



8TH JAPAN-SAARC ENERGY SYMPOSIUM

Centre for Advanced Studies in Energy at NUST

Medium Term Vision for Energy Connectivity in the SAARC region
10-11 March 2015, Islamabad, Pakistan



National University of Sciences & Technology
Centre of Advanced Studies in Energy at NUST (CAS-EN)





SAARC VISION & CAS-EN

SAARC Working Group in Energy is mandated with creating South Asian energy cooperation including the concept of an Energy Ring with aims:

- a) to promote development of energy resources, and energy trade in the region;
- b) to develop renewable and alternative energy resources;
- c) to promote energy efficiency and conservation in the region

With a similar vision, CAS-EN was created in 2011 for addressing energy requirements of Pakistan by influencing policy makers, developing technologies, human resources and mobilizing communities for energy conservation



Activities and Role of CAS-EN

Activities at CAS-EN contribute in developing technologies to attract capital investment necessary to grow the economy of the country and the region through;

- **Excellence in Teaching & Education:**

Provide high quality education in science and technology, while remaining accessible to all sections of society.

- **Focus on Research:**

Undertake high quality, yet relevant research to support the emerging knowledge-based economy and society.

- **Promote Spirit of Entrepreneurship:**

Develop instruments and mechanism for promotion of enterprising spirit and entrepreneurial culture among CAS-EN graduates and create strong linkages with industry.

- **Develop International Collaboration Across the Globe:**

Develop strong international linkages to ensure inflow of new knowledge and state-of-the-art technologies

- **Bringing Positive Social Impact Through Structured Curriculum and Programs:**

Structured curriculum and programs to influence a wider cross-section of the population in terms of education and absorption of innovative technologies.

Centre for Advanced Studies in Energy (CAS-EN) – Quick Facts and Figures

- CAS-EN established in Year 2011
- First Postgraduate Entry in Sept./2012
- Current student enrollment: 74
- Graduated Students with MS: 21
- Current location at NUST, Islamabad:
 - School of Chemical & Materials Engineering
 - School of Architecture
 - School of Mechanical & Manufacturing Engineering (West Block)
- Research Groups: 5
 - i. Bio-fuels Engineering Group
 - ii. Advanced Energy Materials & Fuel Cells
 - iii. FT Synthesis and Coal Technology Group
 - iv. Thermal Engineering Research Group
 - v. Electr Power Systems and Green Buildings Group
- Internationally recognized Faculty: 10+
- Graduate Programs:
 - MS in Energy Systems Engineering, MS in Thermal Energy Engineering
 - Ph.D. in Energy systems Engineering

Key Research Areas @ CAS-EN

- Biomass to energy
- Hydrogen production from Algae
- Passive and low energy heating and cooling of buildings
- Solar-water heating systems for domestic and industrial sectors
- Computational Fluid Dynamics in energy sector
- Thermal hydraulics of nuclear power plants
- R&D in XTL technology
- Development of FT catalyst
- Development of high temperature fuel cell materials and devices
- Development of advanced photovoltaic materials and devices
- Development of gas turbine materials and coatings
- Risk analyses of wind farms
- Power quality related issues in SMART GRIDS
- Green Buildings



CAS-EN Building (Under Construction)

Research Groups @ CAS-EN

Bio-fuels Engineering Group

- Dr. Ehsan Ali
- Dr. Qamar Malik
- Dr. M. Bilal Khan

Projects/Focal Areas:

1. Biomass to Energy
2. Algae cultivation in photo-bioreactors for biofuels
3. Ethanol production from Molasses (industry project)
4. Biomass estimation / Biomass gasification in Pakistan

Research Groups @ CAS-EN

Projects/Focal Areas:

Bio-fuels Engineering Group

- Dr. Ehsan Ali
- Dr. Qamar Malik
- Dr. M. Bilal Khan

5. Development of Biomass to liquid technologies in Pakistan
6. Development of technology park to facilitate biofuel production
7. Enhancement of oil extraction from algae/seeds using SCFE
8. Jatropha Cultivation for biodiesel production at large scale

Research Groups @ CAS-EN

Thermal Engineering Group

- Dr. Adeel Waqas
- Dr. Majid Ali

Projects/Focal Areas:

1. Modeling and simulation of solar-power generation systems & solar water heating system
2. Thermal energy storage using *phase change materials*
3. CFD analyses of gas cleaning device for *filtered vented containment* systems
4. Neutronic and Thermal hydraulics analyses of PWR reactor - modeling and simulation based studies

FT Synthesis & Coal Lab.

- Dr. Naseem Iqbal
- Mr Shahid H. Ansari
- Dr. M. Bilal Khan

Projects/Focal Areas:

1. Development of Gas-to-Liquid technologies for production of liquid fuels
2. Modeling and simulation of FT fixed bed reactor and scale-up for pilot scale facility
3. Synthesis and development of FT catalysts
4. Integration of gasification (coal>gas) and FTS technology

Research Groups @ CAS-EN

Projects/Focal Areas:

Advanced Energy Materials & Fuel Cells Lab.

- Dr. Zuhair S. Khan
- Dr Naseem Iqbal,
Hafiz Saleem

1. Development of High Temperature Fuel Cells materials and devices for SOFC and MCFC
2. Development of 2nd Gen and 3rd Gen photovoltaic materials and devices based on CZTS, CIGS, Graphene composites and DSSCs
3. Development of novel rare earth based nanomaterial for corrosion and HT tolerance
4. Ceramic coatings for gas turbine and aerospace applications

Research Groups @ CAS-EN

Electr. Power Systems & Green Buildings Group

- Mr. Farhan Zulfiqar
- Mr. Rashid Wazir
- Mr. Akif Zia Khan

Projects/Focal Areas:

1. Radiation Monitoring using Meteorological High Precision System @ World Bank
2. Risk analysis of wind forms
3. Smart Grids and power quality issues
4. Green buildings

Selected Research Findings @ CAS-EN

Biofuels Group

Biofilm in PBR Before use of Spiked Balls



Day 0

Biofilm removal in PBR after use of Spiked Balls



Day 1

A successful removal of biofilm from PBR was accomplished using floating / submerged spiked gadgets

This method has no ecological impact and has maximum cost efficacy. This method can be easily upscaled for commercial PBRs with minimal cost



New test proposed to determine origin of biodiesel feedstock (Biodiesel Magazine)



Non Edible Feedstock



Edible Feedstock



***A TEST,
BASED ON
CARBON ISOTOPE
RATIO
CAN
DIFFERENTIATE
SOURCE OF
BIODIESEL***

A test has been designed to differentiate biodiesel from either source (Edible/Non-Edible) based on carbon isotope ratio.

There is conflict regarding fuel from food/feed stuff.

Selected Research Findings @ CAS-EN

Wind–water hybrid system for power generation using still waters

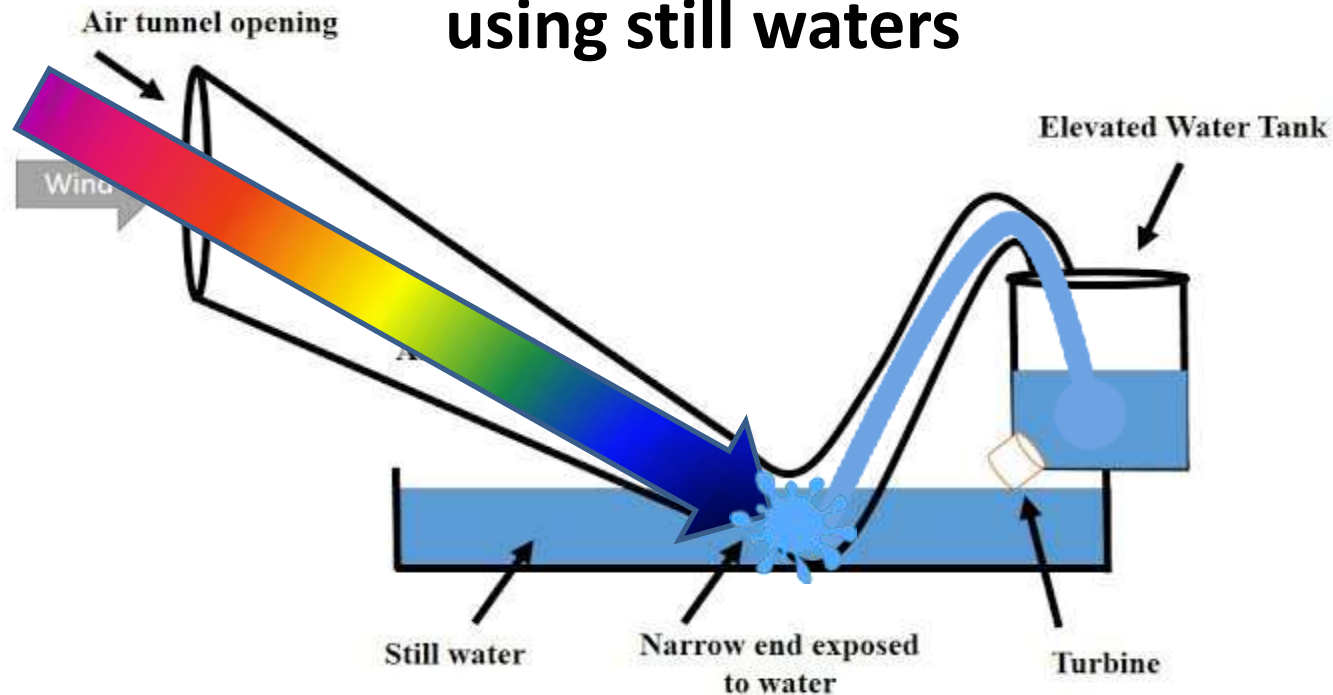


Fig. 1 Wind-Water Hybrid System

> We have recently carried out studies on a novel wind-water system for power generation.

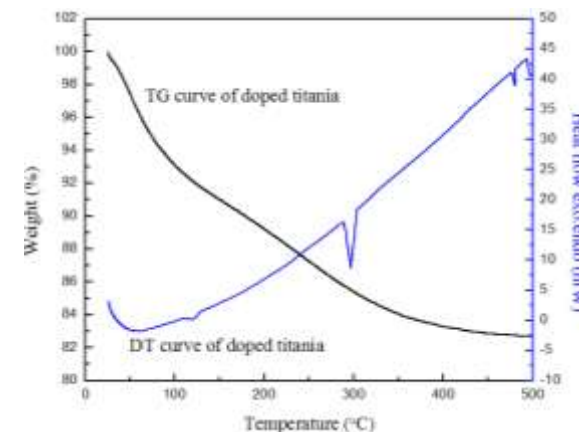
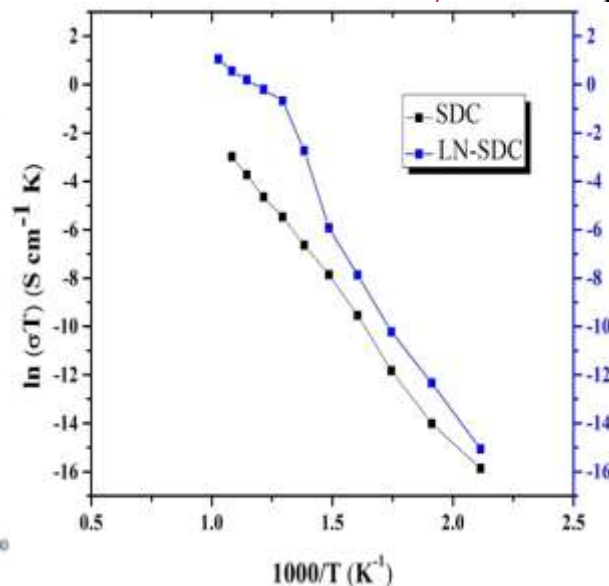
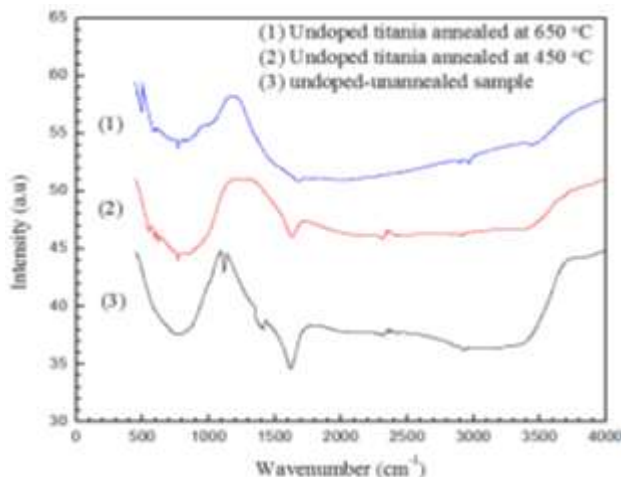
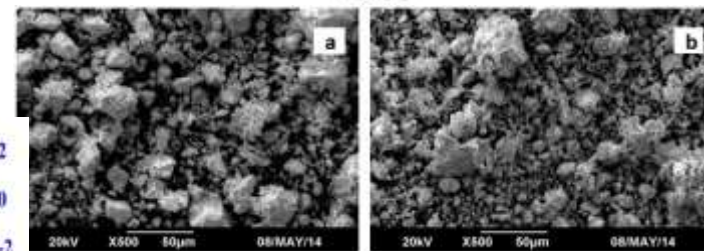
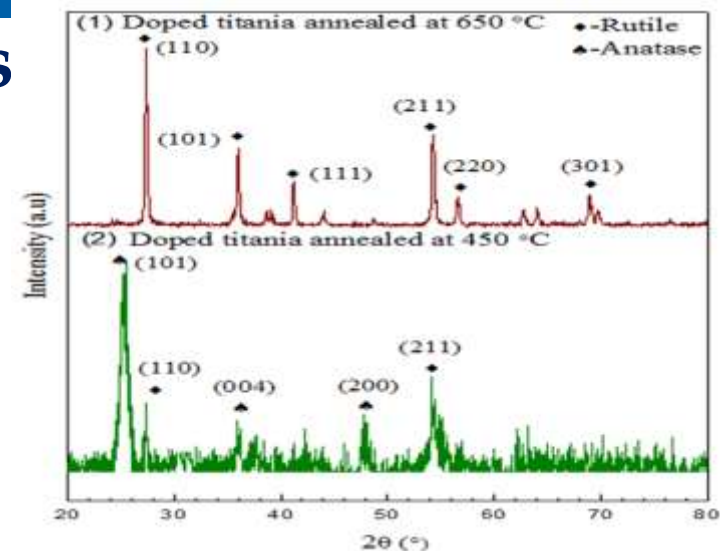
According to this system, wind on entering through a conical pathway interacts with still water. On this interaction, water rises up to an elevated platform, the potential energy of which can be used to drive turbine for power generation.

> Simulation, modeling and prototype is in progress

Selected Research Findings @ CAS-EN

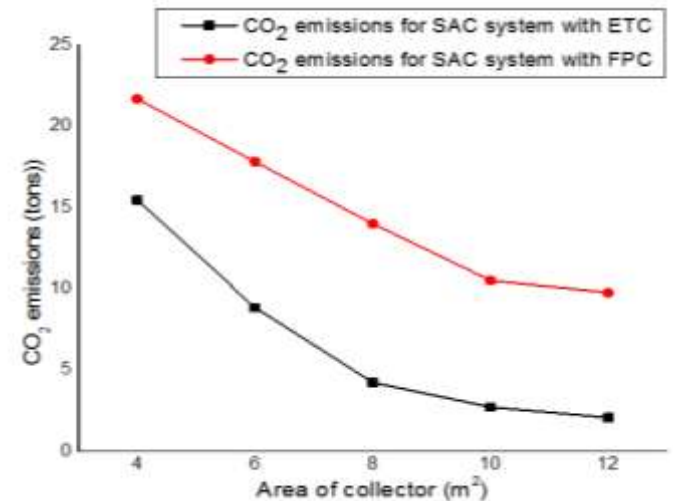
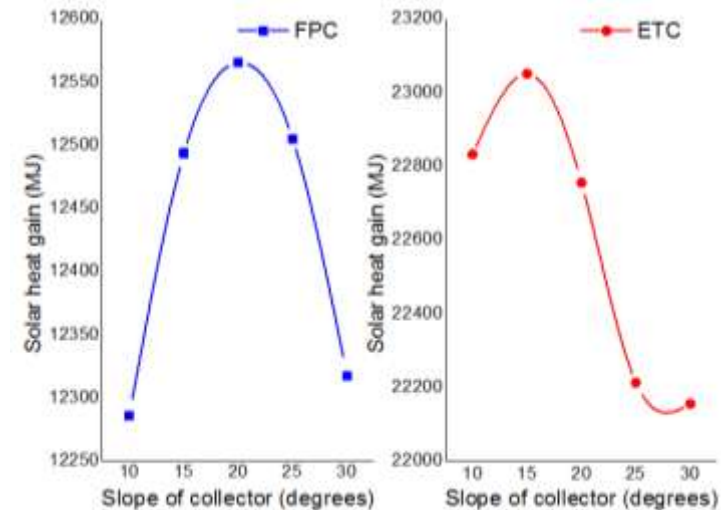
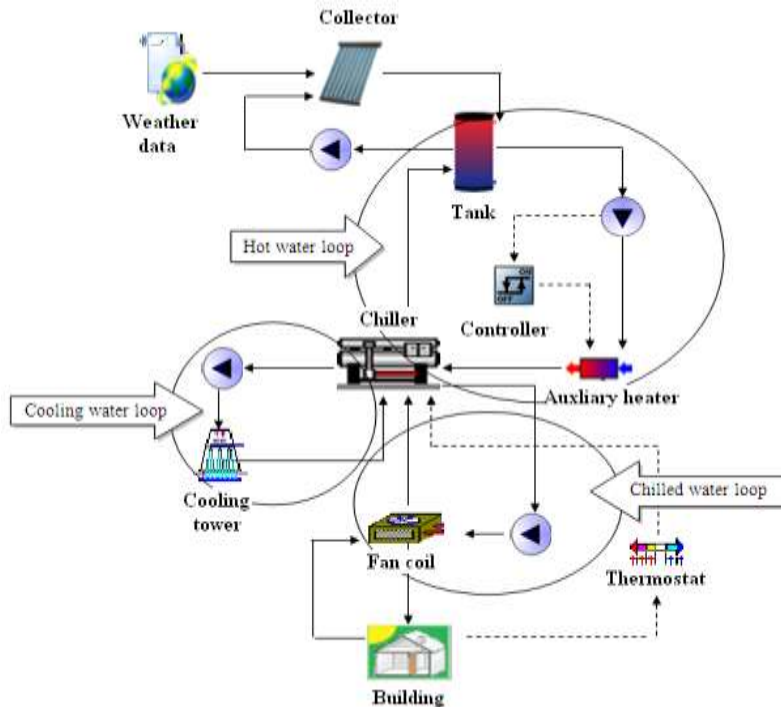
Adv. Energy Materials & Fuel Cells

- ❖ Enhanced conductivity **electrolytes and electrodes** were successfully developed for HT Fuel Cells using the solution-based routes
- ❖ HT/Corrosion tolerant coatings for turbine appl.
- ❖ Cost-effective fabrication of high efficiency dye sensitized solar cells by novel approach of Cu doping and inclusion of C microspheres
- ❖ Hot-corrosion testing of fuel cell matrices by carbonated salts.



Selected Research Findings @ CAS-EN

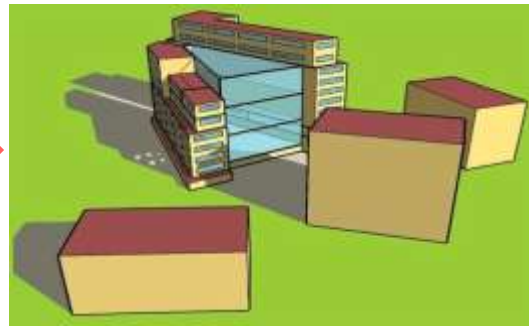
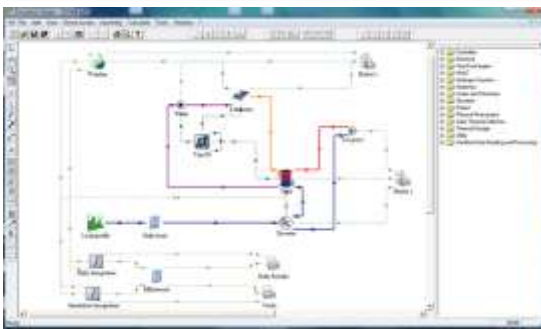
Thermal Engg. Research Group



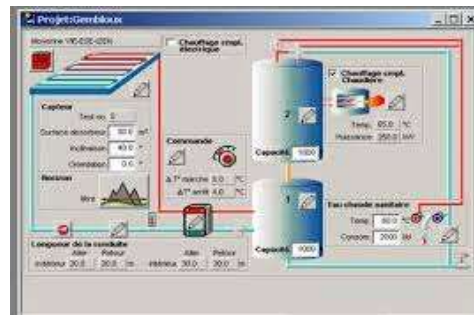
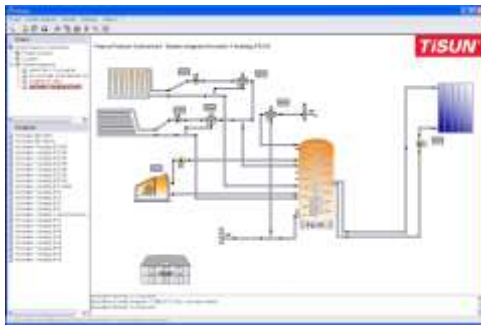
Research was conducted using the TRNSYS software for solar absorption cooling of buildings using various types of solar collectors such as *Flat Plate Collectors* and *Evacuated Tube Collectors* >>> ETC collectors are more beneficial in terms of energy gain and CO₂ reduction

Thermal Engg. Research Group (Licensed Softwares)

TRNSYS is a simulation program primarily used in the fields of renewable energy engineering and building simulation for passive as well as active solar design.



POLYSUN simulation software is the ideal sales and design tool. It Provides optimal support in the design of solar thermal, heat pump and photovoltaic systems as well as combined systems.



MHP St. (CAS-EN)



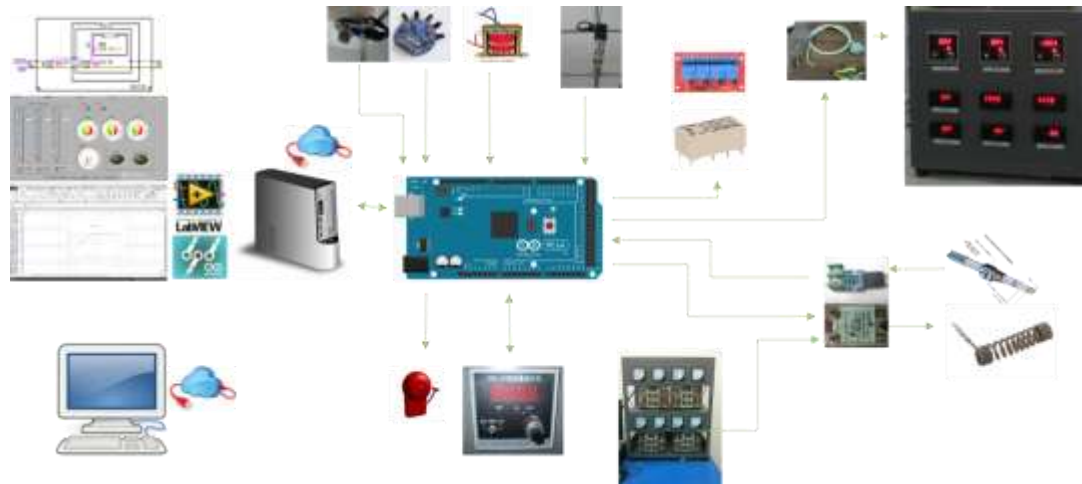
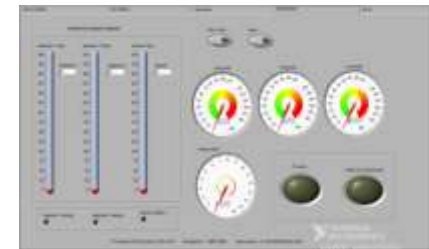
Lab Configuration



Selected Research Findings @ CAS-EN

FT Synthesis & Coal Lab

- ❑ Development of catalyst for the FT-synthesis
- ❑ Supervisory control and data acquisition SCADA system for FT Plant
- ❑ Modeling and simulation of fix bed reactor for FT-synthesis process



Publications Data: 2013 and 2014

	Year	Conferences	Journals	ISI IF Journals	Submitted / Under Review
a	Year 2014	38	11	11	15
b	Year 2013	06	22	18	N/A

Research Projects (ongoing) @ CAS-EN

On Going Projects at CES						(Rs. in million)
SN	Project Title	Funding Agency	National/ International	PI Name	Cost	Duration month
1	Centre for Advanced Studies (CAS)	USAID	Int.	Dr. M. Bilal Khan	2000	60
2	Promoting Sustainable Energy Production and Use from Biomass in Pakistan	UNIDO	Int.	Dr. Ehsan Ali	38.0	24
3	Fabrication & testing of DTL Autoclave / GCMS	NRG Biofuels	Int.	Dr. M.B. Khan Dr. Qamar Malik	5.5	24
4	Microhydel potential in Pakistan	US NSF – CES/NUST	Int.	Dr. Kendra Sharp / Dr M.B. Khan	5.0	12
5	To assess current biomass availability in Punjab with respect to major crops	IFC-World Bank	Int.	Dr. Ehsan Ali	2	12
6	Development of Environmentally Tolerant Materials and coatings for Gas turbines for electric power generation and vehicular propulsion	HEC	Nat.	Dr. Zuhair S Khan	15.0	36
7	GTL FT Synthesis facility with GC	FFCL	Nat.	Dr. M. B. Khan	5.3	24
8	Enhanced hydrogen production from algae using artificial electron donors and inhibiting agents for ferredoxin NADP reductase	HEC	Nat.	Dr. Ehsan Ali	~ 6.4	24
9	Installation of solar-mapping instruments at NUST	World Bank	Int.	Dr. MB Khan/A. Sohail /	10.0	24

Tot. Rs. ~2100 Mill ~ US\$ 21 Million

Curriculum – MS Program in Energy System Engg.

Course Structure	Course No.	Course Title	Credits
Core Courses			
1	ESE-800	Clean Coal Technologies	3
2	ESE-801	Biofuel Engineering	3
3	ESE-803	Photovoltaic Devices	3
4	ESE-810	Computer Applications in Energy Systems	3
Elective Courses			3
1	ESE-811	Solar Energy	3
2	ESE-812	Energy Management in Buildings	3
3	ESE-813	Energy Economics and Policy	3
4	ESE-814	Fuel Cells	3
5	ESE-815	Thin Films	3
6	ESE-816	Development and Evaluation of Energy Projects	3
7	ESE-817	Wind Energy	3
8	ESE-818	Power Distribution Systems	3
9	ESE-819	Power Distribution Systems	3
10	ESE-820	Energy and Environment	3
11	ESE-821	Energy Resources and Technologies	3
12	ESE-822	Geothermal Engineering	3

Curriculum – MS Program in Thermal Energy Engg.

Course Structure	Course No.	Course Title	Credits
Core Courses			
1	TEE 8XY	Advanced Thermodynamics	3
2	TEE 8XY	Design and Modeling of Thermal energy systems	3
3	TEE 8XY	Conventional and Renewable Energy Power Plants	3
4	ESE-823	Thermal Hydraulics	3
Elective Courses			3
1	ESE-822	Geothermal Energy	3
2	ESE-811	Solar Thermal Energy	3
3	ESE-824	Nuclear Energy Engineering	3
4	TEE 8XY	Advanced Fluid Dynamics	3
5	ESE-814	Fuel cells	3
6	TEE 8XY	Turbomachinery	3
7	ESE-816	Development and Evaluation of Energy Projects	3
8	TEE 8XY	Advanced Heat and Mass Transfer	3
9	ESE-800	Clean Coal Technology	3
10	TEE 8XY	Fuels and Combustion	3

Curriculum - PhD Program in Energy Engg.

Course Structure	Course No.	Course Title	Credits
Core Courses			
1	ESE 901	Recent Trends in Energy System Engineering	3
2	ESE 902	Socio-Economic Aspects of Energy Systems	3
Elective Courses			
1	ESE 903	Contemporary Materials for Advanced Energy	3
2	ESE 904	Advanced Energy Materials: Synthesis & Characterization	3
3	ESE 905	Advanced Heat and Mass Transfer	3
4	ESE 906	Biomass/Coal Gasification	3
5	ESE 907	Photocatalysis - Advancement and Applications	3
6	ESE 908	Nuclear Thermal Hydraulics	3
7	ESE 909	Smart Grid Architecture	3
8	ESE 910	Smart Power Systems	3
9	ESE 911	Carbon Capture and Utilization	3
10	RM 899	Research Methodology	3

CAS-EN Mandatory Activities – USAID Funded Project

- **New programs:**
 - MS in Advanced Energy Materials w.e.f. 2016
 - MS in Entrepreneurship in Energy w.e.f. 2017
- **During next 5 Years, 200 students / faculty will be exchanged with US counterpart universities**
- **We expect that there will be 250 graduates in energy sector**
- **50 applied research projects will be completed in next 5 years**
- **Pakistan centric industry specific Curriculum reforms will be carried out**
- **Water, Energy, Food nexus for sustainable development will be strengthened**
- **6 research labs will be upgraded in the next 5 years with a total cost of US\$ 6.6/= (Million)**

THANK YOU

SMART GRIDS RT PHIL RESEARCH LAB

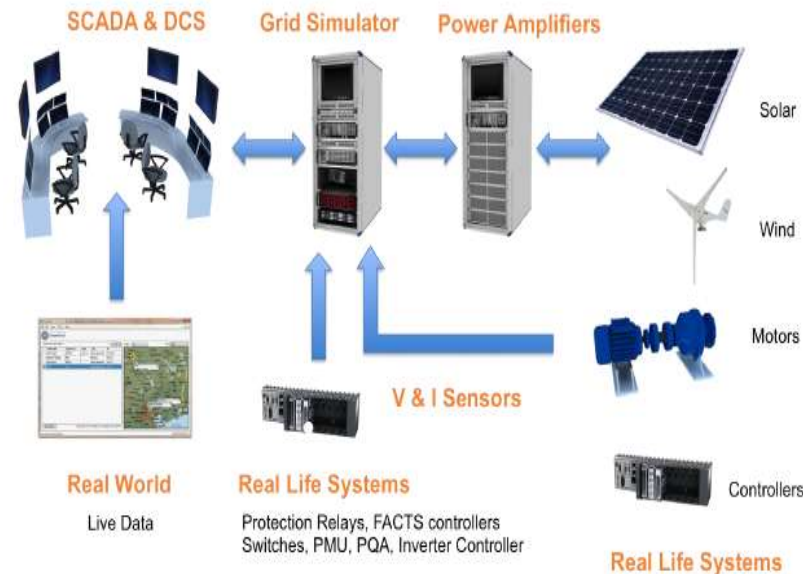
**SMART Grids
Research Group:**
- Engr. Akif Zia
Khan

The research group covers the following

focal areas :

- ❖ Real Time (RT) Power Hardware in the loop (PHIL) and Software in the loop (SIL) Simulations of SMART Power Systems
- ❖ Wide Area Monitoring , Protection and Control (WAMPAC) Applications in SMART Grids using PHIL Simulators
- ❖ Rapid Control Prototyping
- ❖ PMU AND PDU Development Systems
- ❖ Energy Management and Demand

Lab Configuration



PHIL

