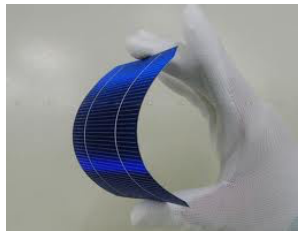




Materiali per l'Energetica



Prof. Vito Di Noto





Introduction and Background



A **major effort** is currently undertaken by the EU to **modernize its whole energy sector**. In detail, in the short-to-medium timescale (up to 2020-2030):

- The **share of electrical power** in the total energy consumption is **expected to rise significantly**;
- By **2030**, **at least 35%** of the **electrical power** will be obtained from **intermittent renewable sources** (wind and the sun);
- The wide electrification of the surface transportation has to start as soon as possible.

Overarching challenges

- **Significant time lags** between the **generation of energy** and its demand by the users
- Necessity to achieve:
 - ✓ **fast response times**;
 - ✓ **high energy capacities**;
 - ✓ **high energy and power densities at an acceptable cost.**



Urgent need to achieve innovative conversion and storage energy systems

Main Electricity Storage Technologies

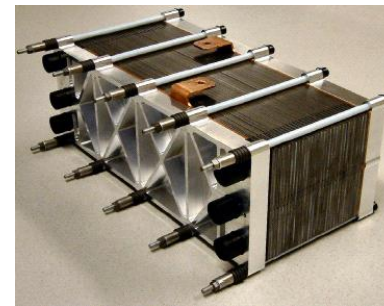
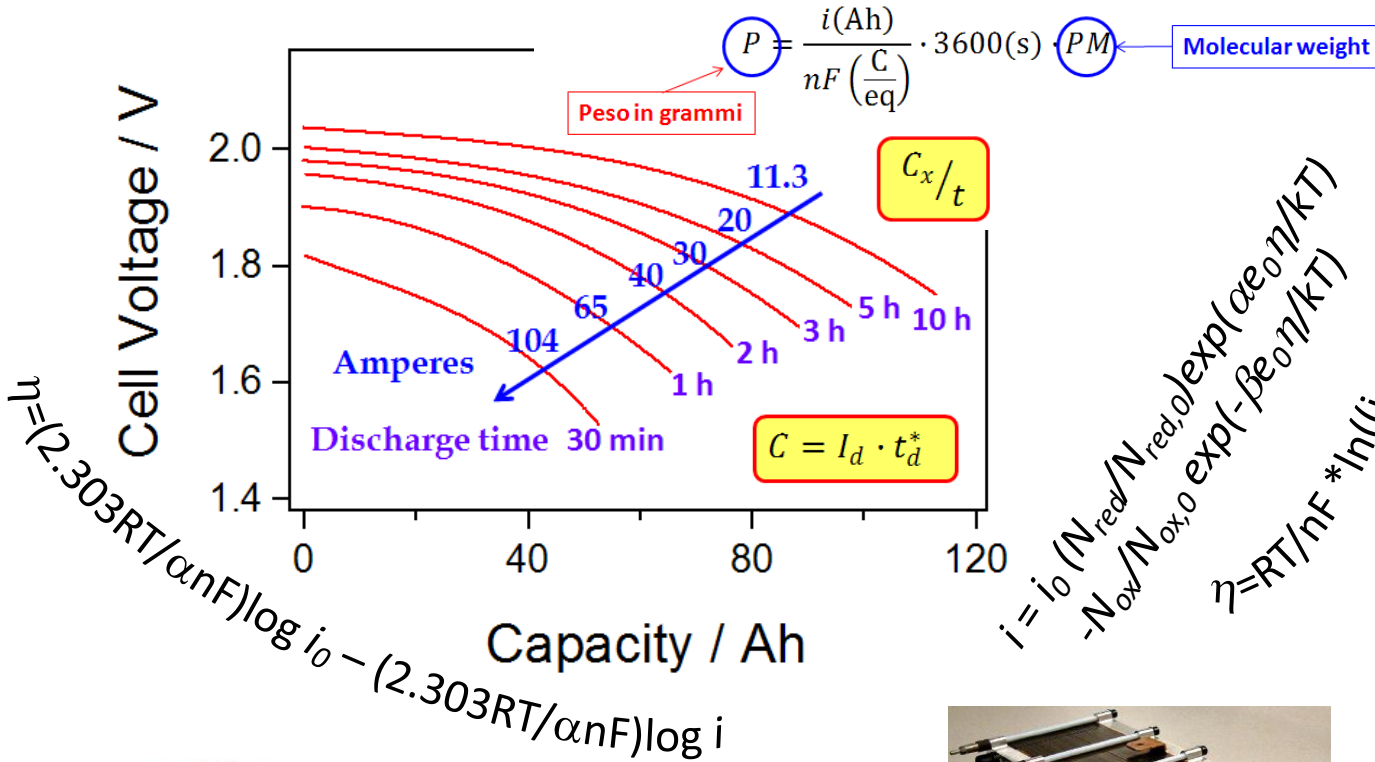
1		MECHANICAL storage	<ul style="list-style-type: none">- Pumped hydro storage (PHS)- Compressed air energy storage (CAES) (& advanced concepts)- Flywheel energy storage (FES)
2		THERMAL storage	<ul style="list-style-type: none">- Hot-water storage- Molten-salt energy storage (MSES)- Phase change material storage (PCM)
3		ELECTRICAL storage	<ul style="list-style-type: none">- Supercapacitors (SC)- Superconducting magnetic energy storage (SMES)
4		ELECTROCHEMICAL storage	<ul style="list-style-type: none">- Fuel Cells and Electrolyzers (FC and EL)- Lithium-ion batteries (Li-ion)- Vanadium redox-flow batteries (VRB)
5		CHEMICAL storage	<ul style="list-style-type: none">- Hydrogen- Synthetic natural gas (SNG)- Other chemical compounds (Ammonia, Methanol...)**

Source: Schlumberger Business Consulting (SBC) Energy Institute Analysis; EPRI (2010), "Electricity Energy Storage Technology Options", Bradbury (2010), "Energy Storage Technology Review"



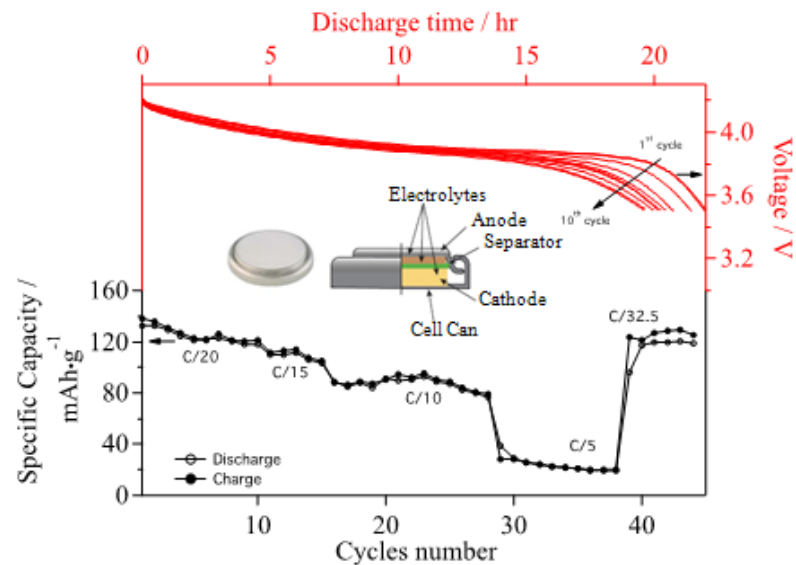
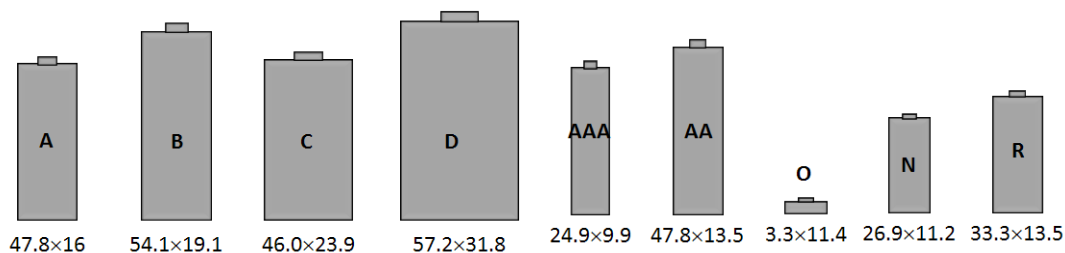
Background

The fundamentals of the **electrochemical processes** taking place at the electrodes are discussed, with a detailed analysis of the **interplay between the thermodynamics, kinetics and electrochemistry of the various phenomena**



❖ Primary and secondary batteries: materials, methods and devices

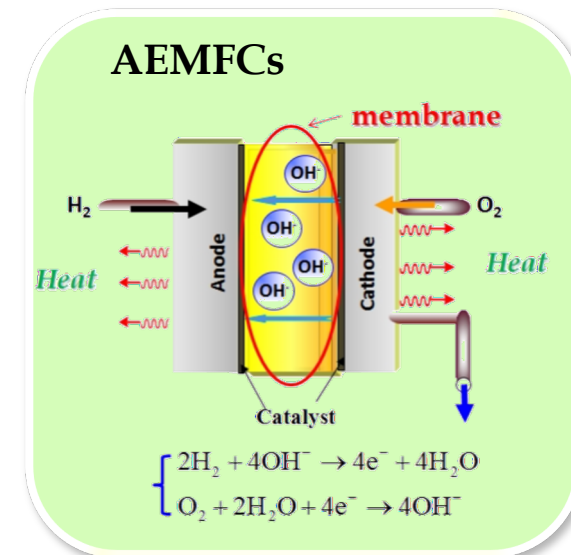
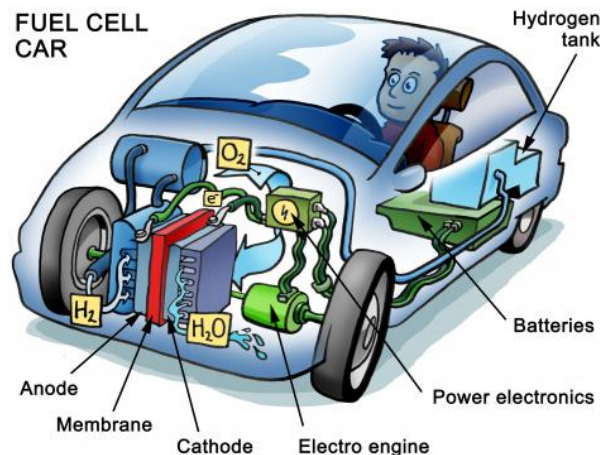
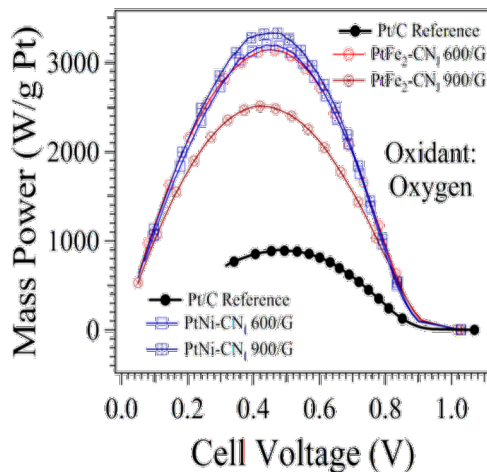
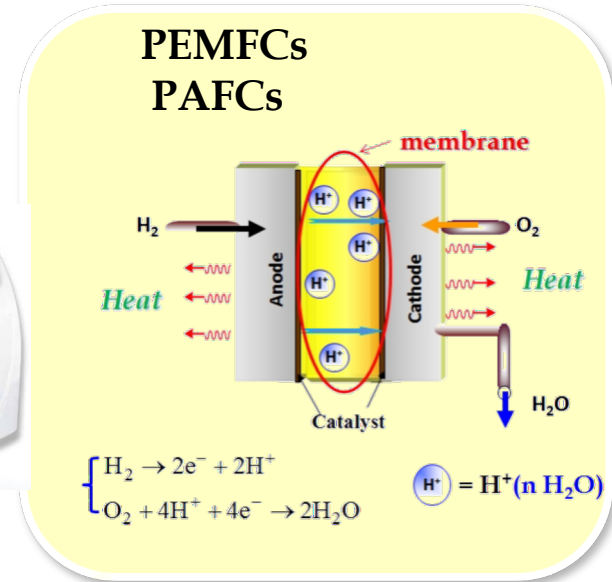
- ✓ **Solid Electrolytes:** Synthesis and properties;
- ✓ Conventional and innovative **electrode materials:** synthesis and properties;
- ✓ **Structural and morphological characterization techniques;**
- ✓ **Electrochemical characterization;**
- ✓ **Devices and figures of merit;**
- ✓ **Primary batteries:** materials, devices and electrochemical processes;
- ✓ **Secondary batteries:** materials, devices and electrochemical processes.



Program, part II: Fuel Cells

❖ Part II. Fuel cells and electrolyzers

- ✓ **Fuel cells:** types and characteristics;
- ✓ **Electrolyzers:** types and characteristics;
- ✓ **Devices and figures of merit;**
 - ❑ Electrolytes;
 - ❑ Electrocatalysts;
 - ❑ Structural and morphological characterization of materials;
 - ❑ Electrochemical and electrical characterization;
 - ❑ Membrane-electrode assembly (MEA);
 - ❑ Single cells and stacks.



Program, part III: Open Batteries

❖ Part III. Open Batteries: Materials, methods and devices

- ✓ **Electrolytes:** Synthesis and properties;
- ✓ Conventional and innovative **electrode materials:** synthesis and properties;
- ✓ Techniques for **electrochemical characterization;**
- ✓ **Devices and figures of merit.**

