

Turkey's Energy Profile and R&D Activities at TÜBİTAK Marmara Research Center Energy Institute

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1. Introduction

Turkey is geographically located between energy producing countries of its region with more than 75% of the world's proven oil and gas reserves and the well-developed European energy consumer markets. This privileged natural position provides Turkey with both opportunities and responsibilities in terms of energy security. Turkey remains convinced of the need to strengthen this unique role given by its geostrategic location. In this regard, while developing its energy strategy, Turkey aims to strengthen its position between East-West and South-North Energy Corridors. Turkey's demand for energy and natural resources has been increasing due to economic and population growth. In recent years, Turkey has recorded the fastest growth in electricity demand among OECD members, with an annual growth rate of 5, 5% since 2002.¹ Turkey's energy use is expected to increase by 50% over the next decade. Turkey's installed capacity has exceeded 88 GW as of January 2019, which represents a threefold increase in 15 years.

Economic expansion, rising per capita income, positive demographic trends, and the rapid pace of urbanization have been the main drivers of energy demand, which is estimated to increase by around 6 percent per annum through 2023. In order to satisfy the increasing demand in the country, the current installed electricity capacity is expected to reach 120 GW by 2023 through further investments to be commissioned by the private sector. As part of its efforts to provide sustainable and reliable energy to consumers, Turkey offers investors favorable incentives, such as feed-in-tariffs, purchase guarantees, connection priorities, license exemptions, etc., depending on the type and capacity of the energy generation facility.

In addition to the growing energy demand, the other characteristic of the Turkish energy markets is the dependency on imports. Recent energy data indicate that Turkey is a net energy importer country, depending on such imports for 73% of its energy needs. This high rate of energy dependence has been the main driving force behind the formulation and implementation of new policies to commission local and renewable energy resources. The recent energy trend in Turkey has paved the way in legislative and practical terms for increasing renewables' share in total installed capacity and electricity generation.

The main elements of Turkey's energy strategy can be summarized as follows:

- 1) Taking into account increasing energy demand and import dependency, prioritization among energy supply security related activities
- 2) Within the context of sustainable development, giving due consideration to environmental concerns all along the energy chain
- 3) Increasing efficiency and productivity, establishing transparent and competitive market conditions through reform and liberalization
- 4) Augmenting research and development on energy technologies.

¹ Turkey has become one of the fastest growing energy markets in the world, paralleling its economic growth over the last 15 years. The success of a privatization program that has been ongoing since 2002 has resulted in power distribution now completely in private sector hands, while the privatization of power generation assets is set to be completed within the next few years. This privatization program has given the country's energy sector a highly competitive structure and new horizons for growth.

Through application of these four basic principles, Turkey aims for the following goals;

- 1) Diversification of supply routes and sources for imported oil and natural gas
- 2) Increasing the ratio of local and **renewable energy** in our energy mix
- 3) Increasing energy efficiency
- 4) Adding nuclear to our energy mix.

Turkey continues its efforts to increase the share of **clean & renewable energy sources** in and add the nuclear power to its energy mix for the purpose of reducing its energy import dependency, maximizing the use of domestic resources, and combating climate change.

Clean & Renewable Energy

Turkey has a substantial amount of renewable energy potential, and the utilization of this potential has been increasing over the last decade. As of the end of February 2018, hydro and wind resources constitute the vast majority of Turkey's renewable energy resources, accounting for 27,456 MW and 6,580 MW respectively of the total installed capacity of more than 86,100 MW. However, solar, biomass/biogas, and geothermal energy resources will also comprise a significant portion of the total capacity as rapid growth in utilization of these resources will be experienced in the coming years. Turkey has made it a priority to increase the share of renewable sources in the country's total installed power to a remarkable 30 percent by 2023. This will run in parallel to the government's commitment to energy efficiency, whereby it is enacting laws that set principles for saving energy, at both individual and corporate levels, as well as providing incentives to energy efficiency investments. For example, the Turkish government introduced **the new Renewable Energy Resource Zone (YEKA)** model in 2016 in order to commission large-scale renewable energy projects through utilization of locally-manufactured components in the renewable power plants. Under the model, the largest-ever solar power auction in Turkey's history took place on March 20, 2017, while a similar tender for 1-GW wind power plants took place in August 2017 with local manufacturing and R&D requirements.

As an indication of the importance given to **renewable energy**, Turkey also became a founding member of the International Renewable Energy Agency (IRENA) on 26 January 2009.²

Turkey's 11th Development Plan (2019-2023) also mentions biomass and waste utilization, utilization of lignite through gasification for the production of valuable chemicals as areas of technology development. The plan includes the support for R&D projects on clean coal technologies.

Sources:

<http://www.mfa.gov.tr/turkeys-energy-strategy.en.mfa>

<http://www.invest.gov.tr/en-US/sectors/Pages/Energy.aspx>

<http://www.sbb.gov.tr/wp-content/uploads/2019/07/OnbirinciKalkinmaPlani.pdf>

² Information related to Turkey's clean & renewable energy potential can be accessed through the following web sites:

<http://www.enerji.gov.tr/en-US/Pages/Hydraulics>

<http://www.enerji.gov.tr/en-US/Pages/Wind>

<http://www.enerji.gov.tr/en-US/Pages/Solar>

<http://www.enerji.gov.tr/en-US/Pages/Geothermal>

<http://www.enerji.gov.tr/en-US/Pages/Bio-Fuels>

TUBITAK Marmara Research Center Energy Institute

Energy Institute is one of the seven institutes of TÜBİTAK Marmara Research Center, conducting project-based studies in the field of energy technologies. The vision of EI is "to be the pioneer and leading research institute in the field of energy in Turkey." The mission statement of EI is "to contribute to the global competitiveness and sustainable development of Turkey by developing new, advanced energy technologies and energy conservation measures." The institute provides and develops technological knowledge into practical applications in advanced and innovative energy and transportation technologies areas. It forms a bridge between fundamental research and commercial & industrial applications.

The Institute, in accordance with other TUBITAK departments, cooperates with national and international institutions on science and technology projects, constantly develops its infrastructure and capabilities. Energy Institute conducts research since 1980s and officially taken the name "Energy Institute" in 2004.

TUBITAK MAM Energy Institute has two campuses, in Gebze at Marmara Research Center Settlement and in Ankara at the Middle East Technical University Settlement.

2. R&D activities related to clean energy technology

Energy Institute's research activities includes areas such as Clean Coal and Biomass Technologies, Fuel Cell and Energy Storage Technologies, Transportation Technologies, Electrical Power Technologies and Power Systems and Renewable Energy Technologies. Among these activities, Clean Coal and Biomass, Fuel Cell and Renewable Energy (solar & hydro) are the ones especially contributes to the development of clean energy technology in Turkey. The sub-divisions under these main areas are generally formed as research teams comprised of experts.

3. Specific Research activities in hydrogen, CCUS, and related technologies

Our expert teams on coal combustion and gasification, coal gas cleaning, coal to liquid, utilizing coal with biomass and thermal power plant technologies conducts various laboratory and pilot scale projects and applies technology in the site of customer. There are many projects all of which have in common is the aim to apply Turkey's own technology to utilize from her coal resources. In this sense Liquid Fuel Production from Coal and Biomass Blends Project (TRİJEN) aims to produce more economic, efficient and clean liquid fuels from coal and biomass and therefore to enhance the utilization of the widespread national resources for sustainable development and energy security. The pilot scale liquid fuel production plant has been successfully established in Soma and another related project of pre-design of commercial plant has been started. Another Project Tunçbilek Methanol production includes the study of entrained flow gasification and synthesis of methanol. Development and Localization of Thermal Power Plant Technologies (MILTES) Project, another one, aimed to work on the development of a 22 MWe thermal power plant based on circulating fluidized bed combustor which is more suitable and more environmentally-friendly for Turkey's coal. The design is completed. On the other hand, Development of a National Flue Gas Desulphurization System for Thermal Power Plants (MILKAS) Project's aimed the development of a flue gas desulphurization system for thermal power plants and completed the design of the system. A waste heat utilization Project (Research and Development of Methods to Benefit from Thermal Power Plant Surplus Heats and District Heating- TSAD) investigated the methods to benefit from thermal power plant surplus heats and district heating. With the Hydrogen Production (via Gasification) from Biomass Project, the institute works on technology development for hydrogen production through gasification of biomass as a renewable energy source.

In the framework of fuel cell technologies; hydrogen production from sodium borohydride and natural gas are being conducted in addition to development of fuel cell stack and system sub-components, fuel cell system integration, power conditioning and control, fuel cell component and stack tests, stationary and portable applications and transportation and intelligence applications. Sodium Borohydride Vehicle and Fuel Cell Based Micro-cogeneration System are among successful projects.

At the renewable energy side, Solar Power and Hydroelectric Power Plants are main research areas. The institute has an expertise on photovoltaic inverter development and command and control systems for photovoltaic solar power plants. Energy Institute is taking part in the Development of Photovoltaic Solar Power Plant Technologies (MILGES) Project which aims design/manufacturing and installation of photovoltaic power plant equipment with 80% local technology (for solar cells with 18% efficiency, solar panels, solar central inverters with 1 MVA capacity, a plant automation system, a solar power plant with 10MW capacity) in order to meet national needs.

For hydropower the research teams work on control, protection, excitation and synchronization systems, speed regulator and generator design. With the National Design and Manufacturing of Hydroelectric Power Plant Components (MILHES) Project, the Institute has worked on design/manufacture and installation of newly developed products (vertical francis turbine, 11 MVA synchronous generator, speed governor, excitation system, power plant automation and prot. system, auxiliary systems) utilizing national engineering and material resources. The manufactured items are successfully installed and commissioned at Kepez-1 HEPP.

The institute also works on wind power monitoring and forecasting systems.

Some of the related projects conducted by the institute (further information on 3 of the projects are found in the template)

TUBITAK 1007 Program -Liquid Fuel Production from Coal and Biomass Blends (TRIJEN) (2009-2020)

Development and Localization of Thermal Power Plant Technologies (MILTES) (2013-2017)

Development of a National Flue Gas Desulphurization System for Thermal Power Plants (MILKAS) (2014-2018)

Methanol Production in Tunçbilek (2013-2020)

Research and Development of Methods to Benefit from Thermal Power Plant Surplus Heats and District Heating (TSAD) (2006-2013)

TUBITAK 1003 Program - Hydrogen Production (via Gasification) from Biomass(2010-2013)

Fuel Cell Based Micro-Cogeneration System (5 KWe/30 KWth) (2006-2010)

Fuel Cell Based Micro-Cogeneration System / Site Application (2 KWe) (2016-2022)

Sodium Borohydride Fuel Cell Vehicle (2009-2012)

Sodium Borohydride Fuel Cell Based Range Extender for Electric Vehicles (2014-2016)

TUBITAK 1007 Program -Development of Photovoltaic Solar Power Plant Technologies (2015-2020)

TUBITAK 1007 Program -National Design and Manufacturing of Hydroelectric Power Plant Components (2015-2021)

Hydroelectric Power Plant Rehabilitation Projects (nearly 10 hydro-power plants) (2012-2024)

Development of a Monitoring and Forecasting System for Wind Power in Turkey (2012-2018)

4. International collaboration

4-1 International alliance/networking development

Under the coordination of TUBITAK Presidency, there are many bilateral cooperation agreements signed with various countries at intergovernmental or inter-institutional level in the field of science and technology. Within the framework of these agreements, joint research projects are supported and monitored and financial support is provided for joint scientific meetings, expert exchanges, study visits and similar activities. The programs are two types: permanent applications and calls for projects. Many of these programs support project proposals on clean energy research and development studies. (For more information see: www.tubitak.gov.tr) The institute conducted projects within the framework of these programs.

There are also MoUs signed between TUBITAK Marmara Research Center and research centers abroad which is reflected as partnership in especially clean coal projects of Energy Institute. Additionally, a partnership with King Abdulaziz City for Science and Technology (KACST)-Saudi Arabia is established in the fields of Solar Inverter Systems and Power Quality Analyzers.

On the other hand Energy Institute is officially a member of below international organizations:

EERA AIBSL- European Energy Research Alliance

- EERA Bioenergy
- EERA Smart Grids
- EERA Wind Energy

IEA-International Energy Agency

- IEA HEV-ExCo & Annex 1: Hybrid and Electric Vehicle Technologies and Programmes Executive Committee and Annex I Information Exchange

N.ERGHY -Fuel Cell and Hydrogen Joint Technology Initiative (FCH JTI)

EUREC- The Association of European Renewable Energy Research Centers

4-2 International joint R&D activities

Joint R&D activities of Energy Institute are mostly within EU Framework programme or bilateral cooperation programmes coordinated by TUBITAK Presidency.

Here is a list of the international joint projects that the Institute is among partners (Most of the projects are completed):

2534 BMBF /Germany – TÜBİTAK / Turkey Collaboration Project -2+2 Joint Research Programme Project: “1 kWe fuel processing system integrated with an advanced high temperature fuel cell stack for UPS application”

2522 NRDI/ Hungary-TUBITAK/ Turkey Collaboration Project- Development of High CO-Tolerant Anode Electrocatalysts for Reformate-Fed PEM Fuel Cells

(H2020) - 5TOI_4EWAS Quintuple Helix Approach to Targeted Open Innovation In Energy, Water, Agriculture in the South Mediterranean Neighborhood (2016 – 2019)

(H2020) - BIOMASUD PLUS Developing the Sustainable Market of Residential and Commercial Mediterranean Solid Biofuels) (2016-2018)

(7th FP) - CITYFiED-RepliCable and InnovaTive Future Efficient Districts and cities (2014-2019)

(7th FP) - IRPWind- Integrated Research Programme on Wind Energy (2014-2018)

(7th FP) - ELECTRA - European Liaison on Electricity Committed Towards long-term Research Activities for Smart Grids
(7th FP) - ETRERA 2020 Empowering Trans-Mediterranean Renewable Energy Research Alliance for Europe 2020 Challenges (2013-2016)
(6th FP) - MCFC-CONTEX Effects of CONTaminants in biogenous fuels on MCFC catalyst and stack compo-nent degradation and lifetime and EXtraction strategies (2010-2014)
(6th FP) - TYGRE High Added Value Materials From Waste Tyre Gasification Residues (2009-2013)
(6th FP) - E2PHEST2US -Enhanced Energy Production of Heat And Electricity By a Combined Solar Thermionic-Thermoelectric Unit System
(6th FP) - MC-WAP Molten-Carbonate Fuel Cells For Water Borne Applications (2006-2011)
(6th FP) - TERMISOL New Low Emissivity and Long-lasting Paints for Cost Effective Solar Collectors (2006-2010)
(6th FP) - EU-DEEP The Birth of A European Distributed Energy Partnership That Will Help The Large-Scale Implementation of Distributed Energy Resources in Europe (2003-2009)
(6th FP) - NATURAL-HY Preparing for the hydrogen economy by using the existing natural gas system as a catalyst (2004-2009)
(6th FP) - CASES (6th FP) Cost Assessment Sustainable Energy Systems (2006-2008)
(6th FP) - HYPROSTORE Improving of the S&T Research Capacity of TUBITAK MRC IE in the Fields of Hydrogen Technologies (2005-2008)
(6th FP) - BIGPOWER Improving of the S&T Research Capacity of TUBITAK MRC IE in the Fields of Integrated Biomass Gasification with Power Technologies (2005-2008)
(6th FP) - NETBIOCOF (6th FP) Integrated European Network For Biomass Co-Firing (2005-2007)

5. Future perspectives

As important as the **clean & renewable energy technologies** are for Turkey's energy strategy in the coming years, technologies in such fields as waste processing, greenhouse gas reduction and clean coal technologies are also as critically important supplementary practices Related measures and regulations that are either currently in effect, or will soon be in effect. As TUBITAK Marmara Research Center R&D on the mentioned areas (clean coal&biomass, hydrogen&fuel cell, solar&hydro) will continue both at national level and the international partnership level.

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2014 Director, TUBITAK Marmara Research Center Energy Institute (current)
2017 Prof. Dr., Gebze Institute of Technology (Gebze Technical University)
Department of Electronics Engineering (current)

2012 Assoc. Prof. Dr., Gebze Institute of Technology (Gebze Technical University) Department of Electronics Engineering

2004 Asst. Prof. Dr., Gebze Institute of Technology (Gebze Technical University) Department of Electronics Engineering

2001 System Planning Engineer, Independent System Operator of New England (ISO New England), Holyoke, MA, USA

1999 Research Assistant, Department of Electrical and Computer Engineering, Polytechnic University, Brooklyn, New York

1993 Research Assistant, Gebze Institute of Technology



Research Biography

2014 – Battery systems for electric vehicles

2010 – Energy management for vehicular applications

2003 – Power Systems, electric machines

2001 – Electromagnetic launchers

Academic Background

2003 Ph.D. in Electrical and Computer Engineering, Polytechnic University, New York.
Polytechnic University, New York.

1997 M.Sc. in Electrical and Computer Engineering, Polytechnic University, New York.
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1992 Bachelor of Electrical Education, Gazi University, Ankara.