ENERGY, ECOSYSTEMS, AND SUSTAINABILITY PROGRAMS @ METU

Prof.Dr. Ahmet Acar
President
ENERGY ISSUES
IN
TURKEY & MIDDLE EAST
World Marketed Energy Use by Fuel Type 1980-2030

Projection of the Future: a projection to 2100 by German Federal Government

World Energy Consumption

EIA Intl Energy Outlook 2004

85% Fossil

World Oil Consumption by Region and Country Group for 2003 and 2030

- North America
- Non-OECD Asia
- OECD Europe
- OECD Asia
- Central and South America
- Middle East
- Non-OECD Europe and Eurasia
- Africa

World Proved Oil Reserves by Geographic Region as of January 1, 2006

- Middle East: 743 billion barrels
- North America: 213 billion barrels
- Central and South America: 103 billion barrels
- Africa: 103 billion barrels
- Eurasia: 79 billion barrels
- Asia: 36 billion barrels
- Europe: 15 billion barrels

World Total: 1,293 billion barrels

World Natural Gas Reserves by Geographic Region as of January 1, 2006

- Middle East: 2,565
- Eurasia: 1,953
- Africa: 486
- Asia: 392
- North America: 265
- Central and South America: 251
- Europe: 201

World Total: 6,112 Trillion Cubic Feet

Turkey as a Transit Country

BOTAŞ Projects: Turkey as an East-West Energy Corridor, East-West Energy Terminal

- Nabucco
- Russian Gas-West
- Blue Stream
- ITG
- ITGI
- Ceyhan LNG
- Iraqi Gas
- Iranian Gas
- Egyptian Gas Arab Gas PL
- Trans-Caspian Kazakh Gas
- Trans-Caspian Turkmenian

Map showing energy routes through Turkey.
# Turkish Oil Pipelines

<table>
<thead>
<tr>
<th>Name</th>
<th>Capacity</th>
<th>Source</th>
<th>Route</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baku-Tbilisi-Ceyhan (BTC)</td>
<td>1 million bbl/d</td>
<td>Azeri light crude</td>
<td>Azerbaijan-Georgia - Turkey</td>
<td>Began in operation in 2006</td>
</tr>
<tr>
<td>Kirkuk-Ceyhan</td>
<td>1.65 million bbl/d</td>
<td>Iraq</td>
<td>Iraq-Turkey</td>
<td>Projected to open in 2015</td>
</tr>
<tr>
<td>Samsun-Ceyhan (proposed)</td>
<td>1 million to 1.4 million bbl/d</td>
<td>Russia and Kazakhstan</td>
<td>Bosphorus by-pass; initial construction began</td>
<td></td>
</tr>
</tbody>
</table>
## Turkish Gas Pipelines

<table>
<thead>
<tr>
<th>Name</th>
<th>Capacity</th>
<th>Source</th>
<th>Route</th>
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</tr>
</thead>
<tbody>
<tr>
<td>South Caucasus Pipeline (SCP) or Baku-Tbilisi-Erzurum (BTE)</td>
<td>20 bcma</td>
<td>Azeri gas (Shah Deniz)</td>
<td>Azerbaijan-Georgia-Turkey</td>
<td>Construction began in 2003; completed in 2006</td>
</tr>
<tr>
<td>Blue Stream Pipeline</td>
<td>16 bcma</td>
<td>Russian gas</td>
<td>Russia-Turkey via the Black Sea</td>
<td>Became operational in 2003; 750 miles</td>
</tr>
<tr>
<td>Iran-Turkey Pipeline</td>
<td>495 Bfc/year</td>
<td>Iranian gas</td>
<td>Iran-Turkey (Tabriz-Ankara)</td>
<td>First gas delivery in December 2001</td>
</tr>
<tr>
<td>Romania-Bulgaria-Turkey Pipeline</td>
<td>635 Bfc/year</td>
<td>Russian gas</td>
<td>Romania-Bulgaria-Turkey</td>
<td></td>
</tr>
<tr>
<td>Turkey-Greece</td>
<td>407 Bfc/year</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Proposed Gas Pipelines

<table>
<thead>
<tr>
<th>Name</th>
<th>Capacity</th>
<th>Source</th>
<th>Route</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trans-Caspian Gas Pipeline</strong></td>
<td>706 Btc/year</td>
<td>Turkmen gas</td>
<td>Turkmenistan to Azerbaijan to Georgia to Turkey</td>
</tr>
<tr>
<td>(TCP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nabucco Pipeline</strong></td>
<td>Up to 1.094 Tcm/year</td>
<td>Caspian and Middle Eastern Gas</td>
<td>Turkey-Bulgaria-Romania-Hungary-Austria</td>
</tr>
<tr>
<td><strong>Blue Stream 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Total Primary Energy Demand and Supply in Turkey

Turkey’s Total Energy Consumption in 2006 (BTU)

- Hydroelectric & Other Renewables: 11%
- Coal: 25%
- Oil: 35%
- Natural Gas: 29%

Energy import increases while the local energy production remains constant.

Turkey’s Oil Production and Consumption 1990-2007

Source: EIA International Petroleum Monthly; Short-Term Energy Outlook

Turkey’s Natural Gas Production and Consumption 1990-2006

Source: EIA International Energy Annual
Conventional thermal sources comprise the largest share of Turkey’s electricity supply.

**Total Generation in 2008**
- Thermal: 164,139 GWh
- Hydraulic: 33,270 GWh
- Wind: 0.846 GWh

**Total Consumption in 2008**: 198,418 GWh

*Source: EÜAŞ 2008-2009 Annual Report*
Turkey’s Wind Energy Potential

50 GWh/Year
Turkey’s Water Resources
Turkey’s Geothermal Energy Potential

1.4 GWh/Year
### Turkey’s Solar Energy Potential

(Turkey’s energy consumption is about 200 GWh/year)

**305 GWh/Year**

#### Regional Solar Energy Potential of Turkey

<table>
<thead>
<tr>
<th>Region</th>
<th>Total solar energy (\text{KWh/m}^2) per year</th>
<th>Sunshine duration (\text{hours per year})</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-eastern Anatolia</td>
<td>1 460</td>
<td>2 993</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>1 390</td>
<td>2 956</td>
</tr>
<tr>
<td>Eastern Anatolia</td>
<td>1 365</td>
<td>2 664</td>
</tr>
<tr>
<td>Central Anatolia</td>
<td>1 314</td>
<td>2 628</td>
</tr>
<tr>
<td>Aegean Region</td>
<td>1 304</td>
<td>2 738</td>
</tr>
<tr>
<td>Marmara Region</td>
<td>1 168</td>
<td>2 409</td>
</tr>
<tr>
<td>Black Sea</td>
<td>1 120</td>
<td>1 971</td>
</tr>
</tbody>
</table>

Source: MENR.

PVGIS © European Communities, 2001-2007
METU
@ A GLANCE
Established in 1956 with an international mandate
English as medium of instruction
MIDDLE EAST TECHNICAL UNIVERSITY (METU)

- 5 faculties, 5 graduate schools
- Engineering (45%), basic sciences (25%), social sciences (15%), architecture (7%), education (8%)

Degree programs:
- 53 undergraduate
- 99 masters
- 62 doctorate
(20 joint-degree programs with US & EU universities)
STUDENTS & STAFF @ METU

- 1,200 teaching staff (950 with Ph.D.); 2,600 academic staff in total
- 24,000 students (20% masters and 10% doctorate)
- Over 1,600 international degree-students from 80 countries
RESEARCH @ METU
RESEARCH @ METU

- Portfolio of nationally and internationally (primarily EU) sponsored scientific research projects
- Largest non-medical university Revolving Fund in the nation (contract research/consulting/testing services for industry)
- Faculty Development Program (FDP) Network
- One of the largest university technoparks on the globe
- Income from sponsored/contract research covering 35% of all university expenses, annually
- Placed 64th in “Industry revenues – innovation” and 119th in “Citations – research influence” among Top 200 universities (THE World University Ranking 2010)
METU TECHNOPOLIS

- 256 R&D companies; 900,000+ sq.ft. floor area; 200 acres land area
- 3,000 R&D workers; 3,500 employed in total
- Incubation and pre-incubation centers
RESEARCH PRIORITIES @ METU

- Renewable Energy, Ecosystems, and Sustainability
- Information Technology
- Biotechnology
- Advanced Materials
- Risk, Disasters, and Security
RESEARCH CENTERS @ METU

- Applied Ethics Research Center (UEAM)
- Audio-Visual Research and Production Center (GİSAM)
- METU-BILTIR Center (Bilgisayar Destekli Tasarım İmalat ve Robotik Araştırma Merkezi)
- Center for Black Sea and Central Asia (KORA)
- Center for Research and Assessment of Historic Environment (TAÇDAM)
- Central Laboratory - Molecular Biology-Biotechnology R&D Center - R&D-Training Center
- Construction Industry Training and Research Center (İSEM)
- Confucius Research and Application Center
- Continuing Education Center (SEM)
- Disaster Management Implementation and Research Center (AFET)
- E-Government Research and Application Center (EDMER)
- Entrepreneurship Research Center (GİMER)
- International Human Rights and Security Research Center
- Solar Energy Research and Application Center (GÜNAM)
- METU-Southeast Anatolia Project Research Center (GAP)
- Modeling and Simulation Research Center (MODSİM)
- Petroleum Research Center (PAL)
- R&D and Production Facility for Micro-Electro-Mechanical Systems (METU-MEMS)
- Research Center for Science and Technology Policies (TEKPOL)
- Research and Implementation Center for Built Environment and Design (RICBED)
- Society and Science Research and Application Center (TBM)
- Welding Technology and Non-Destructive Testing Research Center (KAYNAK)
CENTRAL LABORATORY
(Hosting METU-NANOLAB)

- Research and development center on **advanced material characterization** and **molecular biology-biotechnology**
- Offers state-of-the-art instrumentation for researchers and fosters:
  - Collaboration among researchers
  - Multi-disciplinary research
  - Training & education
  - Industry-university interaction
- Facilities of the Central Lab open to all researchers at METU
- Provides service to other universities, research institutions, and private industry
CENTRAL LABORATORY

MORE THAN 80 TEST AND ANALYSIS SYSTEMS AND EQUIPMENT WITH EXPERTISE IN THEIR USE FOR ADVANCED MATERIAL RESEARCH

- Electron Spectroscopy for Chemical Analysis (ESCA)
- FTIR and Raman
- Inductively Coupled Plasma-Mass Spectrometer

XRD, XRF, EMPA, SEM, AFM, TEM and TOF-SIMS

- Liquid and solid NMR
- Electron Spin Resonance (ESR)

Thermal ionization mass spectrometer
RESEARCH @ METU

Energy, Ecosystems, and Sustainability
METU I-REES
METU INITIATIVE for RENEWABLE ENERGY, ECOSYSTEMS & SUSTAINABILITY
METU I-REES

METU Initiative on Renewable Energy, Ecosystems, and Sustainability

OBJECTIVES

➢ Foster formation of a network of excellence in the areas of renewable energy, ecosystems and sustainability

➢ Provide a collaborative research platform – national and international/university – industry
METU I-REES

METU Initiative on Renewable Energy, Ecosystems, and Sustainability

ACTIVITIES

- Multidisciplinary natural sciences - engineering research and technology development
- Multidisciplinary social and administrative sciences research on the political, social, economic, and international aspects
- Knowledge dissemination, awareness raising, policy formulation
RELATED DEPARTMENTS AND INSTITUTES

- Aerospace Engineering
- Architecture
- Biology
- Biotechnology
- Business and Economics
- Chemistry
- Chemical Engineering
- Civil Engineering
- Environmental Engineering
- Institute of Marine Sciences
- International Relations
- Metallurgical and Materials Engineering
- Petroleum and Natural Gas Engineering
- Physics
- Political Science and Public Administration
- Sociology
RELATED RESEARCH CENTERS

- Solar Energy Research and Application Center (GÜNAM)
- Petroleum Research Center (PAL)
- R&D and Production Facility for Micro-Electro-Mechanical Systems (METU – MEMS)
- Research and Implementation Center for Built Environment and Design (MATPUM)
- Central Laboratory (CENT LAB)
- Center for Black Sea and Central Asia (KORA)
RELATED RESEARCH
@ METU TECHNOPOLIS

• 15 METUTECH enterprises with 200 R&D personnel, specializing in energy, ecosystems, and sustainability research

R&D PROJECT TOPICS
• “Intelligent” Built Environment Products
• Intelligent Power Networks
• New Techniques for the Elimination of Hazardous Substances (such as Solvent Recycling)
• Arsenic Elimination using Microfiltration of Potable Waters
• Biomass Technologies (mélange and wood byproducts)
• Plastic Recycling with Microorganisms
• Optimization Models in Electricity Systems
• Wind Source Modelling and Wind Energy Potential Analysis
RELATED RESEARCH
@ METU TECHNOPARK

R&D PROJECT TOPICS (Contd.)

• Wind Turbine Generators
• Silicon Wafers, Si-Solar Cells and Production Technologies
• Interconnectors and Electrodes for Solid Oxide Fuel Cells
• Silver Zinc Oxide Fuel Cells
• Integration of Hybrid Systems in Automobiles to Increase Fuel Efficiency and to Save Energy
• Carbon Foot Print Calculation Tools
• Design of Carbon Trade Automation Systems
• Renewable Energy Information Systems (Suitable Region Determination and Feasibility)
• Inverter Systems for Solar Energy Power Generation
METU I-REES
Initiative on Renewable Energy, Ecosystems, and Sustainability

Renewable Energy
- Solar Energy
- Wind Energy
- Biomass
- Biohydrogen and Fuel Cells
- Geothermal
- Hydropower
- Energy Storage and Advanced Materials

Sustainable Environmental Management and Technologies
- Energy Efficiency / MEMS
- Sustainable Environmental Management
- Sustainable Environmental Technologies
- Clean Combustion

Ecosystems
- Marine Ecosystems and Climate Studies
- Freshwater Ecosystems
- Biological Diversity

Built Environment
- Sustainable Buildings and Cities
- Sustainable Transportation
- Sustainable Campus
- Materials Science and Construction Technologies

National and Regional Sustainability Governance
- Social, Political and Economic Studies
- Regional Studies

ACTIVITIES RELATED WITH KNOWLEDGE DISSEMINATION, AWARENESS RAISING AND POLICY FORMULATION
INTERNATIONAL RESEARCH COLLABORATION

Energy, Ecosystems, and Sustainability
REES-RELATED INTERNATIONAL RESEARCH PROJECTS

- Nanophotonics Research for Solar Energy Applications (ITTB – WUSTL – METU)(Completed)
- ASCABOS (A Supporting Program for Capacity Building in the Black Sea Region Towards Operational Status of Oceanographic Services)
- BLACK SEA SCENE (Black Sea Scientific Network)
- BLACKMODE (Trophic Controls in the Black Sea Ecosystems)
- ECOOP (European Coastal Sea Operational Observing and Forecasting System)
- IASON (International Action for Sustainability of the Mediterranean and Black Sea Environment)
REES-RELATED INTERNATIONAL RESEARCH PROJECTS (Contd.)

- SEAHELLARC (Seismic and Tsunami Risk Assessment and Mitigation Scenarios in the Western Hellenic Arc)
- CITYZEN (Megacity-zoom for the Environment)
- MEECE (Marine Ecosystem Evolution in a Changing Environment)
- KNOWSEAS (Knowledge-based Sustainable Management for Europe’s Seas)
- SHARE (Seismic Hazard Harmonization in Europe)
- MEDPOL 2010 Pollution Surveillance
- REFRESH (Adaptive Strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems)
- CGS Europe (Pan-European Coordination Action on CO$_2$ Geological Storage)
REES-RELATED INTERNATIONAL RESEARCH PROJECTS (Contd.)

- SYNER-G (Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructures Safety Gain)
- TRANSFER (Tsunami Risk and Strategies for EU)
- EUR-OCEANS (European Network of Excellence for Ocean Ecosystems Analysis)
- MEDAWARE (Development of Tools and Guidelines for the Promotion of the Sustainable Urban Wastewater Treatment and Reuse in the Agricultural Production in the Mediterranean Countries)
- WETLAND and PHYTOPLANKTON (Greek-Turkish Cooperation for the Strengthening of Protection and Management of Wetland Areas – European Directive 2000/60)
PARTNER INSTITUTIONS
Europe

- UNIWERSYTET ZIELONOGORSKI, POLAND
- DANMARKS METEOROLOGISKE INSTITUT, DENMARK
- SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT, SWEDEN
- ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE OGS, ITALY
- CENTER OF MARINE RESEARCH, LITHUANIA
- STATO MAGGIORE AERONAUTICA - UFFICIO GENERALE SPAZIO AEREO E METEOROLOGIA, ITALY
- INSTITUTO SUPERIOR TECNICO, PORTUGAL
- INSTITUT FRANCAIS DE RECHERCHE POUR L'EXPLOITATION DE LA MER, FRANCE
- BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES, FRANCE
- ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA, ITALY
- LABORATORIO NACIONAL DE ENGENHARIA CIVIL, PORTUGAL
- HELMHOLTZ-ZENTRUM POTSDAM DEUTSCHES GEOFORSCHUNGSZENTRUM, GERMANY
PARTNER INSTITUTIONS
Europe (Contd.)

• MACAULAY LAND USE RESEARCH INSTITUTE, UK
• NORWEGIAN INSTITUTE FOR AGRICULTURAL AND ENVIRONMENTAL RESEARCH – BIOFORSK, NORWAY
• INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES, BULGARIA
• SIR ALISTER HARDY FOUNDATION FOR OCEAN SCIENCE, UK
• SUOMEN YMPARISTOKESKUS, FINLAND
• EUCC - COASTAL & MARINE UNION, THE NETHERLANDS
• INSTITUTE FOR EUROPEAN ENVIRONMENTAL POLICY, UK
• AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, SPAIN
• KARLSRUHER INSTITUT FUER TECHNOLOGIE, GERMANY
• STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK, THE NETHERLANDS
• UNIVERSITE JOSEPH FOURIER GRENOBLE 1, FRANCE
PARTNER INSTITUTIONS
Asia & Middle East

- Peking University, China
- National University Corporation Kobe University, Japan
- Academia Sinica, Taiwan
- Korea Institute of Science and Technology Information, Korea
- Chonnam National University, Korea
- Inter-University Research Institute Corporation, High Energy Accelerator Research Organisation, Japan
- The Open University, Israel
- Cairo University, Egypt
- Ben-Gurion University of the Negev, Israel
- Israel Oceanographic and Limnological Research Limited, Israel
- Tel Aviv University, Israel
- Centre de Recherche en Astronomie Astrophysique et Geophysique, Algeria
PARTNER INSTITUTIONS
North America

- WASHINGTON UNIVERSITY IN ST LOUIS, USA
- UNIVERSITY OF ILLINOIS SYSTEM, USA
- UNIVERSITY OF WISCONSIN-MADISON, USA
- TRENT UNIVERSITY, CANADA
- WASHINGTON STATE UNIVERSITY, PULLMAN, USA
- VILLANOVA UNIVERSITY, PENNSYLVANIA, USA
PARTNER INSTITUTIONS
Other Regions

• BIOTEST, COOPERATIVE ENTERPRISE FOR RESEARCH & PRODUCTION, RUSSIA
• STATE RESEARCH CENTER OF RUSSIAN FEDERATION - INSTITUTE FOR HIGH ENERGY PHYSICS, RUSSIA
• INSTITUTE OF MATHEMATICAL PROBLEMS OF BIOLOGY OF THE RAS, RUSSIA
• A.V. TOPCHIEV INSTITUTE OF PETROCHEMICAL SYNTHESIS - RUSSIAN ACADEMY OF SCIENCES, RUSSIA
• SCIENTIFIC FOUNDATION NANSEN INTERNATIONAL ENVIRONMENTAL AND REMOTE SENSING CENTRE, RUSSIA
• MOSCOW LOMONOSOV STATE UNIVERSITY, BIOLOGICAL FACULTY, RUSSIA
• GEOPHYSICAL CENTER OF THE RUSSIAN ACADEMY OF SCIENCES, RUSSIA
PARTNER INSTITUTIONS
Other Regions (Contd.)

- RUSSIAN RESEARCH CENTRE KURCHATOV INSTITUTE, RUSSIA
- MARINE HYDROPHYSICAL INSTITUTE - UKRAINIAN NATIONAL ACADEMY OF SCIENCES, UKRAINE
- A.O. KOVALEVSKY INSTITUTE OF BIOLOGY OF SOUTHERN SEAS, UKRAINE
- UNIVERSITY OF CAPE TOWN, SOUTH AFRICA
- UNIVERSITY OF THE WITWATERSRAND, SOUTH AFRICA
- INSTITUT NATIONAL DE RECHERCHE HALIEUTIQUE, MOROCCO
- MILLI VE BEYNELXALQ ARASDIRMALAR MERKEZI ASSOCIATION, AZERBAIJAN
INTERDISCIPLINARY
GRADUATE EDUCATION AND TRAINING @ METU

Energy, Ecosystems, and Sustainability
Graduate School of Natural and Applied Sciences

M.Sc. and Ph.D. Programs in
EARTH SYSTEM SCIENCES
OBJECTIVES

- To meet national, regional and global demand for trained professionals in Earth System Sciences
- To train professionals and students such that they;
  - Are able to understand scientifically the interactive and complex nature of natural and human activity systems that affect life on earth through processes such as climate change, land use, resource depletion and environmental degradation.
  - Support the processes of planning, techno-economic policy issues, and decision making for sustainable development; alleviation of poverty in natural and unnatural disasters, and rational use of natural resources.
  - To emphasize a research-oriented, global systems approach to study the atmosphere, hydrosphere, and lithosphere, including their interrelationships and interactions with the biosphere
- To emphasize observation and quantitative analysis of Earth systems
<table>
<thead>
<tr>
<th>Track No</th>
<th>Area Name</th>
<th>Program Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Earth System Science</td>
<td>M.Sc. and Ph.D.</td>
</tr>
<tr>
<td>II</td>
<td>Earth System Modeling</td>
<td>M.Sc. and Ph.D.</td>
</tr>
</tbody>
</table>

**Departments involved:**

**Graduate School of Natural and Applied Sciences**
- Aerospace Engineering
- Architecture
- Biology
- Chemistry
- City and Regional Planning
- Civil Engineering
- Computer Engineering
- Engineering Sciences
- Geology Engineering
- Industrial Engineering
- Environmental Engineering
- Physics
- Statistics

**Graduate School of Marine Sciences**
- Business Administration

**Graduate School of Social Sciences**
- International Relations
CONTINUING EDUCATION CENTER

Certificate Programme on

CLIMATE CHANGE, ADAPTATION POLICIES, AND TURKEY
Certificate Program offered through collaboration between

Middle East Technical University
Earth System Science Program

&

United Nations Joint Programme on Enhancing the Capacity of Turkey to Adapt to Climate Change
OBJECTIVES

• To train the employees of public (such as ministries) and private sector institutions, universities, research institutions, and NGOs on
  • climate change,
  • impact of climate change,
  • adaptation strategies, adaptation policies and planning,
  • understanding of the social, communal and economic dimensions of adaptation, as well as interaction between climate change and sustainable development policies
  • current state-of-affairs on the Turkish scene

• To build capacity in this field, also by helping related agencies in their policy formulation and re-organization efforts
NORTHERN CYPRUS CAMPUS

M.Sc. Program
in
SUSTAINABLE ENVIRONMENT & ENERGY SYSTEMS
OBJECTIVES:

• To excel in *interdisciplinary research and education* of *sustainable environment and energy systems*;

• To graduate scientists, managers, and leaders, who *produce high quality designs and services* for a sustainable environment using scientific data, and to advance social awareness and sensitivity in the area.

• Emphasis on “Sustainability of the *vital triad*”, including technology, engineering development, politics, economics, business aspects

• Research supported through 12-month TA/RA programs and industry collaboration
M.Sc. in Sustainable Environment & Energy Systems (SEES)

Mandatory Courses:
Political Economy and Law in Sustainability
Energy Systems and Sustainability
Sustainable Water Resources

SEES Thesis Focus Areas:
Environmentally friendly energy production technologies
Efficient energy distribution and use
Sustainable production and construction
Waste management
Water supplies
Ecological assessment
Climate
FUNDING SOURCES FOR MAGEEP JOINT PROGRAMS AND KEY ACTIVITIES

1. Bilateral agreements for joint research:

   Bilateral agreements between (TÜBİTAK - Scientific and Technological Research Council of Turkey) and research councils of 23 countries: Belarus, Bulgaria, China, France, Germany, Greece, Hungary, India, Italy, Japan, Macedonia, Mongolia, Pakistan, Romania, Russia, Singapore, Slovakia, Slovenia, S.Korea, Syria, Tunisia, United States of America, Ukraine.

2. Research Funding Programme of EU – 7th Framework Programme:

   COOPERATION (collaborative research - EU and beyond)
   PEOPLE (mobility of researchers – EU and beyond)

Themes: Energy, Environment and Climate
FINANCIAL AND LEGAL PARTNERSHIP BARRIERS TO WORK ON

• Limited funding for collaborative research and researcher mobility

• Lack of collaborative research agenda and platforms: disjointed national research programs, technology platforms, research centers, etc.

• Diverse legal and financial systems, administrative regulations, and bureaucratic practices in different countries burdening management of international research projects

• Institutional bureaucracy hindering collaborative programs and joint research projects
THANK YOU
Micro-Electro-Mechanical Systems Research and Application Center (METU – MEMS)

Assoc. Prof. Dr. Haluk KÜLAH
Department of Electrical and Electronics Engineering

Contact:
kulah@metu.edu.tr
METU-MEMS

- Developing various microsensors and systems since 1995 (Director: Prof. Dr. Tayfun Akın)
- 4 patent applications
- 1300 m² clean room allowing Class 100 and 1000 processes
- <0.35µm 4”, 6”, and 8” wafer processing

FACILITIES
- ASML Stepper
- Suss Automatic Photoresist Coater
- EVG Double-sided aligner
- EVG Wafer bonder
- STS DRIE, RIE, PECVD, ICP RIE
- Diffusion and oxidation furnaces
- LPCVD oxide, nitride, poly
- Evaporation (Au, Ni, Cr, Cu, Ti.)
- Sputtering (Al, Cr, Ni-Cr, Cu, Ti, Ta)
- Anisotropic silicon etch (KOH, TMAH, EDP)
- Isotropic silicon etch
- Electrochemical etch-stop (KOH, TMAH)
- Electroplating (Ni, Cu, Au), SU-8 Molding
- Wafer dicing (Disco DAD)
- SEM, FESEM (JEOL)
- Critical point drying
- Veeco Optical Profilometer
- Heidelberg DWL200 Mask Maker
- FTIR-VASE Spectrometer (2-33µm)
- Veeco - Dektak 8
Research Topics

- CMOS uncooled infrared detectors
- Gyroscopes/Accelerometers
- RF MEMS
- BioMEMS/Microfluidics
- **Energy Harvesting (PowerMEMS)**
- Piezoresistive Pressure Sensors
- Capacitive Pressure Sensors
- CMOS Humidity Sensors
- CMOS Thermopiles
- CMOS Temperature Sensors
METU-MEMS Energy Harvesting

Projects

• INTEL Corp, TÜBİTAK, TOFAŞ

Various Prototypes

• Harvesting from vibration
  • Single frequency and wide-band harvesters
  • Micro & macro frequency up-converters

• Harvesting from temperature difference
  • Thermocouples

• Multi-source harvesters
  • Thermal and Vibration
  • Thermocouples

Overall Power Output vs Frequency

Magnitude of Power (Watt)
Middle East Energy Efficiency Research (MER) Center at METU Northern Cyprus Campus

http://www.ncc.metu.edu.tr
Established in 2009 to start collaboration among INTEL Corp., KACST (King Abdulaziz City for Science and Technology, SA), and research groups in the Middle East working on *hardware and software solutions toward energy efficient computing*

- METU NCC Co-chairing the 1st Technical Committee, and Executive + Technical Committee Summit in Istanbul (Oct. 2010)
- 1st MER Sponsored Conference on Energy Aware Computing to be held in Cairo (Dec. 2010) ([http://www.energyawarecomputing.org](http://www.energyawarecomputing.org))

**RESEARCH TOPICS**

- Currently one METU-NCC and one METU-Ankara student at INTEL-USA with *MER Internship Program* – both working on relevant topics in energy aware computing
- Collaboration agreement between METU-NCC and INTEL involves development of MEMS modules for integration of renewable energy sources into computing platforms
- Renewable Energy Design and Applications Research (REDAR) group at METU-NCC collaborates with Micro-Electromechanical Systems (MEMS) group at METU-Ankara
Solar Energy Research and Development Center (GÜNAM)

Prof. Dr. Raşit TURAN
Department of Physics

Contact:
turanr@metu.edu.tr
Activities on Photovoltaics at METU Solar Energy Research and Application Center

SOLAR ENERGY RESEARCH and APPLICATION CENTER (GÜNAM)

- METU Micro-Electro-Mechanical Systems Center
  Wafer based Si cell processing

- METU Central Lab
  (Material Characterisation)

- METU Technopolis Companies
  (Solar Module Production)

- Advisory board
  (Energy Ministry, private companies, international advisors, university representatives)

- METU Hydrogen Research Laboratory
  Prof. Dr. İnci Eroğlu
  Prof. Dr. Gürkan Karakaş
  Chemical Eng.

- GaAs Based (MBE) Solar Cells
  Electrical Eng.

- METU NCC MER Concentrating Solar Power

- BIPV Systems
  Faculty of Architecture

- Thin Film Solar Cells
  Wafer Based Si Solar Cells
  Nanocrystal Based Solar Cells
  Prof. Dr. Çiğdem Erçelebi
  Prof. Dr. Raşit Turan
  Prof. Dr. Mehmet Parlak
  Physics
  Assist. Prof. Dr. Emrah Ünalan
  Metallurgical and Material Eng.

- Organic/Polymer Solar Cells
  Prof. Dr. Levent Toppare
  Chemistry

- GaAs Based (MBE) Solar Cells
  Electrical Eng.

- Dye Synthesized Solar Cells
  Prof. Dr. Macit Özenbaş
  Metallurgical and Material Eng.
Research Topics of Solar Energy R&D Center

- Single Crystal Si Solar Cells
- Thin Film Solar Cells
  - a-Si/c-Si Heterojunction Solar Cells
    - Deposition and electrical, structural, optical characterization of CdS, CdSe, InSe, GaSe, CdTe, Ag(In1-xGax) Se thin films for photovoltaic applications
    - Preparation and characterization of thin film heterojunction and Schottky type solar cell device structures
- Dye Synthesized Solar Cells
- Organic Solar Cells
- Studies towards third generation Solar Cells
- Si nanocrystals in dielectric thin film matrix for photon (solar spectrum) shifting
Thin Film, Wafer Si, Amorph-Si, Nanocrystal Based Solar Cell Studies

Prof. Dr. Çiğdem ERÇELEBİ - ercelebi@metu.edu.tr
Prof. Dr. Mehmet PARLAK - parlak@metu.edu.tr
Prof. Dr. Raşit TURAN - turanr@metu.edu.tr

Department of Physics
Fabrication of Single Crystal Si Solar Cells

METU-MEMS facilities are currently being used to develop a number of MEMS products, and monocystal Si based solar cells

Mono-Crystal and Multi-Crystal Solar Cells with 6 inch wafers
Thin Film Silicon Solar Cells

- a-Silicon thin film solar cells
- Multi Chamber Full automated PECVD System
- E-beam and sputter systems
- Laser scribing system will be installed in October 2010
- Ag(Cu)InGaSe thin film based solar cells
- CdTe/CdS thin film solar cells
- InSe thin film based solar cells

$\mu c$-$\text{Si:H}$

Glass

$\text{Ag(Cu)InSe}_2$

Ag, In, Al, Au

ITO glass

1.8-2.2 $\mu$m

$\mu c$-$\text{Si:H}$

2-3 $\mu$m

Metal back contact

Laser Scribing System
Research on new concepts for new generation solar cell devices

1. Effect of plasmon oscillation induced in metal nanoparticles on solar cell
   - Metal nanoparticles enhance optical absorption

2. Zeolite with nanoporous structure is expected to be useful in fabrication of new solar cell devices

3. Production of Si, Ge nanocrystal for third generation solar cells

Luminescence spectra obtained from Si nanocrystals emmbedded in SiO2 matrix

Nano-Enhanced Solar Cell
Cheap and scaleable synthesis of nanomaterials and their utilization in various PV systems

Assist. Prof. Dr. Emrah ÜNALAN
Department of and Metallurgical and Materials Engineering
Contact: unalan@metu.edu.tr
Nano-Enhanced Solar Cells

Hydrothermally grown ZnO NWs

Polymer infiltrated ZnO NWs

Nano-Enhanced Solar Cells

Organic and dye sensitized solar cells with ZnO NWs

Plasmonic solar cells with Ag nanoparticles

Transparent and conducting thin films with Ag nanowires
Dye Sensitized Solar Cell (DSSC) Studies

Prof. Dr. Macit ÖZENBAŞ
Department of and Metallurgical and Materials Engineering
Surface Sciences Research Laboratory

Contact:
ozenbas@metu.edu.tr
RESEARCH TOPICS

- Production of Transparent Anode ITO Thin Film
- Production of ITO nanowires and nanopowders
- Production of TiO$_2$ Paste and films
- Production of ZnO Film
- ITO- TiO$_2$ Nanocomposite Dye Sensitized Solar Cells
- ZnO Quantum Dot Modified Dye Sensitized Solar Cells (QD-DSSC)

<table>
<thead>
<tr>
<th>Concentration of ITO nanowires</th>
<th>Efficiency of DSSC</th>
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<tr>
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Photovoltaic and Electrochromic Applications of Benzotriazole Bearing Donor-Acceptor Type Polymers
Towards Multifunctional Materials

Prof. Dr. Levent TOPPARE
Department of Chemistry
Contact: toppare@metu.edu.tr
RESEARCH TOPICS

- Two benzotriazole bearing donor-acceptor type monomers were synthesized and characterized.
- Their electrochromic and photovoltaic properties were investigated in detail.
- PPyBT and PHTBT are promising multipurpose materials to be used in ECDs, OLEDs, OFETs and Solar Cells.
Utilization of Concentrating Solar Power

Solar Trigeneration Project
SOLTRIGEN

- Electricity
- Cooling
- Heating

Power Generation Process

Organic Rankine Cycle

Cooling Tower
(Demineralized water)

Absorption chillers

Solar Panels at METU NCC

Heat Source

Cooling Process
Solar Tri-Generation Project
SOLTRIGEN

Partners and tasks of SOLTRIGEN project

SOLITEM GROUP (Germany)
• Provides all the components of the system:
  • parabolic trough collectors
  • ORC system
  • hydraulic system
• Provides technology of solar thermal processes

EUS GmbH (Germany)
• Software applications for process control
• Communications and control system online for monitoring and operating process
• Consulting service for optimization of the process

METU Northern Cyprus Campus
• Responsible for the installation and maintenance of the whole system
• Supports of the optimization of the system and the experimental measurements
• Consumer of the product
Wind Energy Research

Assist. Prof. Dr. Oğuz UZOL
Department of Aerospace Engineering

Contact:
uzol@metu.edu.tr
RESEARCH TOPICS

- Effect of wind shear on turbine aerodynamics
- Rotor blade aerodynamic design optimization
- Active tip vortex control using unsteady tip injection
- Wind farm optimization and aerodynamic interactions

Rotor blade aerodynamic design optimization
Related Research in Metallurgical and Materials Engineering

Prof. Dr. Tayfur ÖZTÜRK
Department of Metallurgical and Materials Engineering

Contact:
ozturbk@metu.edu.tr
Direct Synthesis of FeTi hydrogen storage alloys from their oxides via electroreduction at 900 ºC for 24 hrs 3.2 V
Tan et al., J Alloys and Compounds. 2010

Direct Synthesis of Si from SiO₂ via solid-state deoxidation at 600 ºC
E. Ergül and I. Karakaya. 2010

Mg-5 %Cu thin film with 5.5 wt %H₂ storage capacity
RESEARCH TOPICS

- ZnO Nanowire LED’s
Related Research in Petroleum and Natural Gas Engineering

Prof. Dr. Mahmut PARLAKTUNA
Department of Petroleum and Natural Gas Engineering

Contact:
mahmut@metu.edu.tr
RESEARCH TOPICS

• CLIMATE CHANGE and CARBON CAPTURE STORAGE
  • Identify geological structures (depleted gas and oil reservoir, deep saline aquifers) suitable for CO₂ sequestration
  • Pan-European EU Project - Coordination Action on CO₂ Geological Storage

• NATURAL GAS HYDRATES

• PLUGGING
  • KINETIC and THERMODYNAMIC inhibition of natural gas hydrates
  • Hydrate formation conditions of polymer based drilling fluids

• HYDRATES AS ENERGY RESOURCE
  • Determination of hydrate formation conditions of Black Sea
  • Gas recovery methods from natural gas hydrates reservoirs

• GEOTHERMAL ENERGY
  • Resource estimation studies of geothermal sites
  • Reservoir engineering studies
  • Scale inhibition
Related Research in Environmental Engineering

Prof. Dr. Göksel DEMİRER
Department of Environmental Engineering

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RESEARCH TOPICS

• Drinking water analysis and quality assessment
• Investigation of the quality of the surface and underground water
determination of the polluting sources and development of methods
to remove pollution
• Analysis of the treatment plant sludge produced by different activities
• Determination and application of the suitable disposal methods for
the hazardous wastes and investigation of the environmental impacts
of different industrial activities, risk assessment studies
• Determination of the atmospheric pollutants, exploration of their
sources, and their effects on the environment
• Development and application of mathematical models for waste
disposal systems, surface and groundwater, soil and atmospheric
pollution
• Preventive environmental management and cleaner production in
industrial enterprises
• Bioenergy and biobased products from wastes
Turkey’s Water Resources and Aqueous Processes

Prof. Dr. Melih YANMAZ
Department of Civil Engineering

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myanz@metu.edu.tr
RESEARCH TOPICS

• HYDROLOGY
  • Hydrologic modelling
  • Land-atmosphere interaction
  • GIS and RS applications

• WATER RESOURCES
  • Design of hydraulic structures (Dams, weirs, canals, bridges, etc.)
  • Analysis, operation and management of water resources
  • Optimization of water resources
  • Water quality control, treatment and management
  • Hydropower potential estimation

• SOME APPLIED RESEARCH ACTIVITIES
  • Modeling of water distribution networks of some cities
  • Water Quality Management (EUMETSAT H-SAF Project)
  • Flood forecasting and management studies in several basins
  • Inspection and monitoring practices of river structures
  • Dam instrumentation practices
  • Emergency action plan development for some hydropower dams
  • GIS / RS applications in various fields of water resources
Production of Value-Added Products from Biomass

Prof. Dr. Ufuk BAKIR
Department of Chemical Engineering and Department of Biotechnology

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RESEARCH TOPICS

• CONVERSION OF BIOMASS INTO VALUABLE PRODUCTS
  • Microbial enzyme production from agricultural wastes
  • Microbial organic acid and ethanol production from agricultural wastes
  • Prebiotic production from hemicellulose obtained from agricultural wastes
  • Biodegradable packaging film production from agricultural wastes
  • Cellulose, hemicellulose and lignin separation by the use of ionic liquids

Figure 4. Effect of lignin concentration on film formation of bioethanol lignin/syrup (% (w/v)): (A) 0.567 ± 0.002; (B) 0.609 ± 0.004; (C) 0.686 ± 0.004; (D) 1.061 ± 0.001; (E) 1.242 ± 0.051; (F) 1.42 2 ± 0.005.

Figure 5. SEM images of surface of the films: (A) film dried at 50 °C and 70% RH; (B) film dried at 80 °C and 35% RH.
Biological Hydrogen Production and PEM Fuel Cell R&D Activities

Prof. Dr. İnci EROĞLU - ieroglu@metu.edu.tr
Department of Chemical Engineering

Prof. Dr. Meral YÜCEL - meraly@metu.edu.tr
Prof. Dr. Ufuk GÜNDÜZ - ufukg@metu.edu.tr
Department of Biological Sciences
RESEARCH TOPICS
• Biological Production of Hydrogen
• BioHydrogen Production from Biomass
• Hydrogen Production and Fuel Cell
• Physiology and Biochemistry of PNS Bacteria Genetics -and Strain Improvement

PROJECTS
• Nonthermal Pure Hydrogen Production from Biomass HYVOLUTION
  EU 6th Frame Program Integrated Project: 22 partners, 10 EU countries,
  Photofermentation (WP3): Coordinator: İnci EROĞLU, Turkey (METU)
• Effect of heat and cold stress on the hydrogen production metabolism of
  *Rhodobacter capsulatus*
• Long Term Stability and Development of Composite Membranes and
  Electrocataylst for PEM Fuel Cell
• Development of a Prototype 100W PEM Fuel Cell and Sodium Boronhydride
  Hydrogen Reactor
Simulation of Steady and Transient Radiative Transfer & Mathematical Modelling of Spectral Radiative Transfer in Enclosures

Prof. Dr. Nevin SELÇUK
Department of Chemical Engineering

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selcuk@metu.edu.tr
RESEARCH TOPICS

• FLUIDIZED BED COMBUSTION RESEARCH
  • Pilot-scale combustion and emission testing in the test facilities fired with indigenous lignite, Mathematical modelling of Fluidized Bed Combustion systems

• OXY-FUEL COMBUSTION
  • Results reveal that combustion in O₂/CO₂ environment is delayed to a small extent compared with that in O₂/N₂ environment at the same oxygen concentration. As oxygen concentration increases combustion rate increases and burnout time gets shorter.

• GREEN CEMENT FROM FBC ASHES
  • Chemical, mineralogical and microscopic analyses reveal that FBC ashes up to 25% can be utilized as raw materials in the production of the green cement.

• CLIMATE CHANGE
  • Current results will display the effect of accuracy of the radiation code on the prediction of global temperatures for CO₂ sensitivity analysis
Research Unit for Freshwater Ecosystems (RUFE)

Prof. Dr. Meryem BEKLİOĞLU
Department of Biological Sciences
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Conceptual Structure of Research Unit for Freshwater Ecosystems (RUFE)

Impacts
- Climate Change
- Agriculture, settlement, and industry

Consequences
- Hydrology
- Water Chemistry
- Ecological processes
- Biodiversity

Ecosystem Management
- Mitigation
- Adaptation
- Restoration

Vulnerability, Indicator, References

Nutrients and Pollutants
- Precipitation

Aquatic Ecosystems
RESEARCH TOPICS

- Hydrology, hydrometeorology, Hydro-eology, Hydrogeochemistry
- Ecology, paleoecology, animal ecology, ecogenetics, ecotoxicology
- GIS, RS Modeling
- Socio-economic and planning for ecosystem management
- Training and dissemination

DEPARTMENTS INVOLVED AT RUFE
Marine, Coastal, Ecosystem and Climate Research

Assoc. Prof. Dr. Barış SALİHOĞLU
Institute of Marine Sciences

Contact:
baris@ims.metu.edu.tr
RESEARCH TOPICS

• Some Current Projects
  • SESAME (Southern European Seas: Assessing and Modeling Ecosystem Changes) FP6
  • BlackSeaScene (Black Sea Scientific Network) FP6-FP7
  • ECOOP (European Coastal sea Operational Observing and Forecasting System)
  • MEECE (Marine Ecosystem Evolution in a Changing Environment)
Research and Implementation Center for Built Environment and Design (RICBED)

Assoc. Prof. Dr. Melih PINARCIOĞLU
Department of City and Regional Planning

Contact:
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This R&D center linked to the Faculty of Architecture encompasses the fields of architecture, design and planning ranging from scales at the level of building to urban space.

Human factors, as well as environmental factors are taken into consideration in all research and implementation projects.

RICBED “Energy Efficient Building” (in service since August 2006) is outstanding with its design, construction and management processes.
ENVIRONMENT AND USER-FRIENDLY PROJECTS

• EU HEGEL – MATPUM-FIAT: High Efficiency Polygeneration Application Combi Cycle Application Project for the establishment of an energy park
  • Efficient usage of sustainable energy sources
    (e.g. geothermal heat pumps, solar systems, wind power)
  • Energy economy, rational usage of resources, reduction of greenhouse gas emission and global sustainability
  • System is installed and undergoing initial tests
    • 91% total energy efficiency – two staged energy and heat generation
    • 72% energy efficiency, minimum carbon emission levels
    • 45% of fuel economy

• ESER CONSTRUCTION COMPANY GREEN OFFICE BUILDING PROJECT

• RICBED designed a state-of-art green building for ESER
  • Architectural design and energy-environment consultancy
  • LEED criteria

• Renewable and sustainable mechanical elements for green mechanical systems:
  • wind turbines
  • solar cells (PV)
  • solar collectors
  • energy storage system
  • geo-thermal heat pump
  • natural gas-driven trigeneration system including absorbing cooling machine
  • Reduced redundant water consumption via rainwater collection and greywater systems
ENVIRONMENT AND USER-FRIENDLY PROJECTS

• **MATPUM – TURKISH RED CRESCENT SOCIETY (TRCS):** Red Crescent R&D Building for Turkish Red Crescent Research Unit (TUKAM)
  • “Eco-friendly” building with its energy efficiency requirements reduced by 60% (south facing brick trompe-wall and high efficiency insulation)
  • Electrical energy requirements of building (400 m²)
    • Transparent window-type solar cells (photovoltaic panels) on the roof and walls
    • 2 vertical-axis wind turbines on the roof for experimental purposes
  • In summer, the poly-generation system in the RICBED building will be used for the cold storage used by the TRCS
    • Transforming trigeneration system with minimum carbon emission
Related Research in the Social Sciences

Prof. Dr. Meliha ALTUNIŞIK
Director, Institute of Social Sciences

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SOCIAL SCIENCE PERSPECTIVE on ENERGY in METU

- Underlining Political, Social, Economic and International aspects of energy issues
- Conducting social scientific research within a multidisciplinary perspective

RELATED DEPARTMENTS and RESEARCH CENTERS

- International Relations
- Political Science and Public Administration
- Economics
- Sociology
- Center for Black Sea and Central Asia
RESEARCH TOPICS

• Global Environmental Issues and Political Economy of International Oil
• Law of the Marine Environment and Governance of Transboundary Water Systems
• Environmental Change and International Security
• Transboundary Water Resource Management
• North-South Relations: Environment, Development and Security
• Politics of Water Resources in the Middle East
• Problems in International Security
• Turkey as a Major Gas Transit Hub Country
• Evaluation of the Energy Resources of Turkey with Respect to World Prospects
• Turkey’s Energy Security and Its Energy Cooperation with the EU and Russia
• Causal Relationship between Energy Consumption and Economic Growth
• EU Energy Security and Middle East Oil
• Turkey’s Energy Policies and Eurasian Region
• Caspian Oil and Gas in International Energy Policy: Opportunities for Turkey
• Promoting Energy Efficiency in Turkey in the Light of Best Practices at the Levels of EU and Selected Member States
• International or Supranational Electricity Market? British and Turkish Cases
FACULTY DEVELOPMENT PROGRAM (FDP)

- Initiated in 2001, Faculty Development Program (FDP) is an inter-university network promoting cooperation in research & education.

- Major aim is to meet the need for teaching faculty in Turkish universities, to improve the quality of research and education, and facilitate transfer of knowledge among Turkish universities.

- Currently, there are 580 future faculty members from 51 Turkish and 22 non-Turkish universities studying towards their Ph.D. degrees at METU.
FACULTY DEVELOPMENT PROGRAM (FDP)

JULY 2001  5 FDP UNIVERSITIES IN TURKEY

JULY 2009  51 FDP UNIVERSITIES IN TURKEY
           22 FDP UNIVERSITIES ABROAD