ADOPTING A SUSTAINABLE 2050 VISION FOR NORTH SEAS INFRASTRUCTURE TO DEFINE A WAY FORWARD

MARCH 23, 2017

ECOFYS

A Navigant Company

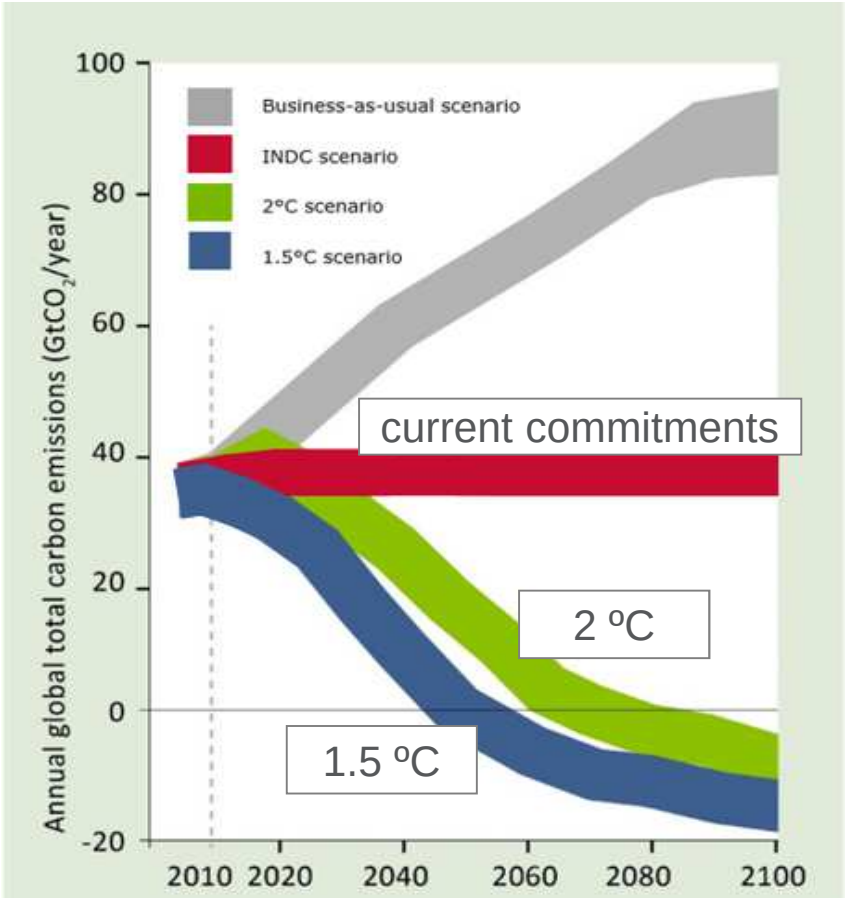
NAVIGANT

COP21: A LEGALLY BINDING COMMITMENT TO HOLDING GLOBAL WARMING WELL BELOW 2 ^{O}C, PURSUING < 1.5 ^{O}C

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Requires

- zero CO_2 emissions before 2050
- a 50% reduction in total energy demand in 2050 (relative to 2010)
- a full de-carbonization of the electricity supply as early as 2045



ECOFYS A Navigant Company NAVIGANT

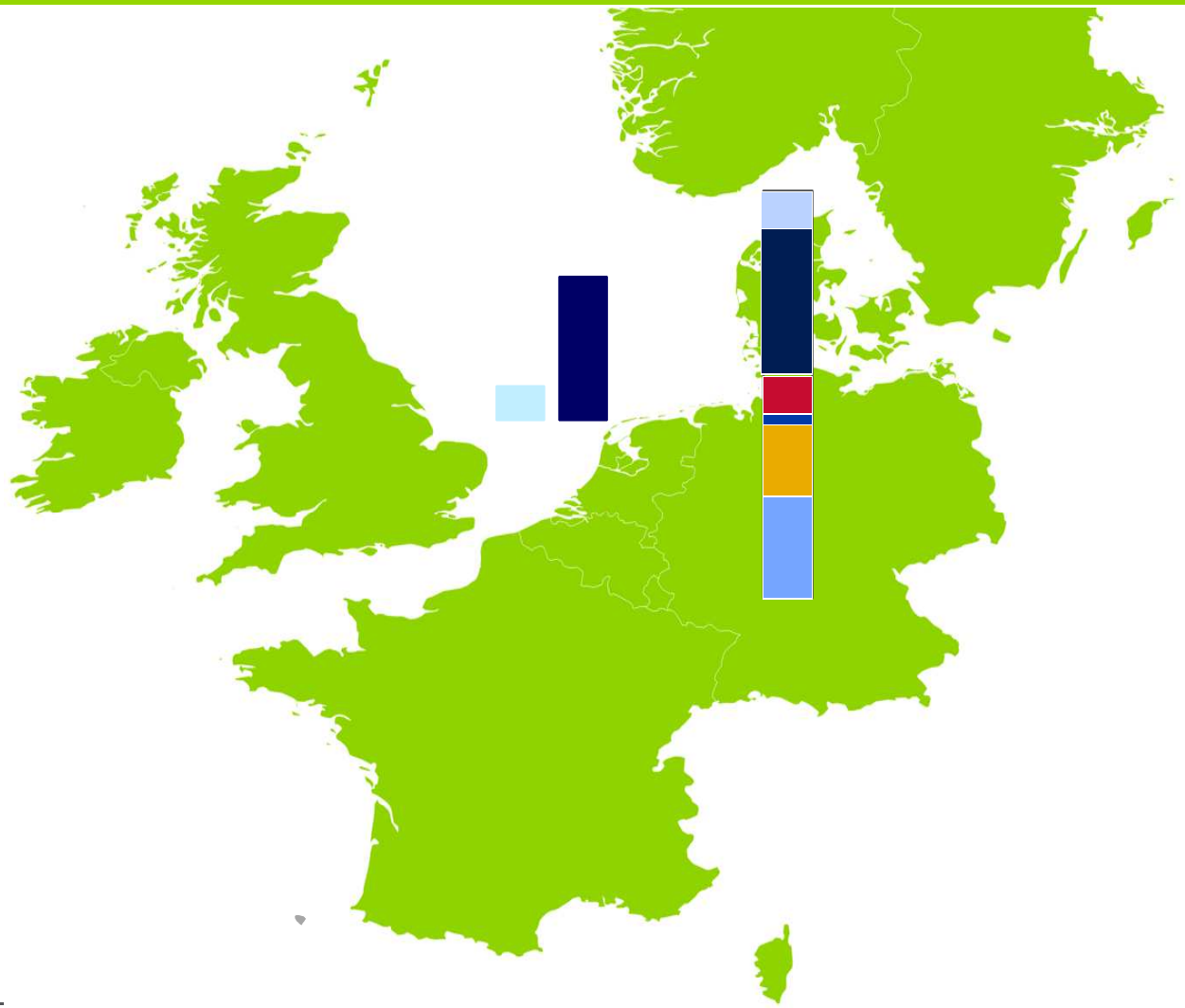
NORTH SEAS OFFSHORE WIND IS PIVOTAL TO REALIZE A 100% DECARBONIZATION OF THE ELECTRICITY SUPPLY

per country in 2045

Electricity demand

Onshore generation resource (wind, solar, hydro, bio, nuclear)

Required offshore wind capacity to meet annual electricity demand



ECOFYS A Navigant Company NAVIGANT

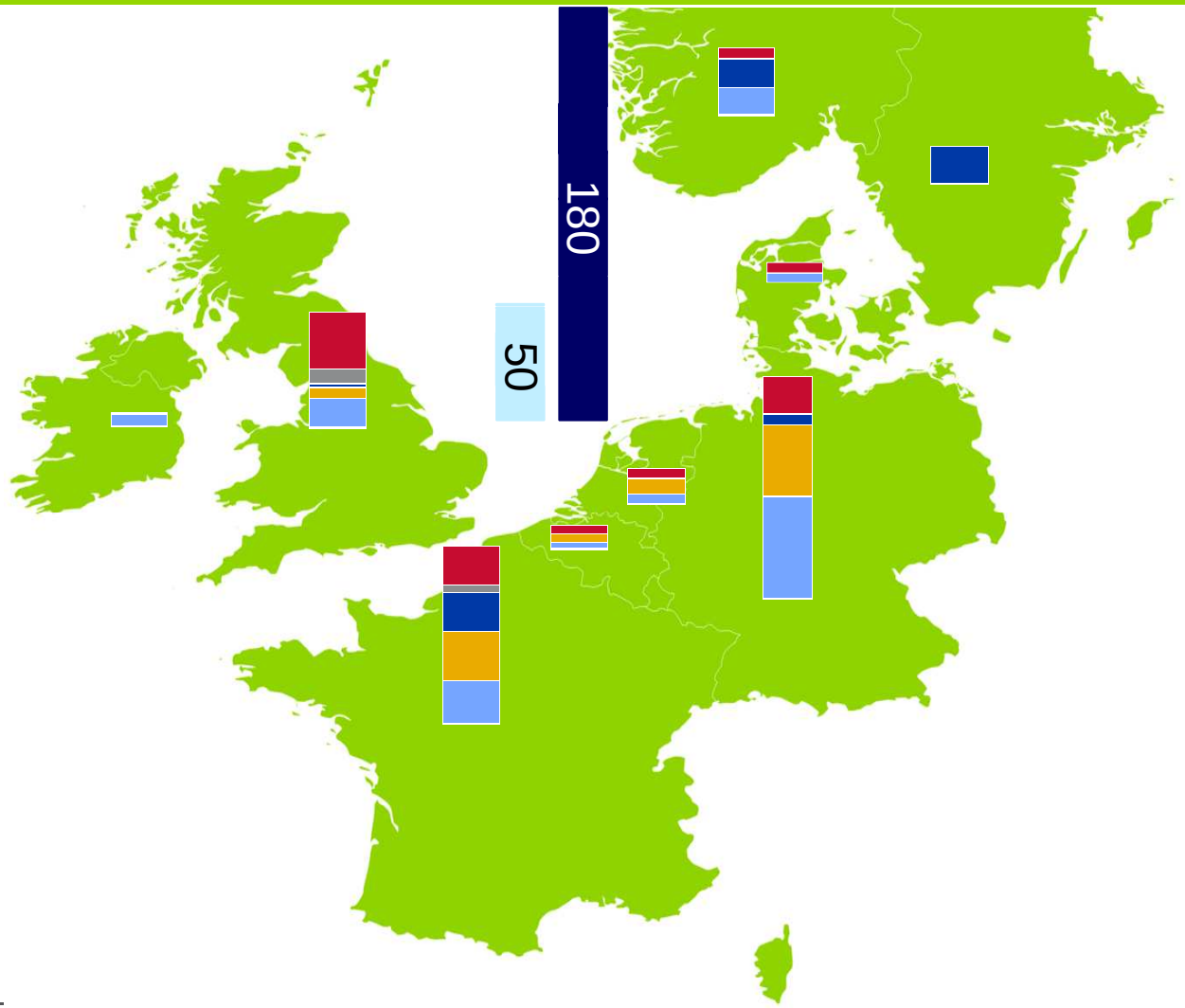
NORTH SEAS OFFSHORE WIND IS PIVOTAL TO REALIZE A 100% DECARBONIZATION OF THE ELECTRICITY SUPPLY

per country in 2045

Electricity demand

Onshore generation resource (wind, solar, hydro, bio, nuclear)

Required offshore wind capacity to meet annual electricity demand



bio
nuclear
hydro
solar
onshore wind

Offhore wind
other seas
North Seas

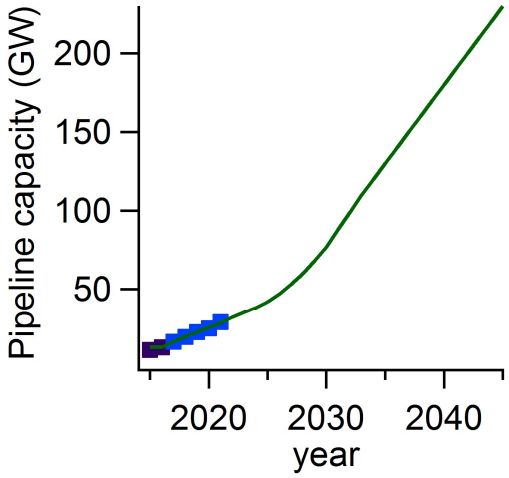
ECOFYS A Navigant Company NAVIGANT

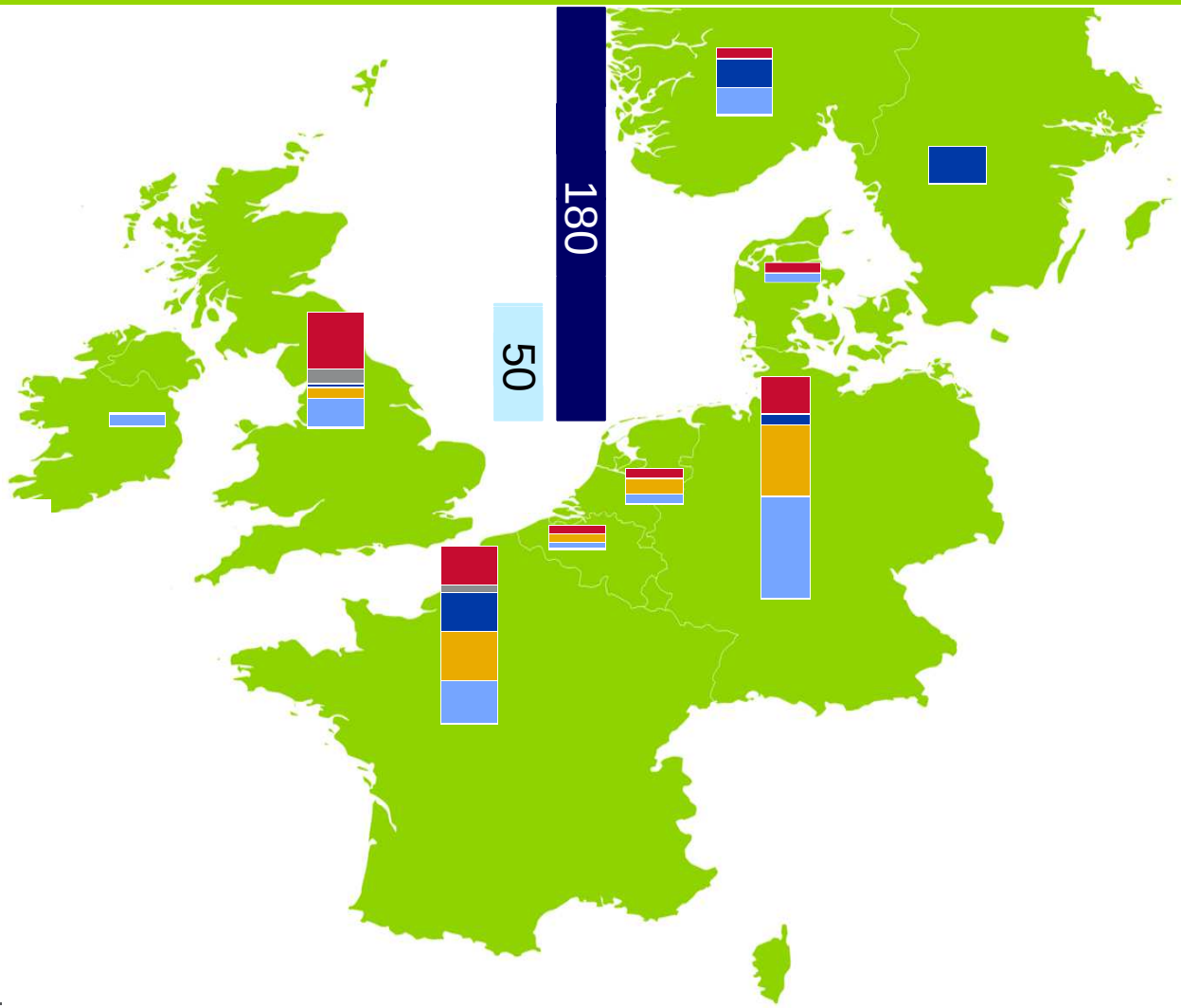
NORTH SEAS OFFSHORE WIND IS PIVOTAL TO REALIZE A 100% DECARBONIZATION OF THE ELECTRICITY SUPPLY

A need for ...

Coordinated roll-out effectively tripling the current rate to

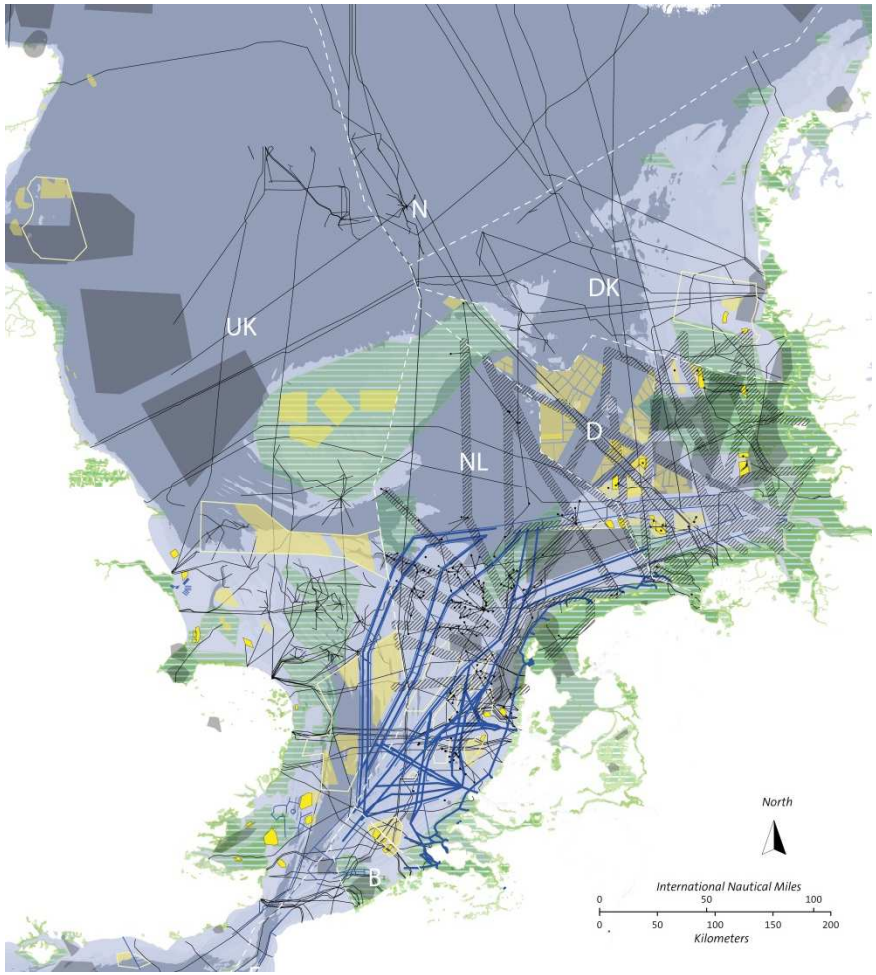
~10 GW/year from 2030 onwards





ECOFYS A Navigant Company NAVIGANT

COST EFFICIENT REALIZATION OF OFFSHORE WIND CAPACITY REQUIRES CROSS BORDER COOPERATION ...



North Seas ...

- an important nature area
- with intense use by a wide variety of economic sectors
- where cost of offshore wind depends on wind resource, depth, distance to shore/port, grid connection concept, inter-array wakes ....
- requires a regional view on resource use, deployment and operation based on a common sustainability commitment and an integrated market .

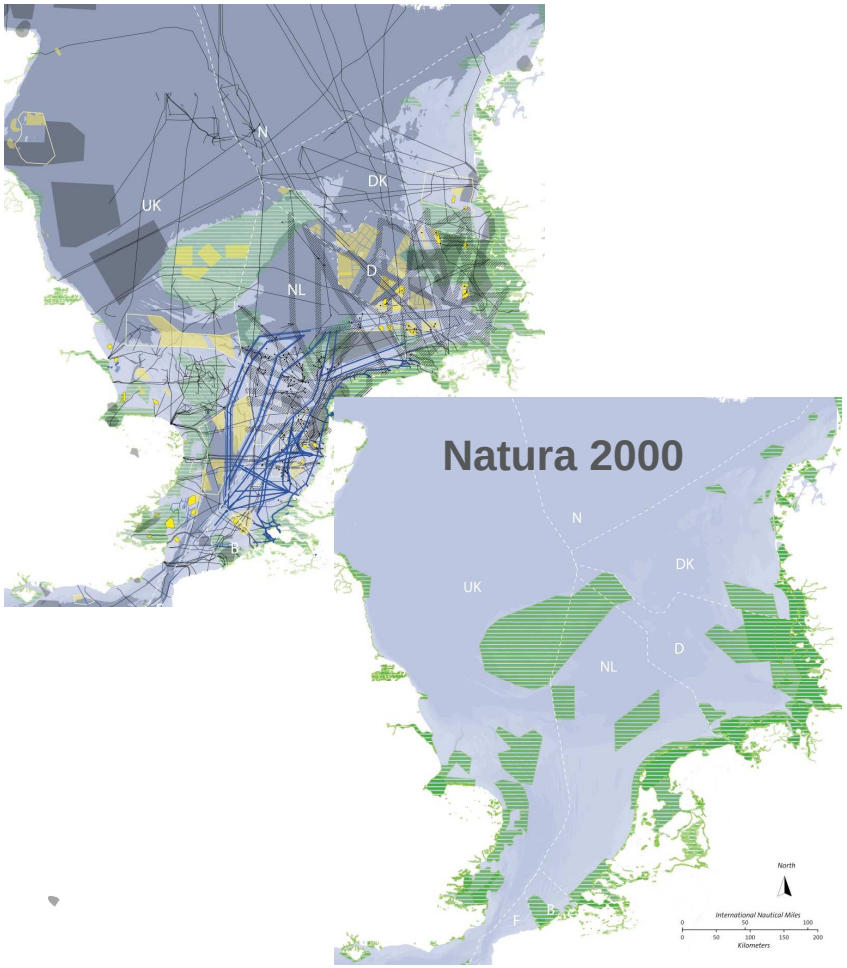
Spatial analysis performed by

Royal HaskoningDHV
Enhancing Society Together

ECOFYS A Navigant Company NAVIGANT

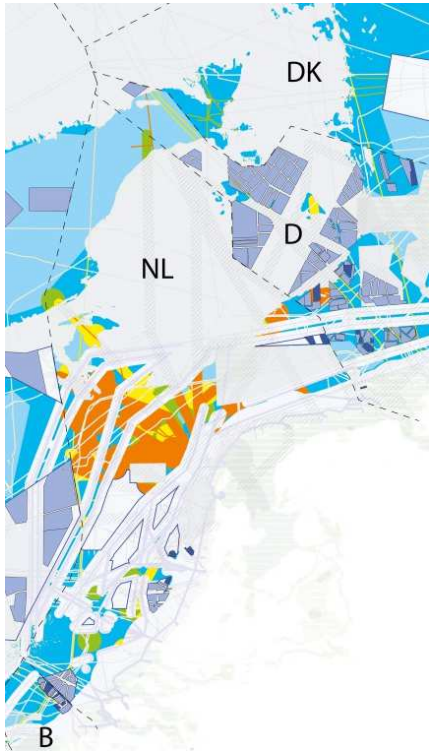
... AND A STRATEGIC APPROACH TO OVERALL SPATIAL PLANNING OF OFFSHORE WIND IN THE NORTH SEAS

Current constraints



Oil & gas decommissioning

(example Netherlands)



A need for ...

An international spatial planning strategy that ensures **cost efficient** utilization of the resource, aligned with **off- and onshore grid developments** and with maximum benefit for the **environment**

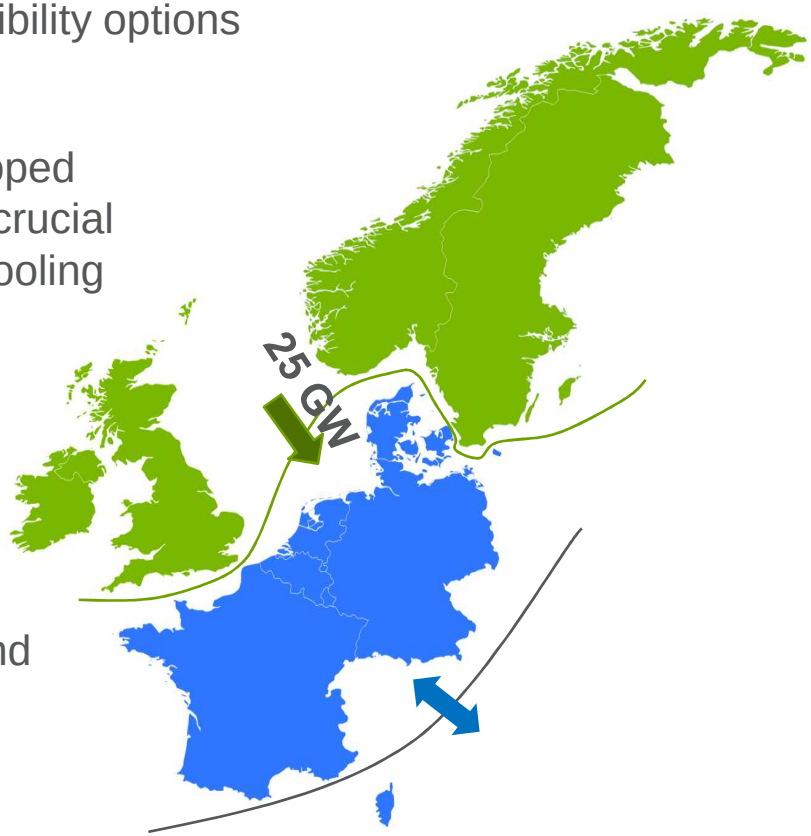
Spatial analysis performed by

Royal HaskoningDHV
Enhancing Society Together

ECOFYS A Navigant Company NAVIGANT

HIGHER LEVELS OF RENEWABLE ENERGY SOURCES REQUIRE INCREASED INTERCONNECTIVITY

- A higher share of variable sources requires increased flexibility options
- A well-developed network is a crucial enabler for pooling of flexibility resources
- 2045 interconnectivity assessment based on first order adequacy, regional correlations, and flexibility potential estimates



ECOFYS A Navigant Company NAVIGANT

230 GW OF OFFSHORE WIND IMPLIES 50-80 GW INTERCONNECTOR CAPACITY FOR FLEXIBILITY OPTIONS AND MARKETS TO FUNCTION

Sufficient interconnection capacity is essential to **maintain operational security**

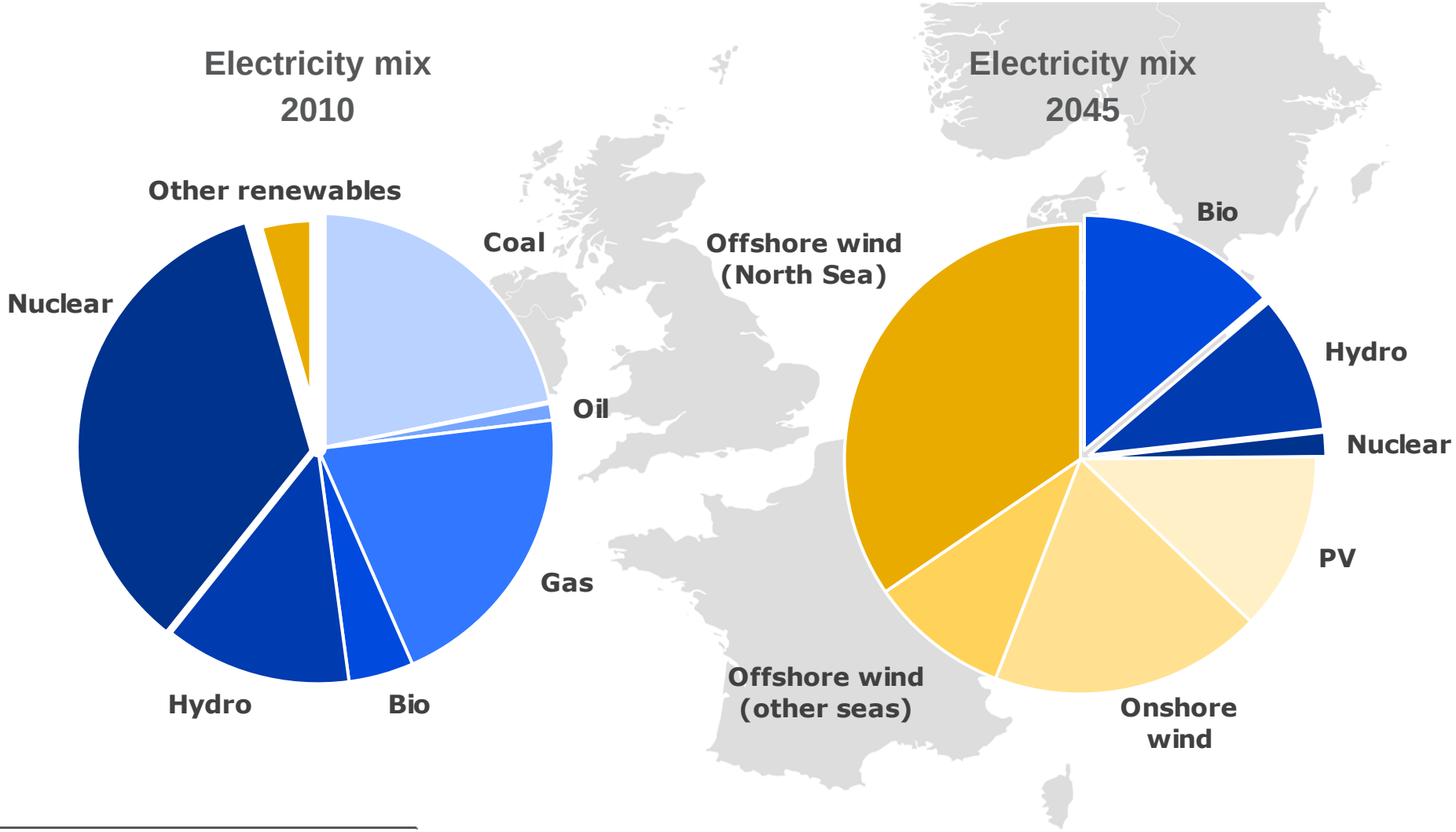
An increased roll-out of interconnector capacity requires a cost-benefit appraisal that goes **beyond current economic triggers** of operational cost savings

The **onshore grid** is an essential part of the North Sea grid too, and needs to cope with new flow patterns.

Based on Ecofys calculations, ENTSO-E, Electricity Highways

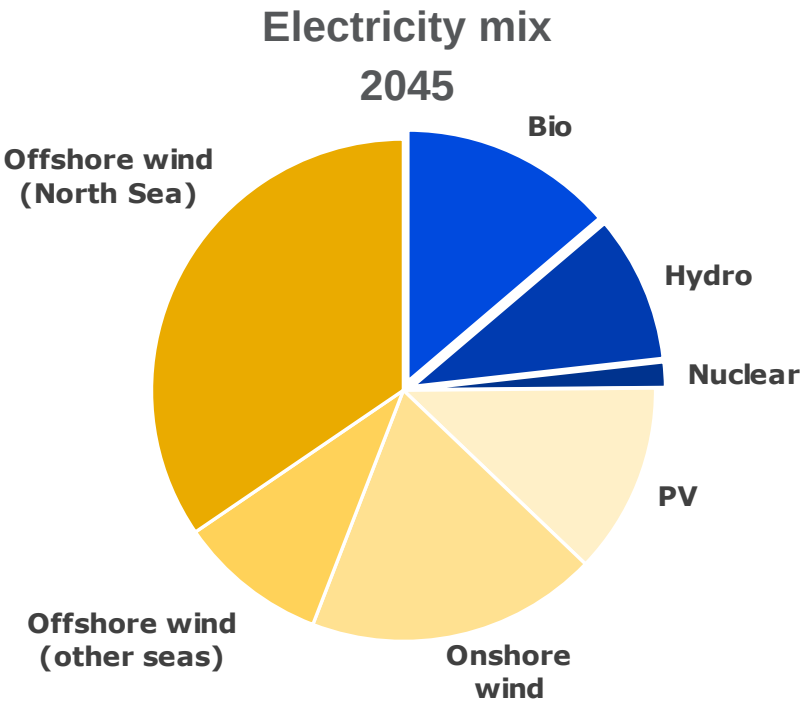
ECOFYS A Navigant Company NAVIGANT

THE TRANSITION TO A DECARBONIZED ELECTRICITY SUPPLY MARKS THE END OF DEPENDING ON CONVENTIONAL RESERVES ...



ECOFYS A Navigant Company NAVIGANT

... AND THUS REQUIRES A SIGNIFICANT INCREASE IN FLEXIBILITY OPTIONS



- There is need for **better understanding of market/operation issues** resulting from this energy mix, including economic triggers and additional capacity reserves.
- **Increased use of cost efficient flexibility options**, such as demand response, small/large-scale storage, power-to-gas, etc., will become essential in the 2045 scenario in face of decreasing dispatchable generation capacity.
- A **realistic and robust potential roadmap** is needed for all flexibility options by 2045, including a trade-off of some flexibility options with interconnection levels.

Based on IEA, Fraunhofer ISI, PRIMES, WindEurope studies and Ecofys expert

ECOFYS A Navigant Company NAVIGANT

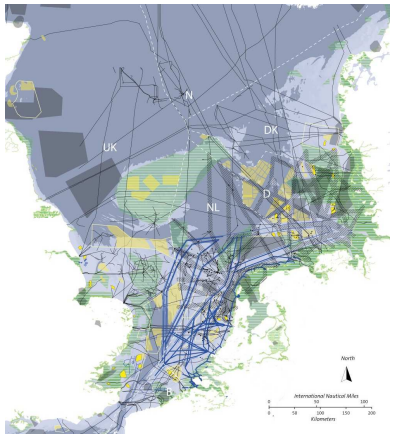
DELIVERING ON THE PARIS AGREEMENT REQUIRES IMMEDIATE ACTION ON THREE FRONTS

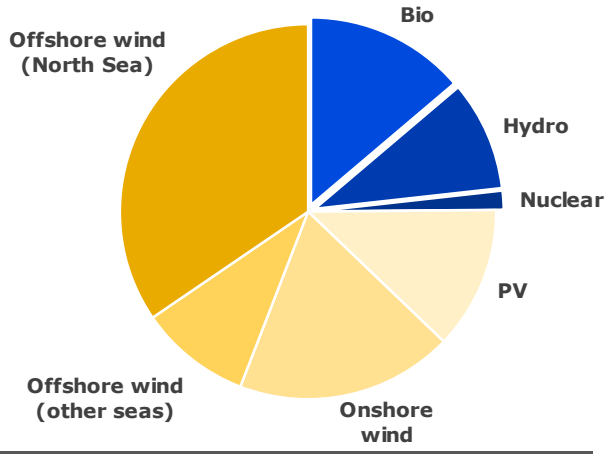
230 GW offshore wind | 50-80 GW interconnection | 25% dispatchable

Spatial planning
Development of **long term spatial planning strategy** (internationally coordinated roll-out, benefit to environment, maximise grid integration, at low cost)

Interconnectivity
Development of methodology to **value grid stability** that incentivizes interconnector capacity to maintain operational security

Flexibility
Development of **2045 roadmap for flexibility options** (storage, demand response, capacity reserves, and other energy sectors)





ECOFYS NAVIGANT

MICHIEL MÜLLER
Managing director
m.muller@ecofys.com

Ecofys.
A Navigant Company.
www.ecofys.com
www.navigant.com

ECOFYS A Navigant Company NAVIGANT