Aslı Kaytaz, Dr. Alper Sarıoğlan, Dr. Atilla Ersöz
TUBITAK Marmara Research Center Energy Institute

INTRODUCTION AND BACKGROUND

Turkey’s domestic oil and gas production meets less than 3% of its energy requirement leaving Turkey a major importer of oil and gas. 90% of Turkey’s crude oil is imported. As for natural gas, Turkey is almost totally dependent on imports.

Turkey’s primary target is to ensure that the share of renewable resources in electricity generation is increased by at least 30% by 2023. This target will be subject to revision based on potential developments in technology, market, and resource potential. In this context, long term works will take into consideration the following targets:

- Ensuring, by 2023, that technically- and economically-available hydroelectric potential is entirely put to use in electricity generation.
- Increasing installed wind energy power to 20,000 MW by the year 2023.
- Ensuring that geothermal potential of 600 MW, which is presently established as suitable for electricity energy production, is entirely commissioned by 2023.
- To generalize the use of solar energy for generating electricity, ensuring maximum utilization of country potential. Regarding the use of solar energy for electricity generation, technological advances will be closely followed and implemented. Within 2009, Law No. 5346 will be accordingly amended in order to encourage generation of electricity using solar energy.
- Preparation of production plants will take into account potential changes in utilization potentials of other renewable energy resources based on technological and legislative developments, and in case of increases in utilization of such resources, share of fossil fuels, and particularly of imported resources, will be reduced accordingly.

UPDATE ON MEMBER’S ENERGY FRAMEWORK

UPDATE ON RELEVANT POLICIES

In Turkey, which is import-dependent by 73%, almost all oil and natural gas and one-fifth of all coal are imported. For the purpose of mitigating the risks of secure energy supply and ensuring that energy is produced and used more efficiently, the main strategies of the country will continue to be establishing free market conditions and developing a competition-based investment environment. To use the limited natural resources in a rational manner, it is of great importance to meet the energy demand of Turkey, diversify energy production using new technologies while increasing the efficiency of the existing technologies, and implement policies and strategies which intend to use alternative energy sources. The General Directorate of Energy Affairs of the Republic of Turkey Ministry of Energy and Natural Resources ensures organization of activities that encourage the development and use of new and renewable energy resources in our country.

In line with our country’s objective to reduce its dependency on international resources in terms of energy supply, studies oriented to exploring and producing energy from domestic coal resources constitute an important part of our national policy as it pertains to the natural resources. Within this framework, in the year 2009, it was targeted to
have all domestic new coal potential revealed until the year 2023. The projects that are
developed by means of networks of cooperation to be established in the field of clean coal
technologies, including the technologies for production of electricity, fuel oil, hydrogen
and chemicals, primarily by gasification of Turkish coal resources (mostly lignites), will be
brought to life with speed.

Activities initiated for use of nuclear power plants in electricity generation will continue.
Our target is to increase the share of these power plants in electricity energy up to at least
5% by the year 2020, and to increase it even further in the longer run.

Through measures for utilization of our domestic and renewable resources, Turkey's share
of natural gas in electricity generation will be reduced down to below 30%.

UPDATE OVERVIEW ON RELEVANT PROGRAMS AND PROJECTS

As stated in Medium Term Program of Turkey (2010–2012), use of domestic and renewable
resources in electricity production will be expedited to reduce the overdependence on
imported natural gas.

This entails the following actions: ensuring that use of renewable energy resources for
production of electricity energy is generalized, such that these resources are brought
into the economy in a reliable, economic, and high-quality manner; that the diversity of
resources is increased; that greenhouse gas emissions are reduced; that wastes are used in
a more efficient manner; that the environment is protected; and that the manufacturing
sector needed for reaching these goals is developed.

Preparation of production plans will take into account potential changes in utilization
potentials of other renewable energy resources based on technological and legislative
developments. In case of increases in utilization of such resources, Turkey's share of fossil
fuels, and particularly of imported resources, will be reduced accordingly.

Turkey's Strategic Plan determines which strategies among the development of domestic
technologies directed to the establishment of gas, petroleum, and hydrogen generation
from coal will be supported.

Funding

Launched in 2004, one of the subsequent triggers in Turkey is the conceptualization of
the Turkish Research Area (TARAL). TARAL set into motion a mobilization with which
the business enterprise and public sectors, together with nongovernmental organizations
(NGOs), strategically focus and collaborate on R&D and innovation.

The TARAL objectives that are to be achieved are to:

- enhance the quality of life,
- find innovative solutions to societal challenges and opportunities,
- increase the competitiveness of the country, and
- foster and diffuse S&T awareness in society.

The Ministry of Industry and Trade's Law on Technology Zones, which enabled creation
of technology support for the establishment of Technology Parks, came into force in
2001, establishing strong linkages between the private sector and the research community.
Most of the R&D projects implemented in the Zones are in the field of ICT followed
by electronics, advanced material technologies, industrial design, nanotechnology,
medical/bio-medical research, automotive industry, sustainable energy and environmental technologies.

As stated in T.R. Prime Ministry State Planning Organization Ninth Development Plan 2007–2013, in order to increase the supply security, a balanced resource diversification on the basis of primary energy resources and country of origin differentiation will be ensured. It is envisioned that the share of domestic and renewable energy resources in the production system will be raised to the maximum extent. For the future, research in nanotechnology, biotechnology, new generation nuclear technologies and hydrogen and fuel battery technologies sectors will be given priority by the industrial policy; R&D activities that aim to transform local resources into value-added will be supported as priority fields as well.
Highlights of Progress

From 1998 through 2009, Turkey experienced a fast-paced, rising trend in Gross Expenditures on R&D (GERD) in current purchasing power parity (PPP $). GERD rose from 2 billion to about 9 billion in PPP $, a four-fold increase attributable to the initiative of Turkish Research Area. In line with the progress on total R&D activities, hydrogen-related activities have also shown a remarkable increase during this period. The hydrogen activities are summarized in section III.

Figure 1: R&D expenditures of Turkey (million current PPP $) (Source: TurkStat) Note: Gross salaries are used for the calculation of R&D labor cost in higher education sector after the year 2006.

HYDROGEN R&D&D SPECIFICS

Programs, projects, initiatives in brief

TUBITAK MRC Gas Technologies Excellency Center Project

Within the long term policy of State Planning Organization, the establishment of the Centers of Excellence (EC) is the highest priority target for Turkey. Twenty-six ECs were established in 2010; 17 within universities and nine in research centers. TUBITAK MRC Gas Technology Excellency Center project is one of these initiatives. This Center will provide its infrastructures and capabilities to all related industrial sector and R&D needs including natural gas and hydrogen business.

Contact person: Dr. Alper SARIOGLAN, Chief Senior Researcher

PEM Fuel Cell Microcogeneration System Prototype

This successfully finalized project was a consortium project among TUBITAK MRC Energy Institute, Istanbul Technical University, Kocaeli University, and Turk Demirdokum A.S.

The main outcomes of the project can be stated as: a fuel processing system capable of generating hydrogen-rich gas mixture from natural gas; a catalytic burner to burn hydrogen & natural gas mixtures; a PEM fuel cell system with a 5 kW electrical capacity; a power conditioning system to convert the electricity output; and a data acquisition & control system; as well as integration of these units as a "PEM Fuel Cell Microcogeneration System Prototype" for residential applications.
Design, manufacturing, mounting, and tests of the first prototype of 5 kWe Fuel Cell Microcogeneration System Prototype were performed. In the prototype system:

- hydrogen-rich gas mixture without CO has been produced from natural gas,
- 5.2 kW electricity has been generated within the Fuel Cell System,
- DC electricity generated within the fuel cell has been converted to AC by means of the Power Conditioning System,
- data acquisition and control of the prototype has been realized via the Control System, and the heat requirement of the Fuel Processing System for steam production and air stream pre-heating has been met via catalytic and conventional burners of the system.

Contact person: Fehmi AKGÜN, TUBITAK MRC

1kWe fuel processing system integrated with an advanced high temperature fuel cell stack for UPS application (2010–2013)

In 2009, a program entitled “Science and Industry (2+2 projects)” between Germany and Turkey was published with the aim to intensify cooperation between German and Turkish representatives of science and industry by means of 2+2 projects. The term “2+2 projects” refers to R&D projects with the participation of at least one German and one Turkish research institution or university, as well as one German and one Turkish industry partner. Over a period of three years, the funding will enable these institutions to lay the foundations for a lasting R&D partnership. It will be provided jointly by the BMBF and TUBITAK.

The project began at the end of 2010, and has four partners: TUBITAK MRC Energy Institute, UMDE Engineering Company (TURKEY), Testing Service GmbH (Germany), and Rheinisch-Westfalishe (Germany). The aim of the project is to develop an advanced high temperature fuel cell system with significantly reduced start up time. The system is based on a reforming process of natural gas (autothermal reforming, or ATR) and a high temperature fuel cell stack (HT-PEM). The main issue is a fast start up of the fuel cell system. This requirement is essential for applications for the uninterruptible power supply (UPS) as well as for microcogeneration (CHP) systems.

HT-PEM fuel cell stacks studies have been started with computational fluid dynamics modeling. Different scenarios for the operation of the whole system have been formed via a commercial simulation program and optimum process conditions and localization of each subsystem will be chosen accordingly. At the end of the project a total new advanced system is targeted to be built up and the functionality of the system will be demonstrated.

Contact Person: Atilla ERSÖZ, TUBITAK MRC

Development of electrodes with a catalytic surface for hydrogen evolution

Çukurova University

KARDAŞ, Gülfeza*; SOLMAZ, Ramazan; YÜCE, Ayşe, Ongun; DÖNER, Ali and ŞAHİN, Ibrahim

The project was successfully finished and an article, “Preparation, characterization and application of alkaline leached CuNiZn ternary coatings for long-term electrolysis in alkaline solution,” was published at the International Journal of Hydrogen Energy, 35, 10045-10049 (2010) by R. Solmaz, A. Döner, and G. Kardaş.
The long-term stability of an electrode prepared for alkaline water electrolysis was investigated in 1 M KOH solution with the help of cathodic current-potential curves and electrochemical impedance spectroscopy (EIS) techniques. It was found that, the NiCuZn coating has a compact and porous structure with good physical stability. Alkaline leaching process further improved the activity of NiCuZn coating in comparison with binary NiCu deposit for the HER. The long-term operation at 100–mA cm\(^2\) showed good electrochemical stability over 120 h.

Development of parallel code for the optimization of geometries of many-particle systems: Investigation of hydrogen storage and nanomagnet structures for nano-systems

Middle East Technical University
ERKOÇ, Şakir*; İŞLER, Veysi; TOFFOLİ, Hande, Üstünel; DUGAN, Nazım; ONAY, Aytun, Koyuncular; POLAD, Serkan

Research on nanomaterials for hydrogen storage and nanomagnet design has been carried out via quantum mechanical calculations of DFT (Density Functional Theory) method. The project was finished successfully in 2010 and the article “Enhancement of H\(_2\) Storage in Carbon Nanotubes via Doping with a Boron Nitride Ring”, at J. Comput. Theor. Nanosci. 6, 933 (2009) was published detailing the results.

Storage of hydrogen, as a clean energy source, on nano structures

Çankaya University
GÜVENÇ, Ziya B.*; ÖZDOĞAN, Cem; BÜYÜKATA, Mustafa; ATİŞ, Murat

The effect of the increasing number of the hydrogen atoms to the cage structure of boron and boranes micro clusters was studied, as well as the charge induction effects on the same cage structures. The investigation on metal added to boron nanostructures has continued in order to improve the bonding capability of the structure with hydrogen and the other molecules.

Biohydrogen production from renewable (biomass) sources

Dokuz Eylül University
Fikret KARGI, Ilgi KAPDAN*, Serpil ÖZMIHÇI

The objectives of the finalized project were to develop novel bioprocesses and to determine the process conditions to maximize hydrogen gas production from wheat powder and hydrolyzed wheat starch by dark and light fermentations. Clostridium sp. and heat treated anaerobic sludge were used in dark fermentation while Rhodobacter sp. was employed in light fermentation. Hydrogen gas production performance at different conditions and processes was evaluated in terms of cumulative hydrogen gas volume (CHV, ml), hydrogen production potential (P, ml), production rate (Rm, ml/h), production yield (Y\(_{H_2}\), mol H\(_2\)/mol glucose), specific hydrogen production rate (SHPR, H\(_2\)/g biomass h). The results were compared with the available literature. Fed-batch operation, combined fermentation, and annular hybrid reactor are the most novel contributions of the project to the bio-hydrogen studies.
National Energy Technologies Research and Development Platform

Under the leadership of OSTIM INVESTMENT, National Energy Technologies R&D Platform has started its works with the cooperation protocol signed by Ministry of Energy and Natural Resources General Directorate of Energy Works, Electricity Generation Cooperation (EUAS) and Technology Development Foundation of Turkey (TTGV) in 21 January 2010.

Energy Technologies Research-Development Platform is aimed to be a national constitution that all energy related institutions (public, university, industry, NGO etc.) will constitute together.

The main objective of this platform, through the cooperation network formed by all parties of the sector, are:

• determination of roadmap for the meeting R-D the needs of local producers, and
• enhancement of national added value of the sector that is largely foreign-dependent by increasing the share of local production.

The aim of the platform is to establish a knowledge-based network between the relevant parties of the sector. In this context, in the studies of platform besides all energy technologies based on coal and natural gas, renewable energy technologies (hydroelectric, wind, solar, biogas, biomass, geothermal), energy efficiency systems, eco-buildings, eco-regions, energy-environment relation, and other related topics will be addressed. With working groups that will be formed on the basis of subjects, more effective results are expected. Platform members improve their capacity by strategic, technologic and economic partnerships under these working groups:

• Hydroelectric, Thermic power plants WG
• Wind Energy WG
• Solar Energy WG
• Bioenergy WG
• Energy Efficiency Practices WG
• Others (Hydrogen, Geothermal, etc) WG

Source: http://www.ttgv.org.tr/en/energy-technologies-platform, info@ostimenerjik.com

Stimulation Activities for Hydrogen and Renewable Energy

Advanced Technologies Workshop was held in Kocaeli University on April 30, 2010. More than 150 researchers and 250 students participated in the event. Hydrogen energy was the one of the special topic being discussed.

Contact Person: M. Oktay ALNIAK

Every year, TUBITAK organizes competitions, called HIDROMOBIL to stimulate the use of hydrogen and solar technologies at the industrial level, while increasing the awareness of hydrogen and renewable energy technologies among the young researchers and power the human resources on alternative technologies. University students from engineering faculties participate in the competition by constructing their hydrogen fuelled and PV panel-battery packed vehicles.
The FORMULA G organization started in 2005, whereas HIDROMOBIL began in 2007. Every year, the number of participants to the races increase and the rules become more restrictive. Hence, the competition forces students to design better vehicles in terms of durability and aerodynamics.