Alexandria university  
MECHANICAL ENGINEERING DEPARTMENT

POWER TO GAS APPLICATIONS

**Project overview:**

A Mobility scale "Boat" based Power to Gas Project will be erected for a better energy handling enables communities in Egypt to face the hard times and over expensive of power now a days. It will have the ability to be established with in any types of boat such as (Cargo Ships, Yacht, Catamaran…).

The issue of limited fossil fuels combined with the vast technological improvements in recent years has initiated numerous installations of renewable power production, particularly in form of photovoltaic cells and wind turbines. Since the volatile character of wind and solar radiation leads to a fluctuating power production, these renewables are incapable of providing reliable base load power. To enable the transition to a renewable energy system, large-scale energy storage is required to compensate for short-term and seasonal imbalances and to save temporary excess power.

Power to Gas unit will provide the most useful power output from  
renewable energy by storing it in the form of hydrogen gas along daytime and peak generation hours. To be used over the peak load hours.

Power to Gas will utilize a small community. It is expected to completely enable the off grid power supply, protecting the environment from greenhouse gases, sulfur and nitrogen harmful emissions.

A power plant grid supply replacement for clean, reliable, efficient power production. With a low maintenance needed all over the year comparatively. It is the smarter and improved path for a cleaner and healthier future.

**Problem definition:**

In 2014, Egypt was experiencing one of its most serious energy crises for decades,  
with parts of the country facing around six power cuts a day for up to two hours at a time. Natural gas supply shortage; aging infrastructure, inadequate generation, and transmission capacity are making it very difficult for the country to cope with the sharply rising demand. In addition, recent political and social unrest have slowed the government’s plans to expand power generation capacity by 30 GW by 2020.

Starting there, government and individuals put their eyes on renewable energy  
especially; wind & solar energy.  
Minister of Housing announced the launch of the trial of the first central solar energy  
plant lighting along 4km of the Tiba-Qena eastern desert road. The launch comes  
besides the launching of a solar energy plant with the capacity of 90 KW in New Tiba City.

The project targets finding solutions for energy efficiency and dependency on  
new and renewable energy. It comes in light of cabinet directives to light streets in new cities using solar energy and LED lamps.  
Several solar energy plants are currently being implemented in numerous new cities, including Sadat City, 15th of May City and New Minya. However, the problem still as it is how we can store the surplus electricity produced?

Offering a Solution to the Energy Storage Problem:

The increasing levels of renewable energy generation bring challenges for our  
existing systems. Their variability means that they rarely provide just the amount of energy needed at any moment. Indeed, at peak levels of production, wind power output is already being curtailed due to the limited capacity of the electricity grid, and the difficulty of storing electricity.

The wind does not always blow and the sun does not always shine when wanted.  
Conversely, not all of today’s electricity grids have enough capacity to carry all of the renewable energy produced during strong wind and bright sunshine. There is  
therefore need for huge, long-term energy storage as the proportion of renewables in our energy mix increases.

The result is that quite often wind and solar installations have to be switched off as the grid is overloaded whilst, at the same time, significant amounts of compensation are paid, which is an unnecessary waste of energy and money.

With the fast pace in developments, the problem of electricity storage has gained a new dimension. At times of peak production of renewable-generated power, existing electricity transmission lines are found inadequate in terms of capacity.

Power Grid Is Older, And Has Trouble Handling Solar And Wind:

In order for the power grid to function, demand for energy must exactly match  
supply. Power demand is relatively predictable and conventional power plans, like  
nuclear plants and natural gas, can adjust output accordingly. Solar and wind power, however, cannot easily adjust output. They also provide power unpredictably relative to conventional power sources.

On an especially cloudy or windless day, the electrical grid can’t supply enough  
power from solar or wind alone. Wind and solar also run the risk of producing too  
much power which can overload and fry the power grid.

Solar and Wind Do not Provide Power at Useful Times:

Power demand is relatively predictable. The output of a solar or wind power plant is quite variable over time and generally does not coincide with the times when power is most needed. Peak power demand also occurs in the evenings, when solar power is going offline. Adding power plants which only provide power at intermittent and unpredictable times makes the power grid more fragile.

Green House Gas emissions

Burning of Fossil Fuels: Fossil fuels like coal, oil and natural gas have become an  
integral part of our life. They are used on large basis to produce electricity and for  
transportation. When they are burnt, the carbon stored inside them is released  
which combines with oxygen in the air to create carbon dioxide.

**Project details:**

We all come across renewable energy term knowing that it is the future, renewable energy sources main problem is that it is not always available, so we need to store it.

Power to Gas is the best way to store renewable energy effectively.

Therefore, we have chosen one of application of power to gas cycle in order to apply our project on it

Choose one type of the ships in the river and take its design, and here starts our project

Where we calculate loads and resistance that affect the ship and choose the Motor that can run these loads by using wind turbine, solar panels and power to gas cycle

Then we have a ship ready for use and implementation that can be used in reality.

To make a breakthrough in that field we need young engineers with the knowledge of power to gas cycle, parts, and performance.

We make a scale down to the ship to be demonstration kit in the lab to show the students power to gas principle, and to connect them with the real-world applications and the importance of renewable energy in the future.

# Vision

Because of importance of renewable energy in the future, we need young engineers with the knowledge of power to gas cycle, parts, and performance to make a breakthrough in that field.

**Mission**

Making a design for a ship ready to be constructed which work with renewable energy then make scale down to be demonstration kit in the lab to prepare young engineers with renewable energy knowledge.

**Goals**

- Creating a sustainable power to gas unit relying on the renewable energy and  
 natural resources as the main source for any type of energy needed.  
- Making use of the available natural resources.  
- Introducing a new technology to the Egyptian society in a  
 marketable, acceptable, and affordable way.  
- Enhancing the performance of the Power to gas (P2G) system.  
- Reduction of the energy production footprint.

**Objectives**

* Design and build a system that is compact and able to serve in the mobility scale market.
* Using the input power module as a solar PV module, which makes use of the available solar energy.
* Using another input power module as a wind turbine, which makes use of the available wind energy.
* Introducing a new technology to the Egyptian society in marketable, acceptable, and affordable way:  
  **-** Marketable by serving their needs of sustainable energy source that makes

them independent of the power and natural gas grid.  
**-** Acceptable by making the unit as compact as possible to fit in house or a small  
 community.  
**-** Affordable by the reduction of construction cost and running cost as the running

cost is almost zero.

* Reduction of the energy production footprint: As all the modules are based on the output of the PVs, wind turbine and water, so the output power generated is reducing the water foot print of the entire system.
* Lighten the minds of the students with sources of renewable energy and how we can use and storage it.
* Study the factors affecting each component and how it affects the efficiency.
* Making the load in shape of boat to connect between Power to gas and mobility in the future

Methods:

1. Power production:  
   Exploitation of solar energy from sun as a source of renewable energy using photovoltaic “PV” or concentrated photovoltaic “CPV” systems which contributes in decreasing the hazards of global warming phenomenon because the fact that solar energy has no emissions.

Exploitation of wind energy as a source of renewable energy using

Wind turbine.

2- Energy storage:  
 Since we cannot control the energy received from the sun and the nature of  
 intermittent solar energy, the peak of received solar energy is usually  
 coincide the low demand, and the high demand is at night when there is no solar   
 energy received, by applying the water splitting method (electrolysis) using the   
 available natural resources such as seawater or freshwater to store the excess  
 energy at noon in the form of hydrogen which can be reconverted to electricity   
 again.

3- Reconversion of hydrogen:  
 The stored energy in hydrogen could be reconverted into electricity again by   
 means of fuel cell.

## Staff

We are a group of ambitious students at faculty of engineering – Alexandria university – mechanical engineering department, working on our graduation project under supervision of three teaching members.

The team structure is divided into two main sub teams:

* Advisors  
  Represented in the teaching members who their role is to guide us by their knowledge and experience and to assure that we are following the right trend.
* Students

Who are responsible technical work such as (study of the project, design and manufacturing of the model …...etc.).

#### Advisors:

1. **Prof. dr. Hassan Warda**

Professor of Fluid Mechanics, Mechanical Engineering Department at Faculty of Engineering Alexandria University.

Vice Dean for Community Development & Environmental Affairs Faculty of Engineering, Alexandria University since September 1998.

Consultant at Behaira water and Drainage Company since December 1998.

1. **Prof. dr. Essam Wahba**

Professor of Fluid Mechanics, Mechanical Engineering Department at Faculty of Engineering Alexandria University.

PHD in Mechanical and Aeronautical Engineering from the University of California, Davis in 2004

Head of the Mechanical Engineering Department for two years at the American University of Sharjah.

The author and co-author of more than 50 papers.

Principal Investigator in several industry related research projects funded by general electric.

Received several awards during his career such as Joseph Steger award for excellence in Computational Fluid Dynamics from the University of California, Davis.

1. **Eng. Sherief Haddara**

Several teaching, research and administrative positions at Cairo University, Alexandria University and Pharos University.

Former Egyptian Minister of Petroleum and Mineral Resources.

1. **Eng. Khaled Mohamed Ahmed Saleh**

Former Chairman & Managing Director of the Arab Petroleum pipeline Co. “Sumed”

1. **Dr.Dina Elgayar**

Lecturer at Chemical Engineering Department, Alexandria University

PHD in mass transfer enhancement. From Alexandria university, Egypt in 2013

She is member in the executive office of Quality Assurance Unit in faculty of Engineering (QAU)

She is leading a lot of scientific students’ chapter in the faculty & the academic advisor for SPE Alexandria University Student Chapter.

Author and co-other for a lot of Publications in the field of mass transfer enhancement.

#### Students:

1. Joseph Samir Faik Sanad.
2. Mohab Mohamed Said.
3. Mohammed ahmed abdelazeem Hussein
4. Mohamed Ibrahim Mosaad.
5. Mahmoud Hassan Abd-El Aziz Dwedar.
6. Mahmoud Khaled Ragab.
7. Mina Adel Bashout Bakhit.
8. Mina Safwat Shawky.
9. Moustafa Zaky Sharaf.
10. Peter Sarabamon Elkomos.
11. Youssry Khaled Elmahdy.

# Needed Resources

Manufacturing Facilities

Purchasing components and accessories

Access to “Power to gas” related companies

We need to get an easy access to high quality materials and ready facilities for  
different manufacturing processes needed for the prototype.  
Purchasing components are a little bit difficult process right now, because of the high prices resulting from the melting down of the currency, and the increased taxes needed during the customs process for imported ones.

Powers to gas different components are of large size and the resulted assembly  
volume is extremely large, so we need a suitable workspace for the complete  
prototype assembly.

**Manufacturing expected budget**

Fuel Cell 30 watt --- 960$

 The H‐CELL 2.0 power kit includes:

• 1x 30W air-cooled PEM fuel cell

• 4x HYDROSTIK refillable hydrogen storage cartridges

• 1x electronic fuel cell control box

• 1x upper deck integration frame (for a TRF‐416X)

• 2x pressure regulators

• 2x electronic valves

• Connectors and silicone rubber tubing

• User manual / assembly guide

Link: <http://www.fuelcellstore.com/h-cell-2.0-fcjj-21?search=H%202.0>

* Electrolyser --- 600$

Link: <http://www.fuelcellstore.com/horizon-hydrofill-pro-fch-020>

* Silicon tube --- 10$ for fuel cell connections.

<http://www.fuelcellstore.com/horizon-fuel-cell-silicon-tubing>

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All component from Dr fuel cell store

Link: <http://www.fuelcellstore.com/>

The cost will be:

- Cost of all parts: 1570$ = 26690 LE

- Cost with banking fees: cost \* 1.06 = 28290

- Cost with shipping and customs = 32000LE (Expected)

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**Evaluation plan**  
Strategy for the evaluation plan:  
• The evaluation plan will depend on probing results from different indicators at different stages of the project.  
• The project consists of three stages, Study & Research stage, Design & planning stage and finally Implementation & manufacturing stage.

• we will have 3 indicators for quality, Time and budget.

Method of collecting info. for these indicators  
• We will have a monthly report that will be sent to persons responsible for the indicators working in each stage.  
• These reports will be assessed by each indicator and assessment results will be presented in another report including evaluation questions, indicator type, data about the question and what constitutes success  
Project meetings   
• We have two meetings per week for the project to assemble the work from different aspects and keep updated with the challenges and progress.  
  
Persons responsible for monitoring the project  
• Moustafa Zaky will be responsible for cost indicator  
• Mahmoud Hassan will be responsible for time indicator  
• Mohab Mohamed will be responsible for quality indicator

Meeting will be held at the end of each month for project evaluation.

# Timeline

This table-containing schedule summery

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| Description | Start Date | End Date | Duration |
| <Research> | Oct, 1, 2016 | Nov, 15, 2017 | 5 months |
| <Preliminary Design Review> | Nov,20 , 2017 | Nov, 26, 2017 | 1 week |
| <Design and Analysis> | Nov, 27, 2017 | Feb, 15, 2018 | 3 months |
| <Design for Manufacturing> | Feb , 16, 2018 | Mar, 16, 2018 | 1 month |
| <Manufacturing and Assembly> | Mar, 17, 2018 | May, 18, 2018 | 6 weeks |
| <Testing and Review> | May, 19, 2018 | June, 30, 2018 | 1 month |
| <Final Product> | July, 1, 2018 |  |  |