Renewable Energy Park (RE-PARK), KTH

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ABSTRACT

Use of green energy generated by solar and wind power technologies would help contribute to a clean and secure energy future for Sweden compared to conventional fossil energy resources. Along with the EU-directive for renewable energy of July 2009, Sweden declared that its primary national target is at least 50% of its total energy use would be from renewable energy resources by year 2020, and out of that, there would be at least 10% in transport sector. Combining renewable energy with modern energy saving techniques and IT-applications will necessarily lead to significant energy-efficient decisions that would profit the consumer and secure the competitiveness of the Swedish industries. Several studies have estimated the general saving potential to be in the range of 20-40% of the total energy costs in addition to the reduced impact on the environment. The concept of the Renewable Energy Park (RE-Park) will play an increasingly important role in the nation energy portfolio targeting the renewable energy integration in smart city with net-zero energy housing and healthcare facilities. The RE-Park is an assembly of small power-generating modules, energy storage system and energy management protocols in order to improve the operation of the electricity and heat supplying system in both presence and absence of a grid connection facility. The project involves the development of communication protocol over the internet which is ready for smart grid applications to monitor, control and manage the RE-Park for electricity and heat delivery options.

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PRIMARY GOALS

- Set up a working RE-Park experimental facility within KTH
- Use the unit for teaching and experimental purposes
- Stimulate young engineers for power industry
- Stimulate and evaluate innovative ideas in R&D of hybrid energy systems
- Develop a platform for smart grid applications in power industry
- Establish and enhance contact of academia with industry and energy companies
- Stimulate and conduct economic, entrepreneurship and marketing studies in the energy sector
- Stimulate studies on integrated energy systems focusing on renewable grid balancing

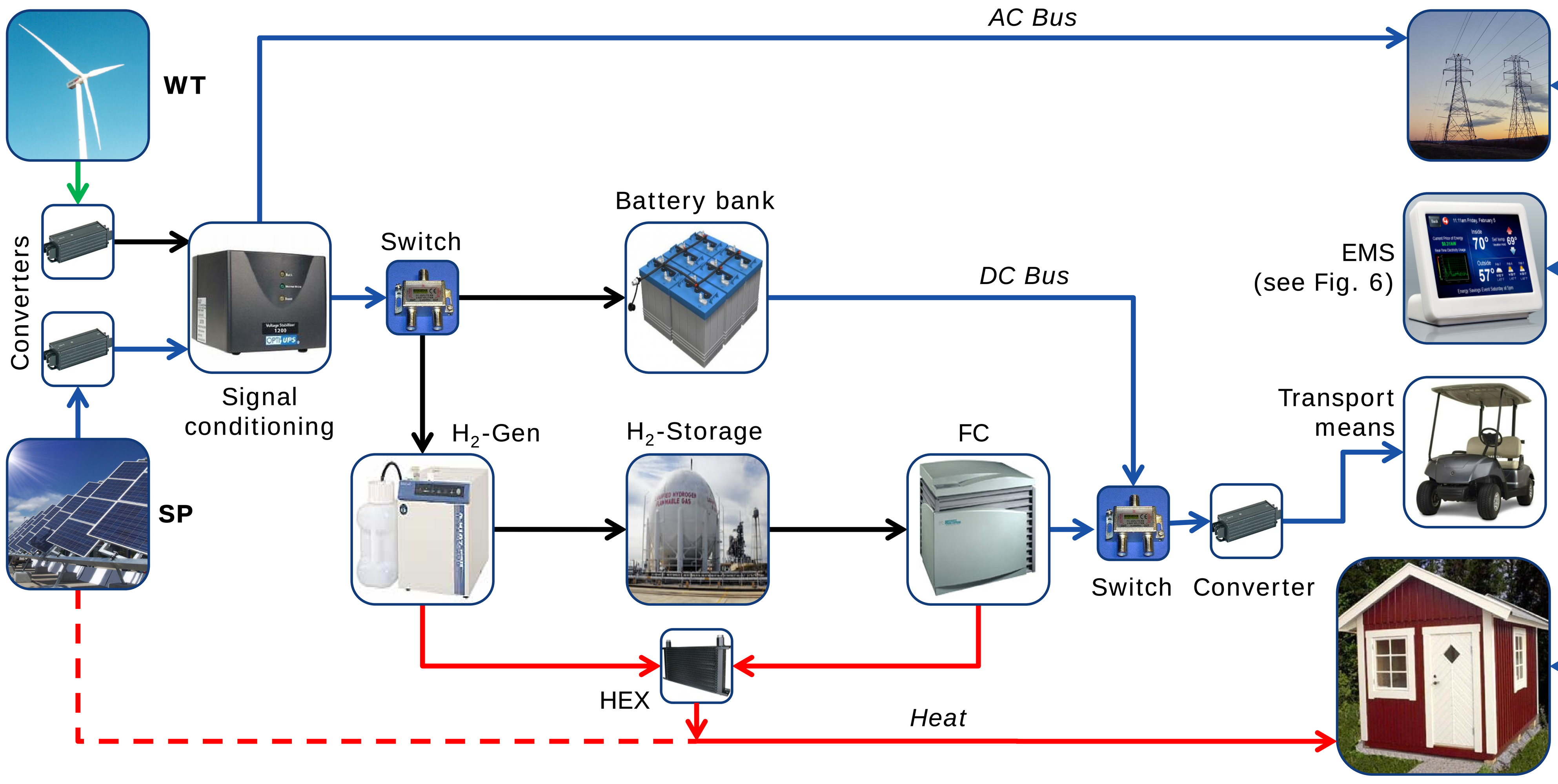

Fig. 1: Flow scheme over RE-Park

SYSTEM OVERVIEW

Wind Turbines (WT)

Wind turbines are the devices for harnessing the wind energy by converting it into electricity. The size of WT available in the market ranges from 5W to 5MW. The main components of WT are: 1) **Propeller** (nacelle & blades), 2) **Drive Train** (gearbox) and 3) **Generator** (see Fig. 2).

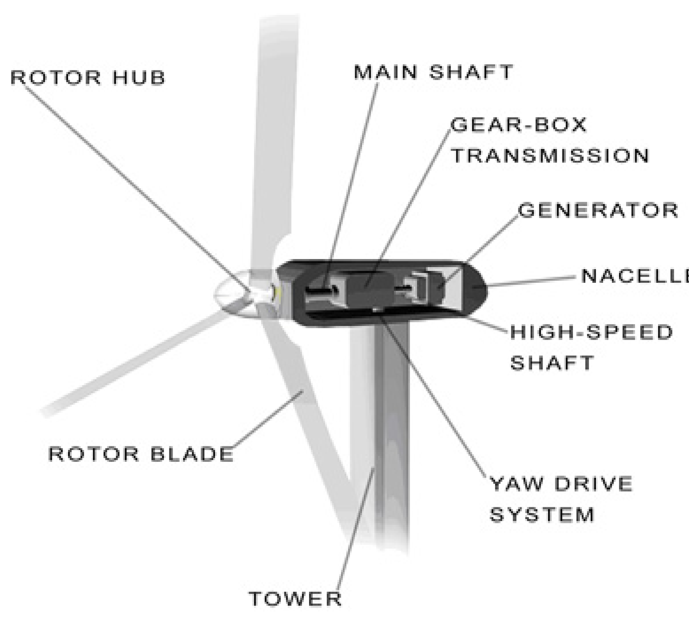

Fig. 2: Wind turbine

By year 2020, EU is expected to have 180GW wind power installed including 70GW off-shore, yielding an annual electricity generation of 425TWh, thus satisfying more than 12% of the EU electricity demand. The integration of significant amounts of wind energy into the power system brings with it two main issues that need to be addressed, namely, **Balancing needs and costs** and **Grid infrastructure.**

Additional balancing cost in a power system is due to changes in the configuration, scheduling and applying efficient control and storage facility to deal with unpredicted deviations between supply and demand.

Solar Panels (SP)

Solar panels are modules/arrays of solar cells, which are semiconductor devices for converting solar energy (sunlight) into DC electrical power. Solar panels available in the market, ranges from some mW up to 300W peak power. PV modules are suitable for either grid- or off-grid connection. The main types of solar panels are:

1) Solar **Photovoltaic (PV)**
2) Solar **Thermal (Th)**
3) Solar **Hybrid PV/Th** (electricity and heat)

Solar PV Panels are inefficient with a maximum conversion efficiency of 20%, while Solar Thermal ones have 30-40% efficiency. Two types of semiconductor technologies are currently the most widely used:

1) **Crystalline Silicon** 2) **Thin film.**

The fundamental electrical parameters of the solar cell are:

- **Short Circuit Current** (I_{sc})
- **Open Circuit Voltage** (V_{oc})
- **Maximum Power** (P_{max})
- **Fill Factor** (FF)

The world PV production has been exponentially increased from under 300MW (1990) to 4.5GW (2007). Currently, the cumulative world PV electricity generation is about 15GW with Europe accounting for more than 60% (9.5GW). The intermittent nature of wind and solar energy require energy storage facilities in form of battery clusters or hydrogen generation and storage.

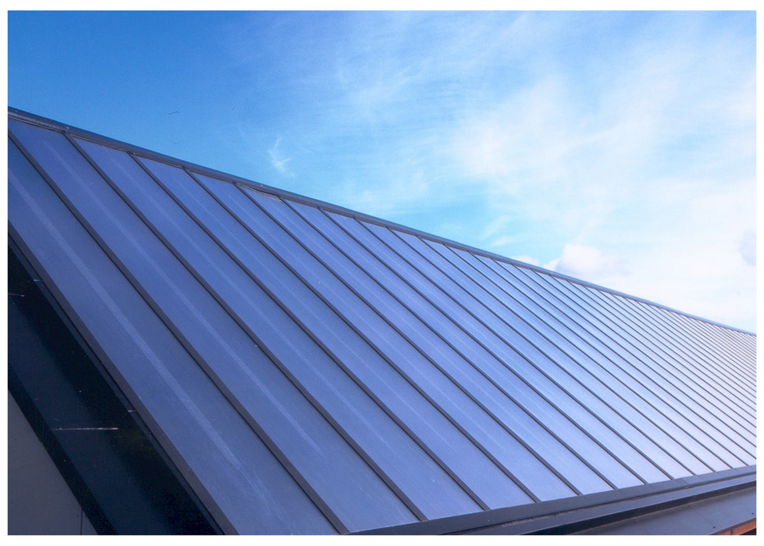

Fig. 3: Solar panels

Fuel Cells and Electrolyzers

Fuel cells are devices to convert chemical energy into electrical and thermal energy. Electrolyzers are the reverse of fuel cells meaning that they convert electrical energy into chemical reaction. Generally, **Fuel cells are power generators**, while **Electrolyzers are power consumers.** Fig. 4 shows the most common types of fuel cells together with used fuels and applications.

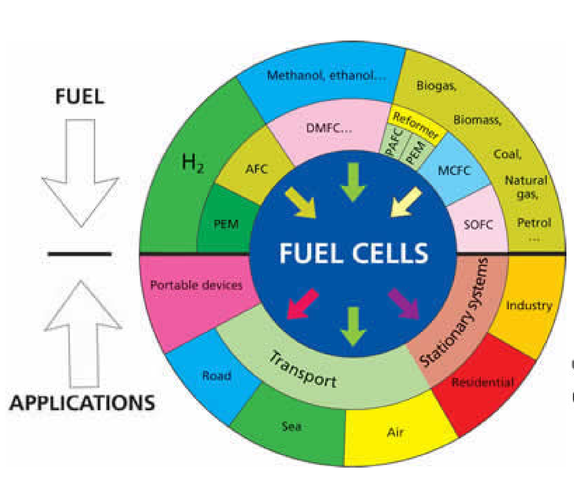

Fig. 4: The main FC-types and applications

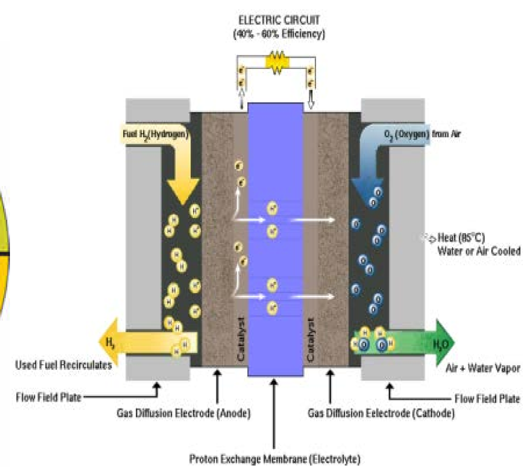

Fig. 5: The basic principles and components of a FC

The Proton Exchange Membrane Fuel Cell (PEMFC) in particular, is a low temperature fuel cell with solid electrolyte and has wide range of applications in both stationary CHP and transport sectors (light auto-vehicles and busses). The commercial PEMFC is a stack of individual fuel cells connected in series to produce the required power. Basic components and function of a fuel cell is shown in Fig. 5.

Commercial **PEMFC** uses pure **Hydrogen** as fuel and **Air/Oxygen** as oxidant at **temperatures 70–90°C** with **Power Output**: **25W-500kW** with **efficiency** of **40-50%.**

Advantages: High power density (kW/lit), silent, quick startup, flexible for shifts in demands.
Drawbacks: Careful water and thermal management, sensitive to catalyst poising.

Communication Protocol

A computer software with the capability to provide in/outdoor visual displays, control and monitoring of the RE-Park and allow for the integration into the system management unit. The protocol uses international communication standard technique thus allowing the data and information to be exchanged with all connected devices while maintaining a high-level security of data transmission. The basic components of the communication package, Fig. 6 are:

1) Converters and data logger
2) PC/comm. protocol to system management unit (Control/SCADA systems) over local net, smart grid (SG) services, and Internet connection.

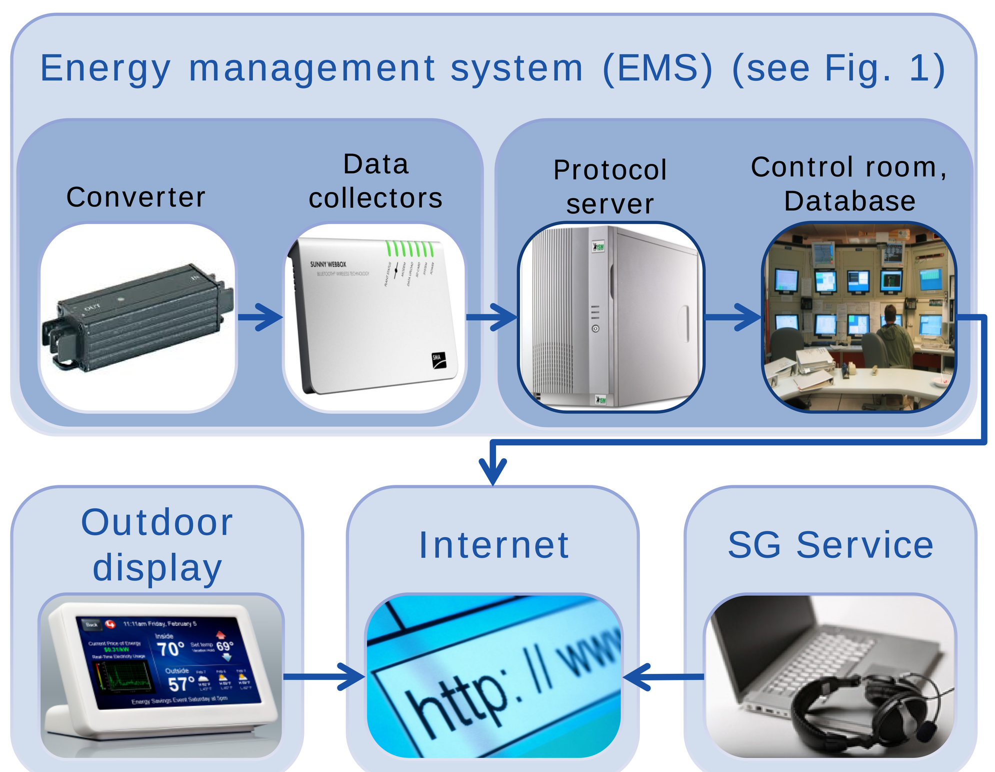

Fig. 6: Architecture of the communication package

CONCLUSIONS

- Solar and wind energy will play a significant role in future energy mix of Europe
- Integrated solar, wind and H2- facilities provides sound sustainable energy systems.
- Combined new energy technology and IT-techniques will lead to innovative smart grid services.
- RE-Park is a suitable platform for innovation, education, and research in energy systems