



WORLD ENERGY COUNCIL

CONSEIL MONDIAL DE L'ÉNERGIE

For sustainable energy.



# **»Global electrical network as support to our path in de-carbonation of energy sector«**

**Focus on increasing global interconnections**

**Krešimir Bakič, ELES, Honorary member of CIGRE, Paris  
Ljubljana, 19 February 2019**

World Energy Council – NC Slovenia - EPC 6 (2019)

The background of the slide is a photograph of high-voltage power lines and pylons silhouetted against a deep blue night sky filled with stars. The lines stretch from the bottom left towards the top right, creating a sense of depth and scale.

*Electricity is becoming more and more  
the cornerstone of functioning our society*

## **PLAN OF PRESENTATION**

1. Global issues and motivation
2. Possibilities of technologies
3. First results
4. Global political support
5. Conclusion

**SLOVENIA AS GLOBAL PARTNER**

*“A leader needs enough understanding  
to fashion an intelligent strategy.”*

John Kotter, Harvard Business School

# Global issues and motivation

**WHY CHANGES?**



# CIGRE C1.35 project

## *“Global electrical network – Feasibility study”*

### *The concept*

A global electricity network has been envisaged to consist of inter-continental backbone, and related reinforcement within the regions, based on many proposals.

A global electricity network would enable the power system **to take advantages of diversity from different time zones, seasons and load patterns of the interconnected countries**, as well from averaging out the intrinsic RES intermittent availability over large climatic areas.

### *Why a global grid*

The justification of the global grid should address the following questions:

- How to **take advantage of diversity of consumption load patterns** deriving from different time zones (East-West interconnections), **different seasons or temperature**, ranges (North-South interconnections), **different climatic patterns** (areas with constant rainy periods or periodic winds blowing), different cultures and religions (off-working day on Sunday or Friday or Saturday)

# Global macro grid or local micro grid



*Sweeping sun irradiation across the globe*

Source: CIGRE WG C1.35

**Interconnections could facilitate efforts to meet global power demand with global RES, in an efficient way.**

**Differences of the time of the demand could be a great advantage throughout the world.**

**Drivers:**

- **Differences due to seasonal effects,**
- **Exchange energy between lighted countries to obscure countries.**

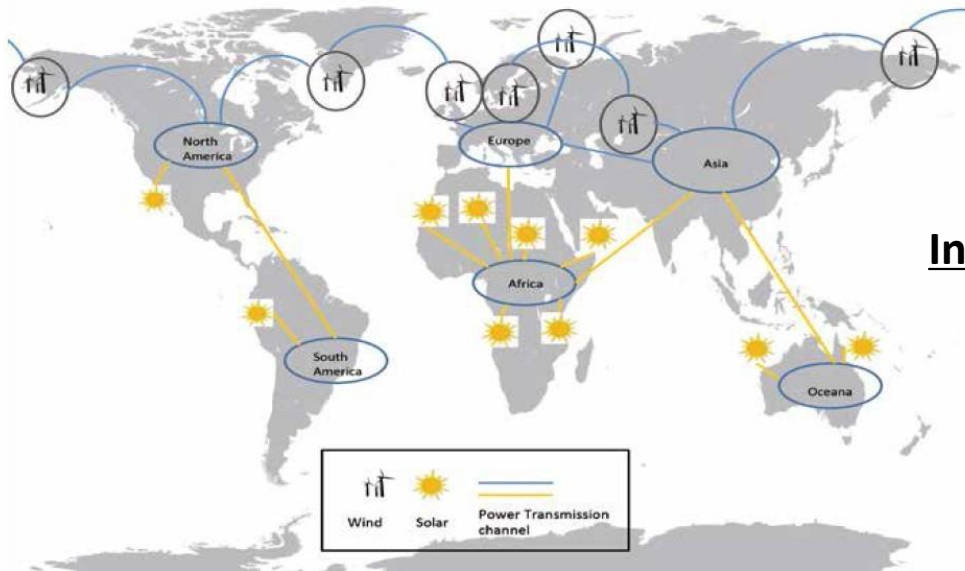
**Global interconnections could be cost effective model for future solving many present obstacles as storages, waste investments, social issues, etc.**

## INTERCONNECTIONS



# Clean energy and interconnections

## INTERCONNECTION



- Supports a balanced coordination of power supply of all interconnected countries.
- Enables clean energy transmission
- Take advantage of diversity of clean energy.

**Increase clean energy consumption**

Source: CIGRE WG C1.35

*“Strategy means making clear-cut choices  
about how to compete.”*

(Jack Welch, Chairman, and CEO of GE)

**2.0**

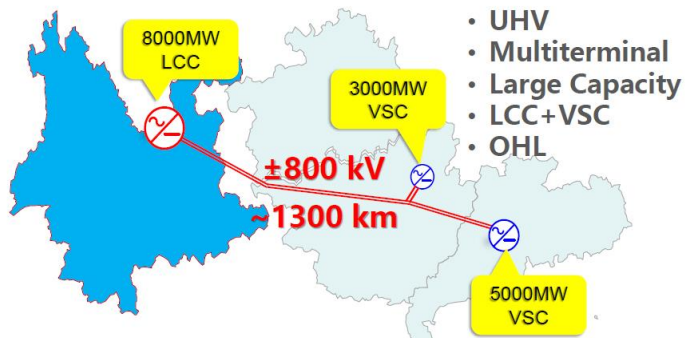
**POSSIBILITIES OF  
TECHNOLOGIES**

# Technologies for Global Grid

*Paris August, 2018: Workshop organized by AGP21*



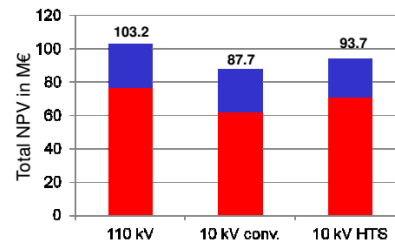
±800kV VSC project



New trends in HVDC –  
The Overlaying idea of the Asian  
Interconnection

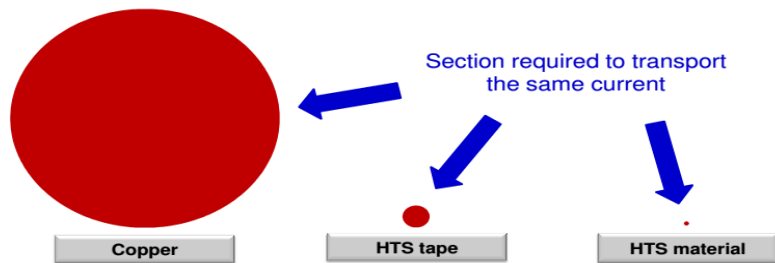
*Source: Marcio Szechtman, Brazil*



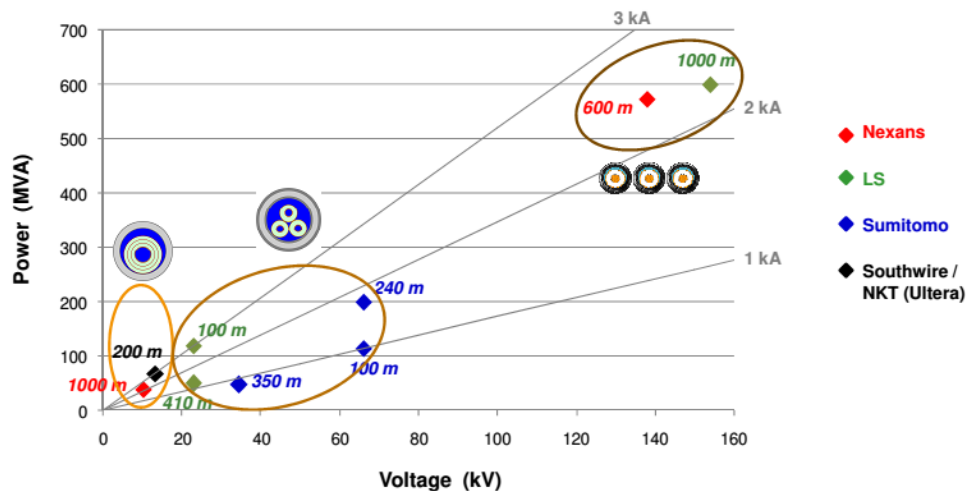


## Main AC HTS cable projects (3 phases & $\geq 100$ m)

## Very large current transport capability



→ High-current cables can be manufactured (> 5 kA AC and tens of kA DC)



**Paris August, 2018: Workshop organized by AGP21**

## ESS (Energy Storage System)

KEPCO 154kV Gim-je S/S 48MW ESS for Frequency Regulation



**Total contract amount**  
about 18M USD (excluding construction work)

- 1) PCS 48MW (2MW \* 24SET)
- 2) Battery 12MWh (LG chem)
- 3) LPMS 1 SET
- 4) HMI
- 5) Transformer 5200kVA 12 Bank  
(3PHASE 22.9kV/440V/440V, Yd1d1)

Frequency regulation

Micro-grid

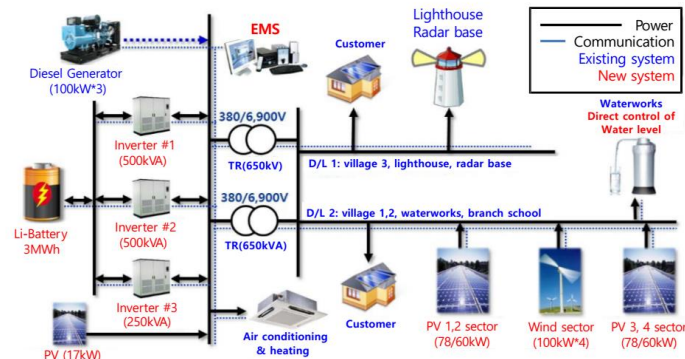
Peak shaving

Renewable integration

**This case was for Micro Grid**



CASE - Gasa Island, South Korea



*“Designing a winning strategy is the art of asking questions, experimenting and then constantly renewing the thinking process”*

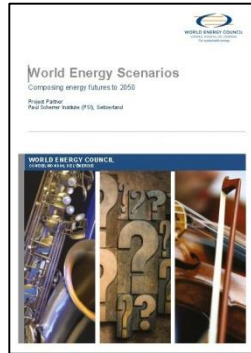
(Constantinos Markides, Professor of Strategic Leadership at London Business School)

# 3.0

## Results of study

# Input data for electricity generation forecast by 2050

The reference source of data: World Energy Council (WEC)



WEC<sub>2013</sub>

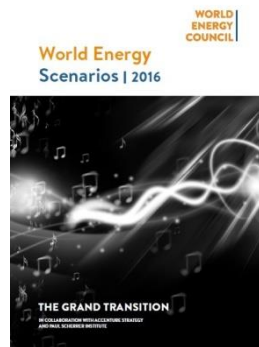
Technology	2010		2050 Symphony	
	GW	TWh/y	GW	TWh/y
Hydro	930	3500	2200	7800
Wind	300	500	1650	4040
Solar	90	100	4500	7810
Geothermal	30	50	100	610
Biomass	70	100	500	2730
Coal (with or without CCS)	1520	8650	1460	8480
Oil	380	1000	60	10
Nuclear	450	2800	880	6950
Gas	1360	4800	2550	9470
	5120	21500	13900	47900

Regions

8 regions



	Unfinished Symphony
2010	2050
21500 TWh	39 490 TWh
5100 GW	12 070 GW



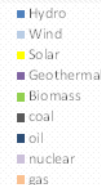
WEC<sub>2016</sub>

Unfinished Symphony



2050 Unfinished Symphony	
GW	TWh/y
1803	6531
3034	7710
3299	5624
61	735
392	2129
262	1503
0	133
829	6311
2389	8815
12070	39490

Source of electricity generation

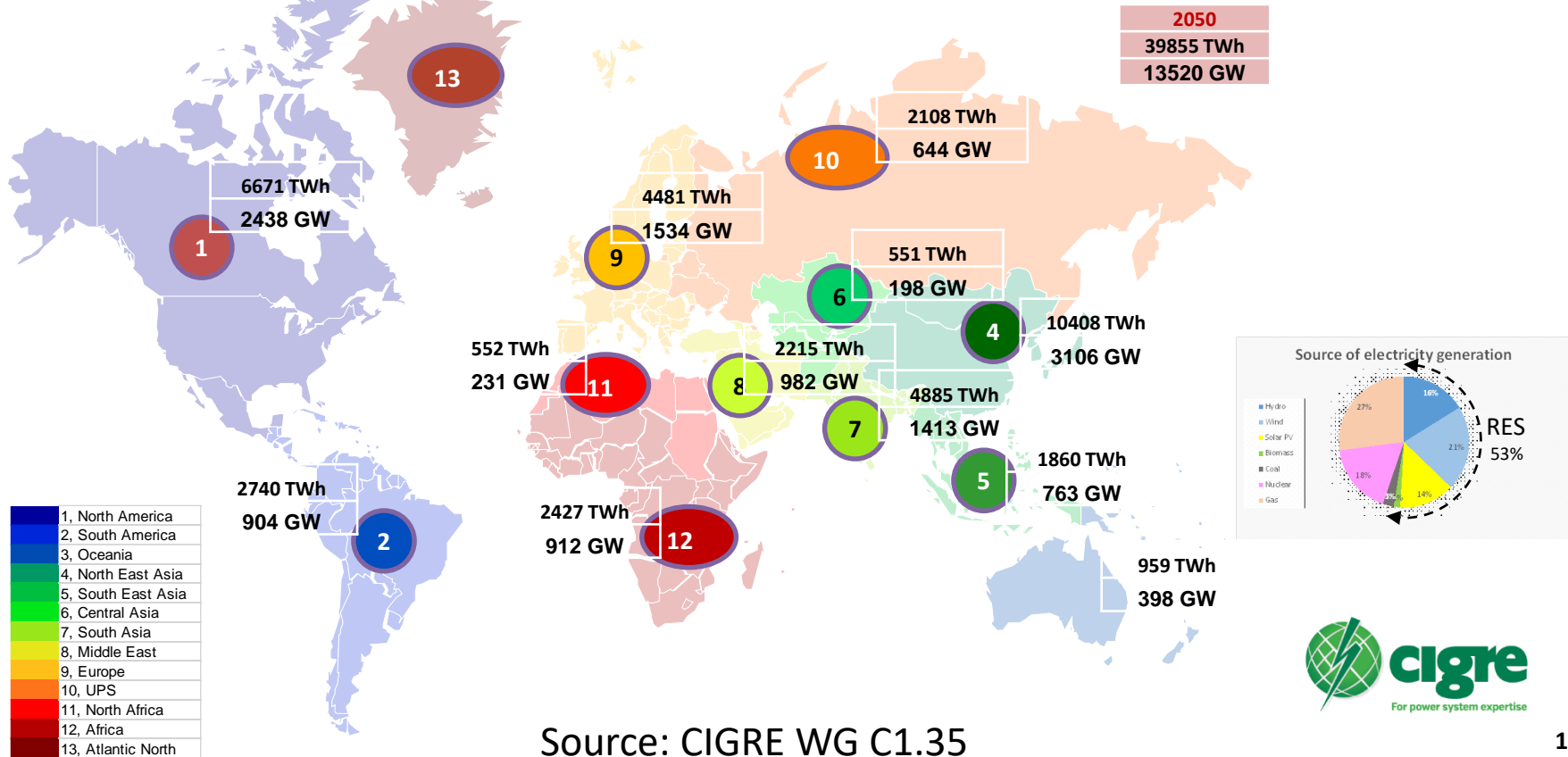


RES  
58%



# Input data for electricity generation forecast by 2050

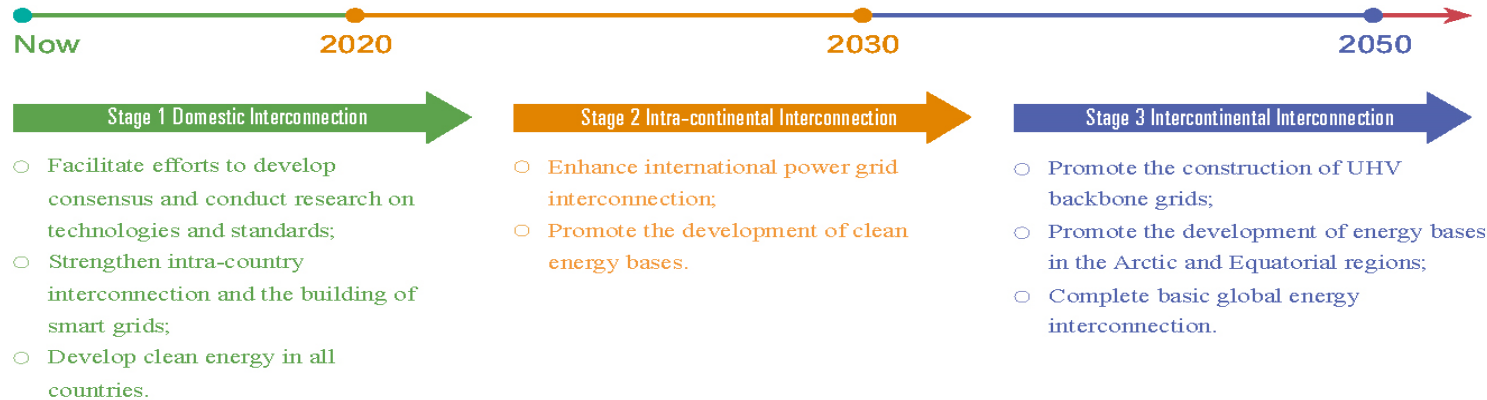
WEC Sources and C1.35 model with 13 regions



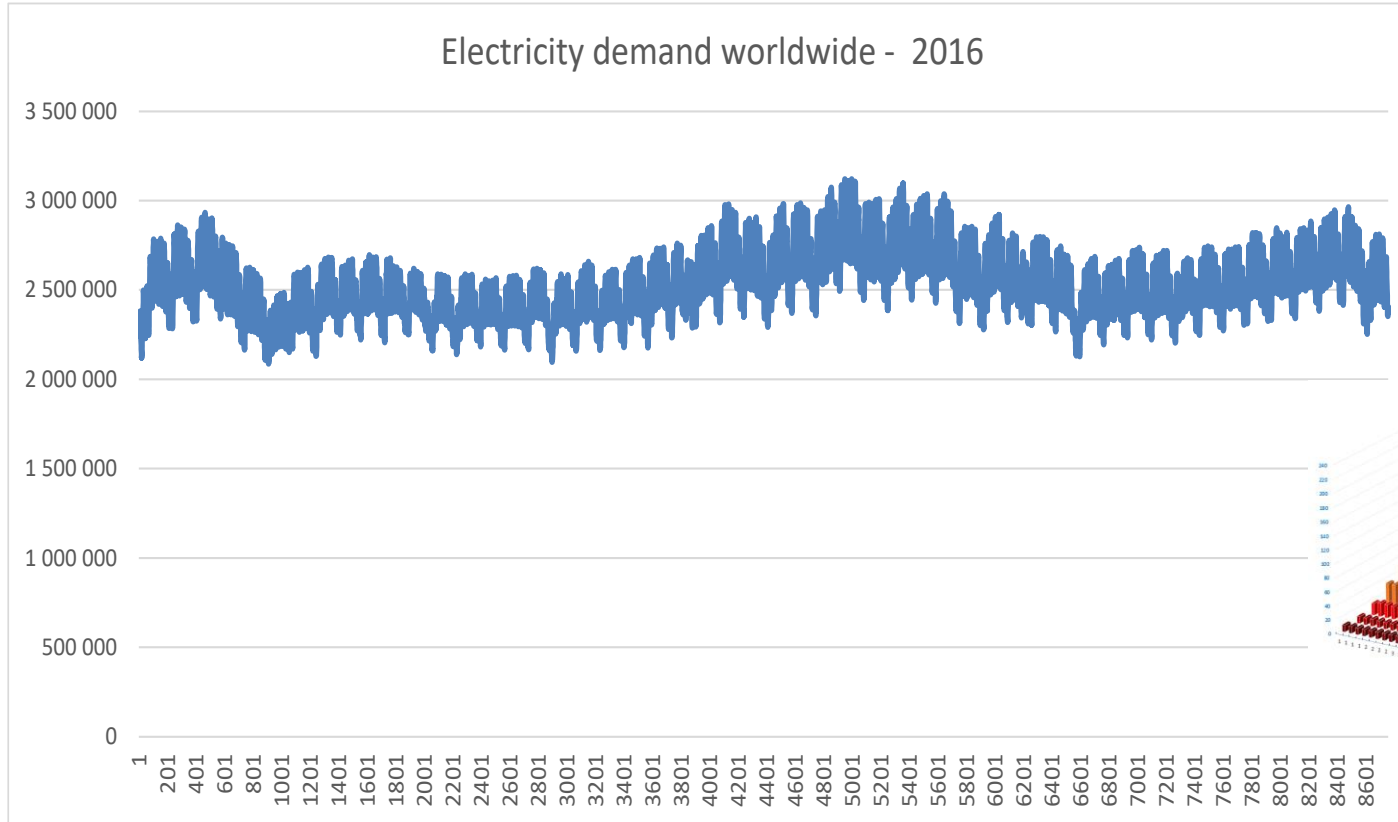
# Roadmap

**The shaping up of GEI can be divided into three phases: domestic, intracontinental, and intercontinental interconnection.**

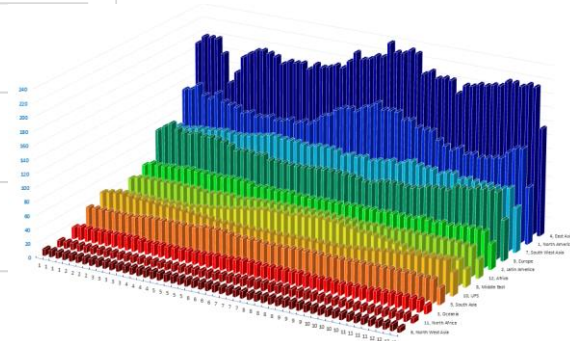
- From now on to 2020, countries will focus on their own clean energy development and grid interconnection projects
- By 2030, large-scale energy bases and cross-border grid interconnections will be promoted within each continent.
- By 2050, energy bases of the Arctic and equatorial regions and intercontinental interconnection will be set up. Global Energy Interconnection will basically come into being.



# The electricity demand worldwide - 2016

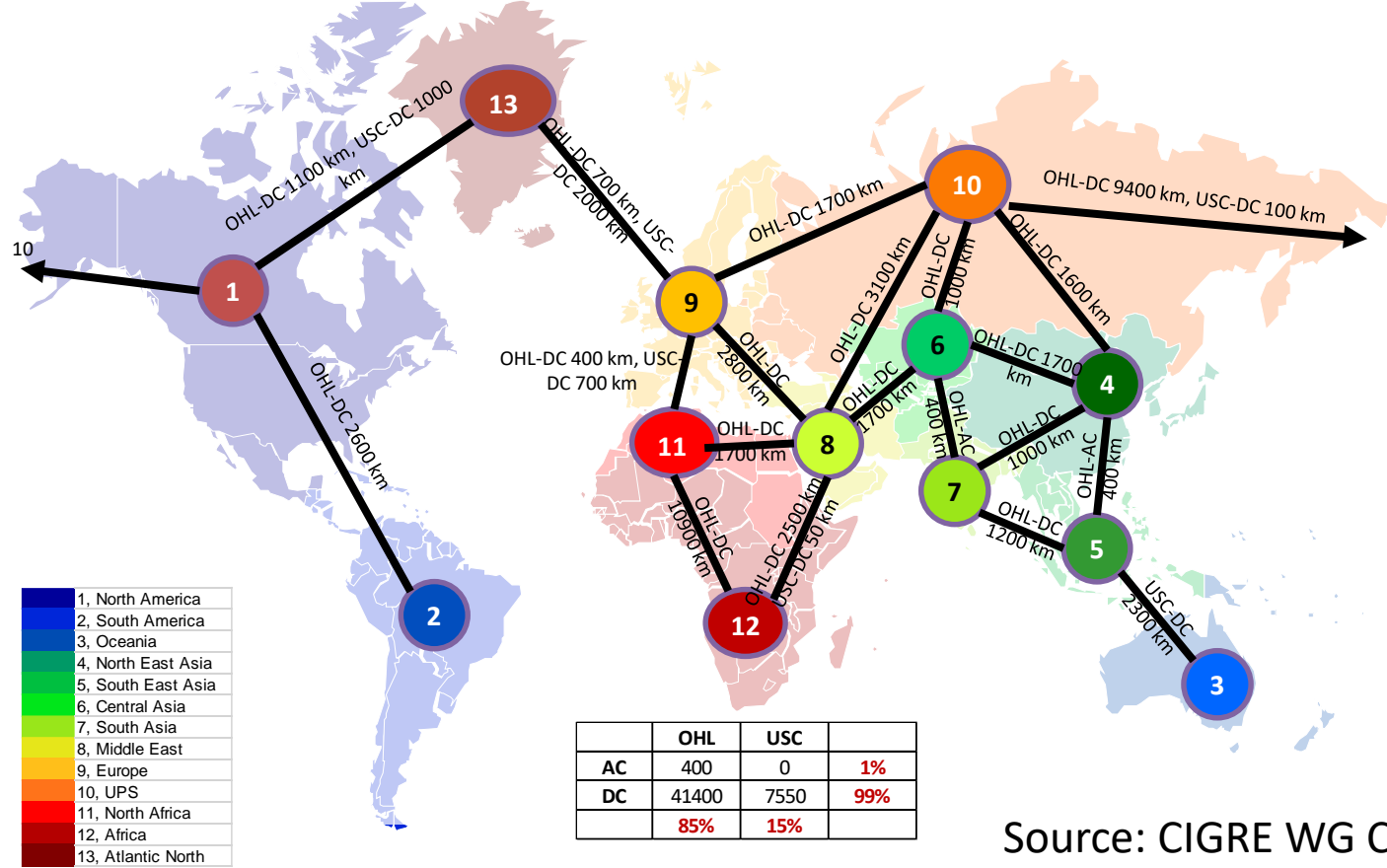


Max = +23%  
Mean = 2500 GW  
Min = -17%



# Interconnections selected

20 interconnections, mainly DC links, and Over-Head-Line technology.



	OHL	USC	
AC	400	0	1%
DC	41400	7550	99%
	85%	15%	

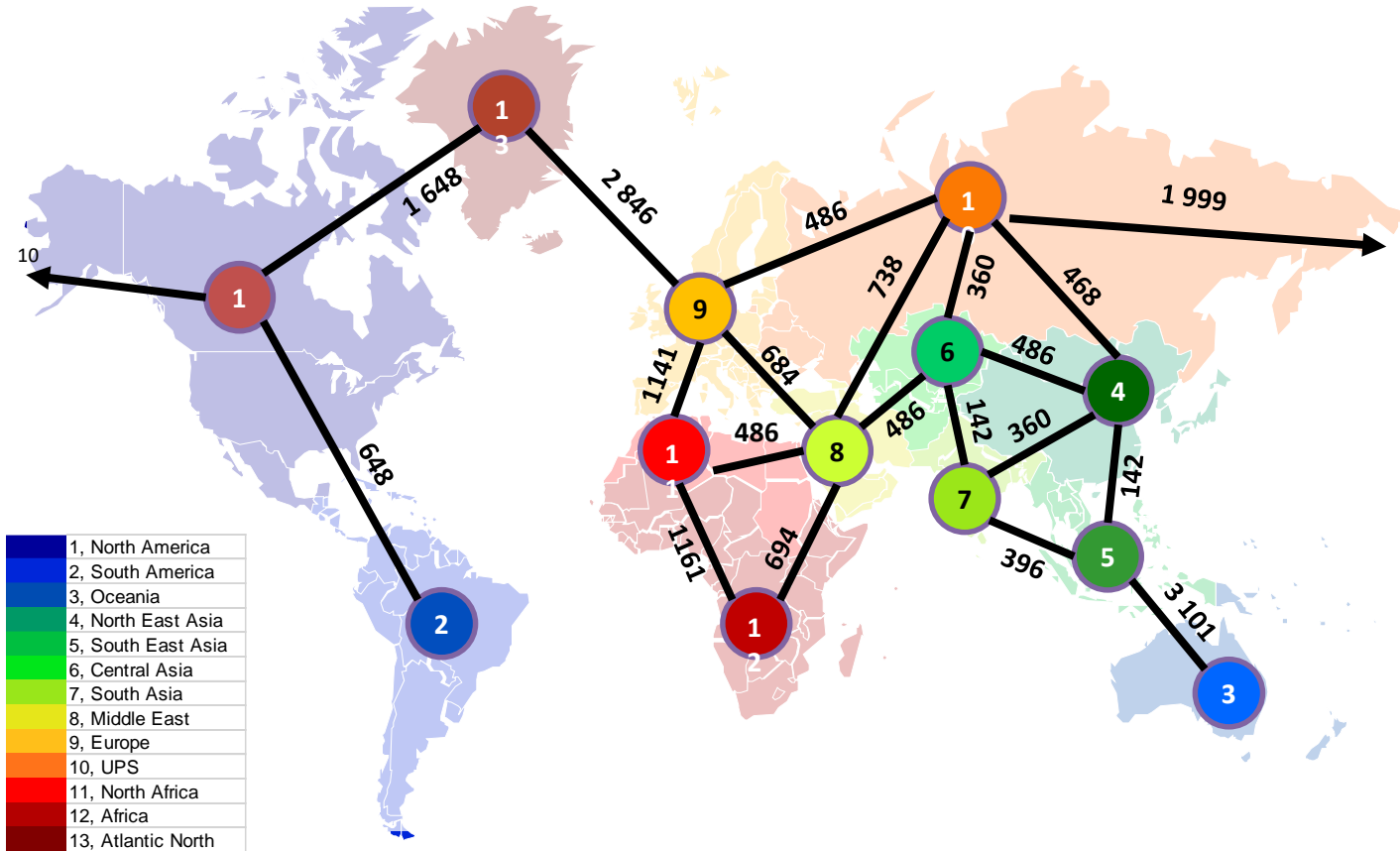
# North Atlantic – Europe – UPS – North Africa – Middle East



# Europe – North Africa – Middle East – UPS – Central Asia – South Asia

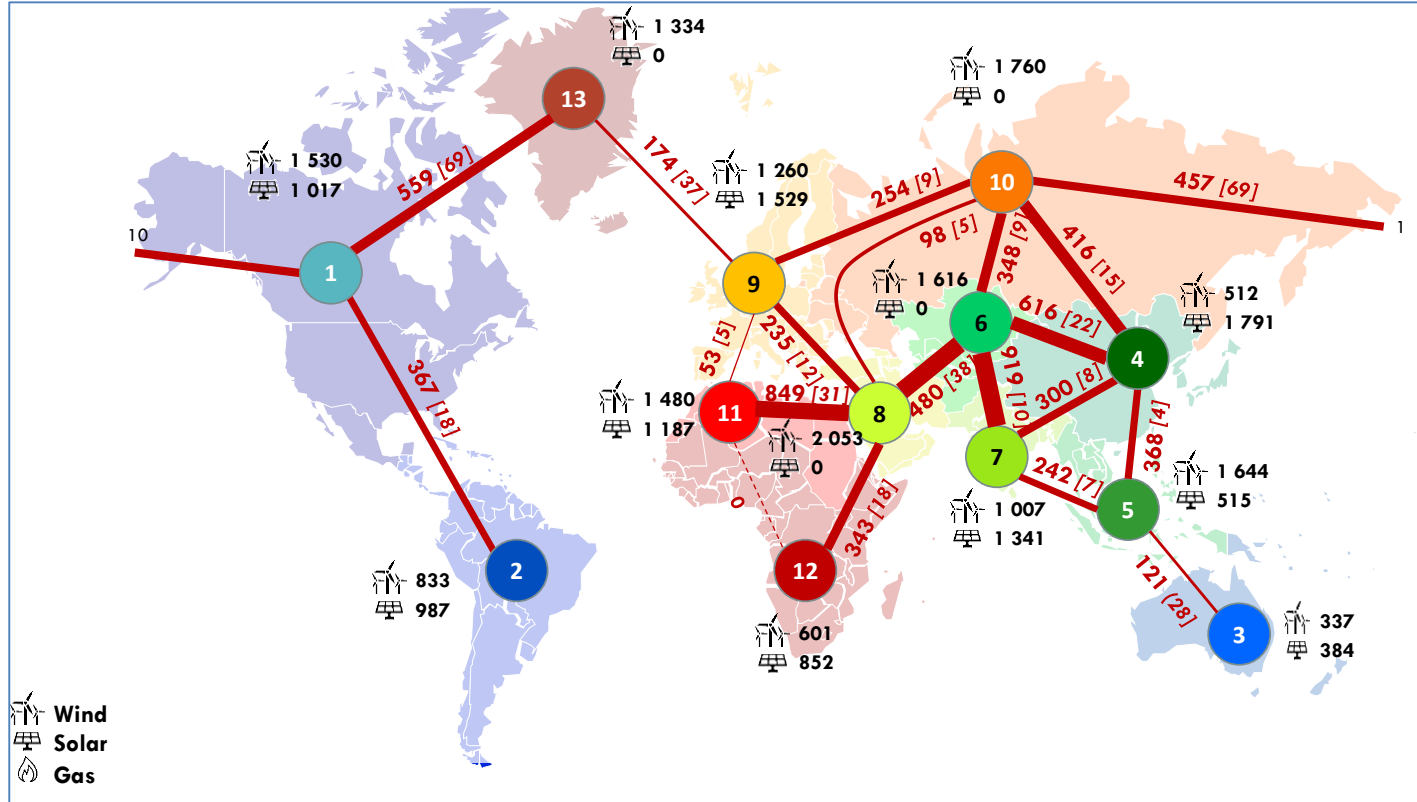


# Interconnection costs (option min cost M€/GW)



## RESULT for one of option.

The optimized capacities – only solar and wind production case

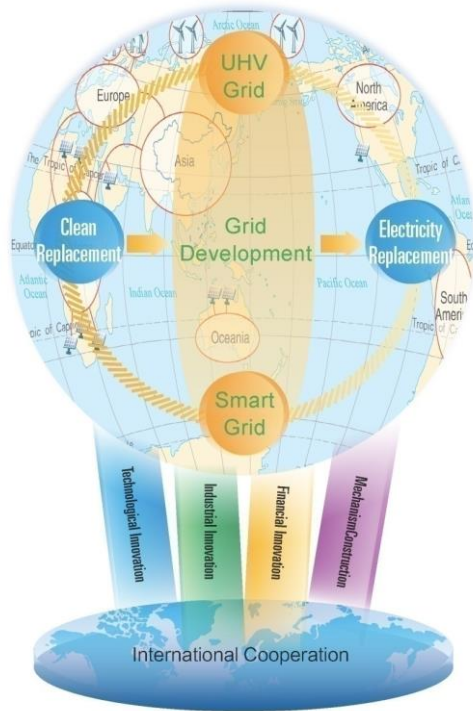


*"However beautiful the strategy, you  
should occasionally look at the results."*  
Winston Churchill (1874–1965)

# 4.0

## **Global political support**

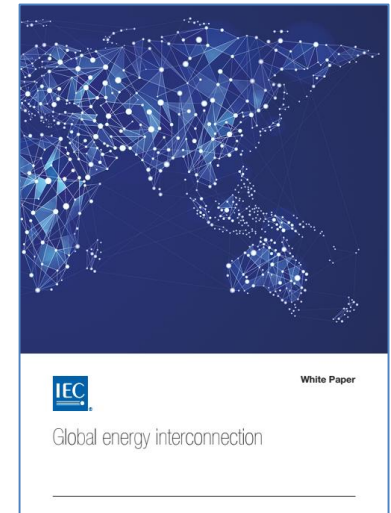
## China's Initiative



Chinese President Xi Jinping proposed discussions on establishing Global Energy Interconnection, or GEI, to facilitate efforts to meet global power demands with clean and green alternatives at the UN Sustainable Development Summit on September 26th, 2015.



Start of  
international  
standardization  
of global grid



*“In the end, a vision without the ability to execute it is probably a hallucination”.*

(Stephen Case, Chairman & CEO of America Online)

# 5.0

## Conclusions

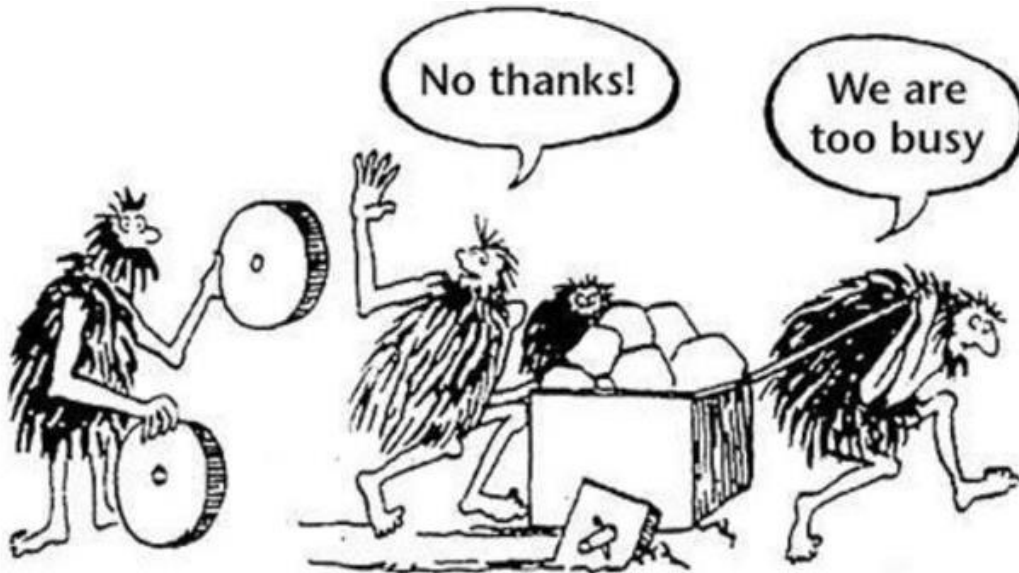
# Statements for final EPC 6 (2019) document

- Engagement with global climatic changing is here and today.
- De-carbonation of energy sector is our obligation to act now taking in account systematic approach with multi-objective optimization.
- One of the good option is creation of **global electrical super grid** connecting different time-zones, existing continental macro interconnections and clean energy sources with lower cost.
- Global electrical super grid offer opportunities and benefits for all, particularly for small countries. Slovenia could be leader in central EU.
- Natural attribute of electrical interconnections is solidarity, as well as cooperation and mitigation of poverty at global level.
- Importance of better collaboration between technical organizations as WEC, CIGRE, IEA, IEC and other new established global organizations, is higher than ever in history,

***"Vision without action is a day dream. Action without vision is a nightmare."***

Anonymous

# Thank you



Source: CIGRE, KMS