OFFSHORE SOLAR TECHNOLOGY: STATE-OF-THE-ART

CHALLENGES AND POTENTIAL FOR OFFSHORE SOLAR IN THE DUTCH NORTH SEA

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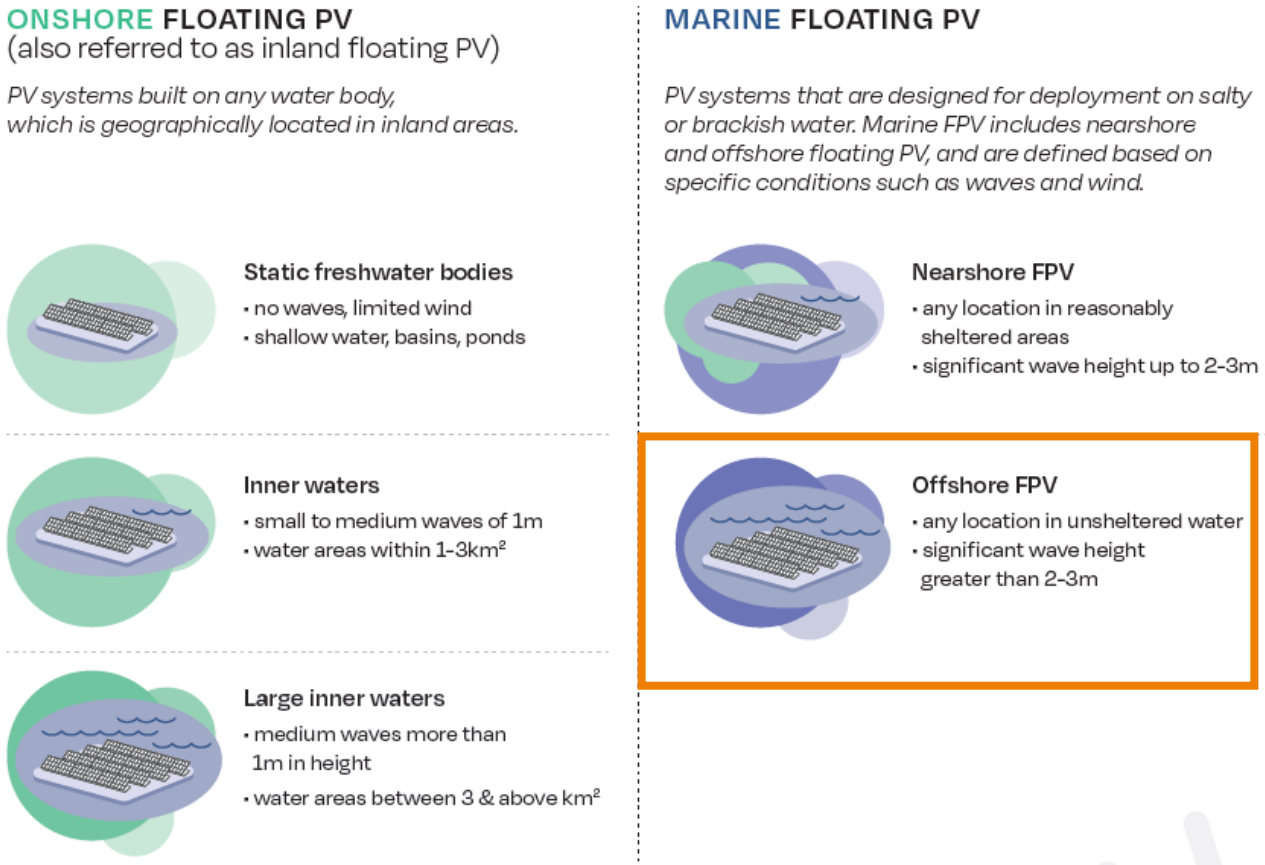
10 JANUARI 2024, NATIONAAL CONSORTIUM ZON OP WATER

FPV CATEGORIES

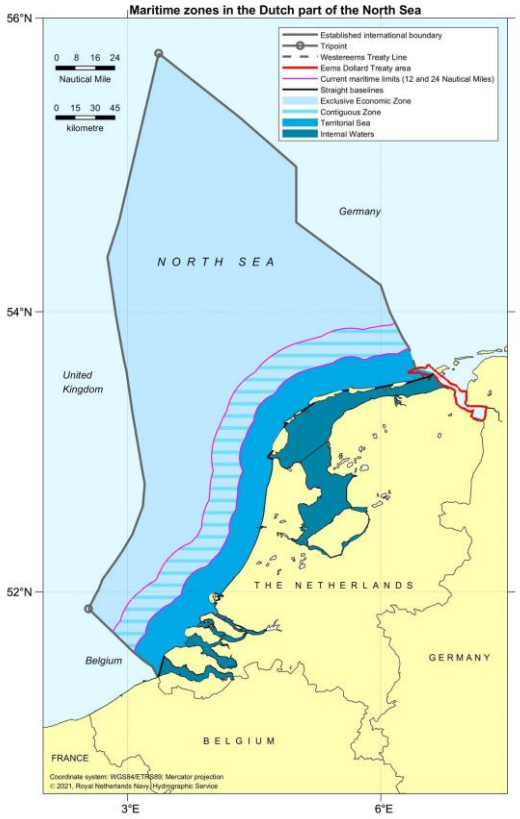
FIGURE 2 PLACEHOLDER FOR GRAPHS COMPARING ONSHORE, OFFSHORE AND NEARSHORE FPV



From : Floating PV, practical guidelines, Solar Power Europe, 2024

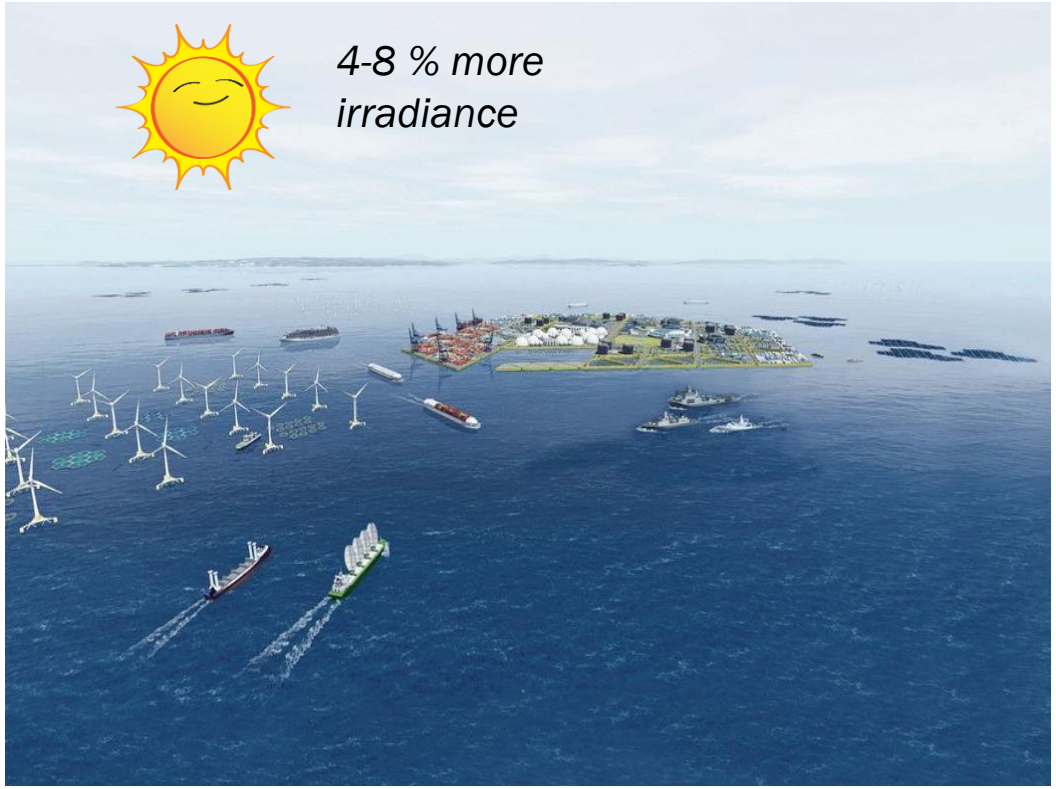
WHY OFFSHORE SOLAR ?

Offshore solar can be the solution for the large scale solar that we need, near areas of dense population.



On sea we can find the km² that we need

Offshore solar & wind offer important synergies



Higher solar production (irradiance, cooling) .

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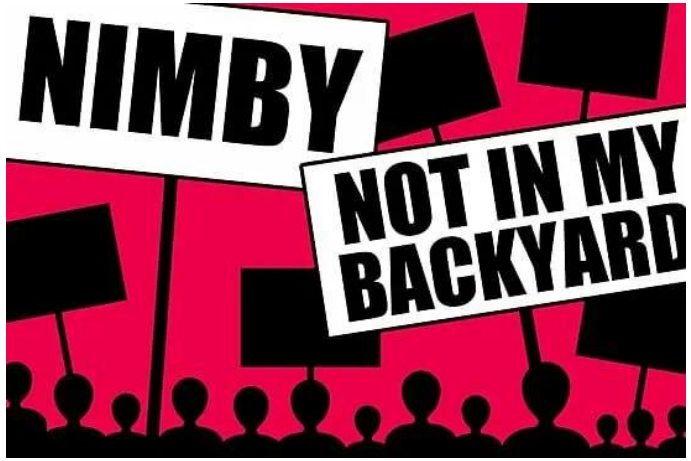
OFFSHORE SOLAR
THE KEY QUESTION

Is offshore solar a good idea?

- Technical feasibility
- Economic affordability
- Societal acceptance



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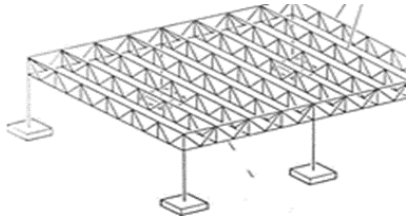
SYSTEM CONCEPTS FOR OFFSHORE FLOATING SOLAR

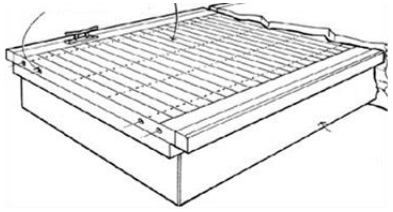
1. Elevated Truss typology
   - SolarDuck (NL)
   - Seavolt(BE)
   - Swimsol (AT)
   - Moss Maritime (NO)
   - Solarinblue (FR)
   - Sinn Power (GE)
   - CIMC Raffles (China)

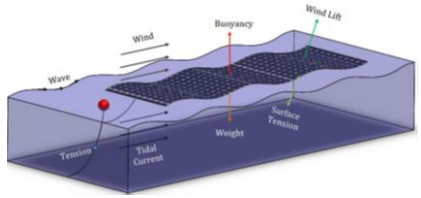
2. Rigid Pontoon typology
   - Oceans of Energy (NL)
   - HelioRec (FR)
   - Fred Olsen 1848 (NO)

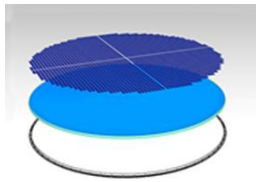
3. Flexible pontoon typology
   - Bluewater/Genap (NL)

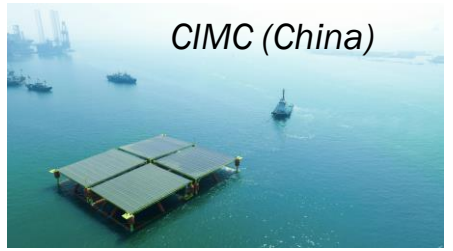
4. Floating foil typology
   - Ocean Sun (NO)
   - Inseanergy (NO)

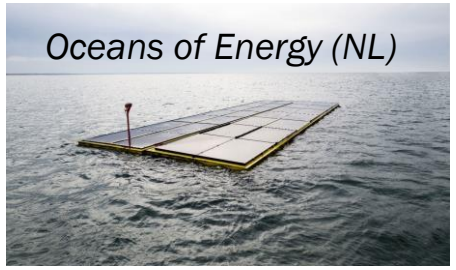


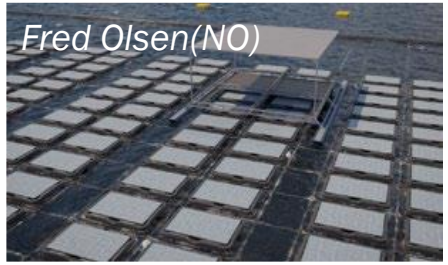












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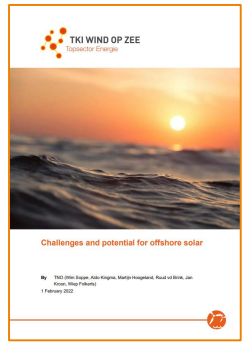
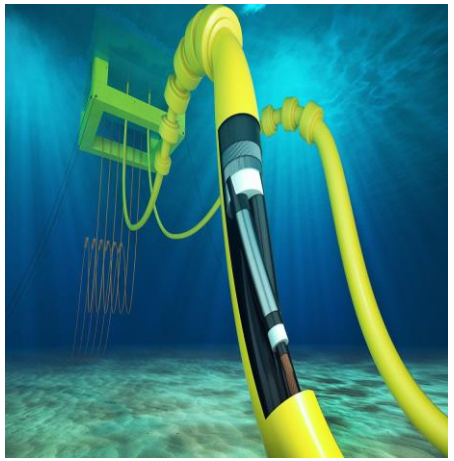
THE 4 CHALLENGES FOR OFFSHORE FLOATING PV

TKI WIND OP ZEE
Topsector Energie



1. Design and construction

- Connectors between subsystems
- Choice of materials
- Structural integrity & mooring
- Reliable dynamic power cable connection
- Calculational methodologies for prediction of hydrodynamic response



2. Operations and Maintenance

- Offshore compatible PV modules and electrical components
- Fouling prevention & fouling removal
- Preventive and reactive maintenance schemes
- Monitoring and digital twinning

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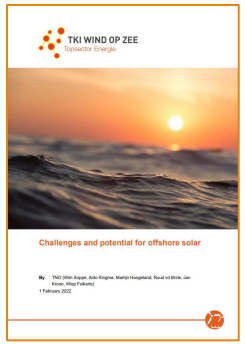

3. Power production and LCOE

- Validated power yield models
- LCOE models & scale effects
- Wind-solar synergy
- Power transfer and electrical storage
- Mutual interaction of solar and wind on production

4. Societal acceptance

- Circularity
- Ecology
- Permitting
- Users of the sea

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ROADMAP OFFSHORE SOLAR IN THE NORTHSEA

- Several pilots/demo's (0.5-5 MWp) planned from 2023-2027
- Collaborations between system developers and research institues
- Integration of offshore solar in offshore windpark tenders

- 2030 Ambition government
  - ➢ 3 GWp Offshore Solar in Dutch North Sea

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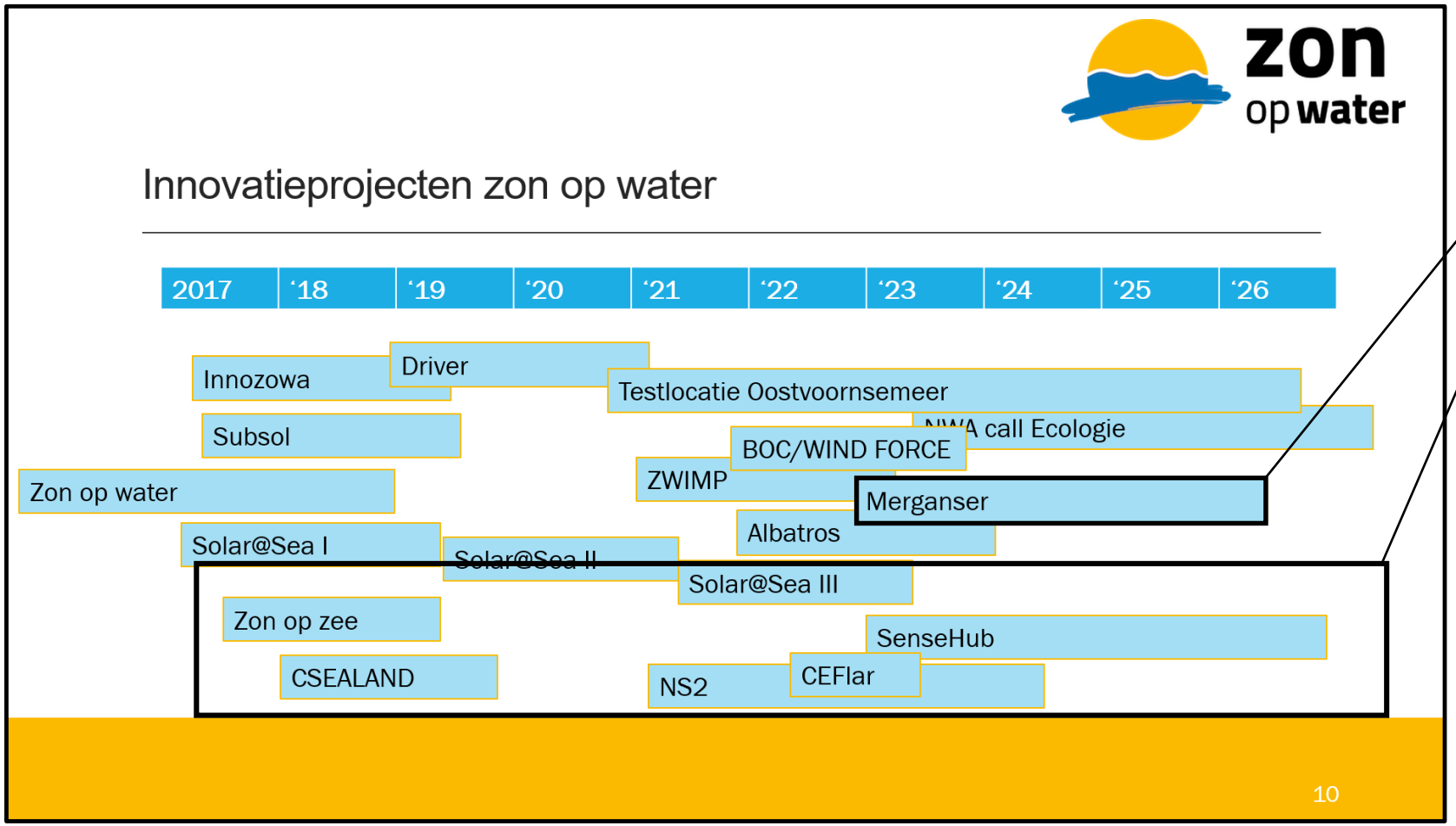
DUTCH RESEARCH LANDSCAPE

Funding sources: TKI, NWO, RVO (HER, DEI+)



From: Robin Quax (TKI Urban Energy)

Joint Development Offshore FPV Projects:

Knowledge development
Pilot building
System integration

Oceans of Energy
Solar Duck
Bluewater/GENAP

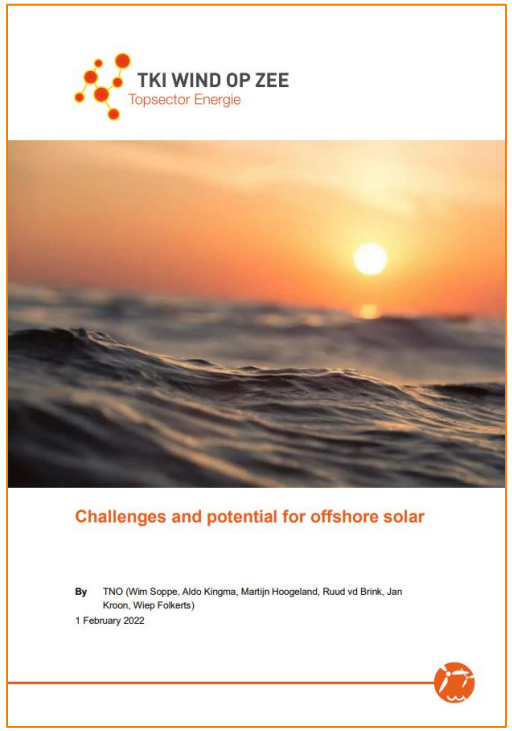
TNO
Deltares, WUR, NIOZ
Marin
Universities

Supportive companies (cables, permits, materials)

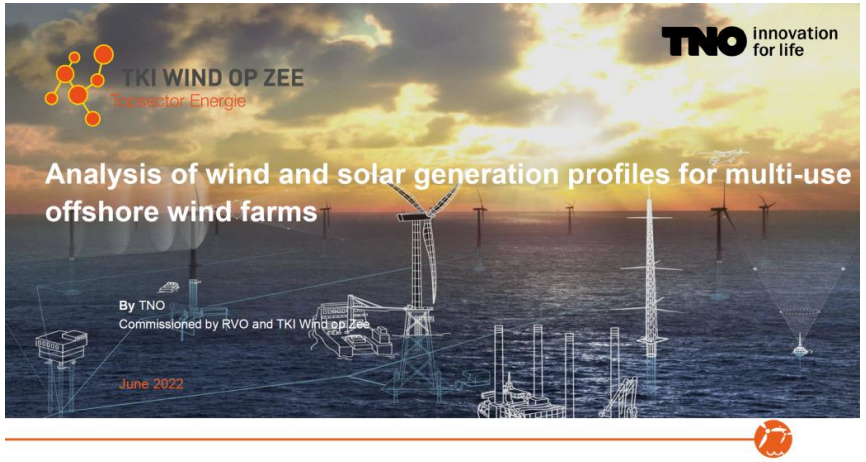
SUMMARY

- Offshore solar is promising and challenging !
- Different concepts are in development; beginning of the learning curve. Pilots and demonstrators needed to accelerate the learning.
- Strong (pre-competitive) research program needed:
  - Construction, O&M, Power production, Societal acceptance

LINK TO TNO REPORTS



- 20220331_RAP_Challenges_and_potentialfor_offshore_solar_Final.pdf (topsectorenergie.nl)



- Analysis of generation profiles for multi-use offshore wind farms by TNO June 2022 (topsectorenergie.nl)

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Thank you for your attention

Acknowledgements:
TKI Wind op Zee/RVO
Crosswind C.V.
TNO teams involved in FPV research
Solar, Wind, NOS

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BACKGROUND

- Study was commissioned by the Dutch funding agency RVO
- Aim of the study: guidelines for funding instruments to stimulate the development of offshore floating solar on the North Sea
  - Combination with wind parks (20 GW installed in 2030)
  - Research questions:
  - Technical challenges
  - Competitive LCOE

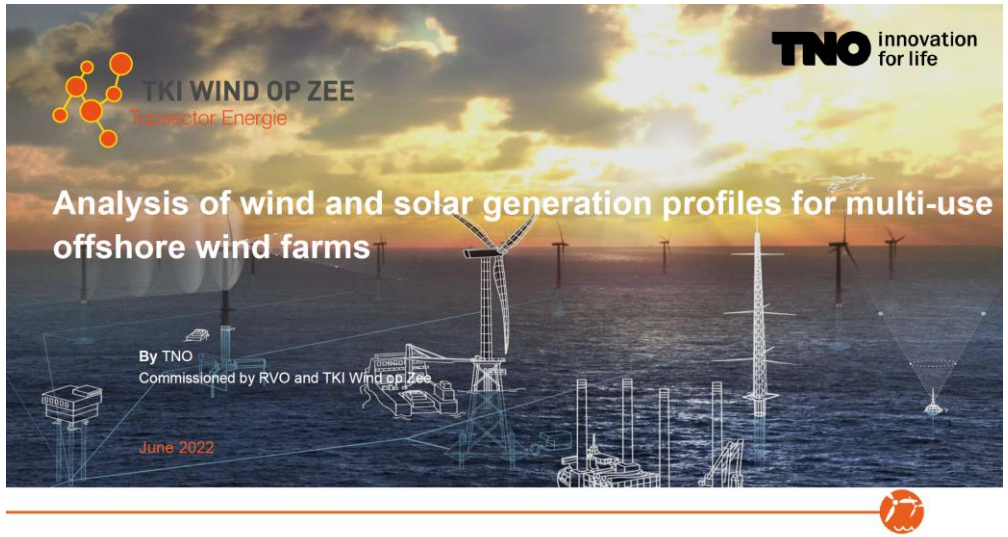
- Desktop study, based on publicly available knowledge and on TNO insights.
  - TNO expertise on Solar, Offshore Wind, Maritime

SYNERGIES AND CHALLENGES OF OFFSHORE FLOATING IN OFFSHORE WINDFARMS

PRELIMINARY TNO STUDIES (1/2)

Studies on resource complementarity

- Analysis of wind and solar generation profiles
- Impact on the business case of a combined offshore wind and floating solar farm
- Impact on the required optimal capacity of the export infrastructure



Potential benefits

- Higher utilization of the electrical infrastructure
- A more constant generation profile overall.

Challenges

- Curtailment in periods where the combined production > the nominal capacity of the grid connection

FPV MARKET SEGMENTATION
WAVECLASS CATEGORY

1. Static fresh water bodies
- No waves, limited wind
- Shallow water, basins, ponds

2. Inner waters
- Small to medium waves until 1 meter
- Lakes, area 1 - 10 km^2

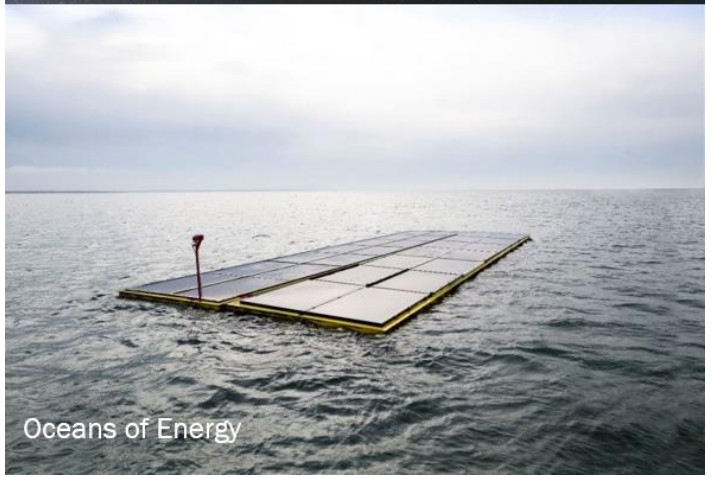
3. Large inner waters
- Medium waves until 2 meter
- Areas 10 - 500 km^2

4. Offshore
- Salt and corrosive environment
- Near- shore: waves until 3-4 meter
- Far offshore: high waves until 10 meter

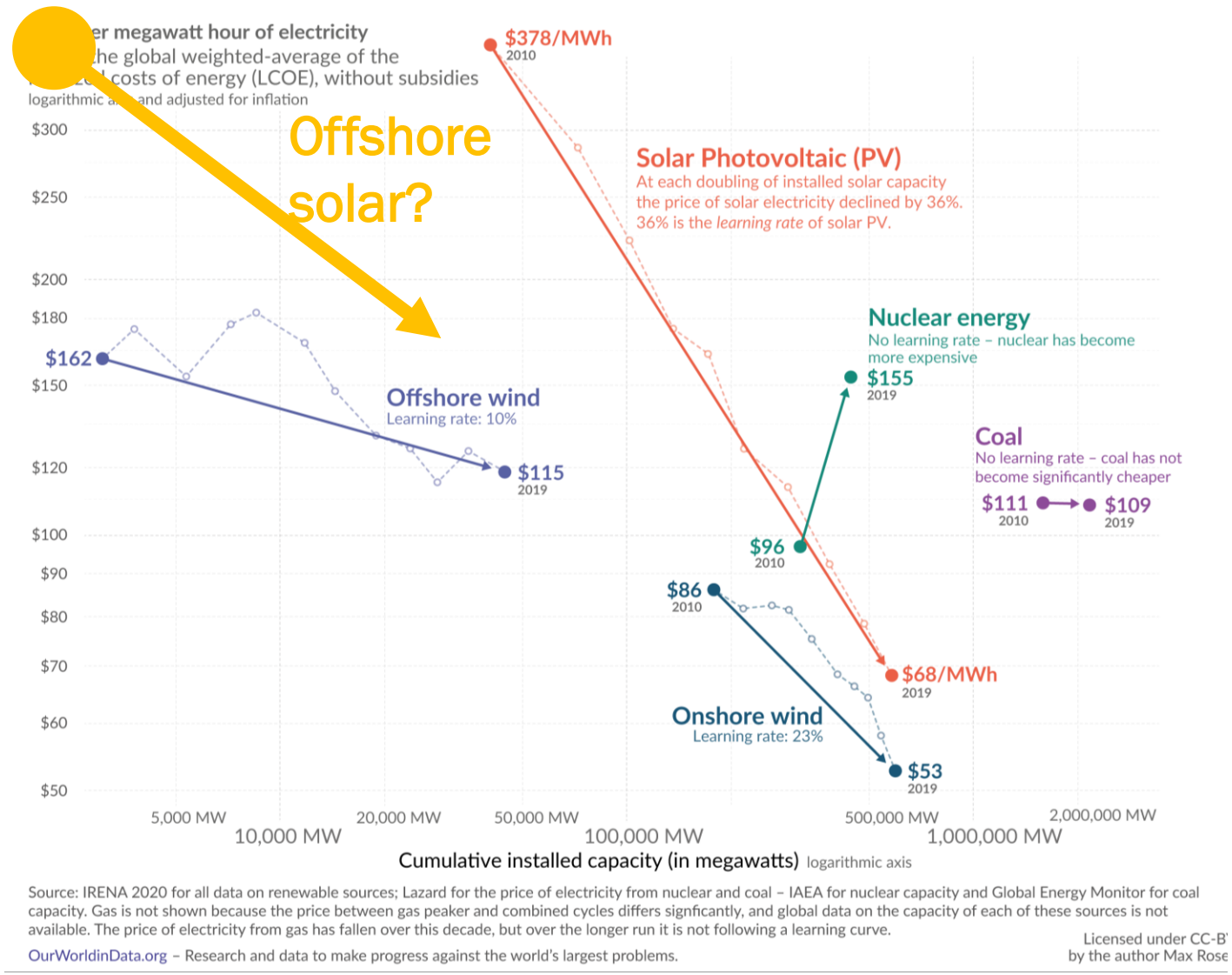
Commercial

Pilots

R&D/Pilot



TRENDS IN COST OF ENERGY



Source: IRENA 2020 for all data on renewable sources; Lazard for the price of electricity from nuclear and coal – IAEA for nuclear capacity and Global Energy Monitor for coal capacity. Gas is not shown because the price between gas peaker and combined cycles differs signficantly, and global data on the capacity of each of these sources is not available. The price of electricity from gas has fallen over this decade, but over the longer run it is not following a learning curve.

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