers and communication networks;
- Identifying software infrastructures to implement the functional big data software;
- Producing the functional software given the wide range of applications in this area.

• Manufacturing and Calibration of DNA Microarray Systems

Application of microarray in breast cancer diagnosis and treatment is a simple example of microarray's capabilities widely used in the country. Currently, a large number of genes and their control agents for breast cancer have been detected. Given the fact that diagnosis and drug prescription for this disease involves accurate detection of all gene expression patterns, detection of these genes helps to design the markers showing a direct relation with breast cancer and put the associated oligonucleotides on the microarray. In this way, patients who do not need chemotherapy can be identified in an attempt to reduce their treatment costs and avoid chemotherapy risks. DNA microarray system may help to:

- Diagnose the disease before its acute phase and help its treatment or control;
- Classify patients with special cancers and help to determine the appropriate drugs and treatments;
- Perform genetic testing on newborns and treat inhibited disorders;
- Identify bacteria and viruses in animals and food contamination;
- Find genetic map of biological species including humans;
- Design new drugs and treatment methods consistent with genetic conditions in the country.

• Securing Electronic Transactions Using Modern Cryptographic Protocols

Today, given rapid expansion of computer networks and internet, people wish to do their daily activities electronically and remotely via the internet in order to speed up their daily routine and save time. The emergence of concepts such as e-commerce, e-business and e-government as well as the rapid expansion of their applications shows their increasing importance in routine life. Any transaction involves providing information security, correct performance, and privacy.

The main point to ensure security of electronic processes is that it should be impossible to cover all security metrics by using traditional encryption tools (such as encoding information, digital signature etc.). To do so, new encryption protocols should be used which ordinary protocols (such as SSL, IPSec, PGP, etc.) lack them.

This plan provides the conditions for production of secure systems of electronic voting, electronic bidding system, electronic exchange, and digital money in the country. The above-mentioned applications lead to increasing interest in these initiatives, their prosperity and dynamism, and as a result their economic benefits.

• Implementing Internet of Things

Internet of things includes connecting embedded processors through the existing internet platform. This technology offers advanced connection of devices, systems, and services beyond machine to machine connection and covers a wide range of protocols, domains, and applications. It has the capacity of sending data for everything including objects via communication networks such as internet and intranet, and consequently collects plenty of information considering their status. Such data can serve as a basis to analyze condition of things and how their performance is related. Also, they can help to provide tailored services and information for things. Moreover, home automation appliances such as light switches, HVAC, and security systems are among important applications of internet of things.

• Techno-Medicine

Design and fabrication of microfluidic chips based on micro-machining for detection of circulating tumor cells (CTCs) was made possible through employing silicon nanostructures. With development of cancer cells in a tumor inside the body, these cells can be isolated from the tumor and enter the bloodstream. When they reach a suitable place to grow and accumulate, they form a

secondary tumor in another location. These cells, which are the main factor in the spread and proliferation of tumors, are called circulating tumor cells and the process of tumor proliferation is called metastasis. Most deaths from cancer have been attributed to this process.
Through implementing this system, the circulating cancer cells can be detected in the blood. For this purpose, by simultaneous use of two properties including different size of CTCs and blood cells as well as electrical impedance difference of CTCs with blood cells, one can detect CTCs from white blood cells. This would be possible using a new microfluidic system on silicon chips equipped with an active electrical structure. This device makes prevention and early detection of CTCs possible. Being user-friendly is the main feature of this sensor.

• Comprehensive Package of Persian Script and Language in Computer Environment

This initiative tries to provide the conditions for investment and participation of the private sector and to support research and development (R&D) focusing on increasing quality of the current products and developing market for Persian script and language-based products and services.
This package includes several initiatives for studying, promoting and developing software and hardware programs related to Persian script and language in the following parts:

- Developing and improving infrastructures and databases;
- Supporting initiatives in three fields of text, sound, and image;
- Increasing quality and reducing errors in the current software programs;
- Encouraging correct use of Persian language in computer and mobile environment;
- Developing training software for Persian script and language;
- Developing software for disabled people (deaf people, blinds, etc.);
- Developing programs to find similarities and fraud detection.

• Design and Construction of 3D Millimeter Wave Imaging System

Millimeter wave imaging technology is one of the newest technologies for full-body screening in security restricted areas to detect prohibited articles carried by individuals. Now, it has several applications including medical systems. This device is designed for optimal performance across frequency range of 30-40 GHz.

• National Grid Initiative

Today, scientists are faced with complex issues whose solution requires high processing power. For example, forecasting weather or earthquake, finding cancer drugs, modeling complex economic problems or recognizing elementary particles are among such issues. Given the fact that current computers lack the capability of solving these issues, scientists try to provoke a new and ideal technology called grid. Developing a new service to share grid computing capacity of a network of computers connected via internet results in a huge computational grid that people can use as easy as urban electric power grids.

IV. Authorities

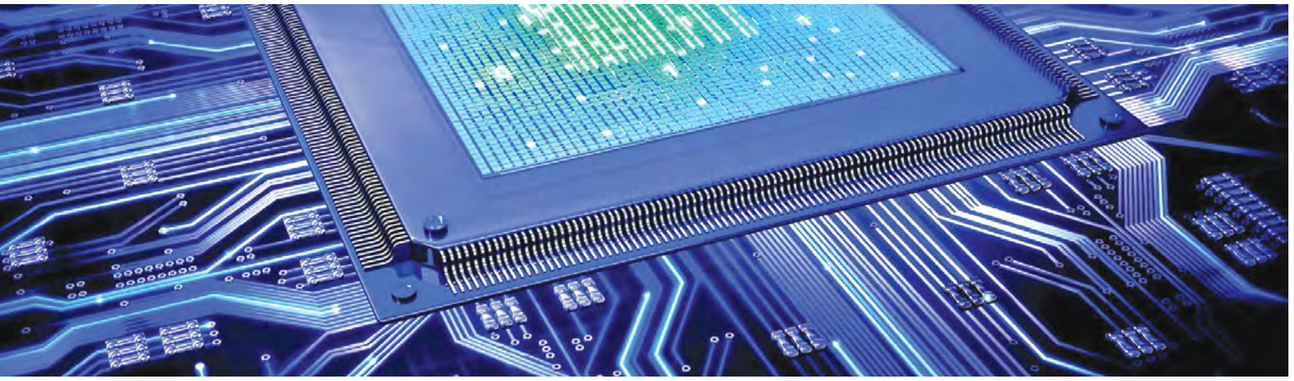
A. Digital Economy and Smart Technology Development Council

Digital Economy and Smart Technology Development Council has been formed to develop policies, set priorities, coordinate different trustee systems, support knowledge-based companies and commercialization of research results, and develop technological activities in line with the targets stipulated in the 20-year vision. Supporting science and technology development, empowering knowledge-based businesses, and specializing policymaking system in the related areas are among the high priority measures that the council has put on its agenda in order to realize ICT objectives. In this line, the council has set its technology priorities in five categories as follows:

IT Priorities: IT priorities include cloud computing, mobile computing, social networks, big data processing, technical infrastructures of software development, location-based systems and geographic information systems (LBS /GIS), and e-commerce, etc.

Priorities of Information Exchange Security: Such priorities include modern identification tools (such as OTP & Biometric), hardware security module (HSM), hardware encryption accelerators, penetration testing tools, local product and infrastructures of IDS/IPS, tools for protecting against pornography, fraud detection tools, tools for mobile devices protection and security, and specialized services for modern computing environments: VM, cloud, pervasive computing, grid, and web service, etc.

Electronic Content Priorities: These priorities include services (content and infrastructure), learning management systems and content management systems (LMS & CMS), big data analysis, applications for mobile devices, computer games, training simulators/virtual labs, data bank, Persian script writing software, and content aggregation and distribution, etc.



Telecommunication Priorities: Telecommunication priorities include IP-based secure millimeter radio wave, smart antennas, NFV-based IMS, implementation of the NFV-based EPC, Internet of things, fifth-generation networks, and fifth-generation services such as context aware services, etc.

Microelectronics Priorities: Microelectronic priorities include sensor, MEMS devices integrated circuits (IC), solar cells, and automotive electronics, etc.

In addition to the above priorities and in cooperation with experts in other economic and technological areas where ICT may play an important role, the most important products and services in the prioritized areas in the country are studied.

B. Other Authorities

Authorities, associations, and institutions involved in this area are presented in table 6 below.

Table 6
ICT Authorities, Associations, and Institutions

Agency	Establishment Date	Current Activities
Supreme Council of Cyberspace	2011	Running public education and creating culture to increase internet literacy and knowledge on the potential risks associated with cyberspace; Prioritizing content over infrastructures and internet services and forms, persisting high investment in content creation according to Islamic culture and the Islamic revolution discourse; Organizing international information exchange; Providing the required platform for maximizing security of the country's cyberspace for all communities of people, cyberspace players, and the regime; Creating high preparedness to protect critical infrastructures against any potential cyber-attacks; and Maximizing use of cyberspace to develop extensive and purposeful cooperation with other nations especially Muslim countries in an attempt to promote and realize the discourse of Islamic revolution.
Iranian Telecommunication Industry Syndicate	1998	The Iranian Telecommunication Industry Syndicate has been formed with the aim of consolidating manufacturers of telecommunications equipment; creating balanced and competitive conditions in order to increase the effectiveness of investments; organizing activities of the members; improving production quality; creating a data bank in the related fields; providing advisory and legal services; preventing unhealthy competition; cooperating with the relevant organizations; developing standards and By-laws; promoting technical knowledge; and updating the related laws and regulations.
Iranian ICT Guide Organization	2005	In accordance with Article 12 of the Law on Protection of the Rights of the Creators of Computer Software and given the rights asserted by that law, the Iranian ICT Guide Organization began its activities since July 2005 in order to regulate the private sector and public sector relations. Also, it is engaged in organizing computer business activities by virtue of the above law (passed by the Islamic Consultative Assembly in December 24, 2000) and the By-law (ratified by the Council of Ministers in July 14, 2004).
Informatics Society of Iran	1983	Informatics Society of Iran has been established with the aim of publishing monthly scientific Magazine of PC Report; holding monthly scientific seminars and webinars; holding training workshops; and holding monthly lecture sessions and scientific meetings for members by 7 specialized groups of the society including «network and hardware», «leadership and management of IT services», «Internet and cloud computing», «basic software», «advanced software», «databases and big data», and «analysis, design, and architecture».
Iranian Security Community	2001	Holding annual scientific-research conferences, monthly scientific-research seminars, and workshops on code and information security as case study; and holding scientific- research competitions in the field of code and information security, biannual Journal Monadi for cyberspace security (AFTA), ISeCure, and the ISC International Journal of Information Security are among Iranian Security Community's functions.
Association for Information and Communication Technologies	2004	The association's main functions include developing culture of utilizing the capabilities of ICT; collaborating with executive scientific/research institutions in ICT area; holding scientific conferences and specialized workshops (including IKT conference); publishing scientific-research quarterly Journal of ICT; and publishing books on ICT (6 books have already been published).
Computer Society of Iran	1994	Computer Society of Iran has been established with the purpose of holding the annual national conference of Computer Society of Iran; holding the annual international conference of Computer Society of Iran; publishing the scientific-research Journal of Sciences and Computer Engineering; and forming technical and vocational committees as well as education and research committee.
Iranian Association of Electrical and Electronics Engineers	1998	So far, this Association has published numerous publications, of which the Scientific-Research Journal of Electricity is the most important one. To honor the scientists, servants, and advocates of electrical engineering industry in Iran, a group of prominent figures are selected and introduced to the Association every year. At present, Iranian Association of Electrical and Electronics Engineers is cooperating with IEEE-USA, the French institute of CIGRE, and many universities and scientific centers in the country.

C. Companies

According to the exhaustive directory of the Iranian ICT companies (http://ictkey.ir), 2700 companies are registered in this system. These companies are classified as follows:

Table 7
Statistics of the Companies Involved in Various Sectors of ICT (2015)

Sector	Number	Field of Activity	Number
IT	2155	Software Hardware Network Internet	766 679 607 101
CT	68	Mobile Phone Fixed Phone Infrastructure Network Radio and Satellite Communications	14 14 27 13
Information Society	277	E-government E-learning E-commerce	75 103 98
Suppliers and Contractors	52	Telecommunications Contractors EPC Contractors ICT Equipment Manufacturers	26 9 17
Consulting, research and development	176	CT Security IT CEICT Standards	38 19 104 9 6
Business Services	17	Import and Export of Telecommunications Equipment Public Services	6 11

D. Universities

Almost all universities of the country admit students at different levels of ICT. A number of accredited universities have made more contribution to ICT knowledge production and the related technological projects. According to statistics provided by the University News Reference (http://unr.ir), the number of academic and higher education institutes is as follows:

Table 8
Statistics of Academic Units in 2013

Academic Institutes	Number
Universities and institutes affiliated to the Ministry of Science, Research, and Technology	318
Technical and vocational universities affiliated to the Ministry of Education	107
Universities and higher education institutes affiliated to executive organizations	28
Payam-e-Noor University (PNU)	569
University of Applied Sciences and Technology (UAST)	740
Non-governmental and non-profit higher education institutes and universities	344
Islamic Azad University	408
Total	2514

8 Cultural and Creative Industries

Cultural and Creative Industries

I. History and Background

History of soft technologies in Iran goes back to the ancient times and it is as old as the country's life. Iranian arts and crafts have been known all over the world since the very ancient times. Various eye catching handicrafts from the gorgeous Persian carpets to exquisite potteries, ceramics, metal works, etc. are the result of Iranian art and creativity whose dazzling beauty have always satiated aesthetic pleasure. Spectacular architecture and the art of Persian historical architecture, the literary masterpieces of the past and current Iran are priceless manifestations of the Iranian soft technology and knowledge.

Nowadays, Iranians have accomplished to incorporate their wealthy heritage into modern technological advances and offer huge potential for cultural and soft technologies. Several capable computer games and animation companies have successfully integrated Persian art into modern technology. Utilizing modern knowledge and Iranian artists' creativity, Persian handicrafts such as elegant carpets and visual arts have also developed significantly.

Along with capacities and capabilities of Iranians for cultural and soft technologies, there are numerous opportunities for development and investment. The highly educated and creative young generation as the main wealth to develop cultural and soft technologies can achieve great success through taking benefit of Iranian cultural treasure and finding access to global markets.

Although several knowledge-based companies have been founded thanks to the efforts of experts and talents of the cultural and soft technologies, the country has the capacity for much more development and investment in this area. In general, Iran's location in the Middle East and its long land and water borders with several countries as well as its full access to central Asian countries and its influential role in east-west path have provided an excellent opportunity for exporting cultural and soft industries' products/services. Currently, Iran enjoys high technical and specialized knowledge in a range of fields such as film, animation, computer games, design, handicrafts, visual arts, just to name a few, that can offer great opportunities for international investments.

II. Objectives and Strategies

Objective 1: Increasing share of cultural products and services in the national economy;
Strategy 1-1: Improving business environment and completing the idea-to-product/service chain to secure growth and commercialization of cultural and soft technologies with an emphasis on entrepreneurship and private sector involvement;
Strategy 2-1: Increasing quality and quantity of production and providing cultural and soft products and services;
Strategy 3-1: Marketing and creating the demand for cultural and soft products/services in the country;
Strategy 4-1: Developing international cooperation, enhancing active, effective, and inspiring interaction and collaboration in cultural and soft technologies;
Objective 2: Promoting policymaking mechanisms and institutionalizing the discourse on cultural and soft technologies;
Strategy 1-2: Consolidating policymaking responsibilities, planning and strategic monitoring of cultural and soft industries;
Strategy 2-2: Establishing cultural and soft technologies as one of the dominant discourses in the comprehensive development of the country particularly in Resistance Economy Model;
Objective 3: Improving institutional infrastructures for development, commercialization, physical and intellectual support for the process of turning idea into product and increasing production share;
Strategy 1-3: Reforming laws and regulations in the field of formation, development, and commercialization of cultural and soft technologies;
Strategy 2-3: Providing technical infrastructures and networking in the existing capacities to achieve synergy and increase the quality of the basic services;
Strategy 3-3: Organizing unions and promoting institutions in the field of cultural and soft technologies;
Strategy 4-3: Developing human resources and improving skills required for entrepreneurship in the cultural and soft technologies.

III. Capacities and Capabilities

A. Some Achievements

• Purposeful Educational /Intellectual Entertainments based on Islamic Culture and Civilization

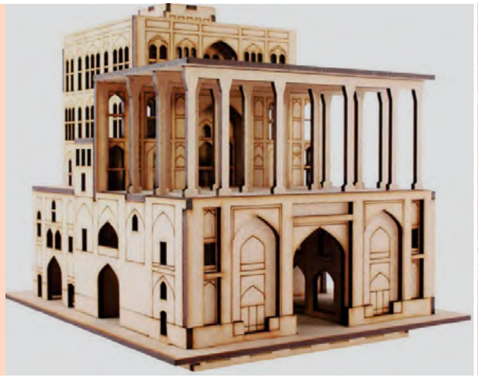
This project involves historical landmarks-3-D puzzles that some of its objectives include: getting acquainted with historical buildings; affirming national identity; increasing precision, discipline, and sparking curiosity; and enhancing the practical skills and knowledge of the youth.

• Siroo Project: IT-based Software and Hardware Platform for Virtual Visit and Tourist Guide

Iran tourism kiosk is a simulator space that introduces Iran's attractive, natural, historical, and cultural sites as well as its science and technology through virtual reality and augmented reality technologies. In this simulator space, users can move in all directions of an XY plane. They can also control the designed elements manually.

• Skill-up Toys, Tehran

This project involves producing educational devices using basic sciences for different age groups. In



fact, simple devices designed as toys contribute to children's and youth's acquisition of information and skills about different sciences.

• Nazbalesh; Animation Movie

The full HD movie "Nazbalesh" is an animation movie based on a novel by H. Moradi Kermani with the same title. This movie symbolically depicts the emergence of modern technologies in a traditional community.

• Designing and Manufacturing Educational Toys and Providing the Related Services, Tehran

This project involves manufacturing 8 training robotic packages, offering robotic classes, and organizing accredited Nadcup competitions. This project also includes holding extra-curricular classes by providing training packages on chemistry, aerospace, biology, astronomy, and creativity.

• Virtual Handicraft Shop with the Purpose of Developing Virtual Handicraft Markets in Iran

Focusing on introducing local crafts of the Iranian ethnic groups, this project is aimed at the following targets:

- Producing Iranian handicrafts catering to modern society taste;
- Emphasizing online sale of handicrafts considering people purchasing power from different social classes;
- Encouraging interaction among craftsmen, customers, and researchers through launching an art/culture base and online sale as well as developing digital supply/sale chain for handicrafts.

• Traditional and Embroidered Clothing (Combination of Islamic Clothing and Traditional Embroidery Stiches)

Designing, manufacturing, and exporting textiles and clothing with modern methods inspired by Balochi embroidery; one of the most common and significant crafts of Balochi women.

IV. Authorities

A. Soft Technology Development Council

The Soft Technology Development Council (STDC) was established by the Vice-Presidency for Science and Technology in 2013 with the mission to coordinate measures related to development and commercialization of the products and services in this area.

The council was founded to create and improve the required platforms to develop soft and cultural industries and support the associated knowledge-based companies. In addition to developing and improving industry chain, the council encourages entrepreneurship through supporting entrepreneurship agencies and events, establishes leading centers for developing cultural entrepreneurship, and promotes cultural industry. Macro objectives of the council are as follows:

- Increasing production and share of cultural products and services in the national economy;
- Promoting policymaking mechanisms and institutionalizing cultural and soft technology discourses;
- Improving institutional infrastructures for development, commercializing, providing physical and emotional support for idea-to-product process, and increasing production share.

B. Other Authorities

Since cultural and soft technologies are pretty extensive, there are various authorities with different responsibilities in either policymaking or executive departments. The Supreme Council of Cultural Revolution; Vice-Presidency for Science and Technology; Policymaking Council of the Islamic Seminaries; Islamic Republic of Iran Broadcasting (I.R.I.B); Ministry of Science, Research and Technology and its affiliated universities; Ministry of Culture and Islamic Guidance; Ministry of Education; Ministry of Industry, Mine, and Trade; Cultural Heritage, Handicrafts, and Tourism Organization; Ministry of Youth Affairs and Sports; Art Academy; Islamic Propagation Organization; Islamic Culture and Communication Organization; and the Center for Progress and Development of I.R.I Presidency are among the major authorities of cultural and soft industries. Eight of the top universities of the country are also among the agents of this area.

C. Companies

There are 1 company in animation area, 6 in audiovisual media and filmmaking, 30 in videogame and 1 in jewelries design, respectively.

D. Incubators

Incubators are one of the important infrastructures to develop start-ups that provide idea developers with the required services in various fields. Universities could be an appropriate place for establishing incubators, because they are generally dealing with innovative ideas. To improve the process of idea-to-product in cultural and soft industries, the council has supported establishment of a number of incubators in collaboration with universities. These incubators are:

• Khorasan Pilgrimage and Cultural Technology Incubator

Supported by the council, this incubator has been able to hold several programs on developing ideas and start-ups. In cooperation with the council, this center also supports projects and active companies in this field.

• Lalejin Specialized Pottery Lab

This incubator intends to be the specialized center for ceramics and pottery through providing specialized services in the fields of body, paint, and glaze of ceramic and pottery produced in Lalejin, Hamadan.

Using knowledge-based technologies and technical knowledge of different paints and glazes in nanoscale results in consuming less amount of paint with higher efficiency and more durability, decreasing adverse environmental effects as well as creating new properties for new products.

• Isfahan Soft Technology Incubator

The objectives of this center can be summarized as follows: developing entrepreneurship and creating appropriate platforms for commercializing art/cultural products & services, supporting economic growth, providing the required environment for developing knowledge-based businesses particularly art, building the platform for creating job opportunities based on soft technologies, and finally supporting improvement and promotion of the Iranian Islamic culture.

• Tabriz Soft Technology Incubator

This center includes 7 specialized units including “design and manufacture of multimedia products”, “design and manufacture of BOT printing sampler”, “design and manufacture of furniture based on Islamic and Iranian life style”, “design and manufacture of shoes based on Iranian local standards”, “algorithmic design of the Islamic geometric pattern of knots”, “smart design and manufacturing system for custom hand-woven carpets”, and “design and manufacture of sustainable packaging for handicrafts”.

• Yazd Soft Technology Incubator

In 2014 through the financial and moral supports of the Soft Technology Development Council and Yazd Science and Technology Park, this center was established in Yazd in an attempt to create animation incubator.

• Qom Cultural Technology Incubator

Idea developing and startup programs have been held in this center under supports of the Soft Technology Development Council. In collaboration with the council, this center also supports projects and active companies in the field.

V. International Cooperation

Because of skilled and low-cost workforce in Iran (as compared with the international market) and relatively low business running costs such as energy, there are plenty of opportunities in Iran for foreign investments and international interactions in animation, computer games, design, fashion and clothing, handicrafts and jewelry sectors.

Animation

Iranian animation industry benefits from highly educated and creative young workforce with technical knowledge enriched by artistic capabilities. Moreover, as compared with the global market, employing workforce does not cost much in Iran and some of the required technical infrastructures for animation production like render farm is available at affordable prices in the country.

Computer Games

Iranian stakeholders of computer games believe that Iran has a rich repertory. The successful experiences of the recent Iranian games show that in case of finding access to global markets, the Iranian game manufactures can produce computer games of world-class, low costs, and high quality.

Handicrafts

Given Iran’s ancient civilization, rich culture, and multiethnic people, there are a wide variety of handicrafts in this country. The amazing beauty of the Iranian handicrafts always draws the attention of foreign tourists. Various forms and applications of these industries together with their delicacy and sophistication are so splendid that dazzle every viewer. Developing the capacities to supply such products provides the ground for investment opportunities.

9 Aerospace

Aerospace

I. History and Background

Aerospace technology has had an ever-present and progressive position in the Islamic Republic of Iran. The aerospace research in I.R. Iran was initiated in the eighth century. The eighth and ninth centuries witnessed the attempts of Abu Abdullah Muhammad ibn Musa al-Khwarizmi`s Zij al-Sindhind, which is a seminal work consisting of approximately 37 chapters on calendrical and astronomical calculations and 116 tables with calendrical, astronomical and astrological data, as well as a table of sine values. Iran's space exploration efforts were continued till the 16th and 17th centuries when Baha al-Din Muhammad ibn Husayn al-Amili has probably written 17 tracts and books on astronomy and the related subjects.

The modern era has also witnessed a lot of aerospace advancements in Iran. In 1869 Iran joined the International Telecommunication Union (ITU). In 1951 the National Geographic Organization of Iran was founded. Iranian Space Agency (ISA) was established in 2003 and in 2005 Iran's 10-year space program plan was released which led to launching of Sina-1 satellite to space as the result of cooperation between Iran and Russia in 2005. Since then, many satellites were built, among them, there are Safir Satellite launch vehicle (SLV); the first and the second sub-orbital sounding rockets named Kavoshgar-1 and Kavoshgar-2; Safir1-A SLV which placed the first domestically made satellite, named "Omid", into orbit; Kavoshgar-4 and Rasad-1; and Navid, etc. 2013 was a fruitful year for Iran's space exploration programs as it witnessed launching of Kavoshgar-6 that was partially successful in recording and receiving images and biological data. In 2013 "Pishgam", the first monkey reaching a height of 120 km by Kavoshgar Pishgam was sent to space and at the same year the second monkey, named "Fargam", was also sent to space by Kavoshgar Pajuhesh. "Fajr" the latest Iranian satellite which was an imaging satellite carrying a locally made experimental navigation system was launched in 2015. At the same year, Iran exhibited the mock-up of new manned spacecraft made by the Aerospace Research Institute (ARI).

II. Objectives and Strategies

Major objectives and strategies for this industry inspired by the comprehensive aerospace development document are as follows:

A. Macro Level Objectives

- Understanding the magnitude and order of the universe and the heavens and discovering the wisdom and power of the Creator of the world by spreading science and technology and space exploration;
- Achieving the first place in conquering and dominating space in the region through the related science and technologies and using capabilities of universities and scientific and research centers of the country;
- Conducting manned space missions and sending man to the earth orbit with an emphasis on indigenous science, technology, and industry through participation of the Muslim world and international cooperation;
- Designing, manufacturing, launching, and utilizing satellites in Geosynchronous orbit and other orbits with such applications as communication and remote sensing, while giving priority to local technology and industry through participation of the Muslim world and international cooperation;
- Developing access to space-based communication services and infrastructure in order to meet national, regional, international, public, and commercial requirements compatible with land-based communication platforms;
- Achieving the necessary technology to meet service requirements of remote sensing and earth observation with less than 10 meter precision;
- Contributing to positioning, navigation, and timing with competitive quality compatible with international standards at national and regional levels;
- Becoming a regional hub and achieving the leading global position relying on science and technology capabilities of the universities and scientific-industrial centers.

B. Macro Level Strategies

- Incorporating all the measures related to policymaking, governance, coordination, and accumulation of knowledge and implementation of macro aerospace programs through exploiting maximum capability of the governmental and non-governmental institutions and entities;
- Supporting privatization and providing the required platform to create knowledge-based industries in the aerospace domain;
- Providing purposeful support for educational-research activities and scientific hubs in aerospace domain;
- Intelligently and actively developing international cooperation and interactions in order to advance space programs, while protecting and preserving space assets of the country;

- Using space achievements in understanding the universe, developing astrophysics and astronomy, reviewing the Islamic resources in this domain, and analyzing their congruence with modern science;
- Supporting basic research relying on Islamic knowledge foundation in an attempt to produce, develop, and strengthen basic sciences in aerospace;
- Designing, manufacturing, and operating launch vehicles for the required satellites including satellites equipped with a biological capsule and geosynchronous satellites;
- Promoting space sciences, technologies, and achievements among different social classes, particularly young people and the elites.

III. Capacities and Capabilities

A. Scientific Productivity

Experienced human resources and advanced scientific capabilities have allowed Iran's aerospace industries to achieve a rapid progress. The growing trend of research papers on aerospace indicates great achievements of the young aerospace experts in recent years. The following table shows the country's rank in terms of citable documents in the world. With a 24-step progress, Iran has successfully improved its rank from 35th to 11th.

Table 1

Iran's Global Rank in terms of Citable Documents in Aerospace (2005-2015)

Year	Global Rank	Documents	Citations
2005	35	46	216
2006	33	54	307
2007	22	97	1088
2008	21	126	1029
2009	19	127	676
2010	19	146	962
2011	17	171	882
2012	17	203	965
2013	14	275	408
2014	12	360	127
2015	11	341	101

B. Some Achievements

Launch Vehicles, Satellites and Other Products

• Safir SLV

The first Satellite Launch Vehicle (SLV) developed by Aerospace Industries Organization (AIO) was Safir-1A. It was used to place Omid, the domestically developed satellite, into orbit. Launching Omid placed Iran among the eight countries enjoying independent satellite launching infrastructures. The achievement of SLV technology for Safir-1A included system engineering, conceptual design, preliminary design, simulation, integration and testing, and quality assurance.

• Simorgh SLV

In 2010, AIO began to develop a more powerful satellite launch vehicle, named Simorgh, with a mission to carry heavier satellites up to 350kg to Low Earth Orbit (LEO). The first stage has four main engines together with an engine for attitude control. The first stage engines enjoy a reinforced thrust which is around four times more than that of Safir launchers. Toloo and Autsat satellites are expected to be launched by Simorgh launch vehicle.

• Sounding Rockets

As the first biological payload was launched by Iran, it was ranked as the sixth country to send animals into space.

Kavoshgar (the explorer) is the name of a series of Iran's suborbital space launchers whose objective is to enable Iran to send human into space. Eight missions have been performed using these launchers- as the stepping stones towards this goal- from 2006 to 2013 as follows:

Table 2

Iran Space Missions and Achievements (2006-2013)

Launcher	Launcher class	Date	Height	Main Achievements
Kavoshgar-1	A	2006	10 km	Iran's first step to engage in space exploration
Kavoshgar-2	B	2008	40 km	Complete success, payload was recovered safely
Kavoshgar-3	B	2010	55 km	Iran engaged in Biospace research
Kavoshgar-4	C	2011	135 km	Complete success, payload was recovered safely
Kavoshgar-5	C	2011	120 km	First monkey in space, receiving images and biological data
Kavoshgar-6	C	2012	120 km	Partially successful, recording and receiving images and biological data
Kavoshgar- Pishgam	C	2013	120 km	Completely successful, Safe return of Iran's first space monkey
Kavoshgar- Pajuhesh	D	2013	120 km	Completely successful, Safe return of Iran's second space monkey

• SharifSat Communication Satellite

SharifSat was built by a group of students at Sharif University of Technology and delivered to ISA on December 2013. It is a 50 Kg imaging, storing and forwarding communication satellite. Having successfully passed all the operational and environmental tests, it is planned to be launched into LEO orbit. Most of its subsystems are indigenously developed including magnetic sensors and actuators, a fault tolerant OBC, communication transmitters and receivers, antennas, solar panels, a camera and an image compression engine, heat pipes and the isogrid structure.

• Mesbah Telecommunication Satellite

Mesbah (meaning 'Lantern'), a low earth orbit (LEO) telecommunication satellite, was jointly built by Iranian Research Organization for Science and Technology (IROST) and Iran Telecommunication Research Center (ITRC). It was the first project to build and launch a satellite in Iran after the Islamic revolution. To run the project, three ground stations were also developed; one at IROST, one at ITRC and a backup station. Mesbah-1 was scheduled to be launched onboard a Kosmos-3M launch vehicle from the Plesetsk cosmodrome in late 2006. However, launching this satellite was deferred due to some unavoidable circumstances.

• Sina Remote Sensing Satellite

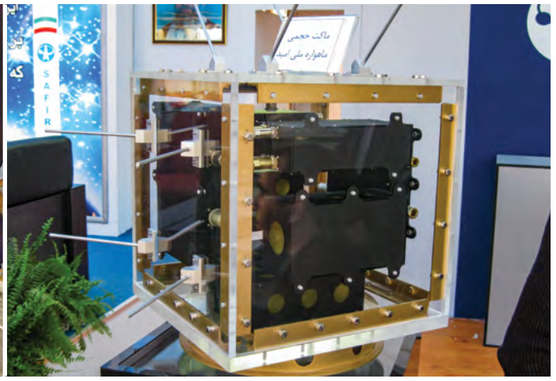
The first Iranian satellite, Sina-1, was launched by a Russian Kosmos-3M rocket from Plesetsk in the Murmansk Province of the Russian Federation on Oct. 27, 2005. Sina-1 made Iran the 43rd member of the world satellite owner club. The satellite is on a mission to gather information concerning agricultural issues, natural disasters, and natural resources. It operates on VHF and UHF frequencies. It has also provided Iran with valuable experiences in ground control tracking and telemetry handling.

• Omid Telecommunication Satellite

On Feb. 2, 2009, Iran successfully launched its first domestic SLV, carrying Iran's first domestic telecommunication satellite called Omid. Omid (means 'Hope' in the Persian language) was developed at the Iran Electronics Industries (IEI) and its launching placed Iran in the club of nine countries enjoying independent satellite launching and manufacturing capacities. The main achievements of Omid project were manufacturing the first domestic space system, acquiring the space technology to drive other industries, persuading academia to cooperate with and contribute to development of space technologies, and capacity building in satellite manufacturing, integration and tests. In fact, Iran was the first country to reach outer space relying on its own independent capacities in satellite launching and manufacturing in the new millennium.

• Rasad Remote Sensing Satellite

In line with research and development plans in space science and technology, Safir Satellite Launch Vehicle placed the Iranian satellite Rasad-1 into the LEO on June 15, 2011. Rasad was equipped with body-mounted solar panels to generate power for the batteries, with no limitation in the power source. Stabilization is provided by an extendable gravity gradient boom. As the country's first imaging satellite, it was developed by Malek Ashtar Technical University.



This satellite performed its mission successfully, beaming images with 150 m resolution to its receiving station and reentering the atmosphere, on July 6, 2011. It was the third Iranian satellite on the earth's orbit and the second one launched by an indigenous launcher.

• Navid Remote Sensing Satellite

The 50 kg Navid microsatellite launched on Feb. 3, 2012 was the first satellite constructed by Iran University of Science and Technology in conjunction with ISA. Navid- a 50 cm cube- was designed to test a camera for taking image of the earth and to collect weather data as well. Navid was the third satellite launched indigenously by Iran and was placed into orbit by a new configuration of Safir-1B satellite launch vehicle, whose second stage was larger than the first stage with a 20% greater thrust.

• Fajr Remote Sensing Satellite

Fajr is the 2nd satellite built and launched by IEI after Omid

Fajr was an imaging satellite, which also carried an experimental locally made GPS system built by IEI. As the first Iranian satellite, it was equipped with solar panels for power generation and cold gas thrusters for attitude control. Fajr was launched by a Safir-1B rocket from the Iranian Space Agency's launch site in Semnan Province. The launch took place on Feb. 2, 2015, Iran's national day of space and the sixth anniversary of the country's first successful orbital launch. It was deployed into a low earth orbit and reentered earth's atmosphere on Feb. 26, 2015.

• AUTSAT Earth Observation Satellite

AUTSAT is a microsatellite with a remote sensing mission and a secondary mission of storing and forwarding communications data. This satellite is at the stage of design and construction by Amirkabir University of Technology, a leading technical university in Iran, in conjunction with ISA. It is also capable of monitoring growth of agricultural products in its coverage area.

• Toloo Earth Observation Satellite, the Heaviest Iranian Satellite

It was built as the first of a new generation of reconnaissance satellites with SIGINT capabilities by IEI. Its imagery products will be used for synoptic land mapping, monitoring water bodies and environmental disasters, agricultural areas and forests, urban distribution, and cloud coverage. Toloo is the first domestic remote sensing microsatellite planned to acquire images of the earth with a resolution of 50 m.

• Nasir-1 Star Tracker

This celestial navigation tool was manufactured for the first time in Iran by the faculty of Aerospace and Electrical Engineering of K. N. Toosi University of Technology. Later, it was successfully tested. Subsystems used to design and manufacture Nasir-1 Star Tracker include optical hardware, electronic hardware, image processing software, star model identification, and attitude determination software. The precision of the sensor has been reported lower than 20 accurate seconds with a 768x512 Pixel CCD.

IV. Authorities

• Space Supreme Council

Being active since July 20, 2005, the Space Supreme Council (SSC) has presented its main goals as follows:

- Manufacturing, launching, and using space technologies in national research satellites;
- Approving the status of space-related programs of the private sector;
- Promoting partnerships in private and cooperative sectors for the efficient use of space;
- Identifying guidelines for regional and international cooperation in space activities.

• Aerospace Industries Organization

The Aerospace Industries Organization (AIO) is a leading high-tech industry which is affiliated to the Defense Industries Organization of the Ministry of Defense and Armed Forces Logistics (MODAFL). Its products include launchers, rocket and booster propellants and components. AIO is the leading Iranian organization in development and production of the space assets such as space propulsion systems, space launch and operations centers, and ground control stations. It is also the main developer of Iranian launch vehicles, namely Safir, Simorgh and their successive versions.

• Iranian Space Agency

The Iranian Space Agency (ISA), established in 2003, is involved in conducting engineering and research in different fields of aerospace such as satellite development, communications and remote sensing. Some of the key tasks assigned to ISA by the Space Supreme Council were to undertake space technological research and development, develop and operate remote sensing systems, strengthen domestic and international space networks, and conduct studies and research in the field of designing, manufacturing and launching satellites.

• Iran Aviation and Space Industries Association

The Iran Aviation and Space Industries Association (IASIA), established in 2007, is a non-governmental entity which started its activities with 27 participating companies involved in the aerospace industry. Now IASIA includes more than 170 active companies with formal membership in the aerospace engineering field. Supporting members to develop their activities and services and also providing the basis for general development of aerospace engineering field in Iran are the main objectives of IASIA. It is also the primary holder of the National Exhibition of Iranian Aviation and Space Industries which is held annually. The exhibition provides the Iranian state-owned and private companies, airlines, knowledge-based aerospace companies, academic centers, aviation publications and producers of aeronautical parts with an opportunity to showcase their capabilities.

V. International Cooperation

Iran is capable of exporting and providing the following services to the developing countries:

- Remote sensing satellites with high spatial resolution;
- Lightweight telecommunications satellites;
- Sounding Rockets;
- Design and development of Spaceports;
- Design and development of lightweight launch vehicles;
- Lightweight satellite launch services;
- Design and development of ground stations to receive images.

Iran is ready to cooperate with the countries enjoying space-related technologies in the following areas:

- Launch technology development;
- Space-based navigation and positioning systems;
- Communications satellite and services;
- Launch services;
- Remote sensing satellite services;
- Ground stations;
- Space science and exploration;
- Promotion of space science and technology;
- Remote sensing cameras;
- Remote sensing satellites.

10 Aviation Technology

Aviation Technology

I. History and Background

Commercial development of the aviation industry in Iran started with creation of the first airline office in Tehran in cooperation with Junkers in 1923. It provided air travel services between Tehran, Mashhad, Shiraz, Bandar Anzali, and Bushehr. A non-civilian body was also established in 1922 as the first official aviation organization in Iran.

Although initiatives for development of the aviation industry in Iran were primarily commercial at the outset, in 1930s the authorities decided to develop the two major categories of this important new industry, namely both civil and military aviation. Providing civil aviation services involves establishment of technical and civil supporting organizations alongside presentation of the military services and logistics. This way, Iranian airlines started their services in 1923, in parallel with the military development. The rapid pace of development resulted in partnership between the private sector and Iran Airways in 1944 through private sector investment. The next in this group was the Persian Air Services (PAS) which began operating in 1952. Iran Airways and PAS merged as Iran Airline in 1961. In 1962 state nationalization of the air transportation industry led to establishment of the Iranian National Airline (called Homa in the Persian language), which operates under the regulations of the International Air Transport Association (IATA).

After the Islamic revolution, the country witnessed huge developments in the industry. In general, the history of Iranian commercial aviation industry from the beginning to present day can be divided into 8 periods:

- 1923-1927: Creation of Army Air Forces;
- 1927-1932: Inauguration of Junkers Airline in Iran;
- 1932-1938: Lack of commercial air transportation;
- 1938-1946: Creation of Ministry of Post, Telegraph and Telephone Airline;
- 1946-1961: Creation of Iran Airways and Persian Air Services;
- 1961-1962: Creation of Iran United Airline;
- 1962-1979: Iran National Airlines (Iran Air), the flourishing years;
- 1979 up to now: Post-revolution, the era of multiple airlines.

II. Strategies and Objectives

Based on development programs in the country and in line with realization of Iran's aerospace and aviation Vision 2025, the comprehensive document for development of aerospace has been prepared through 3 consecutive years of collaborative work of four main committees of aviation, aeronautics, space, and air defense.

These committees, consisted of 27 specialized working groups, have been supported by contributions of more than 450 experts, including representatives of all related institutions.

Development strategies and objectives of this industry, inspired by the Comprehensive Aerospace Development Document, are as follows:

A. Macro Level Strategies

- Integrating, organizing, and regulating institutions to prevent overlapping, boosting productivity and synergy of the institutions, and tailoring authorities to missions while separating and securing independence of the agents in charge of policymaking, implementing, and monitoring;
- Creating supportive business environment, assigning the necessary incentives in an attempt to maximize private sector contribution, and providing the infrastructures required to build knowledge-based industries and enterprises in the aerospace domain;
- Providing targeted support for education and research activities and scientific hubs needed by aerospace and aviation programs;
- Developing and improving supply chain and maintenance measures, and upgrading the required technologies with the contribution of the private sector;
- Utilizing projects based on common platform of subsystem development;
- Creating constructive competition to improve quality in active aviation companies;
- Building R&D networks with national and international universities, research centers, and manufacturing sectors, with an emphasis on value chain creation;
- Revising flight routes, especially transit ones, so as to make economic and effective use of country's airlines;
- Running targeted development of scientific, technological, and innovative collaborations at regional and international levels in addition to strong presence in the global arena and the related effective international institutions;
- Developing general aviation services through maximizing contribution of the private sector.

B. Macro Level Objectives

To become regional hub and achieve global recognition benefiting from science and technology universities and scientific and industrial centers in terms of the following items:

- To design and manufacture 100-150-seat regional aircrafts and general aviation airplanes in accordance with national and global market demands;
- To design and manufacture medium and semi-heavy helicopters;
- To maintain, repair and overhaul;
- To design and manufacture mini turbojet engines, light and heavy turbofan engines and gas turbine engine compressors with capacity of 1-10 MW;
- To design, develop and manufacture avionic systems;
- To create advanced science and technology process and train human resources;
- Effective presence in the global aviation industries by promoting Imam Khomeini Airport as the second aviation hub in the region;
- To develop hardware and software for capacity building with the aim of using all air traffic potential at the national and international level;
- To achieve flight safety and quality standards above the global average;
- To create and implement comprehensive safety management systems;
- To implement new air traffic management systems.

III. Capacities and Capabilities

A. Human Resources and Aviation Centers

Table 1

Human Resources in Aerospace Industry

Title	Number	Period
Admitted Students	37677	1989-2017
Graduates	18964	1988-2016
Faculty Members	380	2017

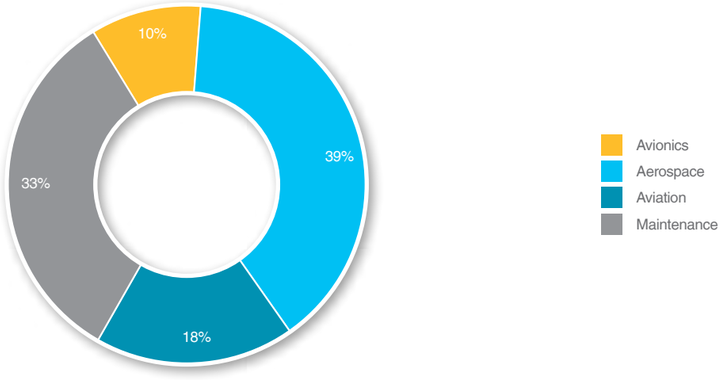


Figure 1: *Percentage of Aerospace Graduates by Field of Study (2013)*

Table 2

Aviation and Aerospace Centers

Educational/ Research Institutions	Number
Universities	46
Research Units	7
Incubators	1
Research Institutes	3
Research Centers	1
Science and Technology Parks	2
Knowledge-based Companies	280

B. Some Achievements

- **Fuel Pump**

An important system in aircrafts is their fuel system in which the fuel pump, as one of its main subsystems, is directly connected to the engine and any malfunction or fault with this part may affect the performance of the engine. The manufacturing processes of fuel pumps have been accomplished through this project.

- **Smart UAVs**

Altitude and position of the UAVs (unmanned aerial vehicles) are estimated precisely through comparing single sensed images with stored images of the reference database by using salient features and descriptors. The suggested strategy is implemented in 2 phases: creating reference geographical database and automatically geo-referencing images resulting in estimation of aircraft's position.

- **72-Seat Aircraft**

With regard to the country's need for regional jet aircrafts up to 100-seat capacity and in accordance with capabilities of design engineers and industrial infrastructures, the project for design and manufacturing of 72-seat aircraft has been operated since 2014; at the moment, the design process is in progress.

- **2-Seat Helicopter**

2-Seat Helicopter project has been defined in order to meet the needs of training and transportation services. Design and manufacture of this light helicopter is in progress based on joint cooperation with technology owners of the product in Europe and Latin America.

- **8-Seat Helicopter**

8-Seat Helicopter project has been defined based on the need for cargo and passenger transportation, search and rescue and offshore operations. This project is in progress on the basis of a co-production with European components.

- **Duct Fan VTOL UAV**

Duct Fan VTOL UAV with the weight of 26 kg and payload of 3 kg is designed and manufactured with the aims of patrol missions, search and rescue, firefighting and forests and environment protection.

- **2.5 MW Turbine Engine Core**

2.5 MW Turbine Engine Core project has been defined in order to be used in aviation industry and other industries such as oil, gas and energy with the power capacity up to 2.5 Megawatts. Modular structure for ease of maintenance and repair is considered to be the most important characteristics of this engine.

- **Firefighting Aircrafts**

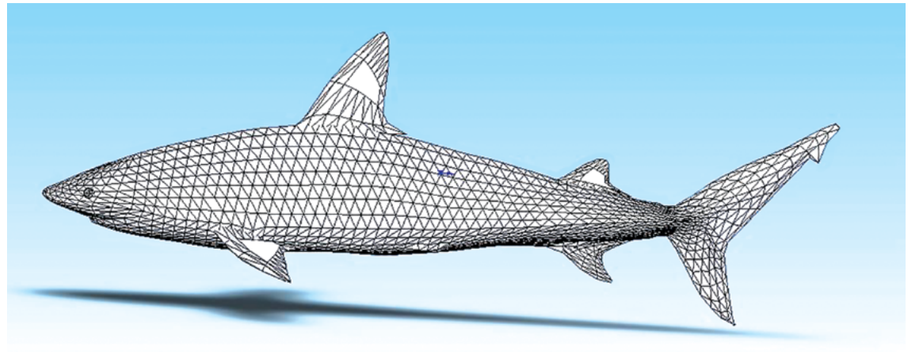
Extensive fire, as a natural disaster, annually threatens environmental health. One way to deal with these large fires is using firefighting aircraft for fire suppression.
Given lack of firefighting aircraft on a large scale in the country, a project for converting Tupolev Tu-154 aircraft into firefighting one with capability of carrying 18,000-20,000 liters of water has been defined in five phases as follows:
1) Studies and research, conceptual design and calculations;
2) Laboratory investigation and simulation of the project;
3) Analysis and verification of the software;
4) Selection and purchase of equipment;
5) Manufacturing, optimizing and assembling.

- **FAJR 6-Seat Aircraft**

The two piston engine aircraft with the capacity of 6 persons has been designed in the form of low-wing configuration with retracting landing gear. The mission of this aircraft with endurance of up to 6 hours is to operate as air taxi.

- **Flapping Wing Vehicle**

Recognizing the importance of Ornithopter, a more optimal mechanism than the fixed wing, Iran has been able to accomplish this project by domestic academic teams. Designing the flapping system involves a range of issues such as flapping frequency, shape and structure of the wing, lift force, etc. The designed wing is stable and capable of performing a safe and stable flight as well. It is made of materials with the same damping property so that it can decrease damages in case of crash. The structure of the vehicle is very similar to the natural shape of the birds' body. Apart from its light weight, it also enjoys a gearbox designed for power transmission.



- **Smart Robot Shark**

Nowadays, there are many debates over the unmanned subsurface vehicles, their uses, benefits, and future prospects. Regarding the vast needs of the country's maritime industry, there would be a large market for unmanned ground handling services promising a booming future for the sector. After the initial research, the final design was selected from several proposals according to the requirments of the project in building floating components and creating the movement mechanism including fish model, propulsion system, and vertical and horizontal motions.The entire project is done domesticaly by the academic teams.

- **Aircraft Load Calculations Software**

This project has been performed by the Iranian academic teams, considering the needs of the mid-range aircrafts. Due to the fact that speed and accuracy of the load calculations are two equally important factors in the design process of aircrafts, this software can speed up load calculations, while maintaining high precision.

- **Air Data Test Set (Pitot-Static Testers)**

Trying to keep pace with the global advances in aircraft test equipment, Iranian academic teams are working on designing a domestic air data test set. It is a specialized pressure generation and measurement instrument used to leak test an aircraft's pitot-static system and test and verify an aircraft's instruments by simulating their altitude and speed.

IV. Authorities

A. Technology Development Council for Space and Advanced Transportation

The Technology Development Council for Space and Advanced Transportation (TDCSAT) was established in 2018 by integrating the Iran Aviation Technology Development Headquarter (IATDH) and the Marine Industrial and Technology Development Council (MITDC).
The Iran Aviation Technology Development Headquarter (IATDH) affiliated to the Vice-Presidency for Science and Technology had the responsibility to implement the plan and achieve the goals mentioned in the comprehensive document for aerospace development.
Since 2013, IATDH has been the most influential body in Iran aviation industry, with the task of policy-making, leadership, coordinating and supervising organizations and entities working in the field. IATDH focused on determining practical solutions to problems and challenges of high-

tech aviation firms and facilitating the business environment regarding the legal and judicial considerations. It had also tried to provide necessary requirements for international companies interested in cooperation with Iranian companies.
Accordingly, policymaking and evaluating goals, strategies and programs; commercialization and development of aviation products and services; setting up Iran aviation value chain network; development of infrastructures; setting up Iran Aviation Technomart; development of international communications and strategic alliances among aviation scientific, industrial and technical centers in the country and abroad; culture making and educational development have been among the main programs and measures of IATDH.

B. Other Authorities

• Civil Aviation Organization

The Directorate General of Civil Aviation was established in 1946 and renamed as the Civil Aviation Organization in 1974.
Responsibilities of the Civil Aviation Organization as government's representative to exercise sovereignty over air transportation sector include: determining the major strategies and priorities of air transportation, planning for training expert human resources and accrediting directors' technical qualifications in all airline companies, compiling flight standards and authorizing aircrafts which can be used for air transportation, setting the regulations and operating procedures of national airspace control, issuing flight permits and monitoring air traffic control units, preparing security guidelines and monitoring their enforcement, examining air accidents and collisions, issuing or revocating licenses of air travel agencies and continuous monitoring of their operations, and membership and communication with the International Civil Aviation Organization (ICAO) and the other related global organizations.

• Iran Airports Company

The Iran Airports Company was established with the aim of constructing, maintaining, and managing all airports affiliated to the Civil Aviation Organization.
Responsibilities and authorities of the company include providing airport services such as operation and maintenance of (freight and passenger) transport terminals and airport security; providing transportation and support services for aircrafts like fuel and ground handling; presenting aviation services such as facilitating flight routes; providing operation and maintenance services for aviation equipment; navigation of aircrafts including landing and take-off; constructing research labs

considering company's targets; providing air traffic control services; and designing, constructing, and providing maintenance services for terminals, ancillary facilities, flight equipment, navigation instruments, and communications tools.

V. International Cooperation

Priorities for international cooperation and collaboration were among the most important programs of IATDH in order to develop Iran aviation industry. In this line, a development strategy was planned for joining Iranian companies to the international supply chain and technology catch-up.
By integrating technical, financial and market demands of different sectors, IATDH could define long-term partnership plans and consequently recognize the potential partners from all around the world. Therefore, the growing number of the demands and inquiries which fall under the same market section would be discussed with qualified international partners.
Furthermore, establishment of joint ventures and formation of international consortiums; general aviation development; collaboration in design and manufacture of medium helicopters and co-production of semi heavy helicopters; network formation for commercial applications of commercial UAVs; regional market coverage in the field of maintenance, repair and overhaul; upgrading and modernizing the technological level of avionic systems; and participation in production of regional aircraft and manufacture of its parts, subsystems and systems are among other international programs.
It is worth mentioning that China, Russia, Germany, France, Italy, and Austria are among the target countries for international cooperation in aviation and aerospace area.

11 Marine Industries

Marine Industries

I. History and Background

Iran with 5800 km coastal line and access to some international strategic waterways is an important country. Since ancient times, Iranians have always been actively involved in marine and its related industries. Ancient Iranian civilization mostly owes its progress to shipbuilding industries. Iran's rich offshore oil and gas reservoirs are also another added advantage for Iranian marine industries.

Maritime industry in Iran comprises a wide range of varying areas such as shipbuilding, offshore structures, fisheries, transportation, ports, and tourism; hence, it is considered to be one of the most strategic sectors of the country.

Shipbuilding

Iran's tanker fleet with a capacity of 15.5 million tons is the first large tanker fleet in the world; It amounts to 21 million tons by increasing the capacity of cargo ships. In fact, the Islamic Republic of Iran Shipping Lines (IRISL) is the biggest merchant company in the Middle East; it operates about 170 vessels with average lifetime of 14 years and annual capacity of over 5 million DWT. Also, the National Iranian Tanker Company (NITC) with 62 carriers and tankers is the fifth largest tanker fleet in the world.

It is also worth mentioning that according to 2013 Clarksons Research, the world overall shipbuilding capacity is over 45 million CGT, of which Iran's share is estimated to be 0.27 percent.

Offshore Structures

Iran's long water borders and huge offshore oil and gas resources along with its massive hydrocarbon reserves in the Caspian Sea and the Persian Gulf make the country's offshore industry highly important particularly over the last two decades. The Persian Gulf with more than 48 percent of the world's oil reservoir and over 40 percent of gas reserves is undoubtedly of great significance in the international economy.

One of the major projects of the offshore industry is the Persian Gulf Bridge which connects Qeshm Island to the main land through a suspended deck and gravity-based structures.

Ports

Nowadays, the international marine transportation accounts for over 90 percent of the global trade transportation, whereas the other forms of transportation including road, railroad and air add up to only about 10 percent. Currently, ports of Iran are gates for 95 and 85 percent of the country's import and export, respectively. Iran has 11 major ports and 82 small and multi-functional ports on the north and south coasts. Many of the ports are production centers in addition to their major contribution to trade. Consequently, most of the important economic activities are carried out in the country's ports. For instance, Asaluyeh port is considered as the energy hub of the country; it has housed different phases of the South Pars project since many years ago and its new phases are well on the way to being completed. This port is globally known as a leading center for production of petrochemical products. Other ports like Shahid Rajaee and Imam Khomeini facilitate most of the country's international interactions.

Marine Transportation

Iran, with about 5800 km coastal line including its islands, has high potential for marine transportation. Iran as a global trade crossroads is on the north-south, east-west, and central Asian trade corridors and thus being in the heart of global trade corridors, it can play an influential role in cargo transit from Asia to Europe and vice versa as well as to/among the Persian Gulf countries and those in the central Asia. Iran with its big fleet of ocean-going vessels has a total capacity of 15,300,000 DWT and 9.5 percent of the world fleet which promotes its rank to 23; albeit 10 million tons of Iran's fleet capacity is due to its oil tankers. According to Clarksons Research, in 2013 Iran had 229 ocean-going vessels, from which 108 are Iran flagged and the rest operate under other countries' flags.

II. Strategies and Objectives

Major strategies and objectives of this industry inspired by maritime development document in Iran's Vision 2025 plan are as follows:

- Ensuring safety of marine navigation in the Persian Gulf waterways particularly the Strait of Hormuz, the Gulf of Oman, the Caspian Sea, and the open waters focusing on the national fleet;
- Proportionally increasing population on the coasts and islands of the Persian Gulf and the Gulf of Oman up to 4 and 2.5 percent of the total population, respectively;
- Improving sea transportation efficiency at least up to twice as that of present;
- Obtaining nominal capacity of at least 300 million tons in different cargo groups and 14 million TEU containers in the commercial ports of the country;
- Increasing the capacity of Iran-owned merchant fleet at least up to 30 percent (capacity of 30 million tons);

- Increasing share of Iranian fleet from the international sea transport proportional to its capacity;
- Enhancing capabilities of the companies building vessel to secure 1 percent of the international market value with an emphasis on supplying domestic market demands;
- Providing the required platform for marine trips of 30 million people in year with average annual growth of at least 7 percent and attracting at least 15 percent of Iranian and foreign tourists to Iran marine tourism;
- Producing at least 1.5 million tons aquatic animals a year, including 1 million tons from fishery and 500,000 tons from aquaculture (inshore and offshore);
- Securing the first place for marine science advancement regionally, developing technology, and international patents and staying among the 10 top countries in marine science, technology, and research;
- Developing bunkering to gain 50 percent of the region's fuel market in the Persian Gulf and the Gulf of Oman (at least 8 million tons annually) focusing on fuel domestic vessels, while adhering to environmental regulations;
- Developing know-how and technologies of manufacturing equipment for marine detection, exploration, mining and extraction as well as exploiting and transferring hydrocarbon reserves at the depth of 1000m;
- Obtaining a 50 percent market share of ship repairing regional per year with an emphasis on domestic market, while considering environmental requirements;
- Supplying at least 70 percent of the required material and equipment from domestic products;
- Increasing capacity and capabilities of the Iranian companies to carry out at least 90 percent of the exploration, extraction, and transfer projects in oil and gas and offshore sectors;
- Covering at least 50 percent of the Iranian ships under international conventions by the National Unity Classification Society and joining the 10 top registry institutes worldwide;
- Reclaiming at least 10 percent of the captured coasts annually;
- Increasing at least 10 percent to the 4 zones of coasts, islands, and seas under environmental protection and management and improving the existing protection measures considering international standards;
- Exploiting at least 40 percent of the flared gas in offshore and inland oil installations;
- Stabilizing the status of Iran flagged fleet in the regional and international MoU white listing of ships' technical and safety control and inspection, and aiming to decrease the number of marine accidents of the Iran flagged fleet in the Iranian ports and territorial waters by at least 5 percent annually.

III. Capacities and Capabilities

A. Human Resources

Here, various marine disciplines of Iranian universities are categorized into three groups of technical and engineering (marine engineering, offshore structures, etc.), marine sciences and fishery (fishery, marine physics, biology), and humanities (maritime business management, economics, etc.).

Table 1

Marine Students in Different Levels and Disciplines in 2016

Discipline	Level		
	B.S.	M.S.	Ph.D.
Technical and Engineering	1971	2161	149
Marine Sciences and Fishery	3131	897	191
Humanities	1362	213	4
Total	6464	3271	344
Sum Total	10079		

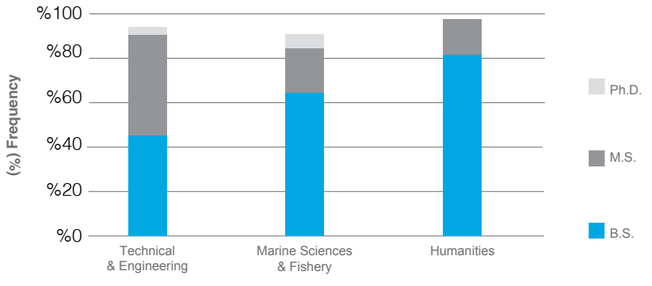


Figure 1: *Distribution of Marine Students in 2014*

Jamaran Battleship

Table 2
Marine Faculty Members in 2014

Active Marine Faculty Members	Ranks				
	Instructor	Assistant Professor	Associate Professor	Full Professor	Total
	73	143	26	23	265

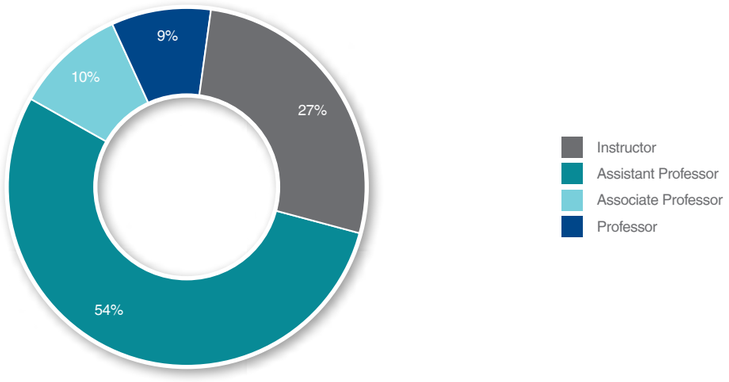


Figure 2: *Marine Faculty Members in 2014*

B. Scientific Productivity

In recent years, Iran has experienced a significant progress in marine science advancement and improved its rank from 24 to 7 within 19 years (table 3). Iran also stands at the first place in the Middle East with other countries of the region lagging far behind it.

Iran/Arak Container Vessel

Table 3
Iran's Global Rank in Marine Engineering Articles in 2017

	Country	Documents	Citable documents	Citations	Self- Citations	Citations per Document	H index
1	China	3221	3144	1011	809	0.31	74
2	United States	1934	1761	659	367	0.34	158
3	United Kingdom	774	684	306	119	0.4	99
4	India	664	631	194	94	0.29	50
5	South Korea	575	559	126	51	0.22	55
6	Norway	551	531	162	104	0.29	69
7	Iran	520	510	154	100	0.3	44
8	Germany	429	388	199	114	0.46	81
9	Australia	410	397	208	79	0.51	83
10	Japan	384	363	82	26	0.21	66

C. Some Achievements

• Naval Vessels (Jamaran battleship)

Jamaran battleship is the symbol of Iranian engineers' expertise in maritime defense industry. Constructing this advanced ship has strengthened the self-esteem and confidence of the Iranian specialists and its launching paved the way for building several more required naval vessels. Along with Iran's self-sufficiency in producing most of its maritime defense equipment, its military presence in international waters in recent years is undoubtedly one of the factors of establishing Iran's marine position in the region and the world as a great power. Recently, Damavand naval vessel, designed and constructed by the Iranian engineers, has joined the potent fleet of I.R. Iran Navy in Mazandaran province- the Caspian Sea.

• Ocean-going Ships

As 90 percent of I.R. Iran exports and imports are conducted through sea by using cargo ships, construction of ocean-going container ships has been one of the most significant

accomplishments of the Iranian engineers in the recent years. Iranian ships like Iran/Arak and Iran/Shahr-e-Kord are clear manifestations of Iran's great potential in maritime industries. These vessels are currently operating in the IRISL Group.

• Tanker Vessels (Aframax)

Iran's great volume of oil exports makes design and construction of oil tankers a top priority for the country. Constructing Aframax ship, ordered by Venezuela, is one of the biggest maritime projects proving Iranian engineers' considerable expertise. Aframax, designed and constructed in collaboration with South Korean engineers, can carry 113,000 tons of oil (750,000 barrels) with the maximum cruising speed of 29.6 k/h thanks to its powerful 15820 KW (21206 HP) engine.

• Offshore Oil and Gas Platforms

Given the large number of Iran's oil and gas fields in the Caspian Sea and the Persian Gulf, the offshore industries are of great importance to the country's economy. Due to the highly advanced technology required for constructing oil platforms, Iranian engineers' accomplishment to construct offshore platforms is of great importance.

• Ports

Regarding country's long and strategic coastal lines in the north and south and the fact that about 90 percent of exports and imports are conducted via sea, ports and harbor facilities are of high significance for the country. Iran has been able to significantly develop the required technology for port design and construction including environmental studies; designing, constructing, and managing coastal structures, breakwaters, and waterfronts; and creating several ports including development projects of Shahid Rajaee, Bushehr, and Chabahar ports. Eleven major commercial ports as well as fishery and passenger ports with loading and unloading capacity of more than 186 million tons and 14 million passengers have made Iran a leading country in establishing port installations and facilities.

• Large Maritime Transport Fleet

Iran with about 200 ocean-going ships boasts the greatest fleet in the region; hence it is one of the powerful countries in sea transport. Nowadays, varying vessels of different sizes including tankers, bulk carriers, and container ships owned by Iranian sea transport companies are operating in international markets. In the recent years, NITC has experienced a considerable development enjoying the world's largest fleet of supertankers.

• Research Vessels

Following big steps towards development of maritime industries, Iran has accomplished to build its first domestically-made ocean-going research vessel, Khaliji Fars (meaning the Persian Gulf). Since most of the parts of this sea explorer are made in Iran, it can be claimed to be totally domestically built. This vessel could be effectively used in investigation and field research of the country's surrounding seas.

• Submarines

Iran has successfully developed submarine design and construction technologies. Ghadir -a midget submarine- is an example of Iranian accomplishments in this area. Some of the special features of this submarine include: ability to perform missions quickly; long range subsurface navigation; small sonar system; automatic depth control system; manual, hydraulic and automatic navigation system; and capability of navigation in shallow waters. Nahang as the second locally-manufactured submarine is equipped with surface detection radar system and telecommunications tower. Additionally, Iran has built a series of wet and ultra-lightweight submarines called Al-Sabhat. Fateh is also an Iranian-designed submarine of semi-heavy class (527 tons) which now is in service.

• Hovercrafts

Iran has accomplished to design and construct a small hovercraft, called Younes 6, which is basically made of composite. Yet another project of this kind is Tondar. This project involves improving and updating electronic and weaponry systems of the hovercraft. Lately, Iranian engineers have succeeded developing new hovercraft technology and they've been able to design and construct two new variants; military and civilian composite hovercrafts.

• WIG Crafts

WIG crafts -the most important strategic marine rivals- have been used since 2006. Currently, a new generation of WIG crafts named "Bavar 4" has been designed and manufactured locally by the Iranian engineers and specialists.

• Semi-Submersible Drilling Platform

Amir Kabir semi-submersible drilling rig platform -the most advanced platform in the offshore drilling industry- is Iran's first achievement in this area. This drilling platform has been designed and

constructed for oil/gas exploration in the Caspian Sea. All the preliminaries for constructing of this drilling platform including detailed engineering activities, workshop drawings, and procurement of advanced drilling equipment and machinery have been performed domestically.

• Jack-Up Drilling Platform

Technical knowledge of designing jack-up drilling platforms is limited to a few companies in the world; however, Iranian specialists have made considerable advances in this field. For instance, the first Iranian jack-up drilling platform, called Iran/Khazar, was built 20 years ago and exploited in the Caspian Sea. Currently, several Iranian companies are capable of designing and constructing such platforms.

• Dry Docks

Dry docks are necessary due to the increasing growth of shipbuilding industry including construction and maintenance of marine structures such as huge ships. State-owned and private dry docks providing construction and maintenance services for the largest ships have been already constructed in the country.

IV. Authorities

A. Technology Development Council for Space and Advanced Transportation

The Technology Development Council for Space and Advanced Transportation (TDCSAT) was established in 2018 by integrating the Iran Aviation Technology Development Headquarter (IATDH) and the Marine Industrial and Technology Development Council (MITDC).

With regard to great importance of maritime arena and the need to focus more on this field, MITDC was established in 2014 through the efforts of the Vice-Presidency for Science and Technology. Some of the important strategies and programs of the council were as follows:

Providing support for marine knowledge-based companies to develop technology and enhance marketing process; coordinating and synergizing maritime development programs and supporting national marine projects; supporting development and empowerment of specialized associations and formations for marine knowledge-based products and services; promoting technological entrepreneurship; and improving the environment of marine knowledge-based business through holding innovation festivals, supporting student competitions, and selecting top marine theses, etc.

Overall, there are 16 universities providing marine programs and 50 marine knowledge-based companies in the country.

B. Other Authorities

• Iran Marine Industrial Company

The Iran Marine Industrial Company (SADRA) was founded in 1968 in Bushehr. Since then, SADRA has established itself as the leading shipbuilding and ship-repairing company in Iran. This company is specialized in building and repairing different vessels such as container ships, tankers, pipe laying; offshore drilling platforms (submersible jack up); fixed offshore platforms; laying subsea pipelines and cables; establishing processing and refinery facilities of gas, oil, and petrochemicals; laying gas and oil pipe lines in land; carrying out infrastructure projects; and constructing heavy steel structures and oil terminals, jetties, and harbors.

• Iranian Offshore Oil Company

The Iranian Offshore Oil Company (IOOC) is one of the world's largest offshore oil producing companies with over a half century of experience. This Company is responsible for extraction and exploitation of oil fields of the country throughout 1200 km^2 of the Persian Gulf and the Oman Sea.

• Iran Shipbuilding and Offshore Industries Complex Company

The Iran Shipbuilding and Offshore Industries Complex Company (ISOICO) is operating in various areas including designing, building, and repairing all types of vessels up to 80,000 tons, and designing and constructing offshore and onshore oil and gas platforms, refineries, and pipelines in the special economic zone.

• Islamic Republic of Iran Shipping Lines Company

The Islamic Republic of Iran Shipping Lines Company (IRISL) with 170 different kinds of ocean-going and service vessels and 5.7 million DWT transportation capacity is operating in all international waters.

• Iranian Offshore Engineering and Construction Company

The Iranian Offshore Engineering and Construction Company (IOEC) is one of the widely-recognized ECPI contractors of offshore and onshore oil and gas industry in the region and the world. With 16 years of experience in oil/gas industry and great achievements in engineering, procurement, construction, installation, and operation of marine structures and pipe-laying in sea bed, IOEC is considered to be a well-established company in the Middle East.

• Industrial Development and Renovation Organization of Iran

Keeping on its privatization policy and decreasing its role as a corporate, the Industrial Development and Renovation Organization of Iran (IDRO) aims to convert into an industrial development agency.

• Azim Gostaresh Hormoz Shipbuilding Industry Company

The Azim Gostaresh Hormoz Shipbuilding Industry Company (AGH) is involved in establishing shipbuilding plants and the related industries; providing facilities and equipment required for shipbuilding, ship repair and conversion; renovating various ships and fixed/mobile vessels; building and installing different structures and equipment of ships; building floating roofs and tanks; selling, purchasing and exporting a wide range of ships and the related industrial products and supporting the licensed minerals such as sand and gravel as well as technical services; and conducting any form of trade operations and binding domestic/international contracts.

• Ports and Maritime Organization

On May 25, 1960, the General Agency of Ports and Shipping was changed to Ports and Shipping Organization and then on April 29, 2008, it was renamed as Ports and Maritime Organization. Some of its key activity areas are as follows:

- Managing ports, and commercial and maritime affairs;
- Creating, completing, and developing ports, commerce and maritime buildings, facilities, dockyards and the related equipment and operating them;
- Managing loading, unloading, transportation, and storage in the ports of the country;
- Managing telecommunications networks (radio, telegraph, telephone, teletype, etc.) on land and at sea to make contact with ships and subsidiary ports and providing the related equipment in collaboration with the former Ministry of Post, Telegraph, and Telephone;
- Fully monitoring coastal and commercial shipping, making great attempts to develop country's shipping and ensure traffic safety, and taking the necessary steps to improve coastal and commercial shipping activities;
- Providing services for management and maintenance of lighting and signs at seas and on rivers in order to ensure safety of traffic of ships and vessels;
- Registrating of commercial and recreational ships and vessels with Iranian nationality and implementing the related regulations.

• Iran Fisheries Organization

The Iran Fisheries Organization, a governmental institution affiliated to the Ministry of Agriculture, was founded in June 2004 with the aim of protecting and preserving aquatic resources and reserves in the waters under Iran's authority and jurisdiction as well as implementing tasks stipulated in the Law on Preservation and Exploitation of Aquatic Resources of the Islamic Republic of Iran and other related regulations.

• Petropars Groups

Petropars Ltd was established on January 27, 1998 along with development of the 1st phase of the South Pars Gas Field in order to contribute to promoting and taking advantage of the capabilities and experiences of the local contractors and transferring project management knowledge and the latest technology into the country. At present, NICO Company -a subsidiary of the National Iranian Oil Company- owns 100% of its shares.

• Pars Oil and Gas Company

The Pars Oil and Gas Company (POGC), a subsidiary of the National Iranian Oil Company (NIOC), was established in 1998. It aims to develop the South Pars, North Pars, Golshan, and Ferdowsi gas fields as well as the South Pars oil layer in the Persian Gulf.

• Khazar Exploration and Production Company

The Khazar Exploration and Production Company (KEPCO), a subdivision of the National Iranian Oil Company (NIOC), was founded in January 1998. KEPCO is in charge of exploration, development, and production of hydrocarbon resources in the South Caspian Sea and three coastal provinces of Mazandaran, Golestan, and Gilan in Iran. KEPCO supervises all the contracts awarded to local and international companies to study and develop oil fields in the Caspian Sea and monitor environmental issues related to exploration and development of oil and gas reserves.

V. International Cooperation

1. Exchange of design and construction information in shipbuilding industry;
2. Joint cooperation with reliable international companies involved in vessel construction and ocean-going shipbuilding.

12 Water, Drought, Erosion and Environment Technologies

Water, Drought, Erosion and Environment Technologies

I. History and Background

Technologies have enabled human to give up a hunter–gatherer lifestyle supported a few million people globally in an effort to pursue a modern agriculture which has to feed more than 8 billion people by 2040. Environmental degradation influenced by human activities has led to a reduction in quality of resources such as air, water and soil; destruction of ecosystems; extinction of wildlife; and an increase in pollution. More food per unit of land, water, and agrochemicals must be produced using new technologies in future. Efforts to counteract these challenging problems include environmental protection, environmental resource management, and higher food production by developing new technologies.

It is a major challenge to reverse degradation of ecosystems, while meeting the increasing demand for the related services. The technology that has conquered the earth should also spare it. What technology has to do with four paramount resources, i.e. energy, materials, land and water? Technology must grow faster than demand and should provide abundant green goods and services with clean processes. So, the message from history is that technology wisely developed and used can spare the earth.

II. Policies and Objectives

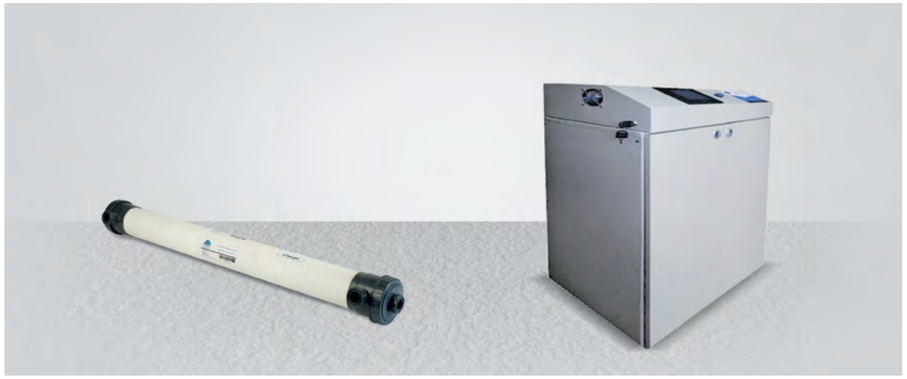
Major policies and objectives devised by the Technology Development Council of Water, Drought, Erosion and Environment are as follows:

A. Macro Level Policies

- Providing the technologies required for wise governance of water, soil, environment, and drought management through public participation and organizational cohesion;
- Running intelligent and integrated management for the environment and climate risks, soil erosion prevention and control by ensuring multilateral coordination among social and economic infrastructure and service sectors;
- Developing and localizing the technologies required for comprehensive watershed management, and conservation, restoration, development and optimal utilization of water resources, soil and habitats in line with the principles of sustainable development;
- Developing, promoting and implementing the necessary technological standards to secure the safety and quality of water, soil, air, and environment as well as protect them against pollution;
- Providing support for developing technologies in water treatment, drought management, soil conservation, and environment preservation, besides promoting investments in these areas;
- Facilitating national coordination and synergy to develop the required technologies with an emphasis on participation of the public and private sectors, cooperatives, knowledge-based companies, and scientific associations;
- Expanding the scope of communications and interactions with a view to maximizing utilization of the national and international capacities in developing and exchanging technologies;
- Expanding green economy and environmental economics by making use of technological capacities;
- Providing access to equitable opportunities to acquire and develop the related technologies;
- Giving priority to clean and renewable energies in producing technologies to conserve water, soil and air resources and the environment;
- Exploiting environmental science and technology to increase sustainability of biodiversity and habitat restoration;
- Institutionalizing public participation and social associations in developing the technologies related to water, soil and environment;
- Establishing an advanced system of innovation and technology in the domain of water, soil, and environment.

B. Macro Level Objectives

- Providing access to new technologies for comprehensive management of watersheds and aquifers in addition to sustainable development of habitats and environmental protection in the region;
- Providing access to the most advanced techniques for wastewater treatment including wastewater recycling and refining, as well as reducing the pollutants in water, soil and air;
- Providing access to the technologies required for conservation, restoration, development and sustainable use of water, soil and air resources;
- Getting access to the most advanced technologies in supplying, consuming, and utilizing water resources;
- Providing access to optimum conditions to protect and improve biodiversity and genetic resources in the country.



Water Treatment Membrane Modules *BACO Multi-Oxidant Advanced Disinfection System*

III. Capacities and Capabilities

A. Some Achievements

• Pilot Projects for Precipitation and Cloud Seeding

In July 2011, a pilot research operation project was conducted by a knowledge-based company in a number of sites across the country by using orgone energy in atmosphere to invoke precipitation. The project showed great promises.

• Subsurface Irrigation

Subsurface irrigation makes use of porous clay pipes with controllable porosity. In this method, water flows in the pipes by a light pressure resulting from the difference between tank level and depth, and gradually seeps into the soil. Soil suction is the main factor which directs water from porous clay pipes into the soil. As the moisture content of the soil increases, water drainage from the clay vessels decreases and eventually stops. In other words, the clay pipes have a self-control function and are able to control water outflow. This project has been carried out in linear and drip models in some orchards of the southern city of Kerman and in the northern cities of Gorgan and Gonbad. The system has also been implemented in some paddy fields of Gonbad, leading to a significant reduction in water consumption and an increase in production efficiency.

• Sediment Breaker

This device helps to control scale deposit formation and prevents depreciation and decay of pumps, boilers, water tanks, steam boilers, central heating packages, as well as the plumbing system for aviaries, fish ponds, animal farms, greenhouses, construction materials production factories, light and heavy industries, and indoor heating and cooling systems.

• Water Disinfection Using BACO Multi-Oxidant Method with a Capacity of 2,000 m^3/day

This advanced disinfection system involves designed and pre-packaged BACO multi-oxidant systems which can be easily installed and put into operation. By electrolysis of brine, the system produces a solution consisting of several oxidants which contribute to effective water disinfection.

BACO Disinfection Pen *Nitrate Removal System from Drinking Water*

• BACO Disinfection Pen

Through brine electrolysis, this pen is able to produce a solution to disinfect a glass of water where there is limited access to safe drinking water.

• Portable Disinfection System with Water Quality Assessment Laboratory

Access to safe drinking water can be jeopardized or rendered impossible when natural disasters like floods and earthquakes occur. Portable BACO Multi-Oxidant Advanced Disinfection System can meet the basic water needs in such conditions, considering the capacity of the system. The system's operation includes passing water through a pretreatment material to reduce the turbidity of the contaminated water and removal of dirt to meet the standards. The required dosage of multi-oxidants is then inserted into water. Considering the high speed of disinfection by multi-oxidants and the system's capacity to adjust the free residual chlorine, safe drinking water can be prepared for disaster victims. As its name implies, this portable system is embedded in a van with triple applications, i.e. functioning in normal conditions, being helpful during emergencies, and working as a portable water quality assessment laboratory.

• Electrochemical Removal of Nitrate from Drinking Water

High concentration of nitrates is among the main causes of groundwater pollution. This happens when fertilizers find their way into the groundwater. Since nitrate is found in water in ionic form, it cannot be removed via conventional methods. There are a variety of nitrate removal methods including reverse osmosis, using ion exchange resins, electrolysis, and distillation and electrodialysis. In addition to being economical, electrochemical removal of nitrate has more advantages in comparison with other methods requiring low-temperature and low-pressure design without any chemicals. This system is capable of reducing nitrate concentrations to acceptable levels.

• Water Treatment Systems (Ultrafiltration and Nanofiltration)

A. Hollow Fiber Membrane, Polyacrylonitrile Hollow Fiber Membrane, Polyvinylidene Difluoride (PVDF) Hollow Fiber Membrane

A main problem in desalination of seawater is disturbances caused by organisms, so that permanent use of membranes could lead to their clog-up and malfunction. This system has the advantage of using chlorine-resistant hollow fiber membranes made of cellulose acetate for water treatment. Hollow fiber

Water Treatment Systems (Heavy Metals and Nitrate Removal)

membranes with ultrafiltration in the pretreatment phase also can replace reverse osmosis membrane in order to prevent decay and obstruction. Other advantages of this method include ease of cleaning, higher flow rate, and reduced operation and maintenance costs. Research has demonstrated that through using hollow fiber membrane, recycling rate of conventional reverse osmosis systems can be improved by 20 percent and reach to 60 percent.

B. Ultrafiltration and Nanofiltration Modules

Modular structure, portability, and low pressure have made hollow fiber membrane technology applicable in desalination of the produced oilfield salt water. In many oil and gas wells, salt water is produced as a by-product. However, treatment of produced water can be expensive due to its considerable volume and compounds. On the one hand, water desalination at oil and gas wells can be extremely difficult. On the other hand, although the produced water is preferably used for water injection in oil wells in order to increase oil extraction rate or simply be discharged in nearby lands to avoid further costs, the increased demand for water and low-costs technologies like the above-mentioned system will encourage setting up desalination units in oil and gas wells.

- **Water Bank (Ab Bank)**

Providing moisture for soil with clay has been common in Iran since ancient times. This is a highly efficient and intelligent method in meeting the crops' water needs. The ancient clay innovation has inspired the concept of Water Bank. Water Bank is an intelligent device which provides the crop with water only to the extent they need. This technology not only helps to save water, but it also permanently provides the soil with moisture for agricultural purposes. There will be no need to use any electrical or electronic equipment by Water Bank. This product can also be used for watering garden and potted plants.

- **Removing Heavy Metals and Nitrate from Drinking Water**

This technology applies fixed-bed columns containing ion exchange resins to remove nitrate, arsenic, iron and chromium from drinking water. Ion exchange resins in these columns are particularly useful for nitrate removal. The overall mechanism involves getting water out of a well by a pump and making it pass through pretreatment filters and nitrate removal filters, successively.

A Portable Turbidity Removing System

During this mechanism, water nitrate is exchanged and absorbed by the ions on the resins. This system is equipped with special sensors switching the electric current on and off. With the passage of time, the chloride ions are totally replaced with nitrate ions. Once the resin becomes saturated and reaches its exchange capacity, it is backwashed and regenerated by sodium chloride solution.

- **Portable Turbidity Removing Systems**

Studies have demonstrated that an important issue during disasters is the removal of turbidity (mud) from drinking water. The particles can reduce production efficiency and clog the pretreatment system. The new portable system is designed and manufactured to efficiently reduce turbidity and increase water clarity. It provides an excellent mechanism for portable water treatment in comparison with similar methods developed worldwide.

- **Water Desalination Using LTTD Technique**

Low-temperature thermal desalination (LTTD) is a desalination technique which takes advantage of water being evaporated at lower temperatures and, as a result, produces water with lower amounts of energy. Thus, renewable sources of energy such as solar energy or sea water energy can be utilized for desalination. This method can be applied for desalination of saline water as well as other unconventional water resources. Since the produced water has the quality of rainwater, it is suitable for drinking. This method can be categorized in Zero Liquid Discharge (ZLD) group of water treatment technologies as it leaves no effluents or discharge behind.

- **Technologies for Dust Management and Air Pollution Control**

Nowadays, it is crucial to think of new methods to stabilize soil and control dust storm and sand movement crisis centers because of problems caused by petroleum mulch disadvantages. To cope with such problems, new technologies have been developed for production of different kinds of biologic and polymeric mulch, which enjoy advantages like ease of use, durability, and lower costs. Field testing and evaluation of the new products indicated that their operation in soil stabilization and dust control was durable and efficient.

Main Achievements

- The capability of producing biologic and polymeric mulch for different soil types on an

Pilot Field Test and Production of Biodegradable Polymeric Mulch

Pressure Plate Device

industrial scale;
- Setting out the guidelines related to correct mulch storage conditions and consumption for various soils textures;
- The capability of spraying mulch in vast areas in the shortest possible time with low costs using ground or aerial methods;
- Creating the required infrastructure to produce, evaluate, and standardize biologic and polymeric mulch.

• Pressure Plate

Membrane pressure plate is a soil moisture measuring device which is used in water, soil, civil engineering, and environment laboratories. This device was built by an Iranian innovator with the support of the Technology Development Council of Water, Drought, Erosion and Environment.

• Soil Solution Sampler

This device is used for sampling soil solution in a rapid and inexpensive way with field application. It was built by an innovative professor of Shiraz University with the support of the Technology Development Council of Water, Drought, Erosion and Environment. During the sampling process, the device also measures properties such as electrical conductivity and minerals found in the sample. A complementary version of the device which is under construction will also measure pH of the soil solution.

IV. Authorities

A. Technology Development Council of Water, Drought, Erosion & Environment

The council was established in August 2010 as one of the councils of strategic technologies affiliated to the Vice-Presidency for Science and Technology. The council was aimed to work as a trans-sectional and coordinating body with a view to enhancing interagency interaction and synergy in addition to achieving the predetermined objectives.

The scope of the council's activities include the issues related to providing new water resources and preserving the available ones, qualitative and quantitative management of water and soil resources, risk management and crisis management in flood and drought events, erosion reduction, soil conservation in watersheds across the country, as well as environmental conservation and utilization.

B. Other Authorities

• Water and Energy Institute

The Water and Energy Institute was established in 1967 with the aim of making the country independent in terms of water desalination technologies. Since its establishment, the institute has also been involved in staff training and providing technical and engineering services. Being equipped with laboratory appliances such as spectrophotometers, atomic absorption, and field application devices, the institute's Water and Wastewater Laboratory is not only capable of meeting the research and laboratory requirements in the field of water and wastewater, but also it can provide laboratory and consultative services for executive plans. The institute aims to play an effective role in environmental preservation through accurate implementation of the quality control/guarantee regulations and utilization of the latest sampling and analysis methods in controlling/eliminating environmental pollutants.

• Soil Conservation and Watershed Management Research Institute

This institute pursues the comprehensive objectives of the soil conservation and watershed research in the form of seven strategic plans, including: identification of effective factors on erosion and sedimentation; optimization of methods for soil conservation; optimization of management models in watersheds; watershed management for flood mitigation; utilization of flood water and development of small scale water harvesting; management and protection of waterways and streams; and research, management and conservation of coastal areas.

It should be noted that more than 60 universities and 22 knowledge-based companies work in the fields related to water, drought, erosion, and environment.

V. International Cooperation

Technology Development Council of Water, Drought, Erosion and Environment is interested in the following cooperation fields on the international scale:
- Holding joint exhibitions;
- Transfer of technologies related to water resources, sewage and wastewater treatment, measuring and monitoring devices for soil-water resources, and air pollution testing methods.

13 Conventional Energies (Oil & Gas)

Conventional Energies (Oil & Gas)

I. History and Background

The first documented systematic oil exploration and drilling in Iran dates back to early years of the 20th century, making it the oldest in the Middle East. The first oil field in Iran is Masjed Soleyman in southwest. Now, a century later, Iran has gained invaluable experience in oil industry and is a pioneer in the industry. The extensive infrastructure and a legendary reputation is the result of such long history. This is doubly coupled with its 158 billion barrels of proven oil reserves. There are several refineries and oil terminals with an extensive pipeline along the Persian Gulf coast.

The gas industry has a long history which dates back to 1908 when the first oil exploration project was carried out in Masjed Soleyman. Initially, there were quite a few challenges with harnessing natural gas; however, with significant technological advancements and experience gained over time, Iran is currently among the leading countries worldwide in terms of production and gas reservoirs.

II. Macro Level Objectives

To develop Iran's energy sector in the context of economic resilience policies, some of the major objectives of energy sector noted in the strategic national energy document are as follows:

- Increasing and optimizing use of resources and capacities of the country's energy sector to maximize added value in the supply chain;
- Improving and enhancing oil and gas recovery;
- Maximizing use of geopolitics capacity and raising Iran's international status in energy markets;
- Diversification of the country's energy supply;
- Improving security of stable and high quality supplies of energy.

III. Capacities and Capabilities

A. Current Status

• Crude Oil Reserves and Production

Considering the natural gas and oil reserves, Iran comes first and fourth, respectively.
Figure 1 illustrates oil reserves of the country in comparison to the world's largest oil holders.

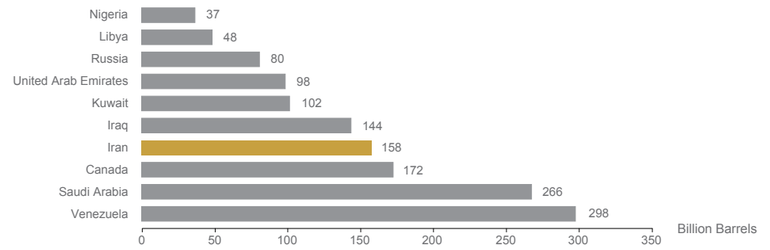
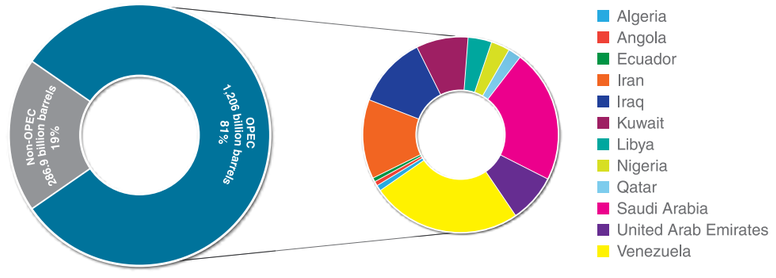


***Figure 1:** The Largest Proved Reserve Holders of Crude Oil (including Heavy and Extra Heavy Oil)*
[Source: Oil & Gas Journal, January 2015]

Crude oil reserves in Iran approximately hold 10 percent of the world reserves and 13 percent of that of OPEC. Iranian onshore reserves account for 70 percent of its total reserves and the Persian Gulf offshore reserves comprise the remaining 30 percent.



Venezuela	299.95	24.9%	Iraq	143.07	11.9%	Libya	48.36	4.0%	Algeria	12.20	1.0%
Saudi Arabia	266.58	22.1%	Kuwait	101.50	8.4%	Nigeria	37.07	3.1%	Angola	8.42	0.7%
Iran	157.53	13.1%	UAE	97.80	8.1%	Qatar	25.24	2.1%	Ecuador	8.27	0.7%

***Figure 2:** OPEC Proven Crude Oil Reserves, at the End of 2014 (billion barrels, OPEC Share)*

Producing over 3,400,000 barrels per day and being a founding member of OPEC, Iran is the 3rd producer of the organization (OPEC Monthly Oil Market Report - April 2016).

- **Natural Gas Reserves and Production**

With 1201.4 trillion cubic foot (34 trillion m^3), Iran has the world's largest proved natural gas reserve (BP Statistical Review of World Energy, June 2016). It accounts for 18.2 percent of the world's proved gas reserves. Over 40 percent of its gas reserves are at South Pars field as the largest gas field globally.

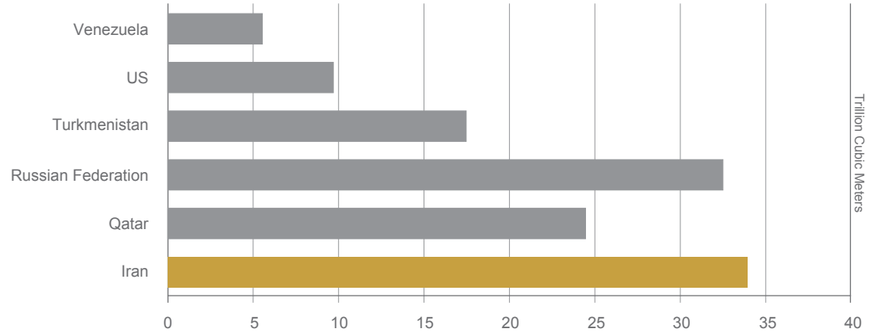


Figure 3: *The Largest Proved Reserve Holders of Natural Gas [Source: BP Statistical Review of World Energy June 2016]*

Both the production volume and strategic geographical location of Iran work together to give it a competitive advantage. According to BP Statistical Review World Energy June 2016, Iran natural gas production in 2015 stood at 192.5 billion cubic meters, making it the third natural gas producing country worldwide.

B. Some Achievements

- **Gas Turbines**

Gas turbines come in a variety of forms to fulfill a variety of power needs across different fields, from driving oil tanks and compressors to driving jets and helicopters and power generation (normally for peak load generation). The high-level knowledge and technology deployed in designing and manufacturing gas turbines have made them suitable for use in the petroleum industry. Since the turbines are used as drivers for large pumps, which drive fluids inside the pipelines, or for off-grid power generation at petroleum-related factories, there is a growing demand for gas turbine in the petroleum industry.
Having gained invaluable experience for gas and steam turbine technology transfer as well as peripherals, Iranian companies are now capable of designing and developing 25 MW gas turbine power plants with two applications including mechanical drive and power generation.

- **Centrifugal Compressors**

Centrifugal compressors are among critical rotating equipment, which have numerous applications in transmitting and processing gas fluids. Iranian companies are capable of producing centrifugal compressors and offer the following services in the field of centrifugal compressor manufacturing and engineering:

- Designing customized centrifugal compressors to meet individual customer needs;
- Transferring the required technologies for manufacturing centrifugal compressors from abroad to meet the immediate needs of customers;
- Manufacturing the required compressors to be deployed in the country-wide natural gas transmission network.

- **High-Speed Centrifugal Pumps**

High-speed centrifugal pumps are commonly used in the petroleum and petrochemical industries due to their unique properties. Customized high-speed centrifugal pumps offer a number of features to meet individual customer needs including a variety of output rounds, working powers, shapes and dimensions for impeller, materials, and stuffing box arrangement.
Iranian companies have successfully managed to design and manufacture API-610, OH6 high-speed/high-pressure pumps and engage in re-engineering and assembling processes. They also have acquired the technical knowledge for pumps' maintenance and operation.

- **Blades and Vanes**

Blades are key components of steam and gas turbines and their manufacturing and maintenance are of strategic significance for power plants, refineries and pipelines. Iranian companies are capable of manufacturing turbine blades, with the advantage of completing the entire production processes at home. These include casting, machining and coating for the blades. The Iranian companies also customize manufacturing blades. Different technologies for blades production have been localized. These technologies include conventional casting, directional solidification, and single crystal methods.

- **Valves**

Iranian valve-manufacturing companies have successfully transferred the required knowledge and technologies for producing standard high-quality valves -for oil and gas industries- through reputable foreign companies. Currently, several types of valves are produced in Iran, including gate valves, globe valves, butterfly valves, and ball valves. API 6D and high-pressure valves in 900, 1500 and 2500 classes are produced locally.

- **Upstream Services**

Iranian companies offer a variety of upstream services including seismic services, data processing,

subsurface imaging, well construction, rig provision and management. They also present drilling services such as cementing, acidizing and providing drill bits and downhole equipment. These services are offered for variety of conditions and at different stages of the well and reservoir life; from simple oil and gas wells to complex reservoirs.

- **Spherical Tanks/Vessels**

Considering the inherent strength of a sphere, spherical tanks are primarily used for high-pressure conditions. Large storage tanks under moderate pressure usually have spherical or quasi-spherical shapes. Iranian companies design and manufacture spherical and cylindrical pressure vessels for refineries and power plants. These vessels come in different capacities, ranging from 1,000 to 25,000 barrels. They cover a range of different pressure from 100 to 2,000 psi.

IV. Authorities

- **Energy Technology Development Council**

The Energy Technology Development Council (ETDC) was established on September 2017 by integrating the “Oil, Gas and Coal Technology Development and Innovation Council”, “Renewable Energy Technology Council” and “Energy Efficiency & Environmental Council” in an attempt to facilitate and accelerate development of the science, technology and innovation ecosystem in the energy sector of the country in line with development of the knowledge-based economy in the field.

Developing the marketplace for knowledge-based products and the important technologies based on the country’s requirements in the energy sector are considered as the high priority goals of the ETDC. The Scope of activities for the council includes oil, gas, coal, energy efficiency and environment, renewable energy, and power sector.

- **Federation of Iran Oil Industries**

In line with systematic and efficient use of the capacities, facilities and capabilities of private sector organizations active in the oil, gas and petrochemical industries, the Federation of Iran Oil Industries, comprising 16 formations, was established in 2016. Its main purpose is to improve business environment, increase competitiveness of member companies of the association, support common interests of oil industry, and contribute to development and self-reliance of oil industry by providing multilateral cooperation between different specialized fields.

- **Iranian Oil, Gas and Petrochemical Products Exporters’ Association**

Oil, gas and petro-chemistry sector is the up-most and first industrial vantage of the country and the pivot of the Iranian economy. Regarding the importance of this sector and the need for coordinating and organizing the most active players in oil, gas, and petrochemical production and export, some entrepreneurs in the private sector decided to come together to remove the obstacles by taking the appropriate measures for closer and more productive cooperation with the National Iranian Oil Company.

The Iranian Oil Exporters’ Association which was established in 2003 consists of 54 member companies holding the permit from the Chamber of Commerce, Trade, Mining and Agriculture of Iran. At the moment, this association with more than 300 members is considered to be one of the biggest economic establishments in the country playing an important role in promoting oil exports, gaining exchange, and creating job opportunities in the country.

- **Research Institute of Petroleum Industry**

The Research Institute of Petroleum Industry (RIPI)- a leading research organization- was established in 1959 taking on the responsibility of performing a wide range of research activities as well as providing laboratory, technical, and consulting services in oil, gas and petrochemical industries. It is the major R&D organization in Iranian oil industry and the largest of its kind in the Middle East. Synthesis of gas, production of gasoline by bi-functional iron-based catalysts, and production of mid-distillates by cobalt-based catalyst are, among others, its notable technological achievements.

- **Companies Active in Oil and Gas Sector**

The energy sector is overseen by the Supreme Energy Council, which was established in July 2001 and is chaired by the President of Iran. The council is composed of the Ministers of Petroleum; Economy; Agriculture; Industry, Mine and Trade, among others. Under the supervision of the Ministry of Petroleum, state-owned companies dominate the activities in the oil and natural gas upstream and downstream sectors, along with Iran’s petrochemical industry. The four key state-owned enterprises are the National Iranian Oil Company (NIOC), the National Iranian Gas Company (NIGC), the National Petrochemical Company (NPC), and the National Iranian Oil Refining & Distribution Company (NIORDC).

• National Iranian Oil Company

Since 1951, the National Iranian Oil Company (NIOC) has undertaken the responsibility to formulate policies for exploration, drilling, production, research and development, refining, distribution and export of oil, gas, and petroleum products.

NIOC, with a vast amount of oil and gas resources, is considered to be one of the world's largest oil companies. With advances in technology and the increased complexities of economic and political relations, NIOC has risen to a privileged status. Making national and regional policies, cooperating with industrial countries in the field of energy, and stabilizing global oil markets are on its agenda.

NIOC- in accordance with Article 44 of the Constitution- gives authority to different sectors, while supervising oil industry activities. The company has taken major steps towards establishing business enterprises, allocating financial resources for development, and helping to upgrade technologies for exploration, drilling and production by relying on the domestic experts.

• National Iranian Gas Company

The National Iranian Gas Company (NIGC) was established in March 1966 to refine, transfer and distribute natural gas. At present, NIGC is operating in compliance with international valid standards on its own. NIGC is one of the top ten gas companies in the gas industry in the Middle East and one of the four major subsidiaries of the Petroleum Ministry. It has over 45 years of experience in providing over 61 percent of the required fuel in the country. The company plays a key role in terms of supplying gas, both domestically and internationally.

• National Petrochemical Company

The National Petrochemical Company (NPC), a subsidiary to the Iranian Petroleum Ministry, is owned by the government of the Islamic Republic of Iran. It is responsible for development and operation of the country's petrochemical sector. Founded in 1964, NPC began its activities by operating a small fertilizer plant. Today, NPC is the second largest producer and exporter of petrochemicals in the Middle East. Over these years, it has not only expanded the range and volume of its products, but has also taken steps in areas such as research and technology to become increasingly more self-sufficient.

• National Iranian Oil Refining & Distribution Company

The National Iranian Oil Refining & Distribution Company (NIORDC) was established with the view to separating the upstream (exploration and production of crude oil and gas) from the downstream (refining, transporting crude and petroleum products, export, import, and distribution of petroleum products) activities in March, 1991. Later that year, NIORDC officially began its activity as one of the four major subsidiaries of the Ministry of Petroleum. NIORDC fulfills its mission through four operating subsidiaries and nine oil refineries. In view of the increasing demand for petroleum products, NIORDC has embarked upon expanding, upgrading and optimizing its existing refineries, as well as building new grass-root refineries.

In addition to crude oil refining, NIORDC's activities are also focused on engineering, construction, distribution and transportation of oil products which are undertaking by its four major subsidiaries, namely the National Iranian Oil Products Distribution Company (NIOPDC), the National Iranian Oil Engineering and Construction Company (NIOEC), the Iranian Oil Pipelines and Telecommunication Company (IOPTC), and the Oil Refining Industries Development Company (ORIDC).

14 Renewable Energy

Renewable Energy

I. History and Background

With the first largest gas reserves and the fourth oil reserves in the world, Iran is a global hydrocarbons giant. The Iranian policymakers, however, are very eager to develop renewable energies to increase energy security, reduce the country's dependence on hydrocarbons, and realize its growth targets in electricity demand. Iran's advantageous topography for renewable energies, make it possible to fulfill these objectives in the country. In addition, Iran boasts a young and educated population and currently, the country is relatively open to acquire the requisite technologies and finance. Iran, therefore, tries to cut down hydrocarbons and replace them with the clean and renewable energy sources.

II. Policies and Strategies

Major policies of energy sector based on the national document of knowledge-based development of renewable energies are as follows:

Macro Level Policies

- Taking into account the human resources as the main factor in creating competitive advantage and value-added;
- Adopting an endigenous outward-oriented approach in developing renewable energies;
- Prioritizing non-governmental sector, private sector in particular, in implementation stage of the policies, while focusing on policymaking and supervisory role of the government;
- Centralizing policymaking and planning, while securing decentralized implementation;
- Specifying authorities' roles and responsibilities in areas of policymaking, implementing, and monitoring;
- Considering environmental requirements and preparing the country for sustainable development of renewable energies;
- Taking benefit of the commercialized local technologies for developing of renewable energies.

III. Capacities and Capabilities

A. Current Status

- **Hydropower**

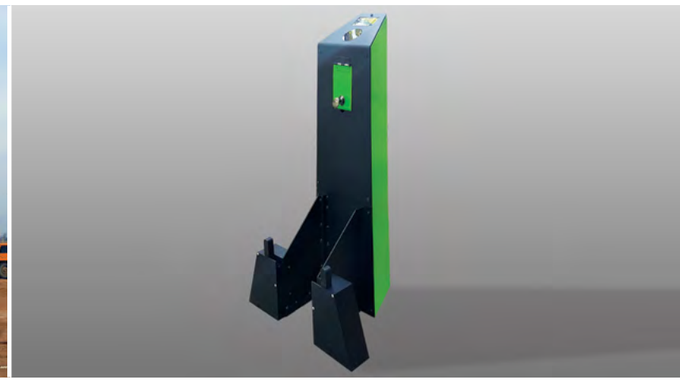
Hydroelectric power emerged as a renewable alternative in Iran in the 1950s. Iran, unlike most Middle Eastern states, is home to a vast network of rivers that allowed the country to rapidly scale its hydroelectric infrastructure until the early 2000s. Recent widespread droughts, however, have greatly reduced Iran's hydroelectric capacity.
Once contributing to 14 percent of Iran's total electricity supply, hydroelectric sources have been reduced to about 6 percent, as river levels continue to fall.

- **Wind**

With more than 100,000 MW technical potential, Iran's wind power potential can keep up with that of major wind developing countries such as France and Britain. Therefore, wind power is one of the major priorities in renewable energy development due to the country's topography and existing manufacturing and production capabilities.
Stated in the 6th National Development Act, 5% of the total installed capacity should be met by renewables. A considerable share of this capacity is expected to come from utility-scale wind farms throughout the country. Due to its strategic location along several major wind corridors, including Atlantic, Mediterranean and Indian Ocean currents, Iran's northwest and northeast experience high winds year-round.
The relative consistency of the wind currents allows for sustainable access to wind energy that will significantly reduce the need to use peak power thermal generators for daily power generation. Iran is well-positioned to rapidly scale up its wind power sector. The country has already operated around 100 MW of wind power and the vast majority of the components used to develop those farms have been developed locally. Due to the impact of Western sanctions, the country has capitalized on its abundant human capital to develop technological capabilities in turbine, generator, and inverter production. It has also considered exporting this equipment to Azerbaijan and India.

- **Solar Development**

Iran enjoys a high diversity in its climate and vast arid regions. Because the south, northwest and southeast regions receive around 300 days of sun per year, they are uniquely suited for solar energy. Iranian government has prioritized the central region in particular due to its climate and proximity to the national power grid. The country has already operated about 115 MW of largescale solar powerplants and 17 MW of rooftop ones.
Involvement of foreign partners in solar projects is both practical and economical. A lack of access to key solar technologies like inverters for voltage control and appropriately advanced semiconductors



has brought about logistical challenges to domestic Iranian companies. With the recent removal of sanctions, Iranian companies now have greater access to a wider range of increasingly sophisticated solar technologies and financing opportunities to purchase and develop them. The immediate benefits will be rapid installation of technologies and, in the long-term, the country is likely to benefit from gaining the ability to produce a significant amount of its solar infrastructure, domestically.

- **Continued Development in Geothermal**

Iran has begun construction of the Middle East's first geothermal power plant. This "pilot" station in the northwest Iranian province of Ardabil is expected to have an installed capacity of 50 MW. Because of its placement in the north of Iran, where infrastructure is underdeveloped and demand for electricity outpaces supply, the impact of the plant is expected to be immediate. While geothermal energy in Iran is at an early development stage, it still offers significant potential. A study conducted by researchers at Stanford University, for instance, posits that development of geothermal energy in Iran is possible in 14 separate geographical regions, spanning nearly the entire country.

B. Some Achievements

- **Fuel Ethanol Production from Bagasse with the Capacity of 1000 Liter/day**

Implementing this project for the first time in Iran and the region, with the mission to acquire the technology to produce alcohol fuel including new ethanol blends (e.x. B5, E5, E10, E15, E85, and E100) and the technical knowledge to produce fuel grade ethanol from bagasse, has brought Iran among the few countries with this technology.

- **Geothermal Heat Pump**

Geothermal heat pump systems are implemented to use clean renewable energy and produce the needed energy for cooling, heating, and providing hot water. Geothermal heat pump systems have already implemented in cities of Qom, Tehran, Taleqan, and Shiraz and their technology has been localized, too.

- **Feasibility Study, Site Selection, and Designing Large-scale Photovoltaic Power Plants**

Using solar energy through large-scale photovoltaic (PV) systems is a new efficient solution for areas with plenty of sunshine. Iran has been able to implement all stages of designing large-scale power plants including site selection, running feasibility studies, preparing overall layout of the plant and estimating the required site area, acquiring the permission for connecting to the grid through examining topography of the proposed land, identifying the estimated location of the power plant considering technical-economic requirements, preparing detailed maps including plant layout, taking into account all the details including solar modules, structures, inverters, electrical panels, posts connected to the grid, and monitoring as well as protecting systems, etc.

- **Electric Motorcycle**

Iranian electric motorcycle with speed of 100 Km/h and capability to travel 100 km on a single charge can be a perfect alternative for conventional motorcycles. This model uses chargeable lithium ion batteries which could be charged in three hours. It enjoys a customizing option so that customers can select their desired features according to their own particular needs, applications, and costs.
Given the growing electric vehicle market, there is an increasing need for charging stations. In this regard, an Iranian knowledge-based company has developed a smart charging station for electric motorcycle.

- **Advanced Parabolic Collector of One Hundred Meter**

This collector with 100 m length and mouth width of 5.7 m is installed at a height of 3.5 m. It can automatically track sunlight by means of a software, a protractor, and a hydraulic system consisting of two jacks and drive/control. This large advanced collector includes a foundation, a collector structure (the main part of the collector), a hydraulic system, an absorber tube, mirrors, and a tracking/control system.

- **Compact 5 KW PEM Fuel Cell System**

Polymer fuel cells are of various applications including residential use (5 KW). The main objective of this project is to adopt metal bipolar plates for PEM fuel cells. Considering the need for reducing volume and weight of the fuel cells, improving fuel cell stack heat management, and facilitating their recharging and reusing, Iranian researchers have made extensive efforts to develop metal bipolar plates in the recent years. Iran has managed to acquire this technology and fortunately, the country enjoys a range of metal reserves required to produce such metal plates. Currently, Iran manufactures 5, 10, and 25 KW fuel cells by using metal plates.

• Pilot Construction and Feasibility of Conversion of Waste to Synthesis Gas and Energy Using Plasma Technology

This project aims to dispose, disinfect, and convert wastes to energy. Currently, the project for producing 100 tons/day of syngas is implemented in Tehran and it is going to be performed in other cities, as well. Some of the unique features of this project are minimizing environmental contamination, maximizing solid waste conversion, decreasing mass and volume of wastes up to 95 percent, producing clean high quality syngas, etc. This technology can be used in other industries such as oil industry to refine oil wastes and it can also provide various solutions to produce energy (electricity, hot water, steam, and several fuels like hydrogen, methane, ethanol, methanol, etc.).

• Hydraulic Turbine Microcomputer Digital Governor, Research Design and Industrial Sample Production

Turbine governor is one of the main parts of power plants that along with monitoring turbine performance is responsible for controlling turbine speed and output power of the generator. This unit has a complicated control algorithm and its design and manufacturing technologies are confined to some developed countries. Iran is making efforts to acquire this technology in line with energy self-sufficiency. In this way, Iranian engineers have successfully produced one model of this system which has not been installed, yet.

• Back-Up PV Invertor

This project is designed to acquire technical knowledge to manufacture back-up PV invertors. Gird-tie invertor can inject the surplus energy into the grid and when it is off-gird, it can supply the requisite energy for sensitive and priority loads. Iran has accomplished developing such systems as a domestic production.

• Reference Testing Laboratory for Thermal Solar Systems

This reference laboratory is built to conduct technical and functional indoor/outdoor tests in accordance with global standards for solar thermal systems including thermal collectors, storage tanks, and solar water heaters in an attempt to commercialize and localize these systems and obtain SOLAR KEYMARK standard. Some of the activities of this laboratory include conducting thermal performance and efficiency tests, rain penetration tests and thermal shock tests (internal and external), and measuring mechanical strength (under stress and tension) and thermal impacts (by steel ball and ice ball) through a portable system.

• Prepregs for Wind Turbine Blades

Epoxy resin prepregs are important products in designing and manufacturing wind turbine blades. Features such as cleanness and ease of use, less material waste, increased speed and precision of manufacture process, product quality consistency, and controlled kinetic and rheological parameters during firing process have made this product popular in many strategic industries including designing and manufacturing wind turbine blades.

• Wind Turbine Gear Box

With the mission to localize gearbox of 660 KW wind turbine and acquire technical knowledge of manufacturing components of wind turbines domestically, Iran has succeeded to manufacture a gearbox for 660 KW wind turbine by means of reverse engineering.

• 660 KW Wind Turbine Generator

Wind turbine asynchronous generator is one of the most complicated parts of wind turbines which has been designed and developed domestically in Iran.

• Solar Cell (PV Cell) Module

Iranian solar panels are under TUV and CE° certificates and enjoy high efficiency and appropriate warranty. Iranian solar manufacturers, along with producing and supplying these panels, are active in other areas of solar power projects such as lighting, residential, telecommunications, industry academia, research, nomadic and rural agriculture, and power plant.

• Solar Residential Water Heater and Desalination System

Due to the need for supplying sanitary drinking water throughout the country, solar water heater and solar water heater/desalination systems have been designed and manufactured using humidification and dehumidification processes and are, currently, in operation in many of the central, eastern, and southern areas of the country.

IV. Authorities

A. Energy Technology Development Council

The Energy Technology Development Council (ETDC) was established on September 2017 by integrating the "Oil, Gas and Coal Technology Development and Innovation Council", "Renewable Energy Technology Council" and "Energy Efficiency & Environmental Council" in an attempt to facilitate and accelerate development of the science, technology and innovation ecosystem in the energy sector of the country in line with development of the knowledge-based economy in the field.

B. Renewable Energy and Energy Efficiency Organization

The Renewable Energy and Energy Efficiency Organization (SATBA) was established by the ministry of energy in 1996 with the missions of evaluating the country's potentials and implementing several renewable projects (solar, wind, geothermal, hydrogen, and biomass), performing pilot projects, and designing and constructing power plants with cooperation of public and non-government sectors. It is also responsible for guaranteed purchase/sales of renewable electricity with the aim of encouraging private sector's participation in this field, providing the required platform to study renewables, and paving the way for utilizing various renewable resources by using the country's rich capacities and capabilities.

C. Universities, Research Centers, and Laboratories

Currently 51 universities and research centers and 83 laboratories are working on renewable energies.

V. International Cooperation

The attractiveness of Iran's renewable energy potential has not gone unnoticed. As early as 2014, German, South Korean, Danish and Indian businesses began closely studying of the sanctioned country's renewable energy industry as a long-term investment opportunity. Iranian officials responded with enthusiasm to Western curiosity by reducing bureaucracy in the energy sector, streamlining its licensing process, and presenting competitive incentives for renewable energy infrastructure development and equipment supply. For instance, SATBA modeled its new feed-in tariff policy on the German equivalent, guaranteed government purchases of power for 20 years, and introduced a bonus (30 percent higher electricity price) for companies that use domestic components.