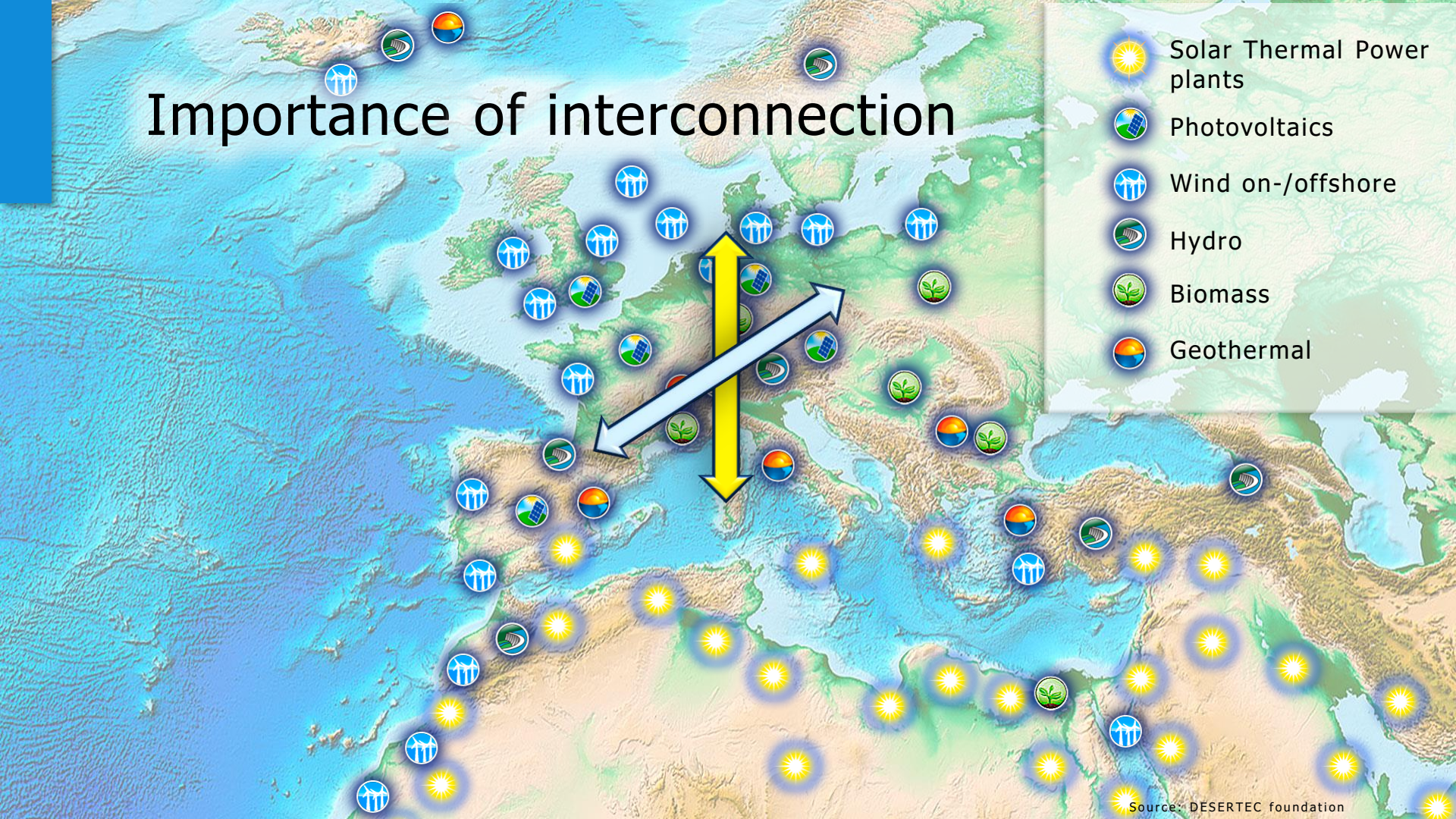
Beschikbare capaciteit
Hoe dan?

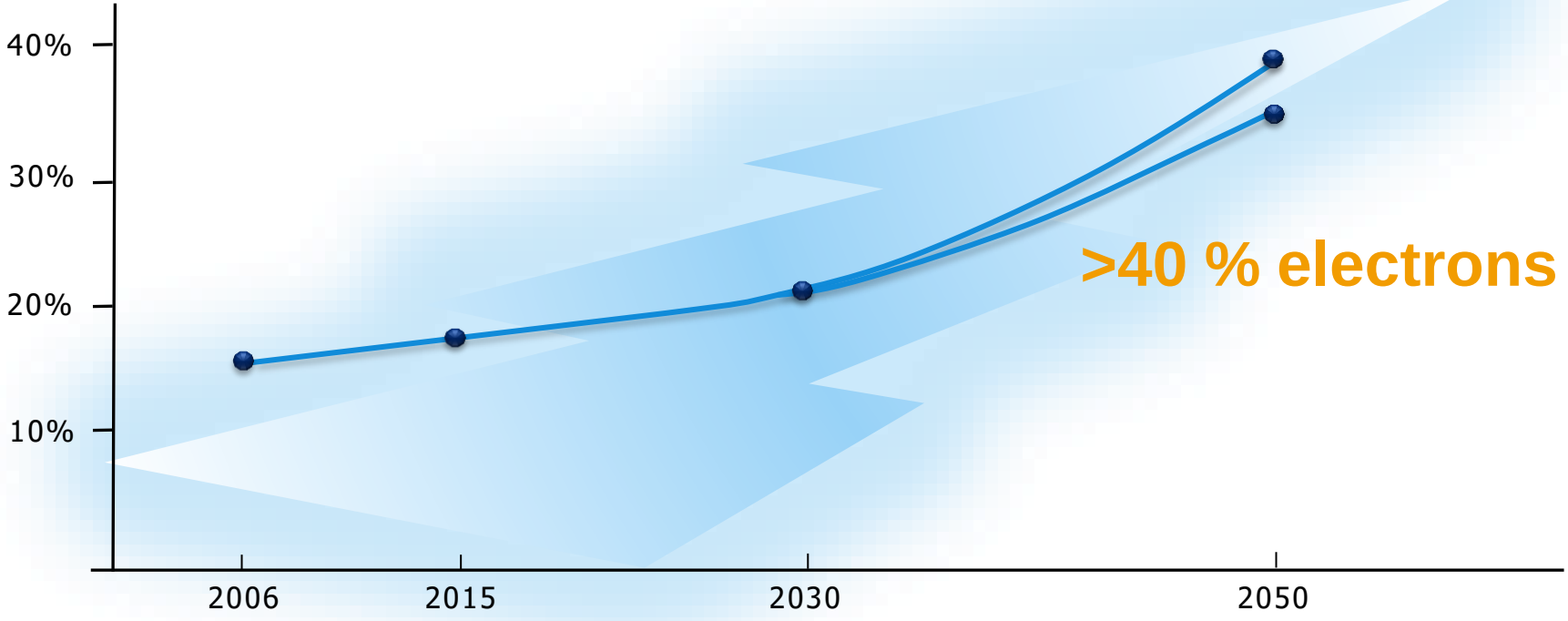
KIVI
Engineering Society
20 september 2023

Mart van der Meijden
&
Maarten van Riet

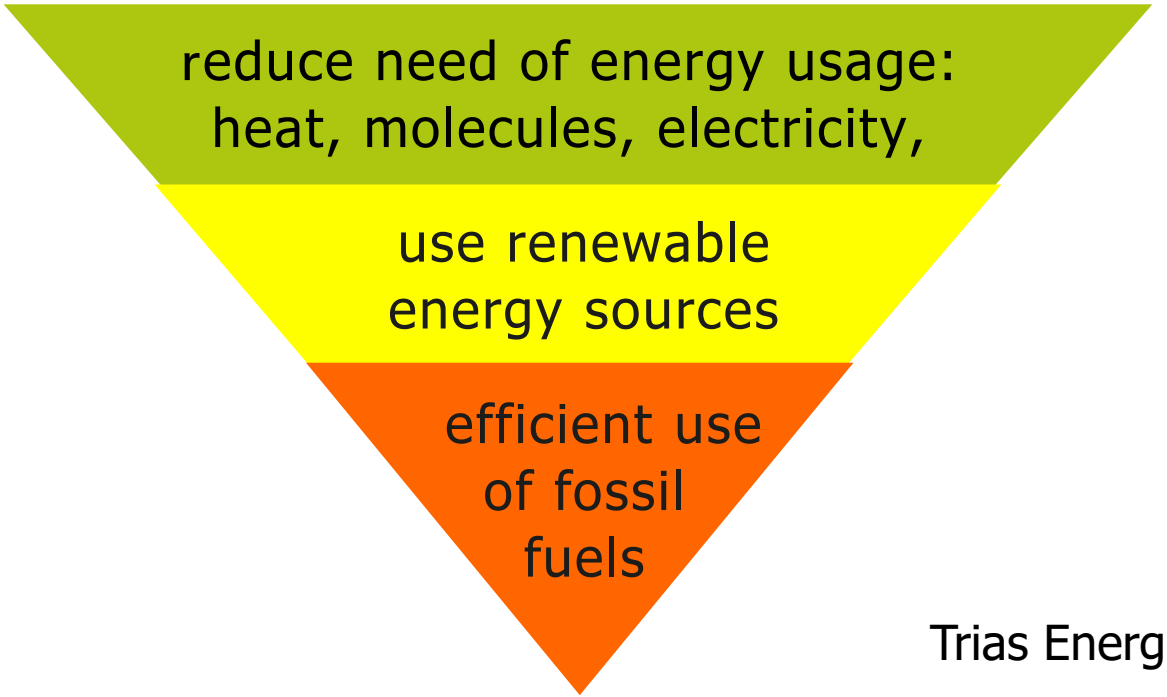
Importance of interconnection



Electricity importance is growing



Energy usage is key



Trias Energetica

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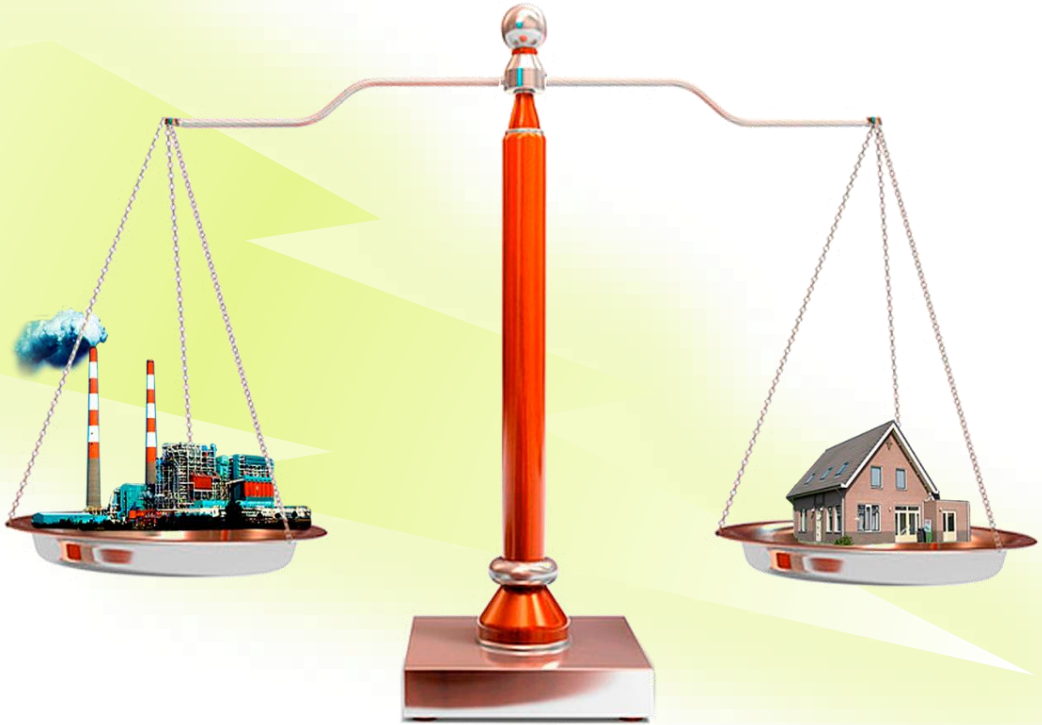
Energy system flexibility

Need for energy system flexibility

- frequency
- congestion
- voltage



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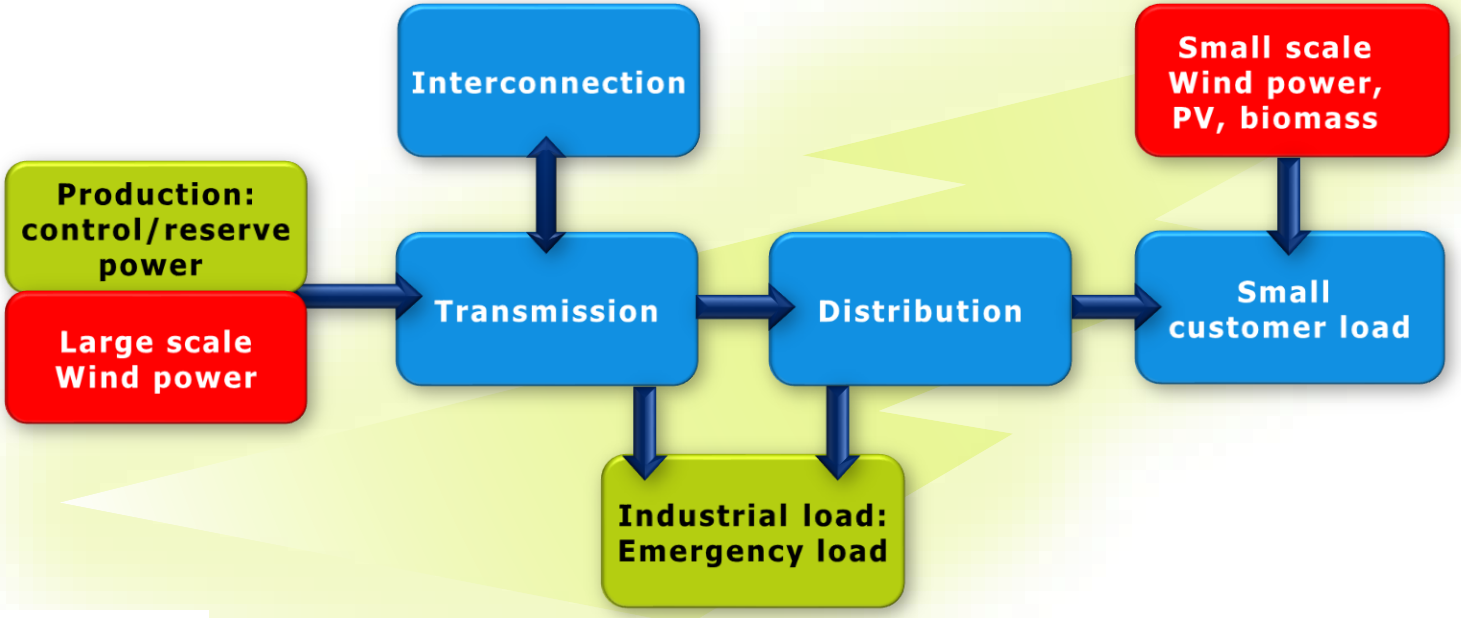
Traditional flexibility measures 12 years ago



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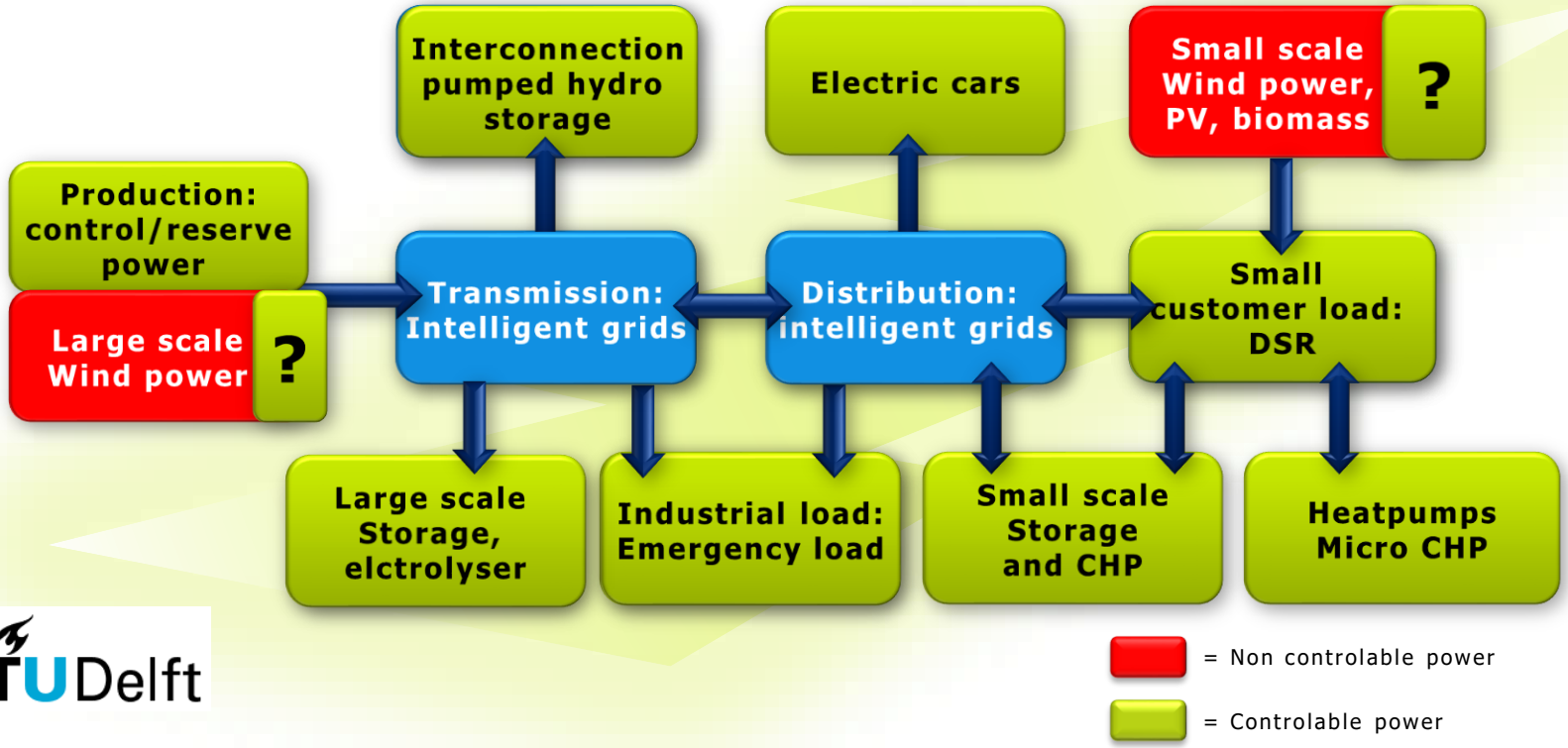
Future flexibilty measures to integrate growing sustainable electricity generation



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Kosten van een onderbreking

Voorbeeld noordzee offshore capaciteit

Gevolgen van een onderbreking verschilt enorm:

Kosten storing op land **200 x** kosten nietgeleverde E
Kosten storing op zee **1 x** kosten nietgeleverde E

Beschikbare capaciteit van het elektriciteitsnet Hoe dan?

Traditional generators (coal, gas, nuclear)

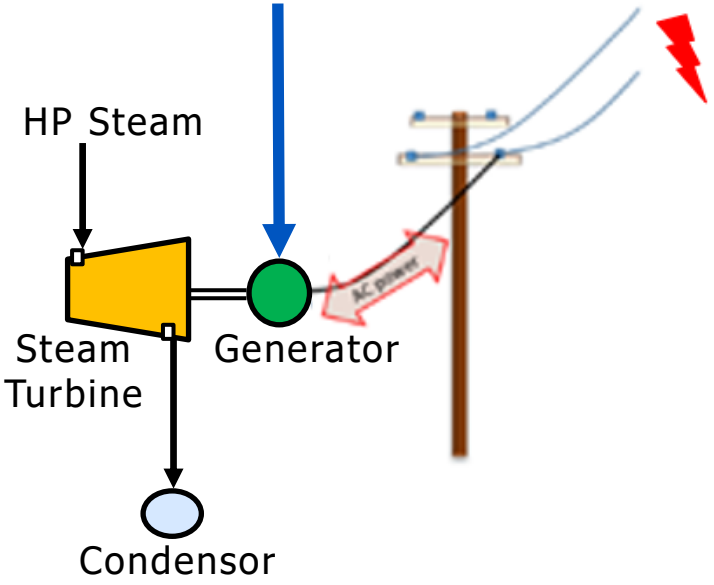
Steam Turbine

Rotor

Generator

Courtesy Siemens

Short Circuit Power
Rotational Inertia



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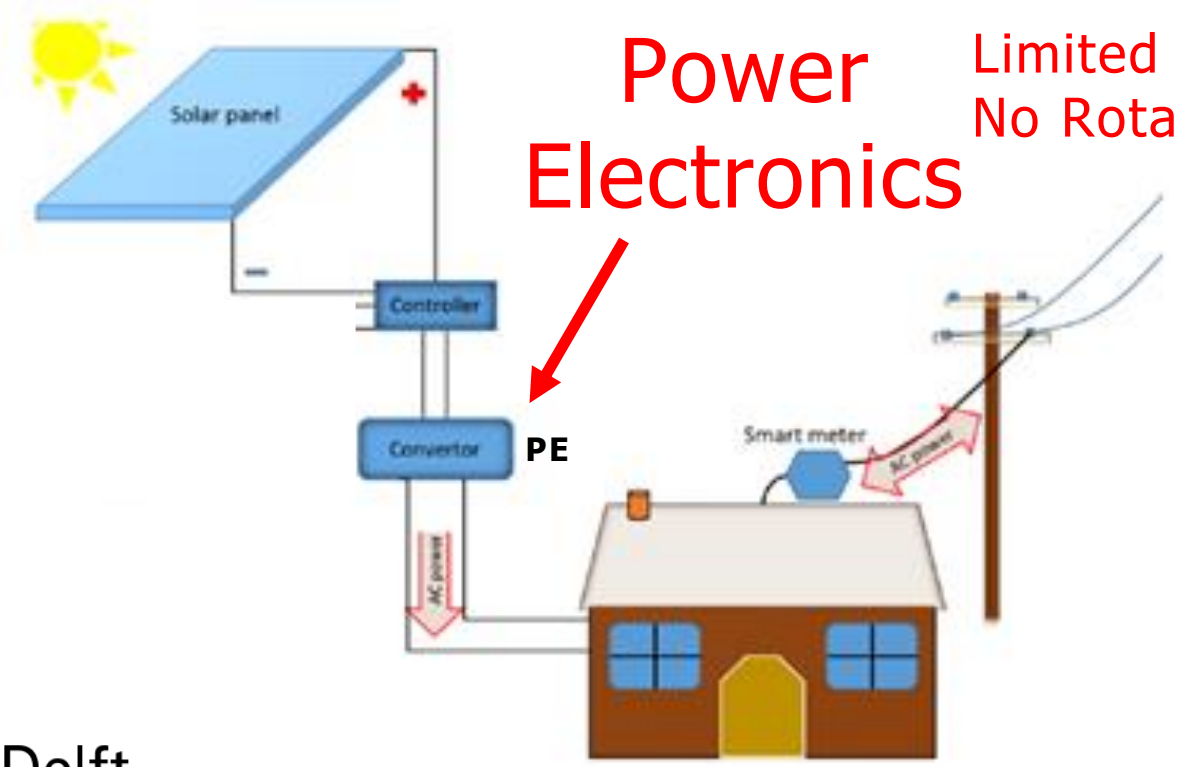
Future generators (wind, solar)

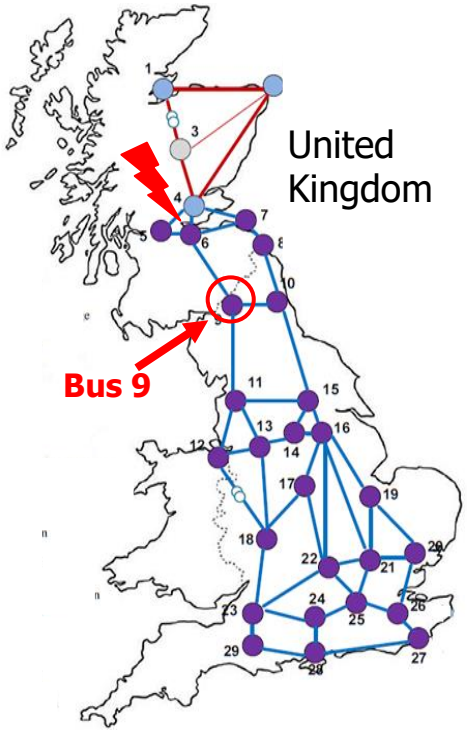


Power Electronics

Limited Short Circuit Power
No Rotational Inertia

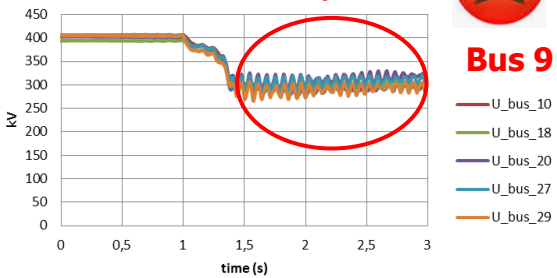
Reduced Stability

High penetration of Power Electronics



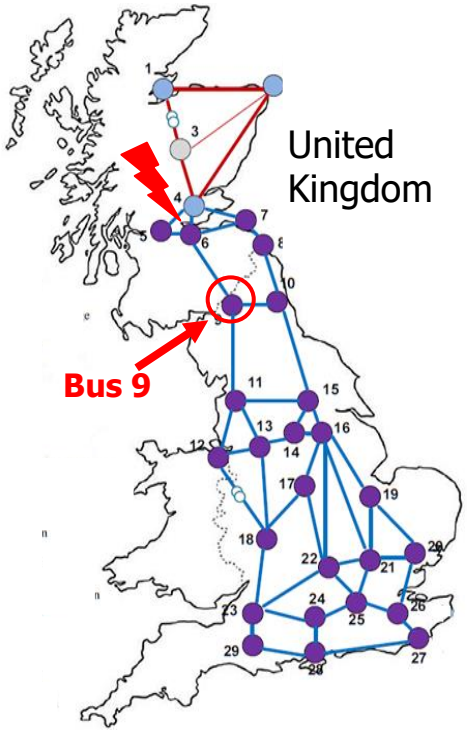
68% Power Electronics
32% rotating mass

Instable System



System instability due to delayed voltage recovery and/or sub-synchronous oscillations

High penetration of Power Electronics



68% Power Electronics
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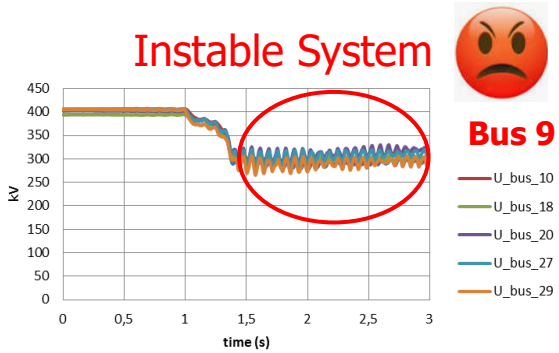
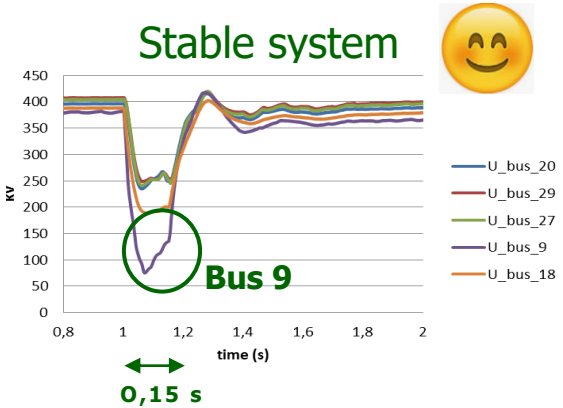


System instability due to delayed voltage recovery and/or sub-synchronous oscillations

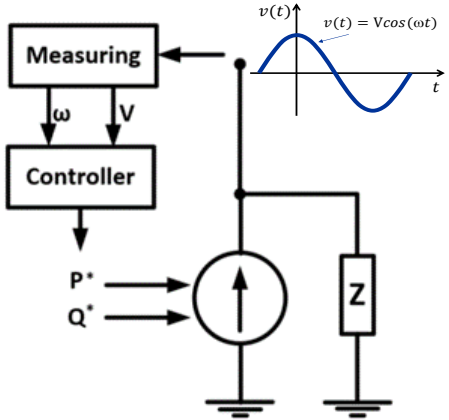
81% Power Electronics
(35% Grid Forming)



System stability due to fast voltage and frequency support

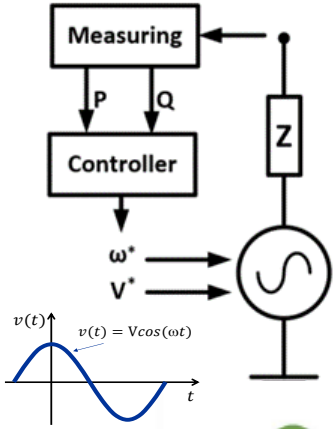
Grid following

controlled converters **follow** voltage and frequency



Grid forming

controlled converters **form**/regulate **output voltage and frequency**



System stability due to fast voltage and frequency support

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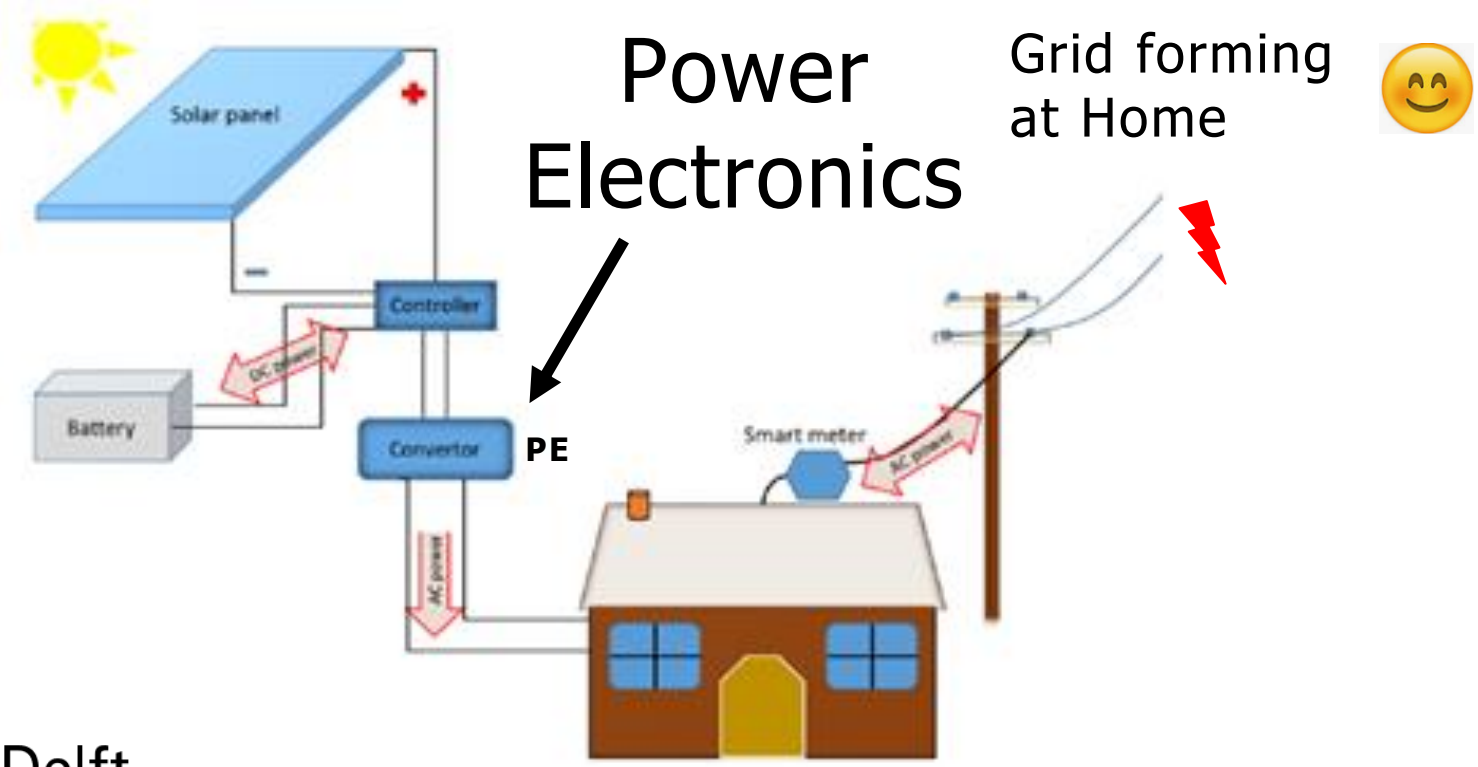
"Grid-forming inverters allow microgrids and macrogrids to be jointed together far more easily"

2028

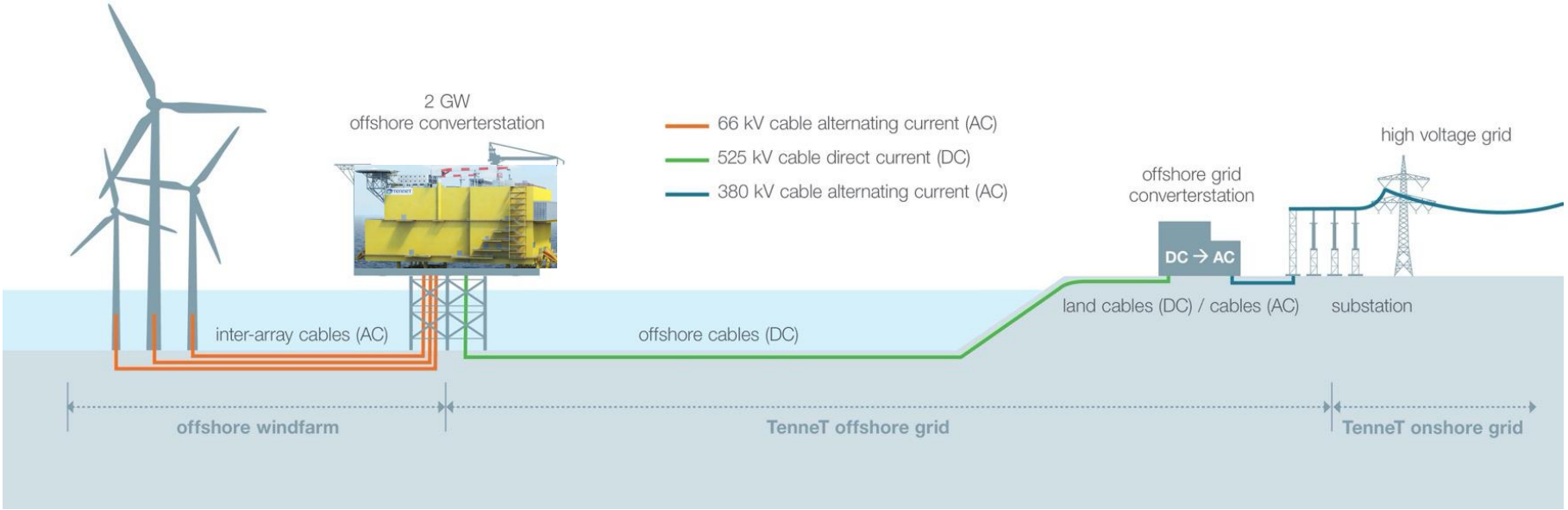
Grid-forming part of the Network Code Requirements for Generators (also wind park modules, solar park modules) and Network Code for HVDC.

Future generators (wind, solar) 2028



DC meets AC

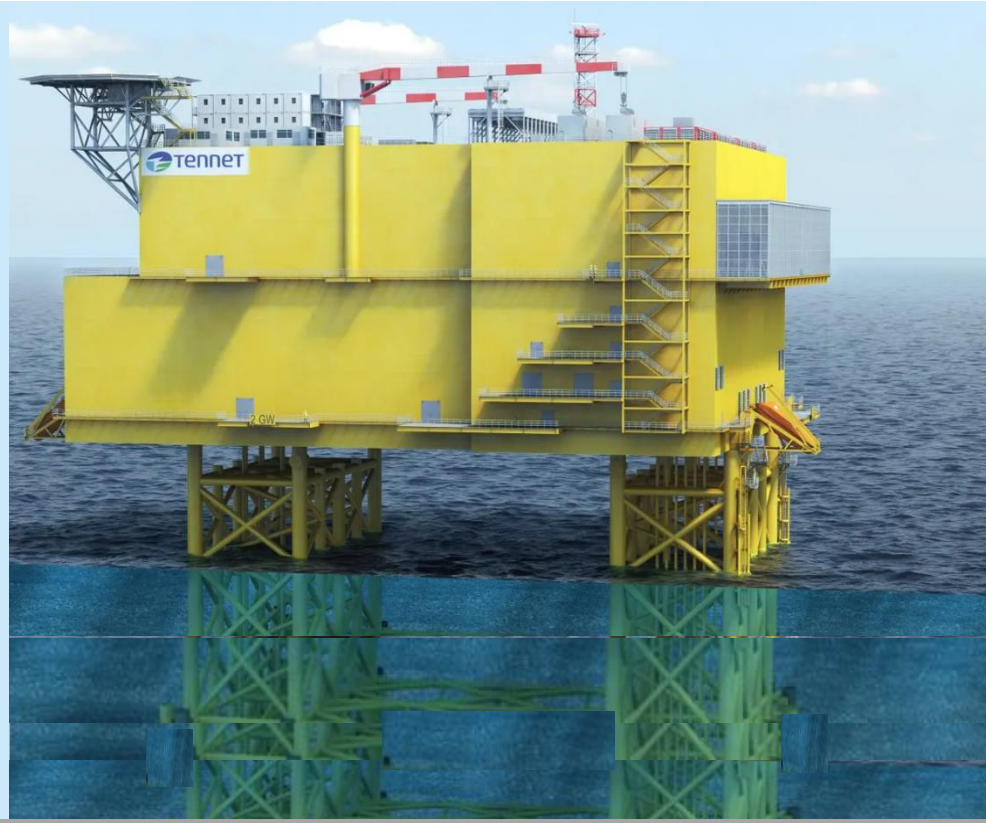
EU Esbjerg 120 GW 2030
300 GW 2050

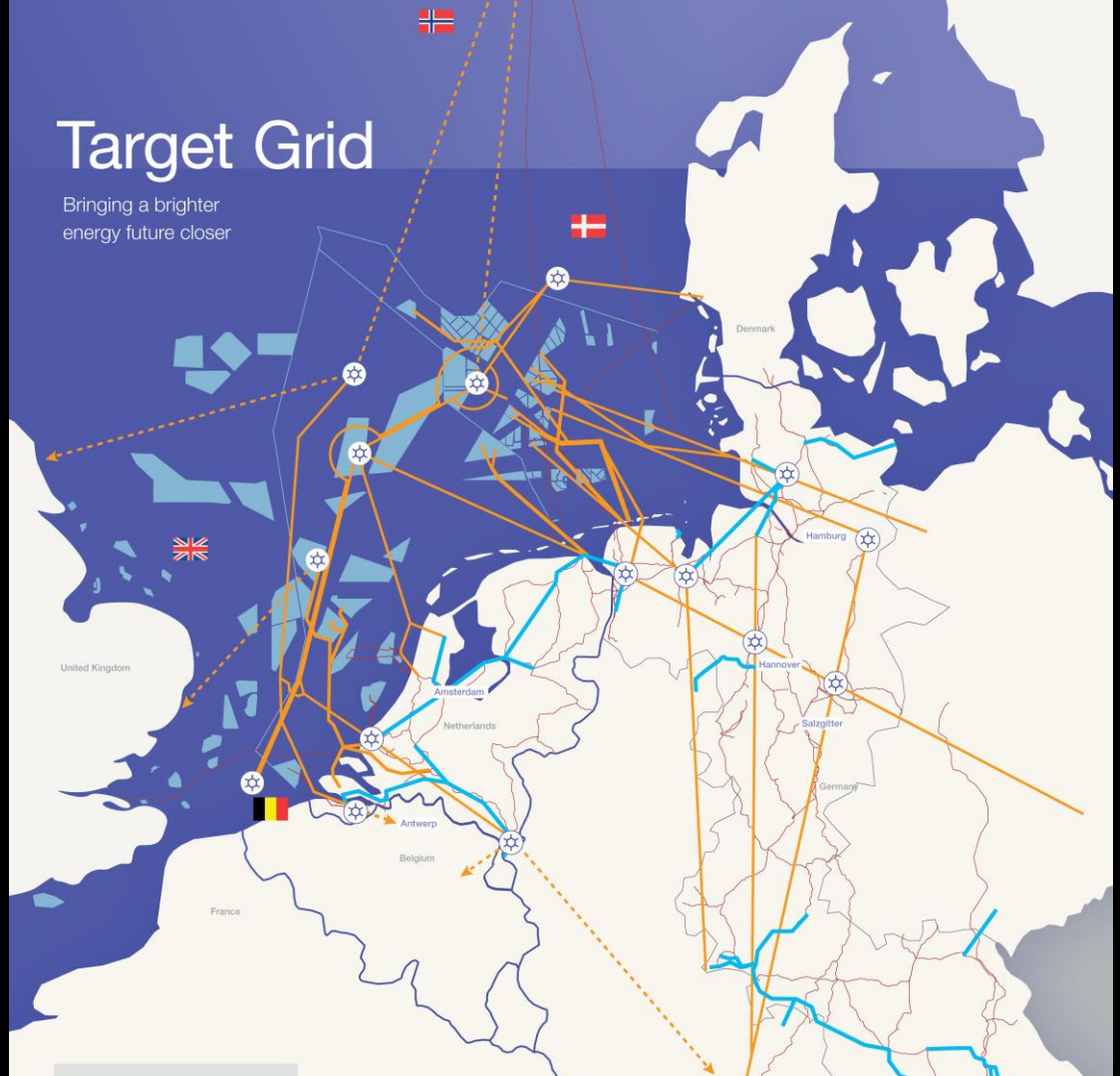


Offshore

TenneT's 2 GW grid converter platform

90m





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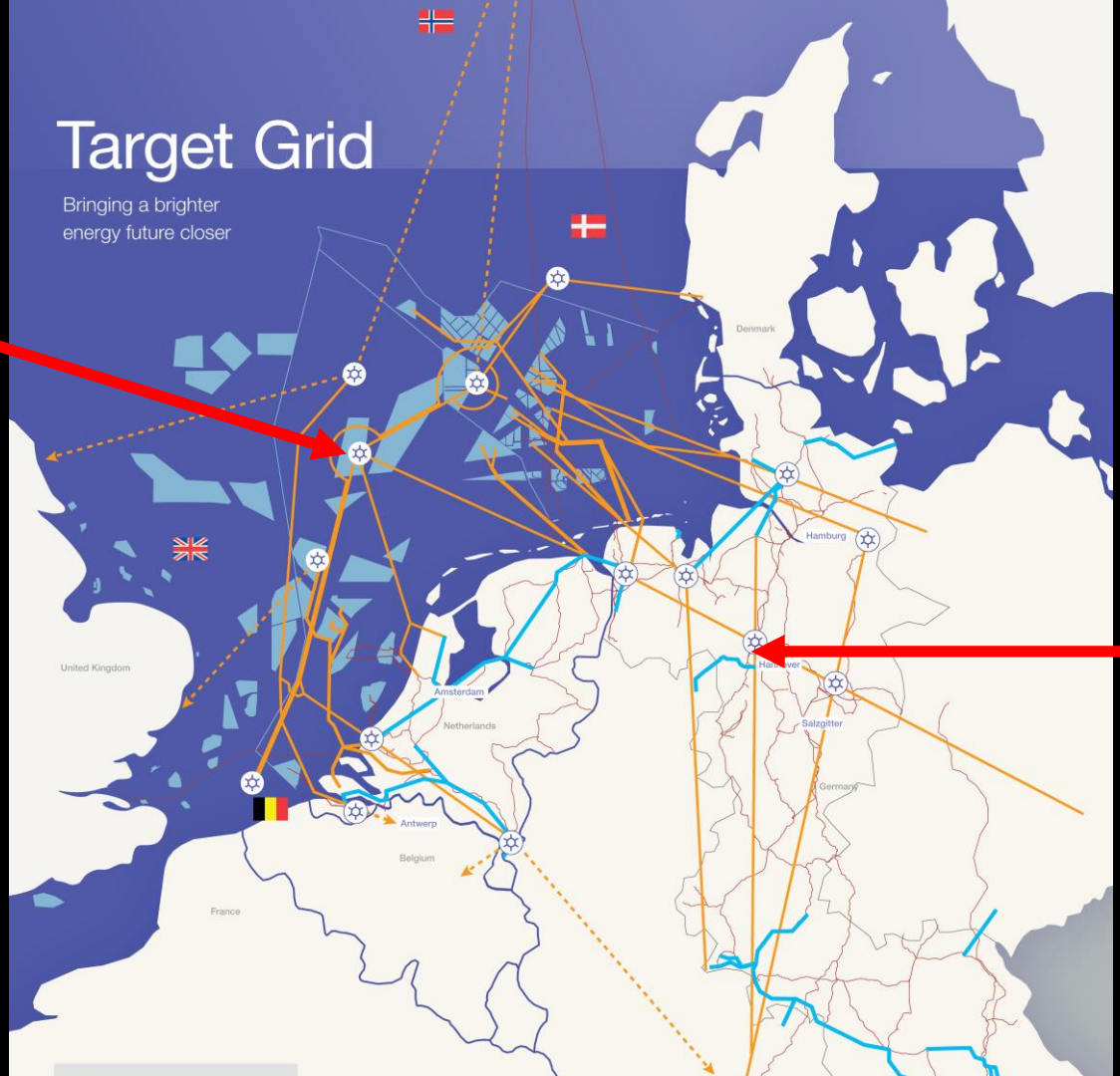
TenneT

Converter



DC Breaker

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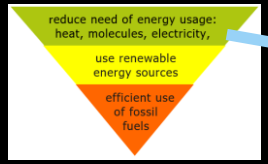
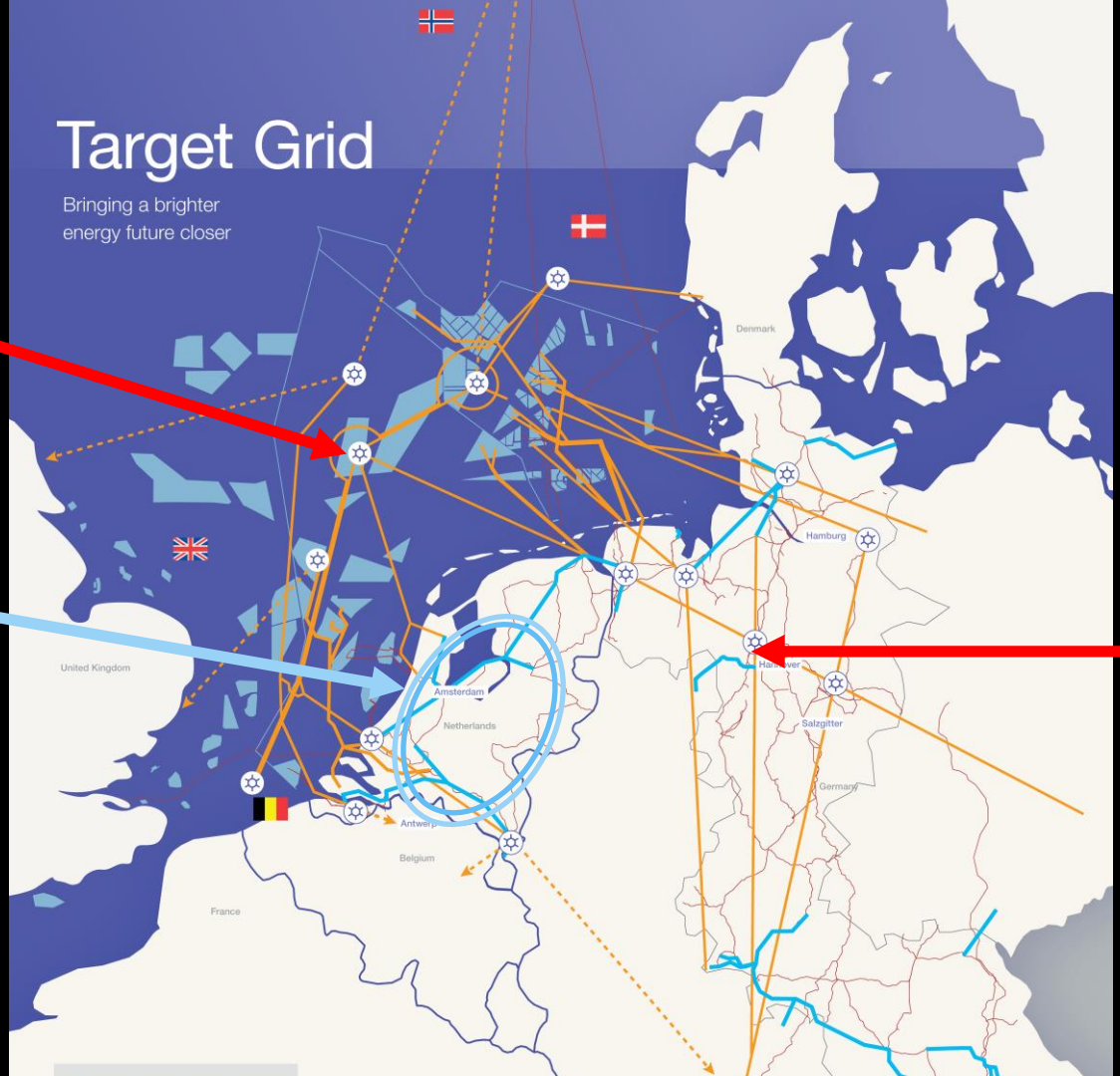
TenneT

Converter





DC Breaker

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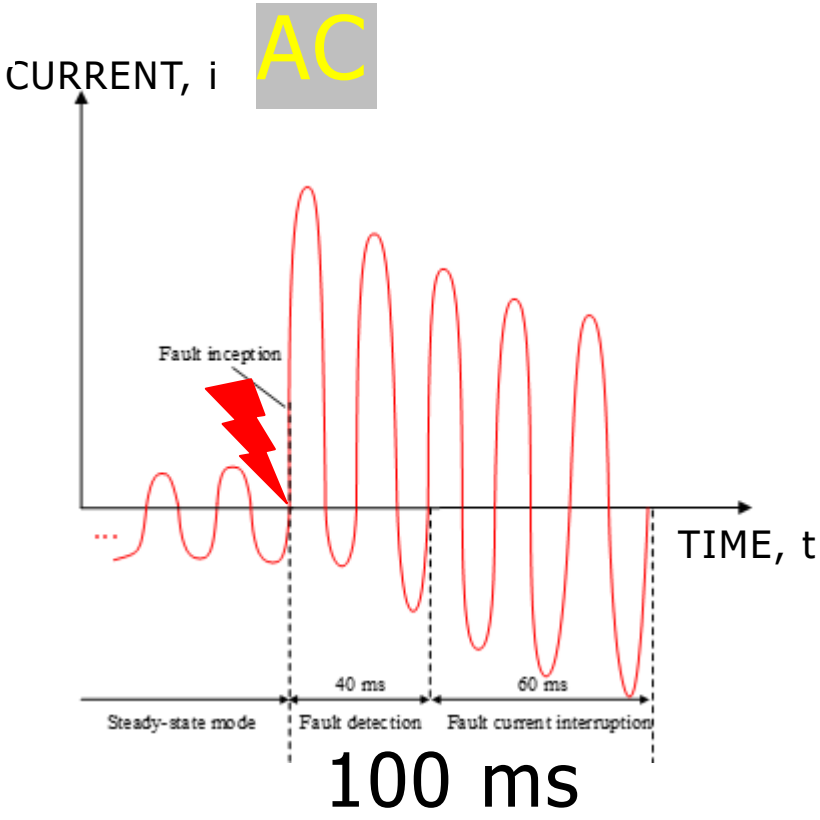
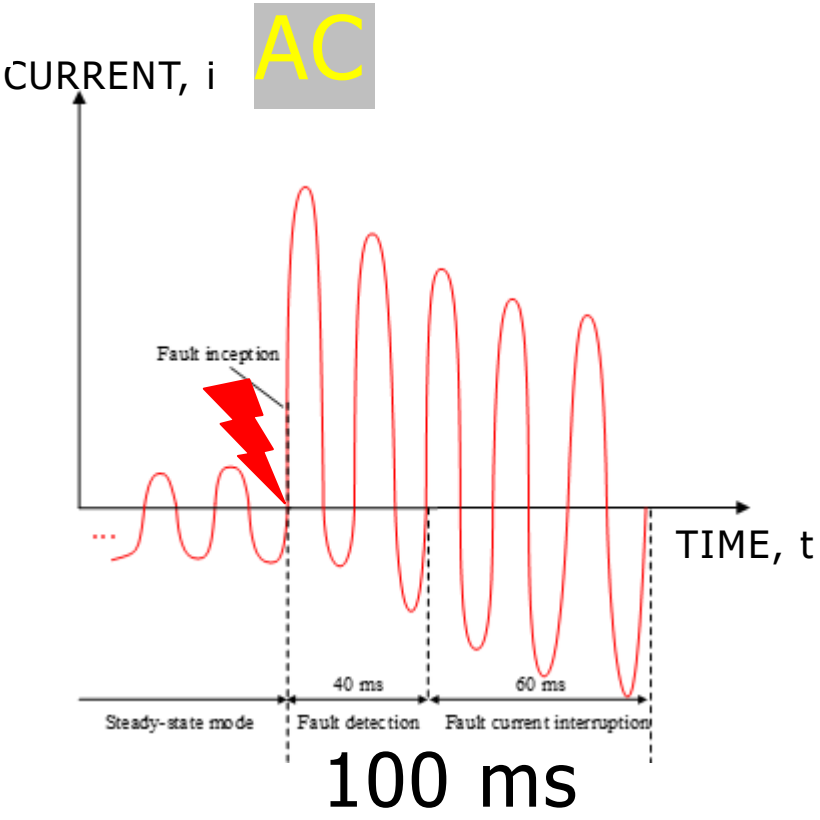
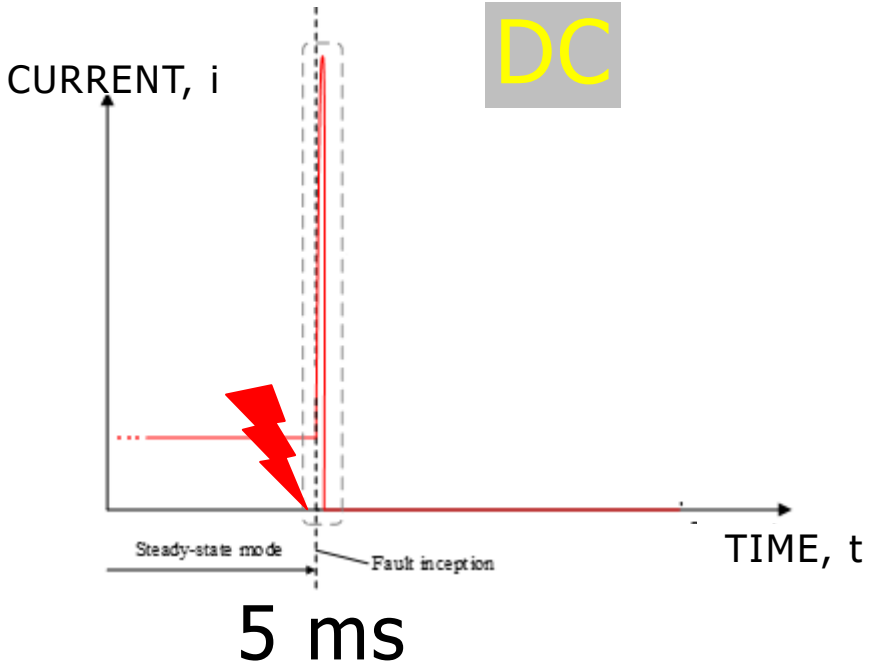
TenneT

Circuit Breaker



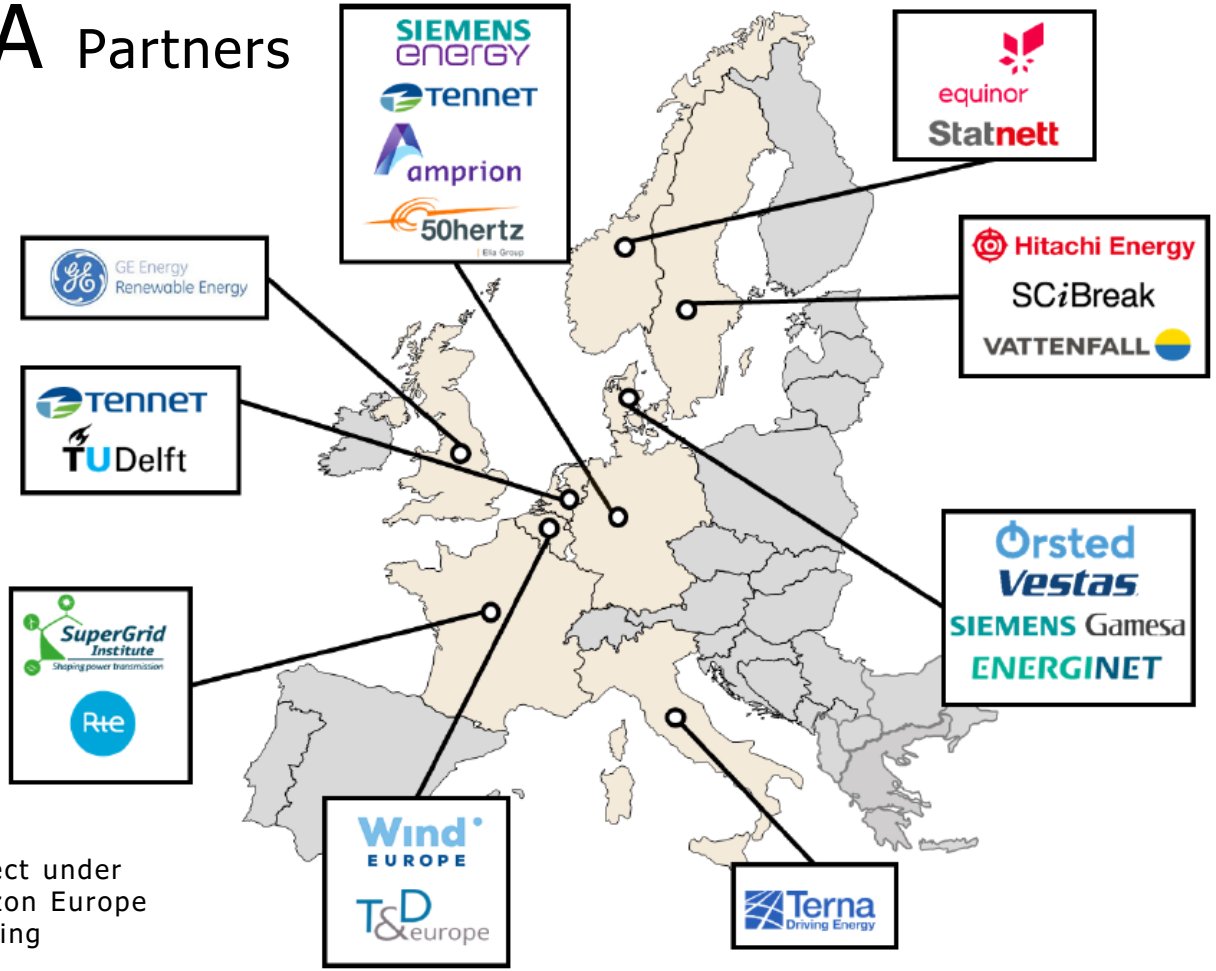
Circuit Breaker





InterOPERA Partners

Total budget
68 million Euro



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Project under
Horizon Europe
Funding

TU Delft Electrical Sustainable Power lab

Opening ESP lab

October 1, 2021

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Finally, what is all about?

To educate and deliver inspired top professionals

Power Systems of the Future