

NEW TRENDS IN POWER SYSTEMS CONFIGURATIONS



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OUTLINE

- **AC VERSUS DC IN POWER SYSTEMS;**
- **SMART GRID CONCEPT;**
- **ENERGY STORAGE TECHNOLOGIES;**
- **HIGH VOLTAGE DC POWER DISTRIBUTION;**
- **RECENT RESEARCH PROGRAMS IN UPT REGARDING ENERGY CONVERSION AND STORAGE;**
- **CONCLUSIONS.**

ALTERNATE VERSUS DIRECT CURRENT

THE CURRENT WAR THE TALE OF AN EARLY TECH RIVALRY

DC

DIRECT CURRENT

The flow of electricity is in one direction only. The system operates at the same voltage level throughout and is not as efficient for high-voltage, long distance transmission.

Direct current runs through:



Battery-Powered Devices Fuel and Solar Cells Light Emitting Diodes

"[TESLA'S] IDEAS ARE SPLENDID, BUT THEY ARE UTTERLY IMPRACTICAL."

- THOMAS EDISON

AC

ALTERNATING CURRENT

Electric charge periodically reverses direction and is transmitted to customers by a transformer that could handle much higher voltages.

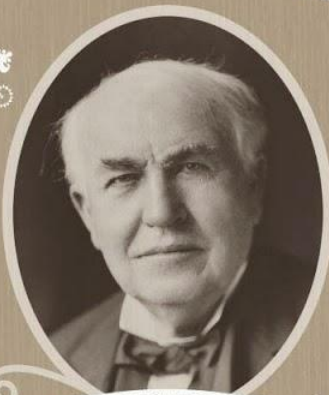
Alternating current runs through:



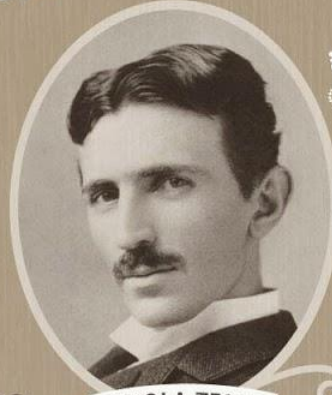
Car Motors Radio Signals Appliances

"IF EDISON HAD A NEEDLE TO FIND IN A HAYSTACK, HE WOULD PROCEED AT ONCE... UNTIL HE FOUND THE OBJECT OF HIS SEARCH. I WAS A SORRY WITNESS OF SUCH DOINGS, KNOWING THAT A LITTLE THEORY AND CALCULATION WOULD HAVE SAVED HIM 90 PERCENT OF HIS LABOR."

- NIKOLA TESLA



THOMAS EDISON



NIKOLA TESLA

VS.

You would have never found two geniuses so spiteful of each other beyond turn-of-the-century inventors Nikola Tesla and Thomas Edison. They worked together—and hated each other. Let's compare their life, achievements, and embittered battles.

1847 BORN 1858

Milan, Ohio BIRTHPLACE Smiljan, Croatia

Wizard of Menlo Park NICKNAME Wizard of the West

Home-schooled and self-taught EDUCATION Studied math, physics, and mechanics at The Polytechnic Institute at Graz

Mass communication and business FORTE Electromagnetism and electromechanical engineering

Trial and error METHOD Getting inspired and seeing the invention in his mind in detail before fully constructing it

DC (Direct Current) WAR OF CURRENTS: ELECTRICAL TRANSMISSION IDEA AC (Alternating Current)

Incandescent light bulb; phonograph; cement making technology; motion picture camera; DC motors and electric power

NOTABLE INVENTIONS

Tesla coil - resonant transformer circuit; radio transmitter; fluorescent light; AC motors and electric power generation system

1,093 NUMBER OF US PATENTS 112

0 NUMBER OF NOBEL PRIZES WON 0

1 NUMBER OF ELEPHANTS ELECTROCUTED 0

1931—Passed away peacefully in his New Jersey home, surrounded by friends and family

DEATH

1943—Died lonely and in debt in Room 3327 at the New Yorker Hotel

LATE BLOOMER

Thomas Edison, the youngest in his family, didn't learn to talk until he was almost 4 years old.

"Genius is one percent inspiration, and ninety nine percent perspiration"

-Thomas Edison

FALLING OUT

Edison promised Tesla a generous reward if he could smooth out his direct current system. The young engineer took on the assignment and ended up saving Edison more than \$100,000 (millions of dollars by today's standards). When Tesla asked for his rightful compensation, Edison declined to pay him. Tesla resigned shortly after, and the elder inventor spent the rest of his life campaigning to discredit his counterpart.

EDISON FRIES AN ELEPHANT

In order to prove the dangers of Tesla's alternating current, Thomas Edison staged a highly publicized electrocution of the three-ton elephant known as "Topsy." She died instantly after being shocked with a 6,600-volt AC charge.

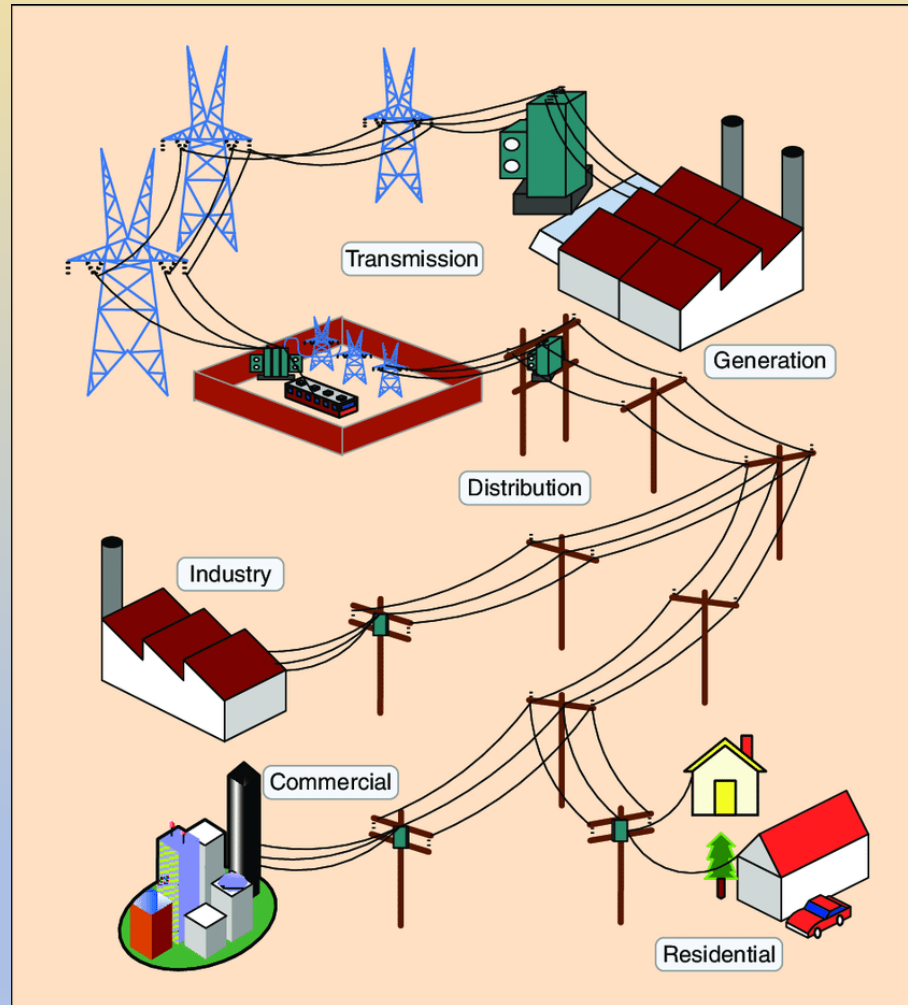
WAR OF CURRENTS OFFICIALLY SETTLED

In 2007, Con Edison ended 125 years of direct current electricity service that began when Thomas Edison opened his power station in 1882. It changed to only provide alternating current.

NOBEL PRIZE CONTROVERSY

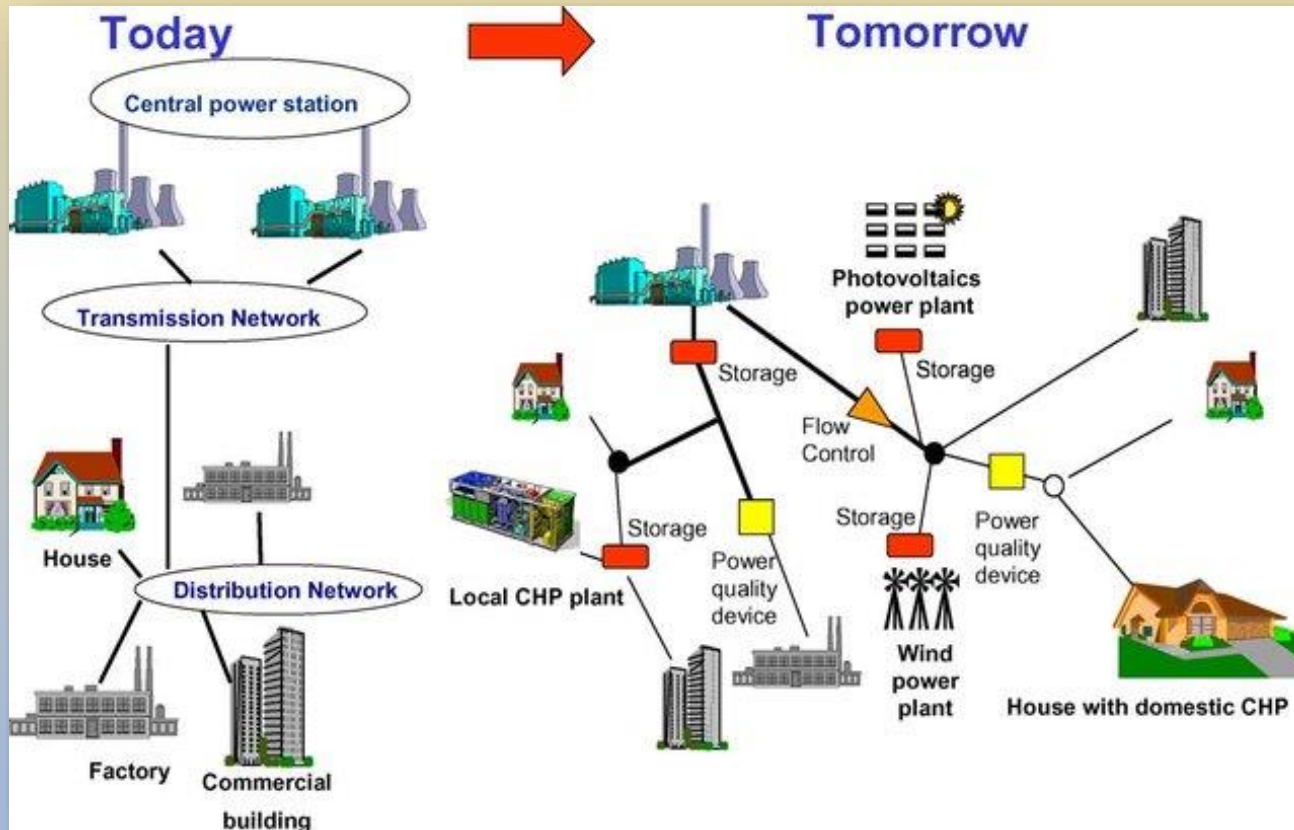
In 1915, both Edison and Tesla were to receive Nobel Prizes for their strides in physics, but ultimately, neither won. It is rumored to have been caused by their animosity towards each other and refusal to share the coveted award.

CLASSICAL POWER DISTRIBUTION SYSTEMS



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SMART GRIDS



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SMART GRIDS

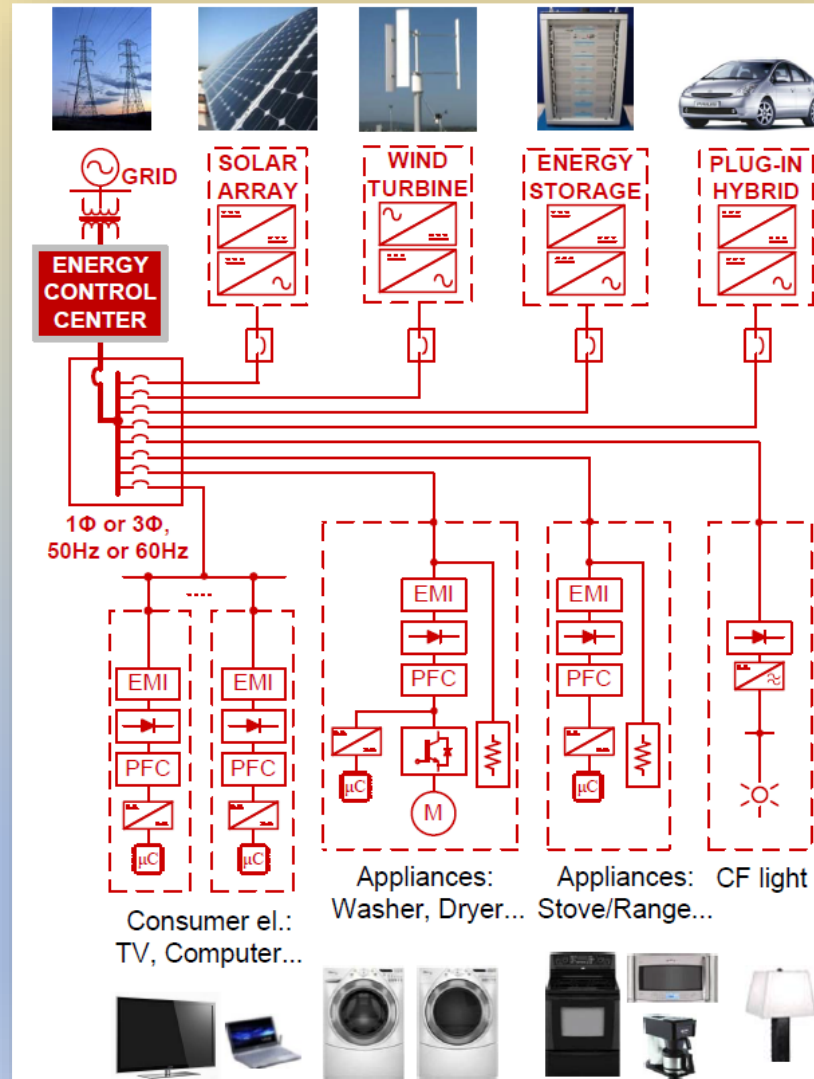
A smart grid is an electricity network enabling a **two-way flow of electricity and data** with digital communications technology enabling to detect, react and pro-act to changes in usage and multiple issues. Smart grids have self-healing capabilities and enable electricity customers to become active participants.

<https://www.youtube.com/watch?v=JwRTpWZReJk>

https://www.youtube.com/watch?v=KciEb1cKyO0&ab_channel=WorldBusinessAcademy

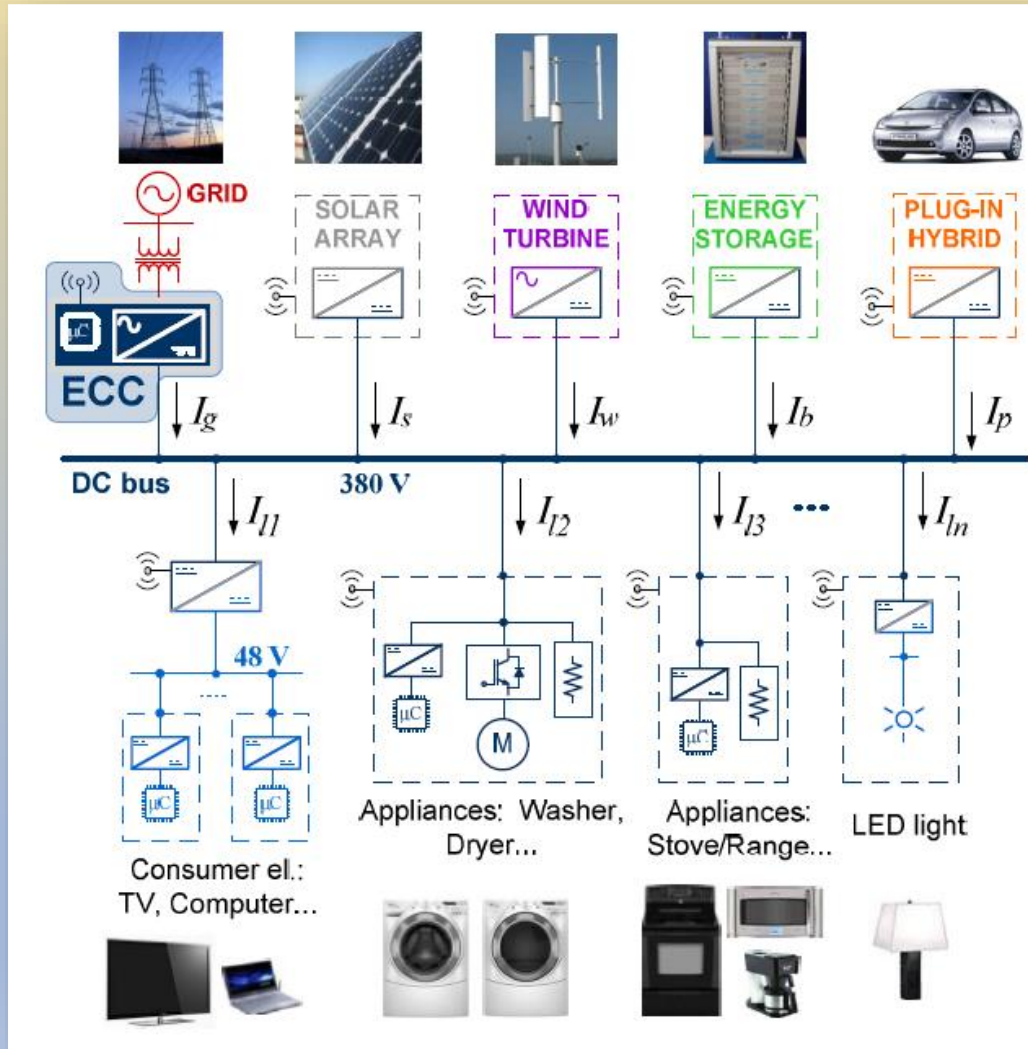
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A CONTEMPORARY STRUCTURE OF POWER DELIVERY IN RESIDENTIAL HOMES



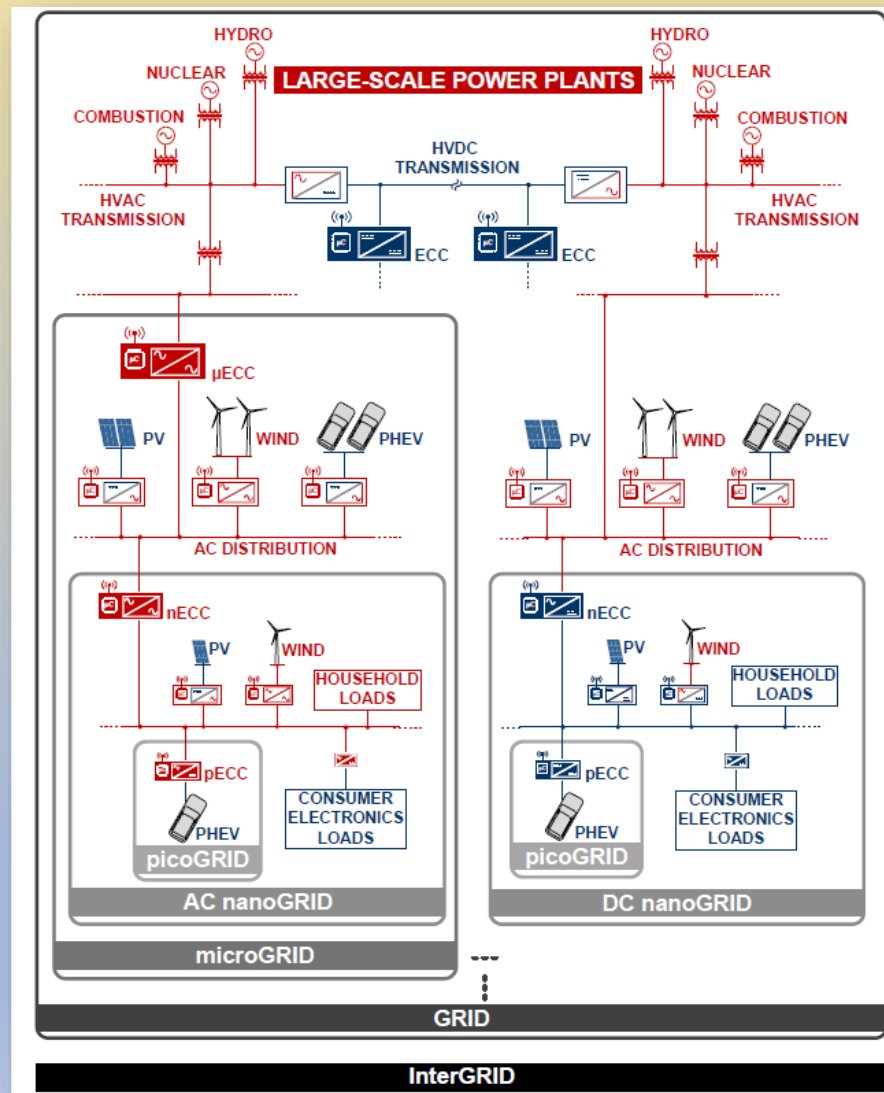
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A DC BASED “SMART GRID” (NANO GRID) IN A FUTURE HOME



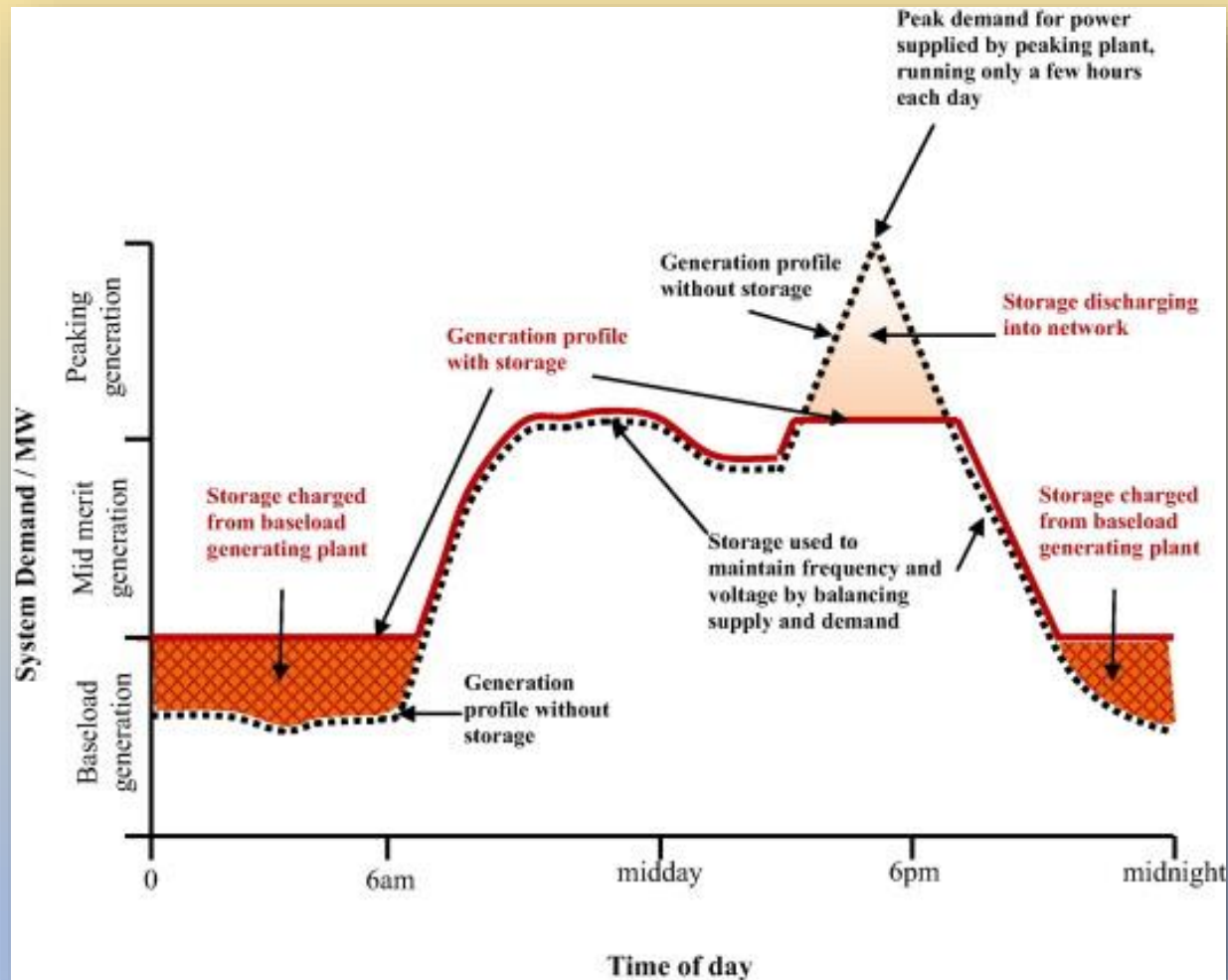
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CONCEPTUAL INTERGRID SYSTEM AS A HIERARCHICALLY INTERCONNECTED HYBRID MIX OF AC AND DC SUB-GRIDS



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SMART GRIDS



Load profile of a large-capacity energy storage system

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ENERGY STORAGE TECHNOLOGIES

LEGEND

FBES Flow battery energy storage
VRFB Vanadium Redox flow batteries
PSB Polysulphide Bromine flow batteries
Zn Br Zinc Bromine flow batteries
SCES Supercapacitor energy storage
SMES Superconductive magnetic energy storage
STES Sensible thermal energy storage
PCM Latent-phase change material
TCS Thermochemical storage
PHS Pumped hydro storage

CAES Compressed air energy storage
FES Flywheel energy
ETES Electric Thermal Energy Storage
Li-ion Lithium-ion
Pb-Acid Lead-acid
Ni-Cd Nickel-cadmium
Ni-MH Nickel-metal hydride
Na-S Sodium-Sulphur
NaNiCl₂ Sodium nickel chloride
Li-S Lithium-Sulphur batteries
M-ion Metal-ion Batteries
LTO Lithium-titanate-oxide
ORB Organic radical

Hydrogen technologies

ENERGY STORAGE TECHNOLOGIES



Fat (animal/vegetable)

37MJ/kg≈10kWh/kg

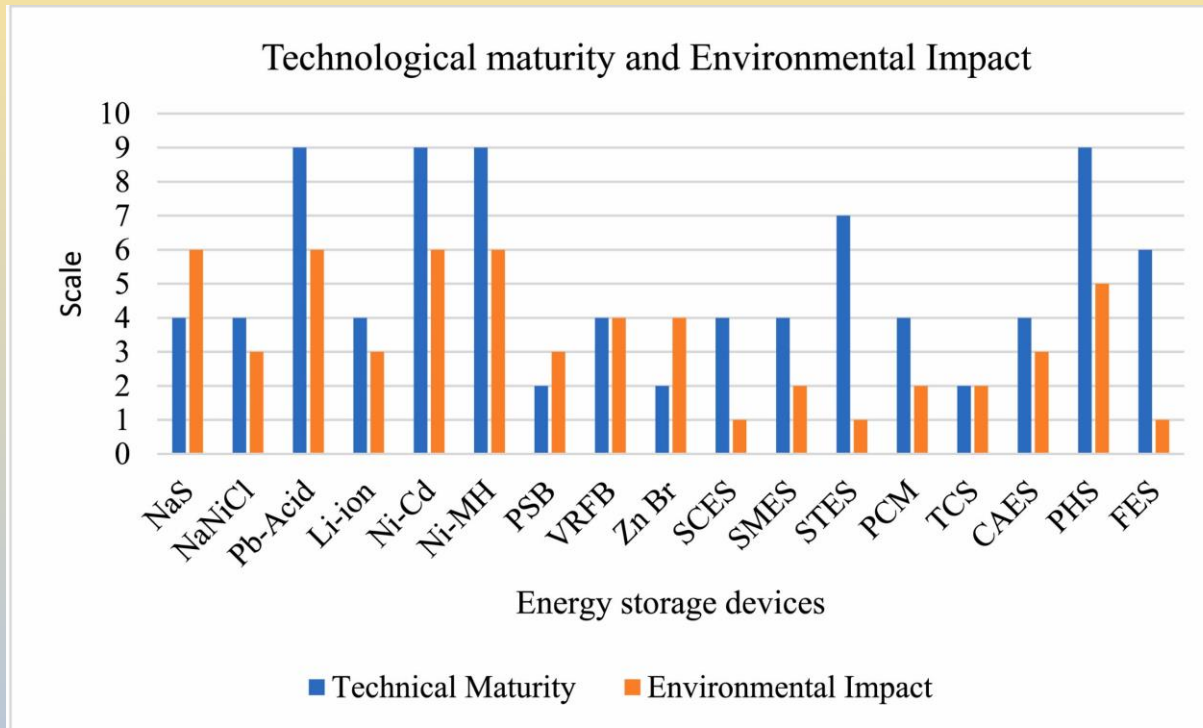
ENERGY STORAGE SYSTEMS

Type	Energy Efficiency (%)	Energy Density (Wh/kg)	Power Density (W/kg)	Cycle Life (cycles)	Self Discharge
Pb-Acid	70–80	20–35	25	200–2000	Low
Ni-Cd	60–90	40–60	140–180	500–2000	Low
Ni-MH	50–80	60–80	220	< 3000	High
Li-Ion	70–85	100–200	360	500–2000	Med
Li-polymer	70	200	250–1000	> 1200	Med
NaS	70	120	120	2000	–
VRB	80	25	80–150	> 16000	Negligible
SCES	95	< 50	4000	> 50000	Very high
Pumped hydro	65–80	0.3	–	> 20 years	Negligible
CAES	40–50	10–30	–	> 20 years	–
Flywheel (steel)	95	5–30	1000	> 20000	Very high
Flywheel (composite)	95	> 50	5000	> 20000	Very high

Vanadium Redox

Compressed air energy storage

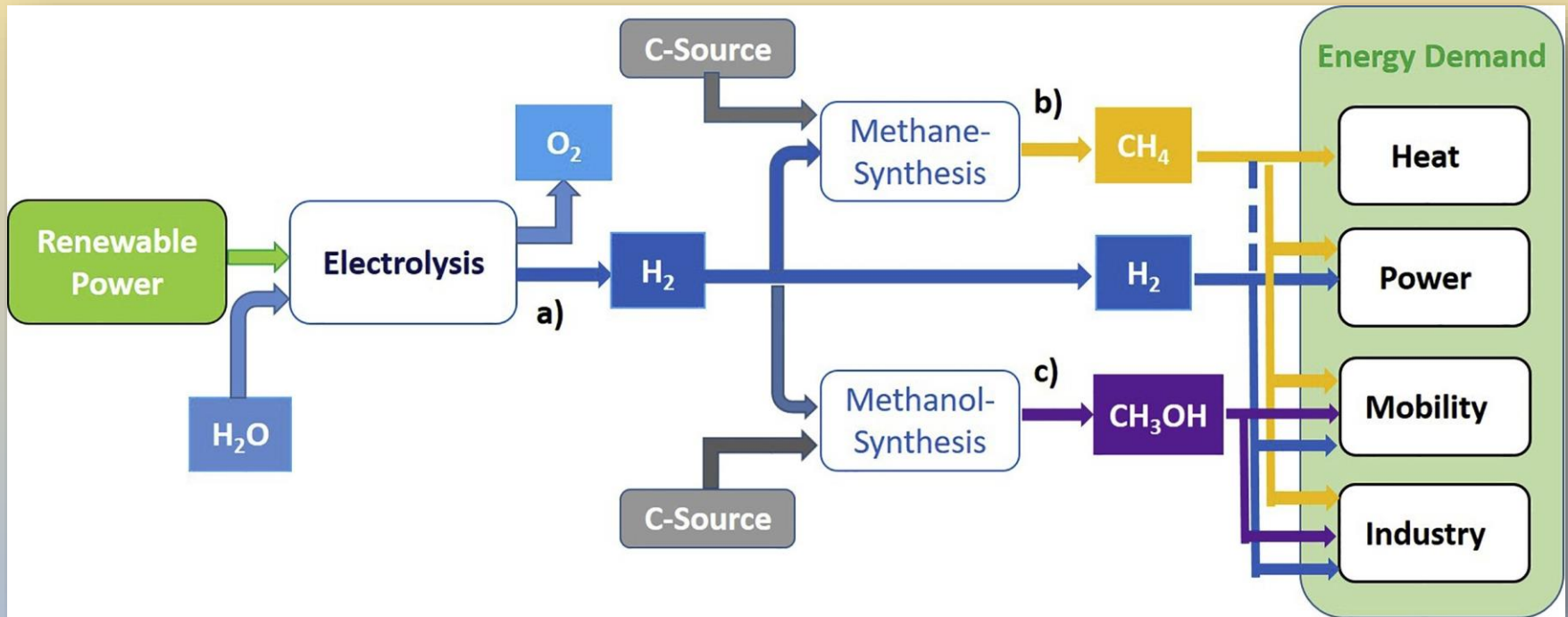
ENERGY STORAGE TECHNOLOGIES



Technology maturity and environmental impact comparison of ESDs

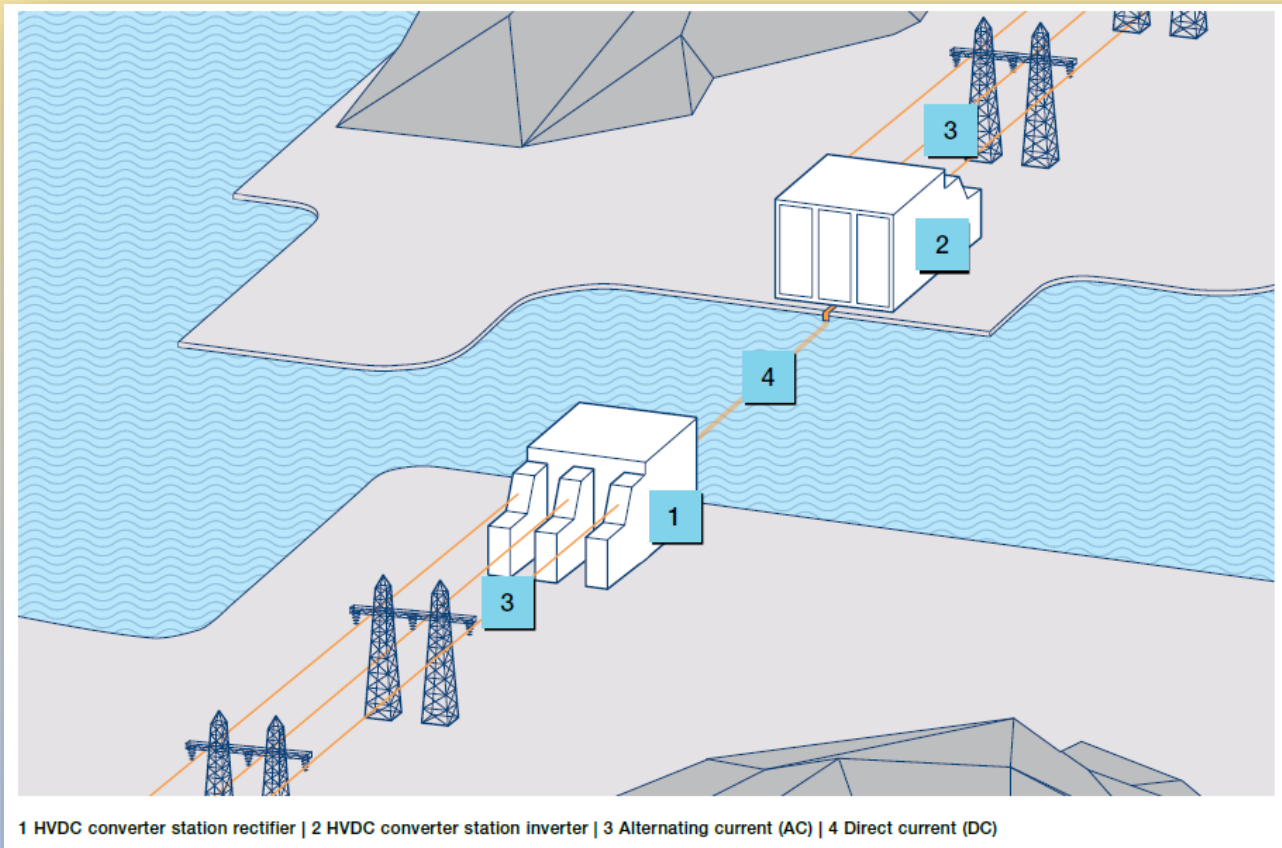
Technical Maturity	Scale Conversion	Environmental impact	Scale Conversion
Very Mature	Fully Commercialized	9	Very High
Very Mature	Commercialized	8	High
Mature	Commercialized	7	High / Medium
Mature	Commercializing	6	Medium
Mature	Limited Development	5	Medium / Low
Proven	Commercializing	4	Low
Proven	Limited Development	3	Very Low
Proven	Developing	2	
Research	Developing	1	

HYDROGEN TECHNOLOGIES



The three P2G methods and their possible applications: a) Electrolysis process resulting in H₂ and release O₂; b) Methanation process converting CO₂ (C-Source) and H₂, into CH₄; c) Methanation process converting an output gas (C-Source) from a biogas plant resulting in methanol (CH₃OH)

HVDC POWER TRANSMISSION



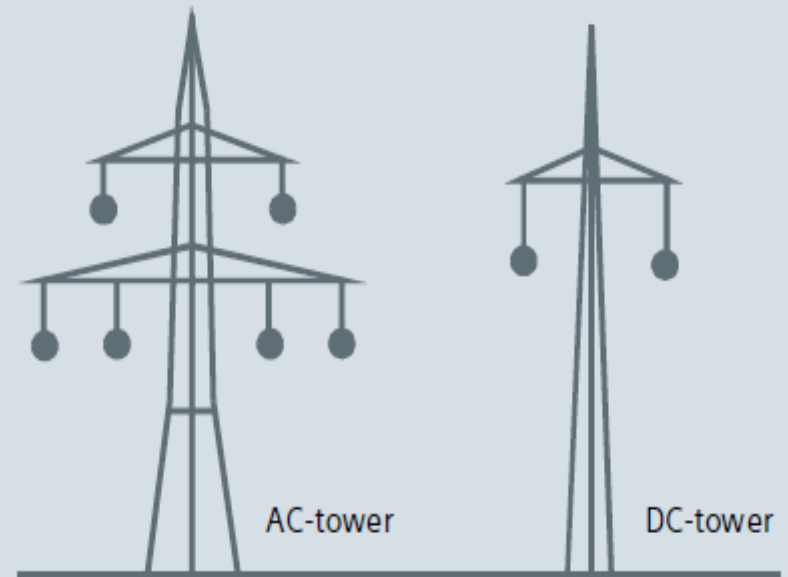
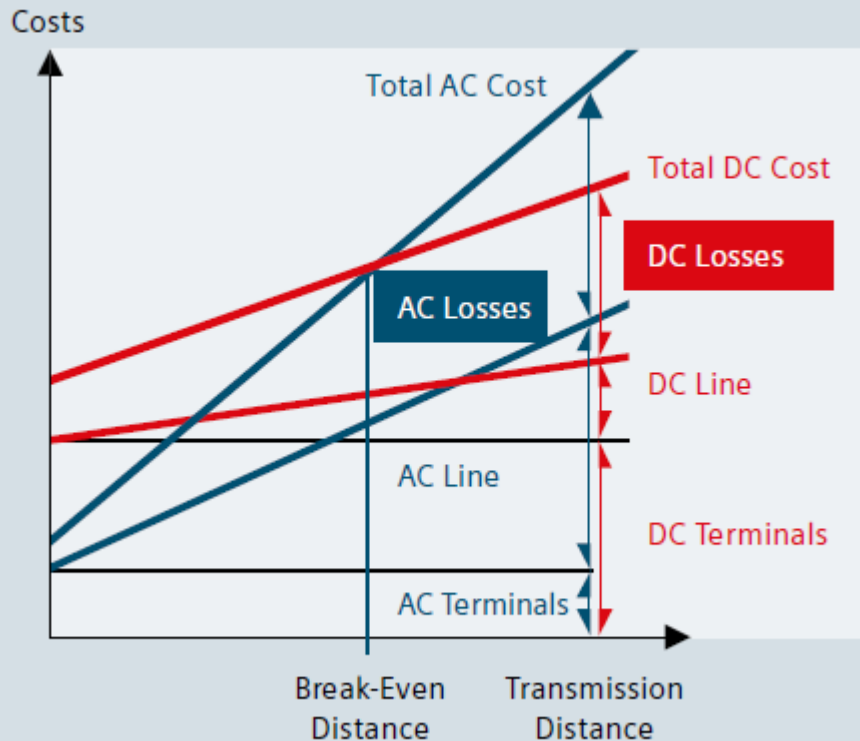
A HVDC transmission link consists of three main components:

- a station to convert the alternating current of the grid to direct current;
- the transmission equipment itself in the form of cables and overhead lines;
- another station that converts DC back into AC so that it can be used by consumers.

Introducing HVDC, ABB AB, Uno Lamm HVDC Center, SE-771 80 Ludvika, Sweden, www.abb.com/hvdc

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HVDC POWER TRANSMISSION



The break-even distance is in the range of 500 to 800 km depending on a number of other factors, like country-specific cost elements, interest rates for project financing, loss evaluation, cost of right of way etc.

High Voltage Direct Current Transmission – Proven Technology for Power Exchange , www.siemens.com/energy/hvdc

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HVDC POWER TRANSMISSION



HVDC "Classic"	HVDC PLUS
Line-Commutated Current-Sourced Converter (LCC / CSC)	Self-Commutated Voltage-Sourced Converter (SCC / VSC)
<u>Thyristors</u> with Turn-on Capability only	Semiconducting Switches with Turn-On and Turn-Off Capability, e.g. <u>IGBTs</u>

HVDC "Classic" and HVDC PLUS – Technologies

HVDC PLUS – Basics and Principle of Operation , www.siemens.com/energy/hvdcplusAnswersforenergy.

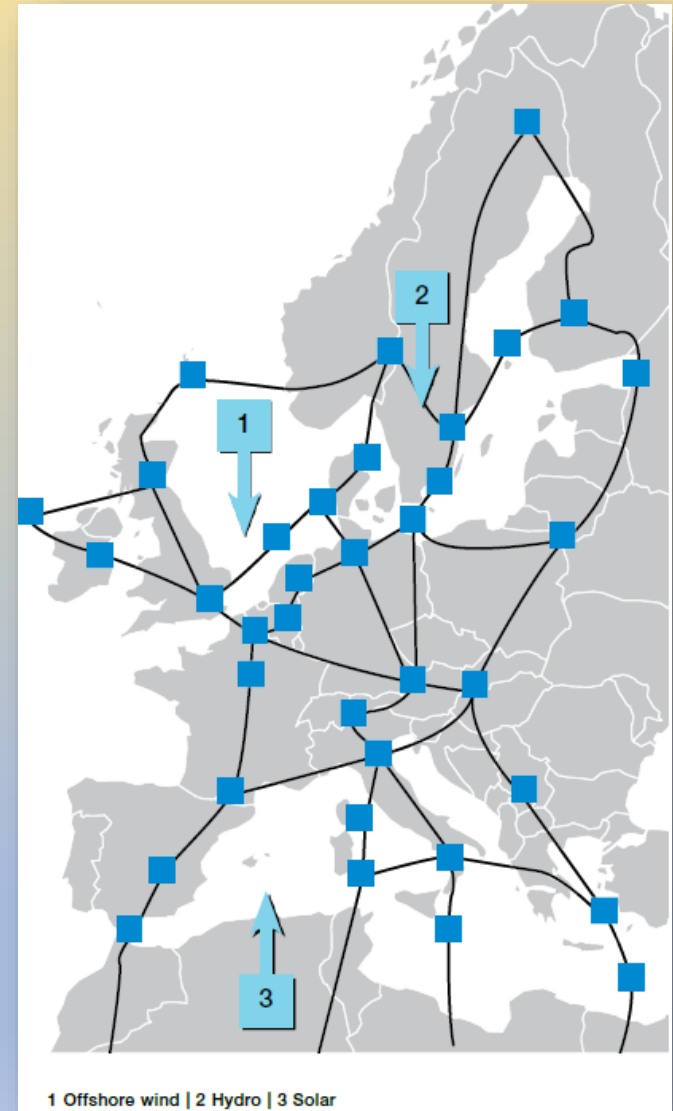
HVDC POWER TRANSMISSION

An HVDC electricity grid that can operate:

- Independently of one or several disturbances (isolate a failure)
- In different operation modes in the connected AC and DC systems

Technology gaps for the full realization include:

- Power flow control
- Automatic network restoration
- High voltage DC/DC converters

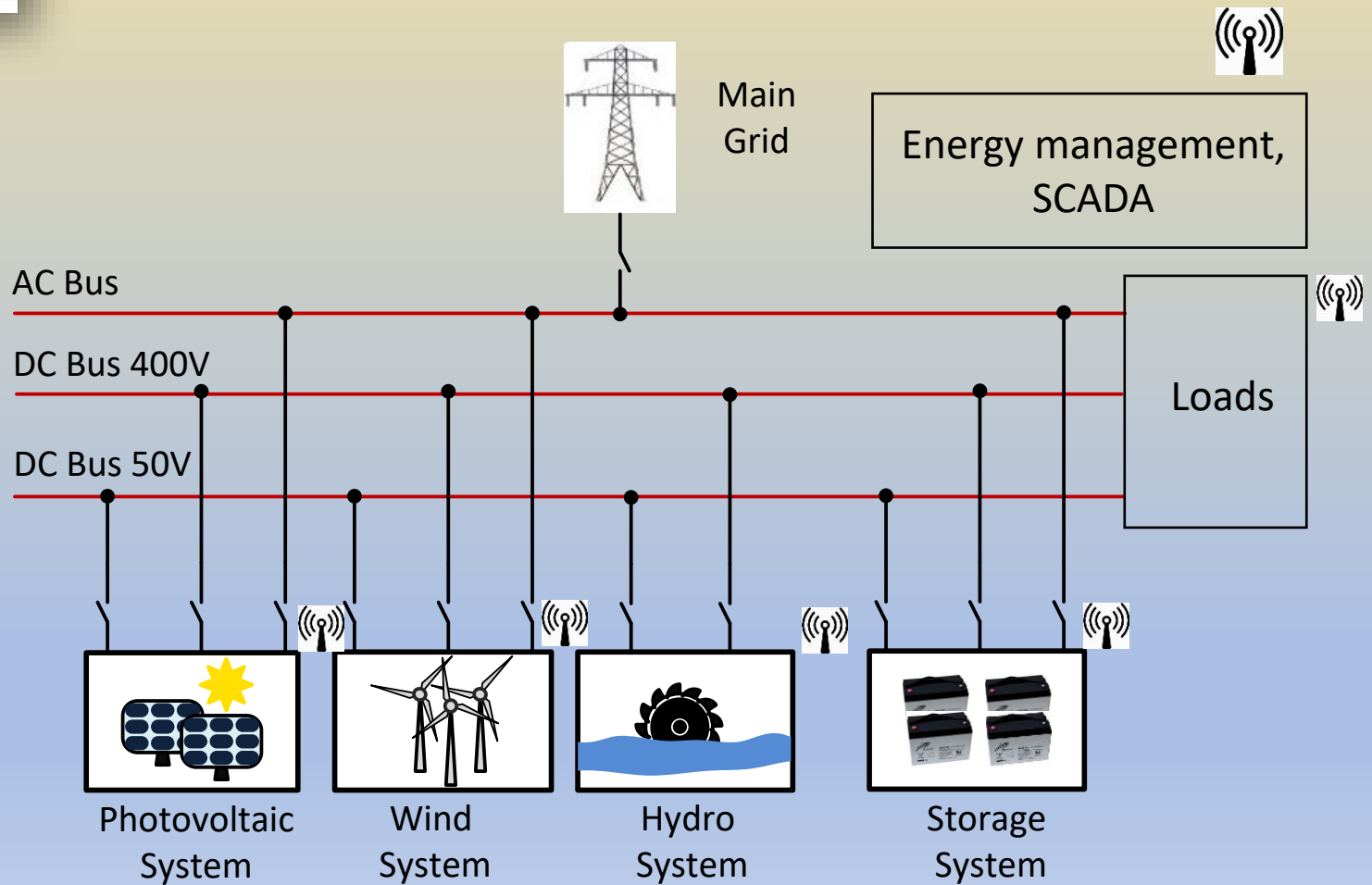


CONFIGURABLE MYCROGRID LABORATORY





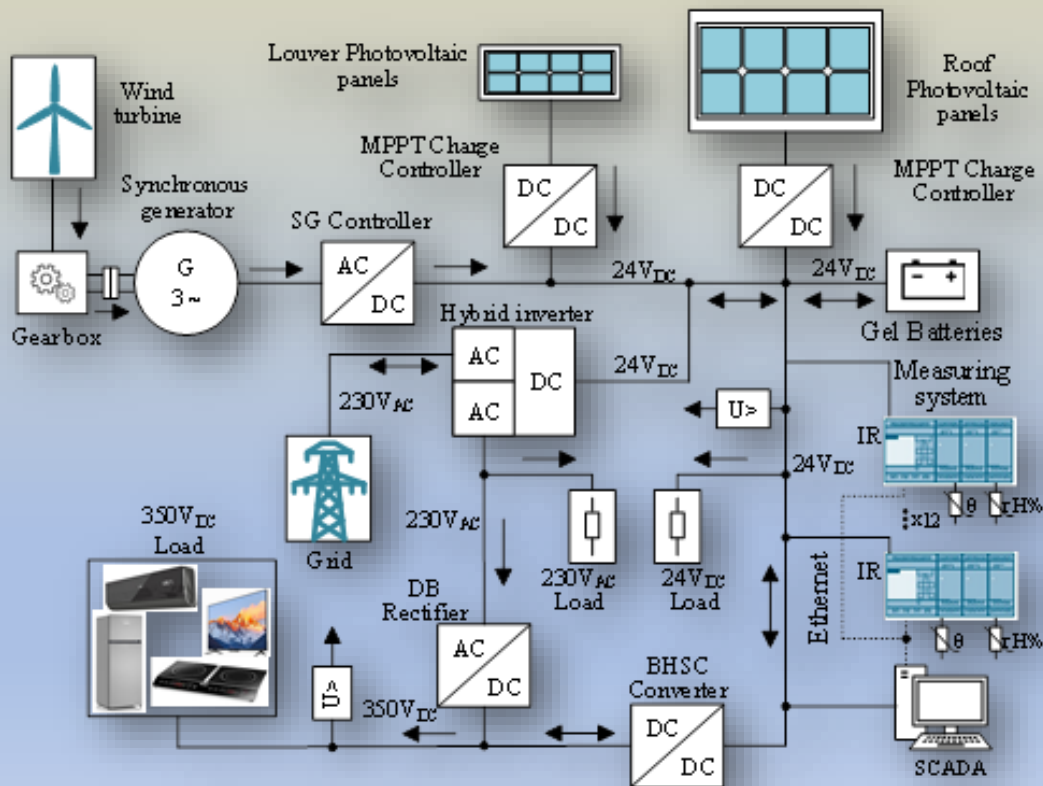
THE MICROGRID ARCHITECTURE



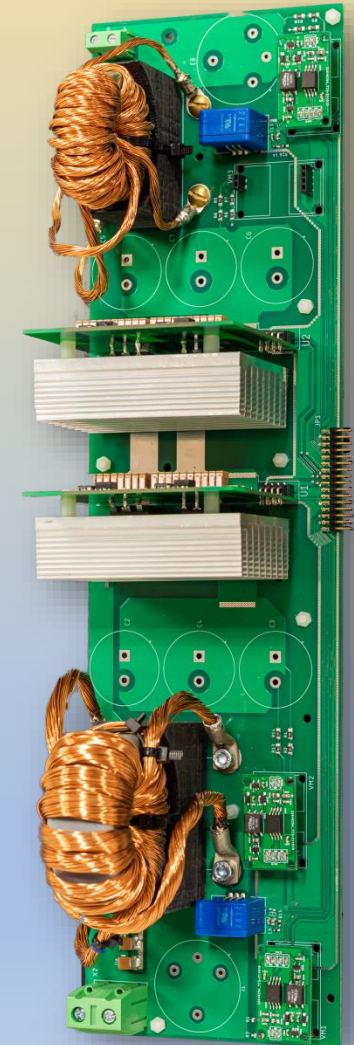
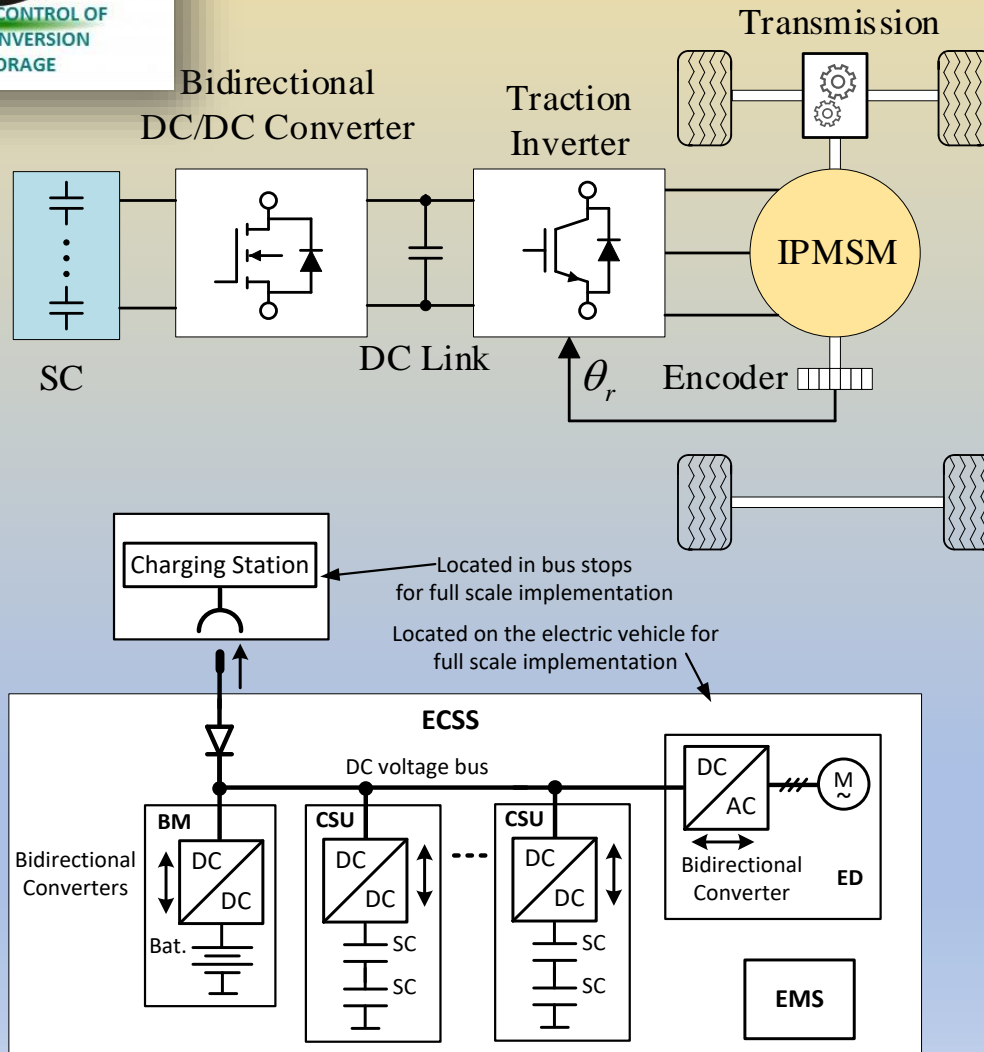


DC NANOGRID WITH INTEGRATED RENEWABLE ENERGY CONVERSION SYSTEMS

PART OF THE PROJECT: PCCDI Nr.30/2018



ELECTRIC DRIVE FOR E-MOBILITY (PROJECT 307PED2020)



CONCLUSIONS

- **THE BATTLE AC/DC IS FAR FROM OVER;**
- **SMART GRIDS ARE THE FUTURE IN POWER SYSTEMS;**
- **A MIXT BETWEEN DC AND AC WILL BE THE SOLUTION IN POWER SYSTEMS;**
- **STORAGE ELEMENTS ARE NECESSARY IN SMART GRIDS, IN ORDER TO USE THE WHOLE AMOUNT OF THE RENEWABLE ENERGY POTENTIAL;**
- **THE STORAGE ELEMENTS NEED TO BE USED ACCORDING TO THEIR PERFORMANCES IN ENERGY CONVERSION;**
- **HYDROGEN CAN BE A SOLUTION IN STORAGE AND E-MOBILITY, BUT A VERY COMPLETE ANALYSIS NEEDS TO BE MADE REGARDING EFFICIENCY, COSTS ETC. DEPENDING THE APPLICATIONS.**



danke 謝謝
teşekkür ederim
gracias
thank you

obrigado
sukriya
kop khun krap
arigato
takk
dakujem
merci
merci

MOTORS RT