

GLOBAL TECHNOLOGY TRENDS

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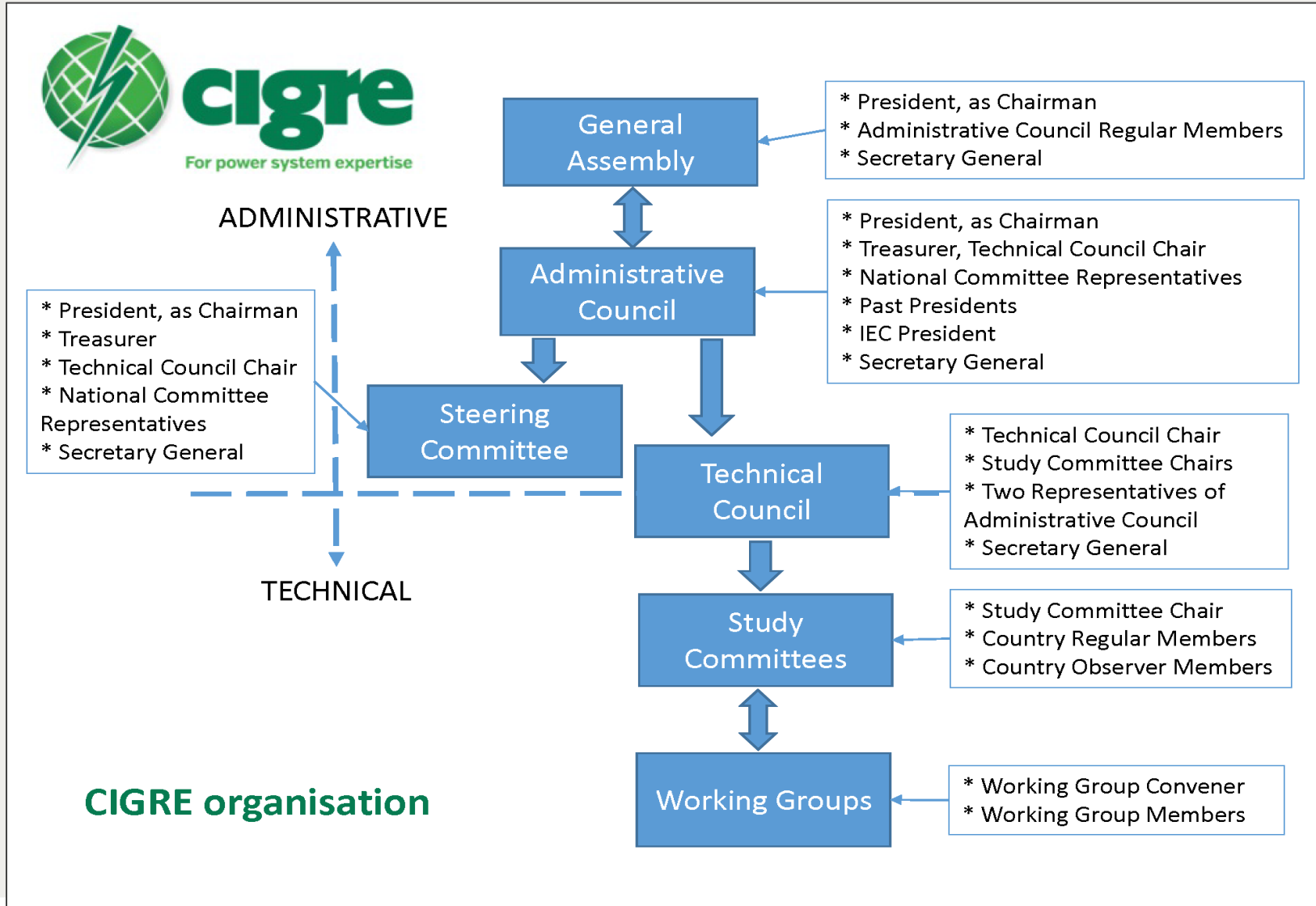
cigre

For power system expertise

WHAT IS CIGRE

- CIGRE is the global expert community for electric power systems.
- Purpose - To foster **engagement** and **knowledge sharing** among power system professionals **globally** to **enable** sustainable provision for electricity for all.
- Mission – Contribute to the betterment of power systems by **enhancing the expertise** of the people within it
- Vision – to be universally recognized as the leading **global** organization for **all aspects** of electric power systems.

CIGRE ORGANIZATION



How CIGRE is organized to deal with all aspects of electric power systems evolution, now and in the future, with the ultimate goal of enabling sustainable electricity for all. The 16 Study Committees of CIGRE, with revised scopes:

A

A1 ROTATING ELECTRICAL MACHINES

A2 POWER TRANSFORMERS AND REACTORS

A3 TRANSMISSION&DISTRIBUTION EQUIPMENT

B

B1 INSULATED CABLES

B2 OVERHEAD LINES

B3 SUBSTATIONS AND ELECTRICAL INSTALLATIONS

B4 DC SYSTEMS AND POWER ELECTRONICS

B5 PROTECTION AND AUTOMATION

C

C1 POWER SYSTEM DEVELOPMENT AND ECONOMICS

C2 POWER SYSTEM OPERATION AND CONTROL

C3 POWER SYSTEM ENVIRONMENTAL PERFORMANCE

C4 POWER SYSTEM TECHNICAL PERFORMANCE

C5 ELECTRICITY MARKETS AND REGULATION

C6 ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES

D

D1 MATERIALS AND EMERGING TEST TECHNIQUES

D2 INFORMATION SYSTEMS AND TELECOMMUNICATION

Historical

- Rotational Inertia
- Dispatchable Generation
- Passive / Predictable Loads
- “Static” T&D Infrastructure



*Operator-Based Grid Management
Centralized Control
SCADA Measurements
Off-Line Analysis / Limit Setting*

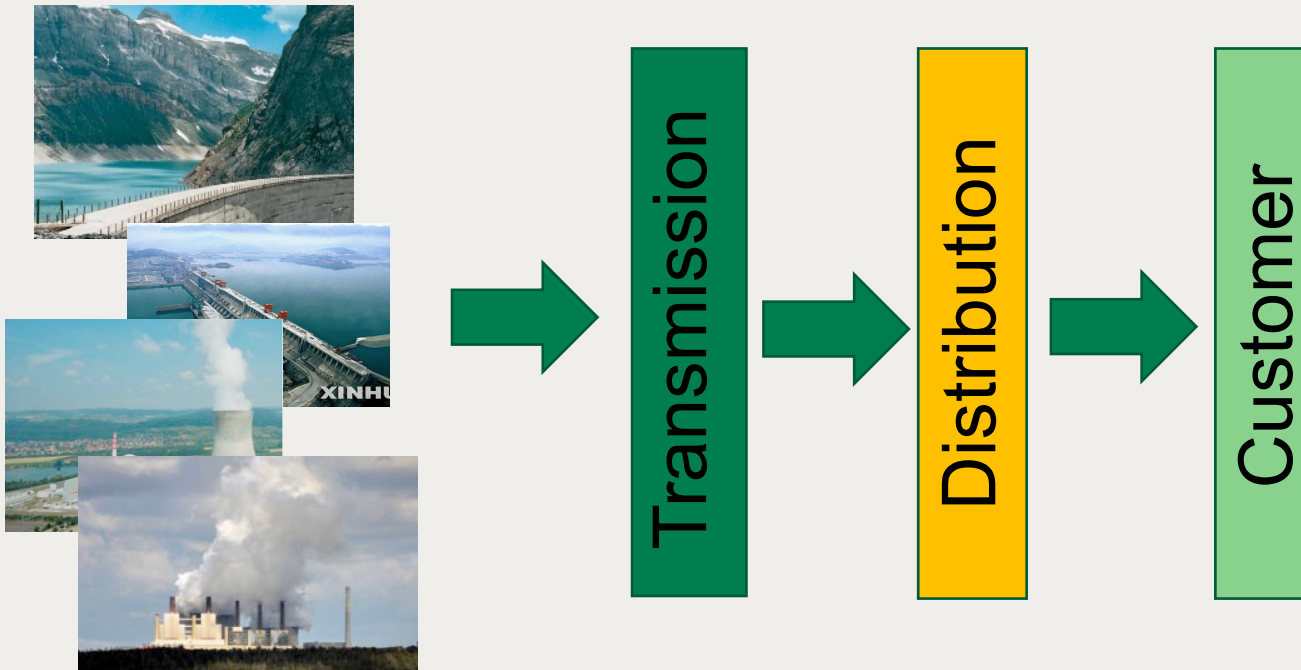
Emerging

- Reduced Stability / Faster Dynamics
- Stochastic Generation
- Engaged Consumers
- “Adaptive” T&D Infrastructure
- Agile, Precise Control for Distributed Generation
- More Efficient, Reliable, and Resilient Electricity Systems



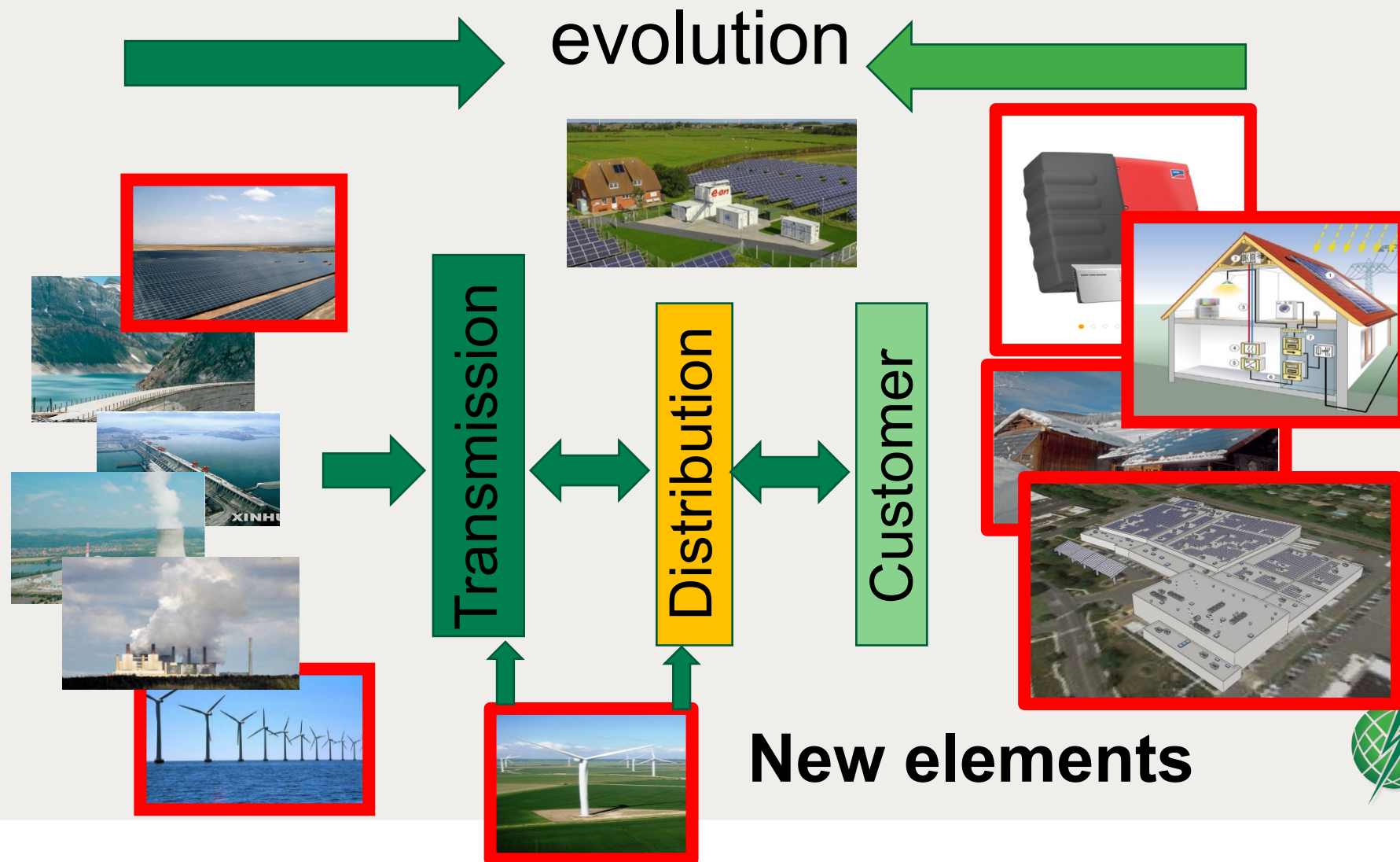
*Sensors and Data Acquisition
Faster-than-Real-Time Analysis
Algorithms and Computer Infrastructure
More Precise Control
Flexible and Resilient Systems
Multi-Level Coordination
PMU Measurements*

PAST SYSTEM



Uni-directional load flow from source to load

EVOLUTION OF GRID USE



FUTURE GRID – 10 FOCUS AREAS

1

ACTIVE DISTRIBUTION NETWORKS

2

MASSIVE EXCHANGE OF
INFORMATION

3

INTEGRATION OF HV AND MV
DC/POWER ELECTRONICS

4

SIGNIFICANT INSTALLATION OF
STORAGE

5

NEW SYSTEMS OPERATIONS
/CONTROLS CONSIDERING
ENVIRONMENTAL ASPECTS

6

NEW CONCEPTS FOR
PROTECTION

7

NEW CONCEPTS IN
PLANNING FOR SUSTAINABLE
SYSTEMS

8

NEW TOOLS FOR TECHNICAL
PERFORMANCE

9

INCREASED USE OF EXISTING
INFRASTRUCTURE AND NEW T&D
DEVELOPMENTS

10

STAKEHOLDER AWARENESS;
MARKET & REGULATORY
INTEGRATED CHAIN

FUTURE GRID – FUTURE LIFE ON EARTH

1

INCREASE USE OF RENEWALS

2

LOW CARBON, LOW
COST, LOW IMPACT

3

INCREASE NEED OF ELECTRICITY IN
MODERN LIFE: SECURITY OF SUPPLY
IS MORE IMPORTANT THAN EVER

4

CAN WE RELY ON SOLAR AND
WIND FOR FUTURE GRIDS

5

HYDRO PROJECTS COMBINED
WITH SOLAR/WIND: THE
RENEWABLE ENERGY SUPPLY
SYSTEM

6

BASED ON THE
PREMISES, CAN ONE
COUNTRY MAKE ITS
EXPANSION PLAN?

7

REGIONAL
INTERCONNECTIONS IS THE
NATURAL SOLUTION

8

ELECTRICITY EXPANSION BASED
ON INTEGRATED PLANNING

9

USE OF SEASONAL, TIME ZONE, AND
WEATHER CONDITIONS TO
INTERGRATE NEW ENERGY SOURCES

10

ROLE OF CIGRE BECOMES EVEN
MORE IMPORTANT

INVERTER BASED RESOURCES-GROWING



wind farms



bulk solar plants



residential production

Fastest growing electricity source: by 2030 expected to be a major source of electricity (IEA)

WHAT GENERATION PROVIDES WHAT SERVICE

WARNING: Relative rankings in table based on specific assumptions and disclaimers documented in white paper—do not use in isolation. Relative scores are based on “typical” capabilities of resources presently being installed.

		SYNCHRONOUS INTERCONNECTION					INVERTER-BASED INTERCONNECTION				DEMAND RESPONSE	
		Coal	Natural Gas Simple Cycle	Natural Gas Combined Cycle	Nuclear	Hydro	Grid Scale Wind	Grid Scale PV	Distributed PV	Distributed Battery Storage	Large (Industrial/Commercial)	Small (Aggregated)
Volt/Var Control		5	5	5	5	5	5	5	4	4	0	0
Short Circuit Contribution		5	5	5	5	5	4	4	4	4	0	0
Frequency Control	Inertial Response	5	4	5	5	5	4	0	0	0	4	0
	Primary Frequency Response (droop)	4	4	4	0	5	4	4	0	4	4	0
	Regulation	4	5	5	0	5	4	4	0	4	4	4
	Load Following/Ramping	4	5	5	0	4	4	4	0	4	4	4
	Spinning Reserve	4	5	5	0	5	4	4	4	4	5	5
Short-term Availability (fuel)		5	4	4	5	5	4	4	4	4	4	4
Long-term Availability (plant)		4	4	4	5	5	4	4	4	4	4	4
Black Start		4	4	4	0	5	0	0	0	0	0	0

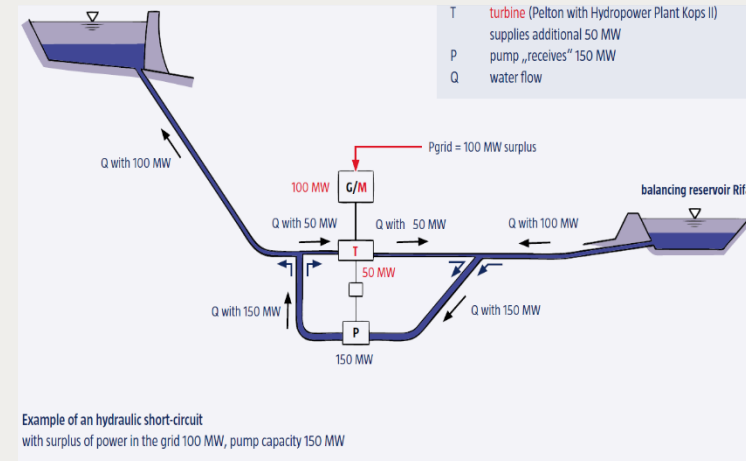
Reliable system operation requires online resources aggregately capable of providing the full range of required reliability services. Synchronous interconnection resources provide the highest contribution across the broadest range of reliability services.

Source EPRI

NEED SCORE
OF AT LEAST 5
CONSTANTLY
AVAILABLE

STORAGE CAPACITIES

Global
145 GW (98%)



PV combined with storage
Global : around 2200 MW
In 2025 expected > 21 GW

TO MAKE REAL ALL THESE INITIATIVES, UHV AC AND DC TECHNOLOGICAL DEVELOPMENT IS ESSENTIAL

- UHV up to 1200 kV AC and +/- 1100 kV DC Equipment and Lines
- Submarine cables to a depth of 3000 m
- Compact GIS substations allow cost reduction and off shore transmission
- Hybrid lines (AC and DC on one tower)
- Technologies for very long distance transmission

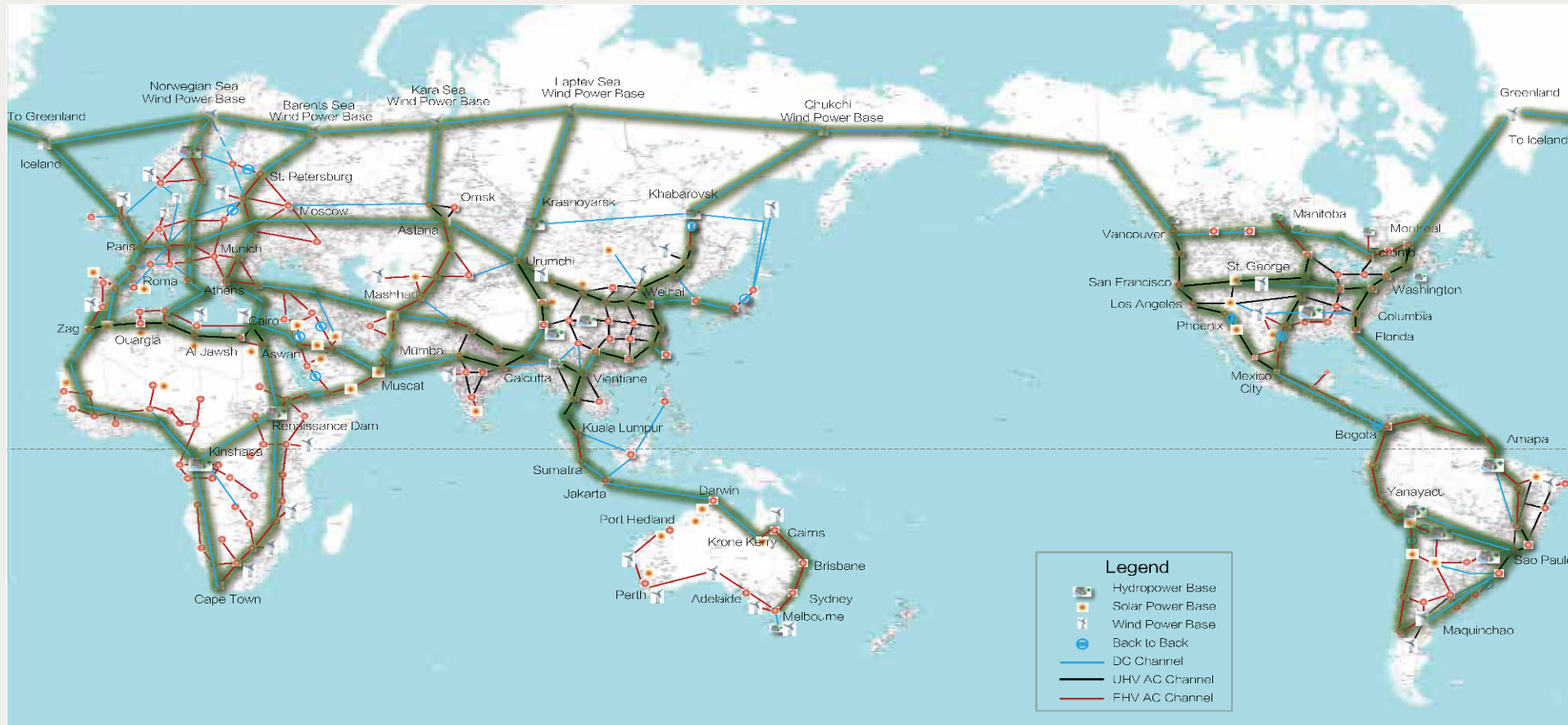
GLOBAL GRID – INTEGRATION OF RENEWABLES - EXAMPLES

1. THE ASIAN INTERCONNECTION



GLOBAL GRID – INTEGRATION OF RENEWABLES - EXAMPLES

3. THE GEI/SGCC INITIATIVE: Worldwide integration through cooperation



TECHNOLOGY FOR GLOBAL GRID

TECHNOLOGY DEVELOPMENT IN UHV

The ± 1100 kV, 12000 MW, 3300 km SGCC Project



587 MVA power transformers supplied by SIEMENS, ABB and Chinese Manufacturers



HYDROGEN AS A VIABLE SOURCE OF ENERGY

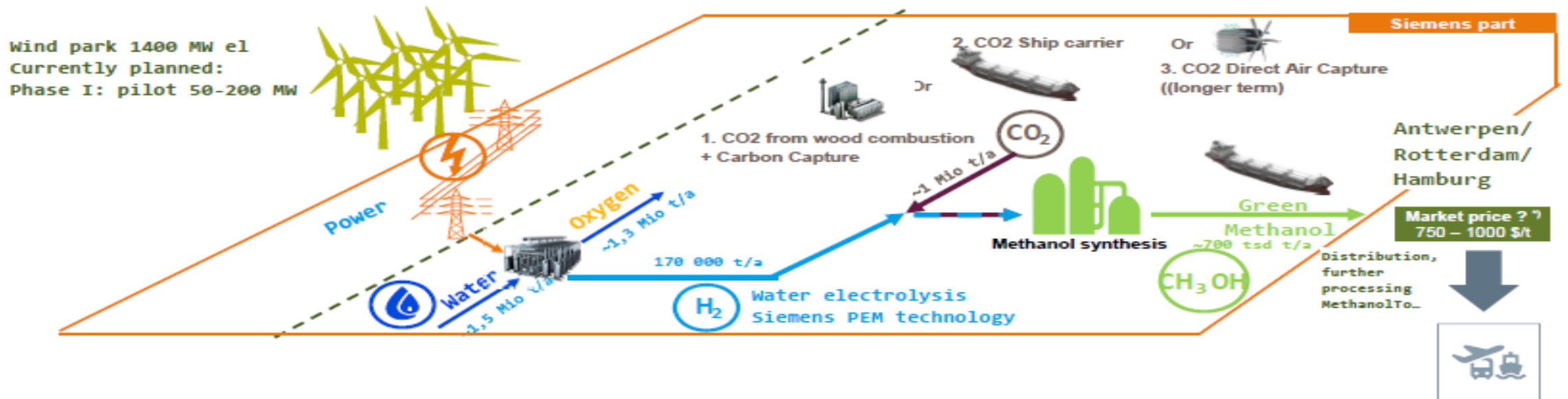
- **By Electrolysis:** IEA: The time is right to tap into hydrogen's potential to play a key role in a clean, secure and affordable energy future....

There have been false starts for hydrogen in the past; this time could be different. The recent successes of solar PV, wind, batteries and electric vehicles have shown that policy and technology innovation have the power to build global clean energy industries.

- **By Fusion:** ITER ("The Way" in Latin): is one of the most ambitious energy projects in the world today.

In southern France, 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars (800 employees, US\$ 20 Billion project).

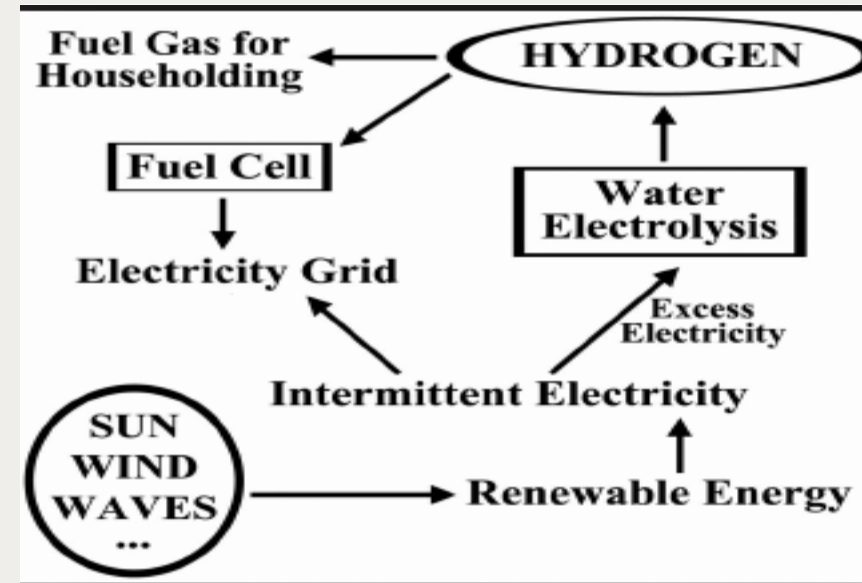
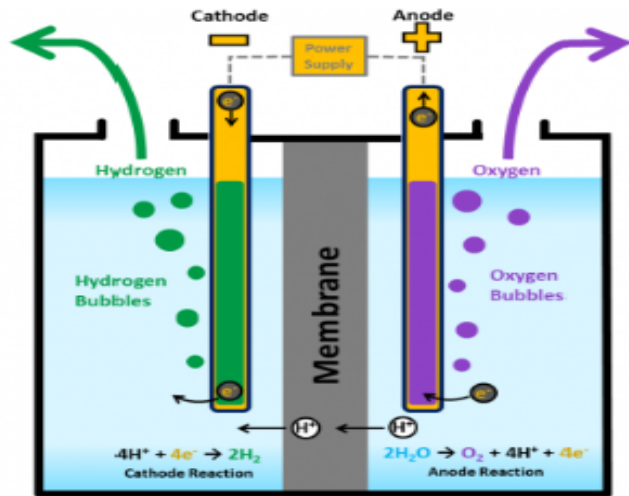
POWER TO GAS - METHANOL



*) First price notation for green methanol at exchange Rotterdam 660 €/t (~760 US\$/t), potential for price increase up to 1000 US\$/t based on biofuel pricing for comparable CO₂ reduction

Claus Möller | Siemens A/S

POWER TO GAS - HYDROGEN



VERY LARGE WIND FARMS BEING CONSIDERED



Grand vision and the North Sea Wind Power Hub

Developing 180 GW of offshore wind power in the North Sea, to be supplied to European markets, using a modular “hub and spoke” concept



- Offshore hubs in the North Sea could each connect up to 10-15 GW wind power and distribute generated power to European markets through a network of cables (spokes) and/or pipelines (H₂ production)
- From the hub, generated power will be transmitted to markets around the North Sea
- The network of transmission cables will also function as interconnectors, directly connecting European energy markets



North Sea Wind Power Hub Consortium

TenneT Netherlands, TenneT Germany, Energinet, Gasunie and Port of Rotterdam joined forces to develop a large scale European energy system for offshore wind in the North Sea.

CONCLUSION

- Inverter based resource penetration will continue to accelerate
- Loads/generators will be interchangeable, mobile, and variable.
- Flow of power will be uncertain.
- Markets will further distort the power and revenue/expense flow
- Hydrogen likely to be the next disruptor
- GREAT OPPORTUNITY
 - Further studies in business models, revenue retention, product development.
 - Future studies in almost all aspects of grid planning, design, operation, protection and maintenance.
- ENJOY THE FUTURE

ACKNOWLEDGEMENTS

- Eskom
- Technical Council – CIGRE



THANK YOU FOR YOUR ATTENTION