New transmission technologies shaping the future grid

A fantastic opportunity for Africa

Benoît DURETZ, Sales & Marketing Director

Johannesburg, South Africa - February 10, 2020

SuperGrid Institute
Shaping power transmission

New transmission technologies shaping the future grid

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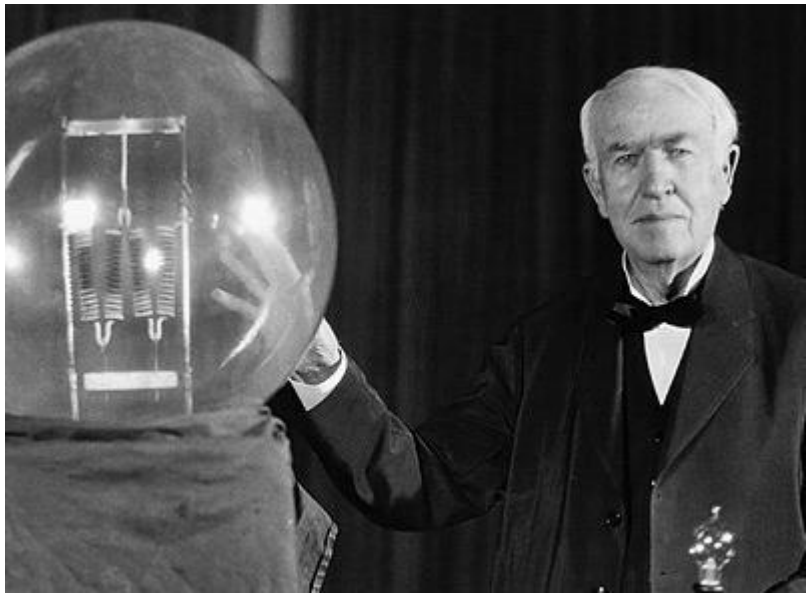
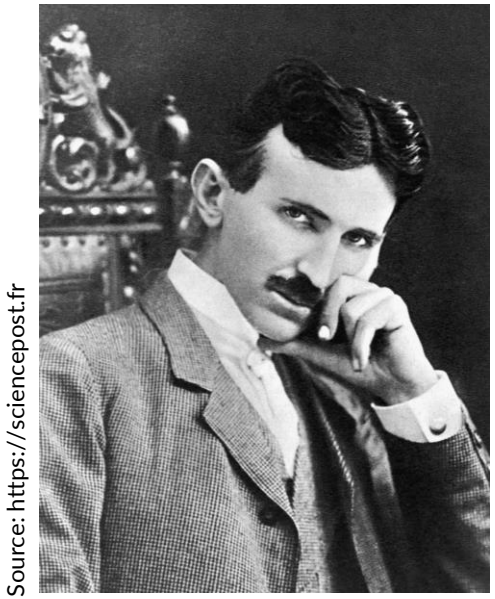
Brief look back through History

"1880s: the battle of currents": where it all began

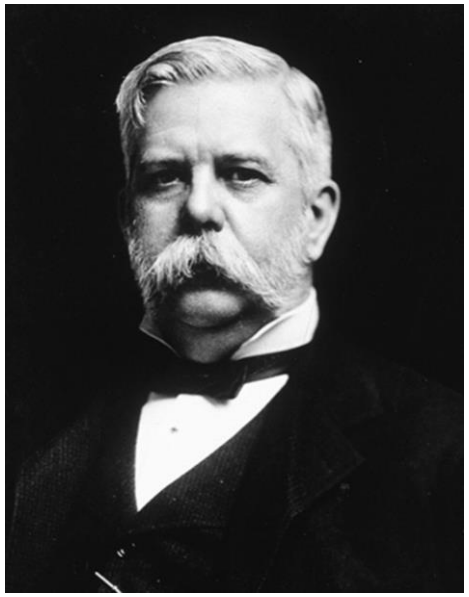


Source: https://medium.com

Thomas EDISON (1847 – 1931), US scientist, inventor and business man. Advocate of **DC technology** for transmission & distribution grid.



Source: https://sciencepost.fr



Source: https://www.biography.com

Nikola TESLA (1856 - 1943), US physicist, electro-mechanical engineer and inventor, supported by George WESTINGHOUSE (1846 – 1914), US engineer and business man. Advocates of **AC technology** for transmission & distribution grid.

Brief look back through History

Thus far, the huge majority of Transmission & Distribution grids worldwide are in AC

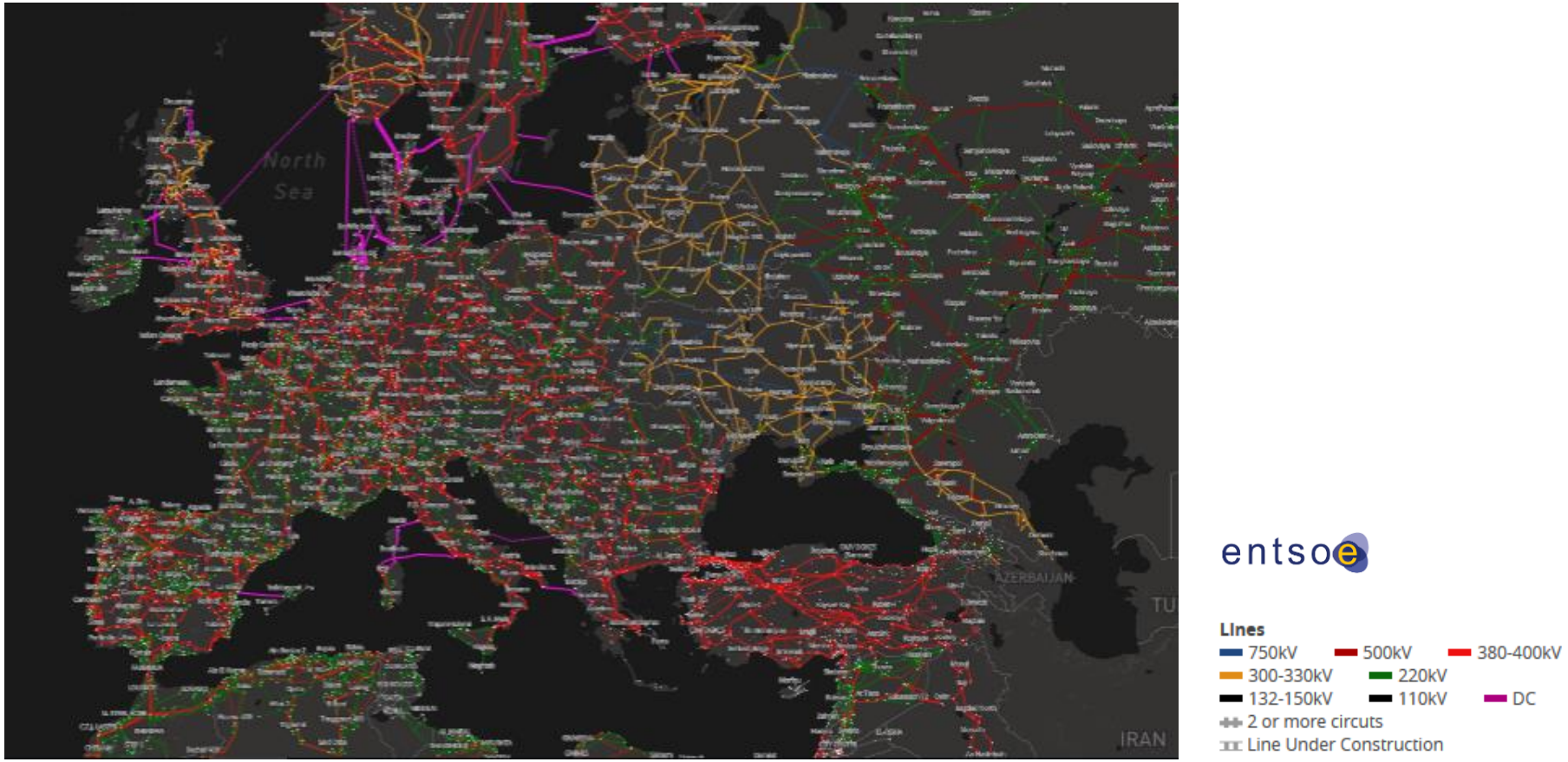
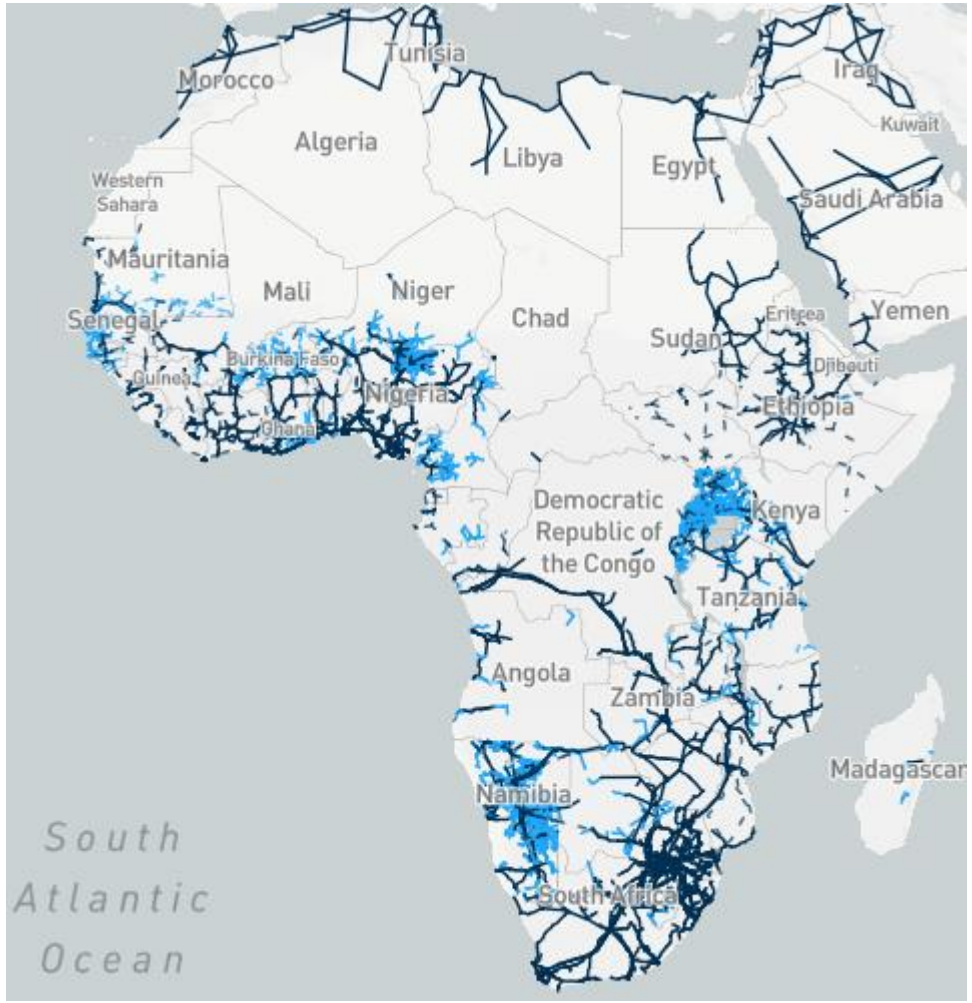


Illustration: European grid map (2020)

Source: https://www.entsoe.eu/data/map

Brief look back through History

African electrical grid is not an exception



Four HVDC links in Africa:

- **Cahora Bassa** between South Africa and Mozambique: 1920MW, ± 533kV, 1979
- **Inga-Shaba**, Zaire (Democratic Rep. of the Congo): 560MW, ± 500kV, 1982
- **Caprivi Link**, Namibia: 300MW, 350kV, 2010
- **Ethiopia–Kenya HVDC Interconnector**: 2000MW, ± 500kV, expected in 2020

< 66kV - LV & MV
> 66kV - HV

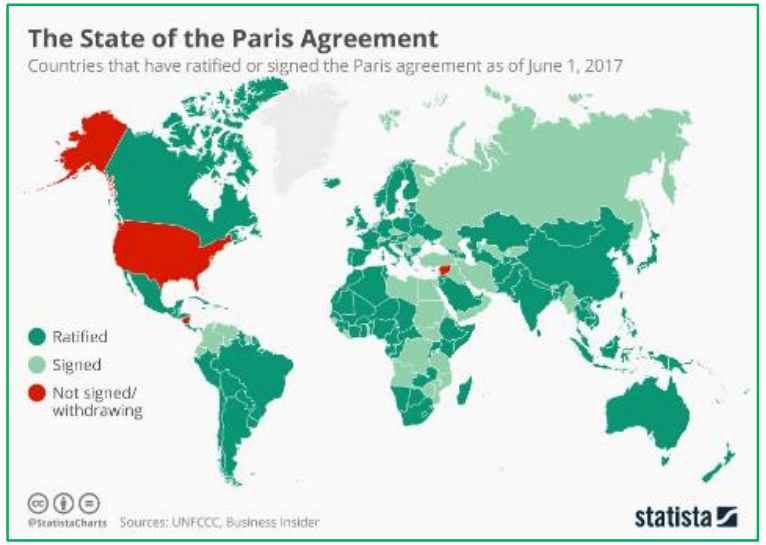
Source: Africa Electricity Grids Explorer (World bank)

Energy transition: a change of paradigm

Main challenges

Humanity is facing 3 major challenges:

- Keep global warming “well below” 2°C
- Reduce air pollution
- Provide everyone access to secured energy



https://www.statista.com/chart/9656/the-state-of-the-paris-agreement/

Electricity is at the center of those challenges and is driven by 3 majors trends:

- Decarbonisation: rush on renewables sources, greater needs for electrification (e.g e-mobility)
- Digitalisation: increased use of data and communication for optimized management
- Decentralisation: distributed energy sources, storage, new uses and markets

Energy transition: a change of paradigm

Main challenges

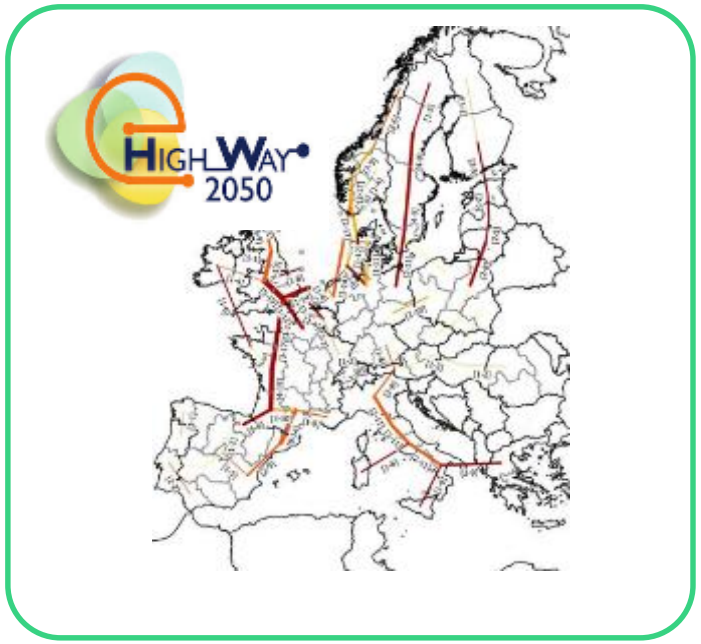
Transmission electricity grids must reinvent themselves and serve the energy transition:

- be able to transmit massive quantity of electricity over long distances, including subsea
  - to allow a better integration of renewable energies
  - to give a greater access to electricity and green electricity in particular
- be strong enough
  - to support huge additional transmission requirements
  - to while being highly reliable and available
- be widely interconnected to facilitate electricity exchanges
  - to optimize globally grid operations and stability
  - to lower electricity prices for consumers

Compelling need for electricity highways

Energy transition: a change of paradigm

Main challenges



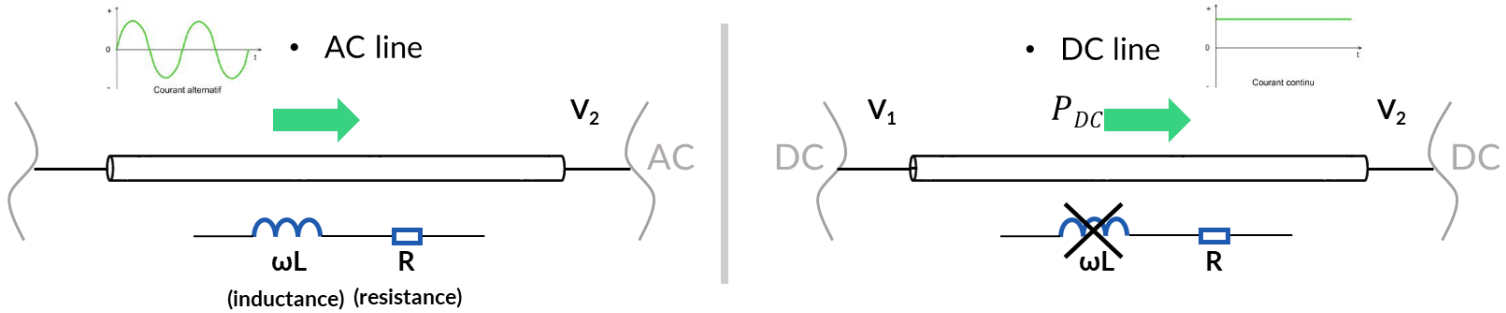
eHighway 2050 (EU funded project)

Long-term vision by GEIDCO: a necessary global electricity backbone

(Source : GEIDCO Membership journal n° 18,2019)

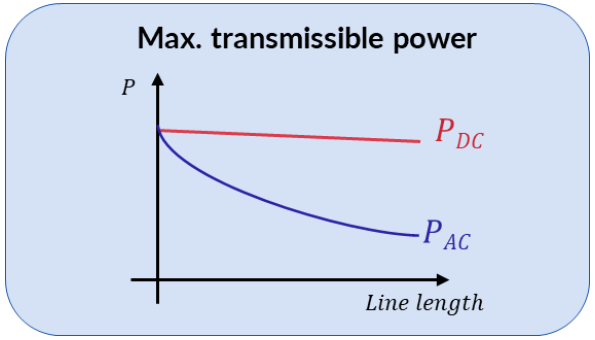
HVDC: the key to unlock future transmission grids

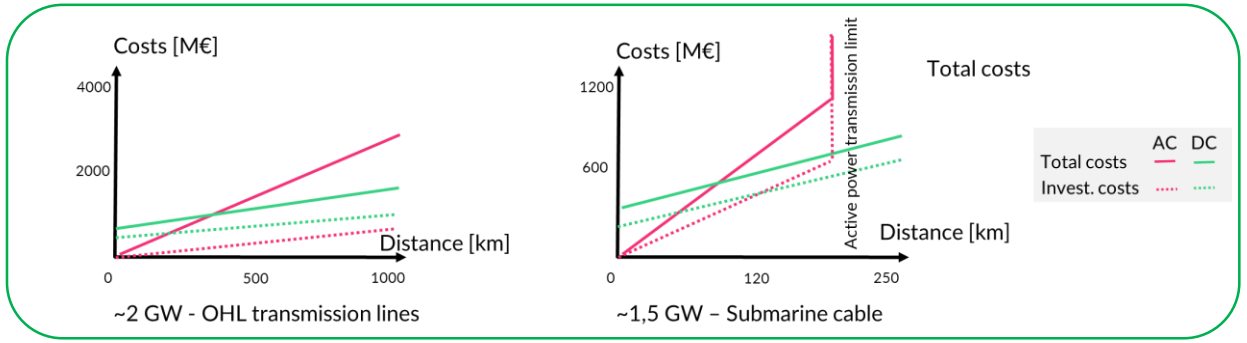
Why DC technology ?



Main benefits of DC technology:

- Less losses, no skin effect → more transmissible power capacity on long distances
- DC system allows better control of power flows than AC system
- Cost-effective when it comes to transmit large power over long distances

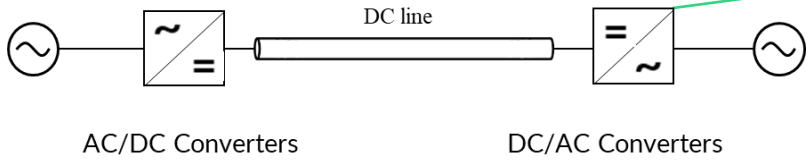




HVDC: the key to unlock future transmission grids

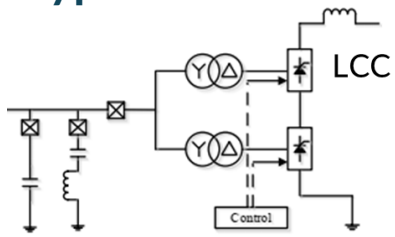
New technologies shaping the future grid

A key component of DC links: Power converters



Source: ge.com

1st type:

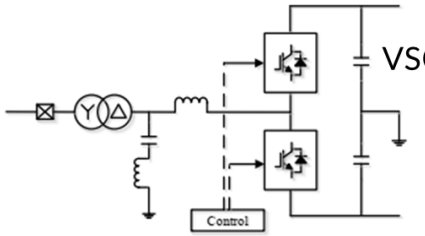


LCC : Line Commutated Converter
(Thyristor based)

Low Losses
Polarity defines power flow direction
Rely on AC grid for commutation
Important filtering needs

Bulk power transmission

2nd type:



VSC : Voltage Source Converter
(IGBT based)

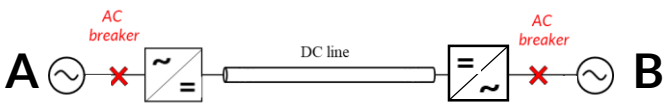
P&Q control features
Smaller converter stations
Black Start capability
Lower filtering efforts
Complex control
Higher Fault rise time

RES Integration & DC Grids

HVDC: the key to unlock future transmission grids

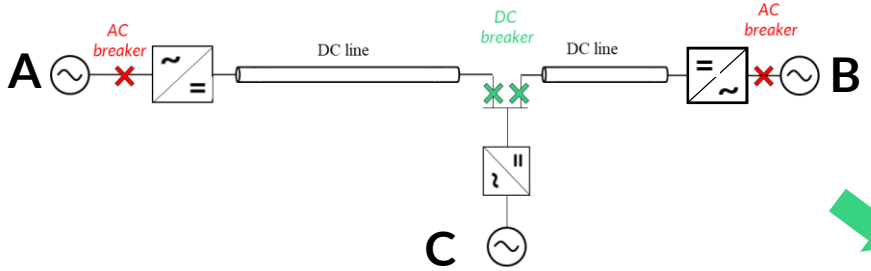
New technologies shaping the future grid

Point-to-Point HVDC link (PtP link)

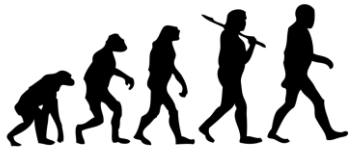


LCC technology
VSC technology

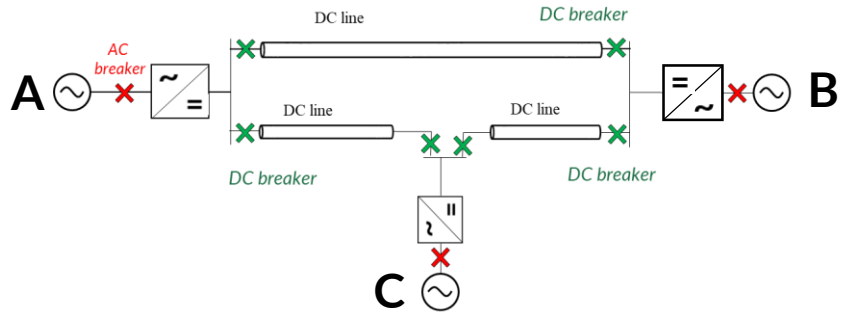
Multi-Terminal HVDC (MTDC)



LCC technology
VSC technology



Meshed HVDC Grid



VSC technology

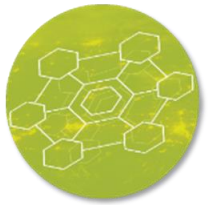
HVDC: the key to unlock future transmission grids

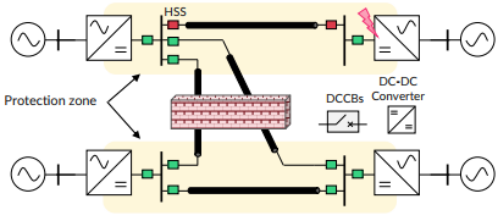
New technologies shaping the future grid

Technological barriers towards MTDC and Meshed HVDC grids are being removed

Supergrid Architecture & Systems

Control, Protection & Interoperability





HVDC grid protection scheme proposed by SuperGrid Institute, France

(Source: "Multi-terminal DC grids: protection and control" by Kosei SHINODA, SuperGrid Institute,, Oct. 2019)

High Voltage Substation Equipment

Circuit breakers, Switchgear & Insulation

±535kV DC circuit breaker (3000MW Zhang Bei DC grid project, to deliver wind & solar power to Beijing, China)

(Source: GEIDCO)

Power Electronics & Converters

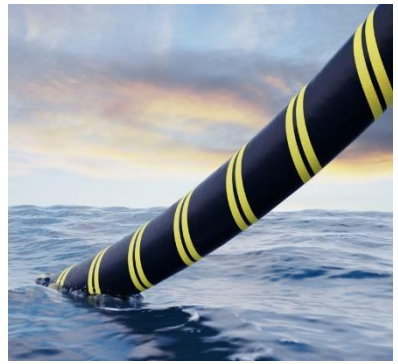
DC converters & Components

VSC converter for the New Hokkaido-Honshu HVDC link in Japan (300MW, 250kVDC)

(Source: https://www.toshiba-energy.com/en/info/info2019_0328_02.htm)

HVDC Cable Systems & Junctions

Submarine nodes, Health monitoring & Materials



HVDC submarine cable

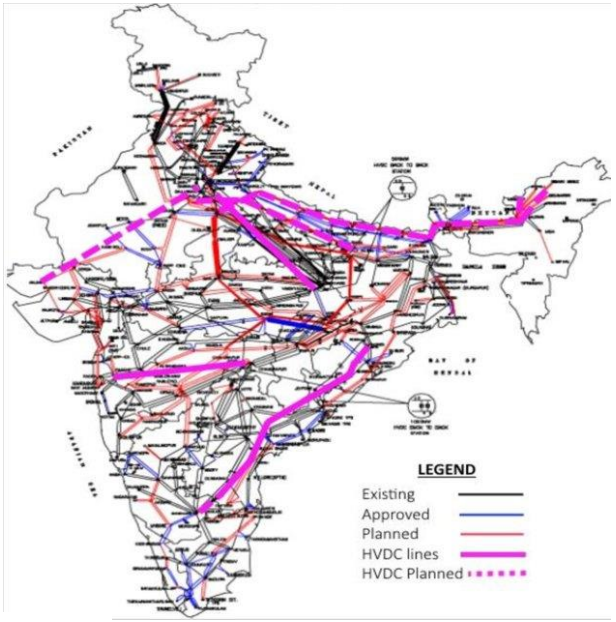
(Source: www.tdworld.com)

The grid of the Future: the transition has started

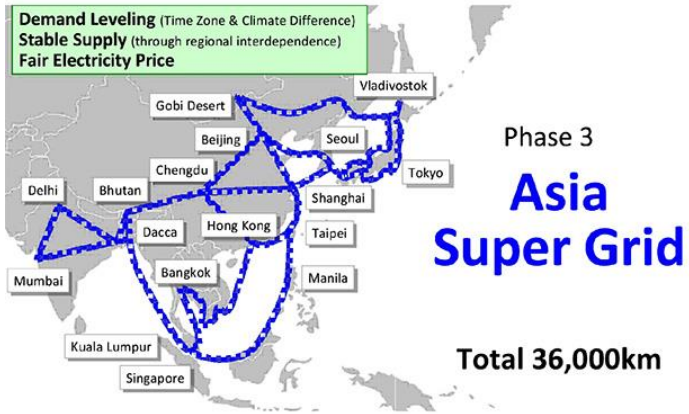
Asia: Major initiatives in favor of HVDC and global interconnected networks

Perspectives

Source:GEIDCO



Source: Powergrid, Ministry of Power



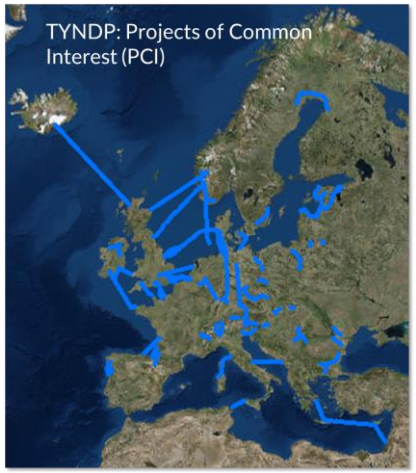
Source:www.renewable-ei.org

The grid of the Future: the transition has started

Europe: Significant growth of Pt to Pt HVDC links, moving towards MTDC

Explore the benefits and pave the way for offshore grid extensions

1



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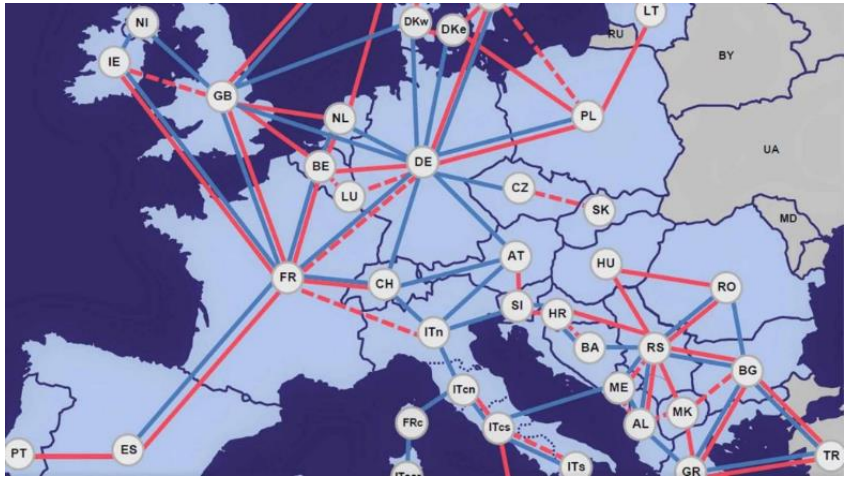

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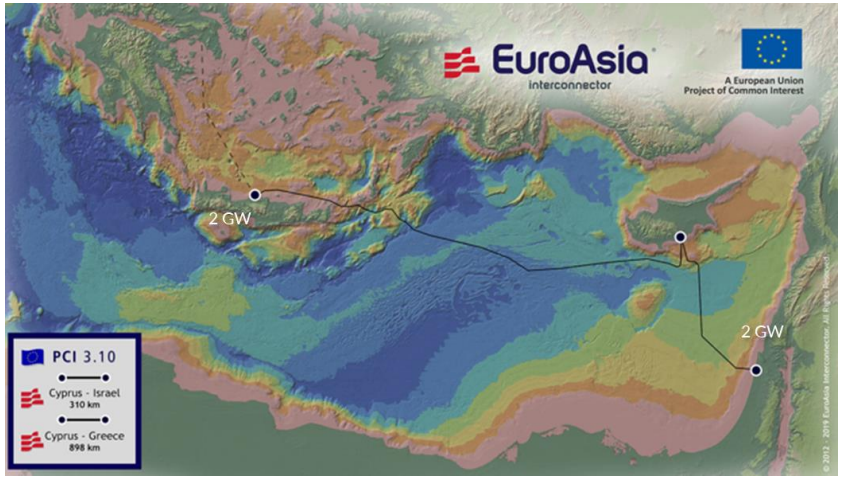


Implementing cross-border and inland electricity highways:

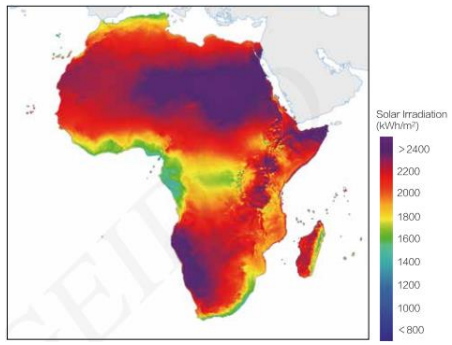
1. TYNDP: Projects of common interest (PCI)
2. Europe Power System 2040
3. EuroAsia Interconnector: 2000 MW 500 kV DC: First HVDC VSC Multi-terminal project in Europe ?

A fantastic opportunity for Africa

Strengthen active participation to the Energy transition while getting major benefits

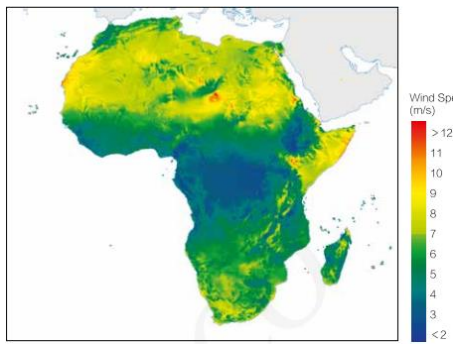
Key drivers for integrating HVDC grids to the transmission development plan in Africa :

- Leverage massive generation resources integration, especially renewables (Hydro, solar, wind)
  - Hydro power resources (12% of worldwide hydro generation potential), especially Congo river
    - The theoretical solar energy reserve takes up 40% of the world's total reserve
    - The theoretical wind energy reserve takes up 32% of the world's total reserve
- Secure transmission grid reliability and availability assuming power consumption increase
- Enjoy societal benefits while giving wider access to secured energy
- Benefit from grid interconnection opportunities, especially with Europe



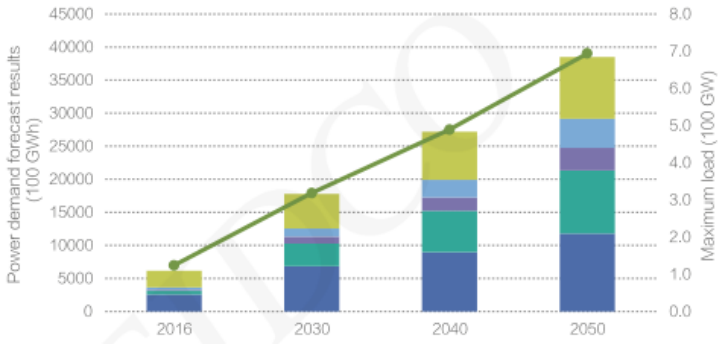
Distribution of solar energy resources in Africa

(Source: GEIDCO / New model of EMMMT Co-development for Africa)



Distribution of wind energy resources in Africa

(Source: GEIDCO / New model of EMMMT Co-development for Africa)



Power demands and Max. load in Africa by Region

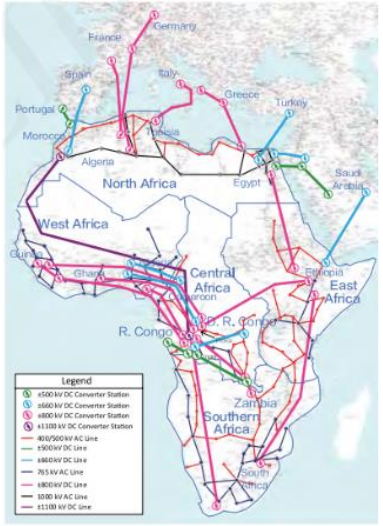
(Source: GEIDCO / New model of EMMMT Co-development for Africa)

A fantastic opportunity for Africa

Shaping the future grid in Africa, by integrating HVDC grids to the strategy, starts today

Some recommendations based on the above:

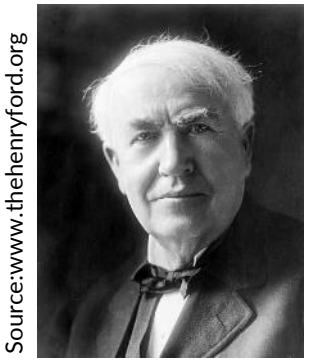
- Integrate at the earliest MTDC / HVDC grids to the transmission development plan in Africa, to orchestrate the construction of large power electricity highways and enable interconnections,
- Benefit of the latest HVDC technologies based on VSC converters, to design and deploy a flexible and scalable transmission grid,
- AC vs. DC, as well as supergrids vs. micro-grids, should not be opposed but must converge to the best optimum in a coordinated way, as we do need all of them.



GEIDCO long-term vision: African power grid interconnection by 2050

(Source: GEIDCO / New model of EMMMT Co-development for Africa)

Think HVDC grids



Source:www.thehenryford.org

(and not only for him)

Thank you for your kind attention

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