rijksuniversiteit groningen

Slimme energietransitie.

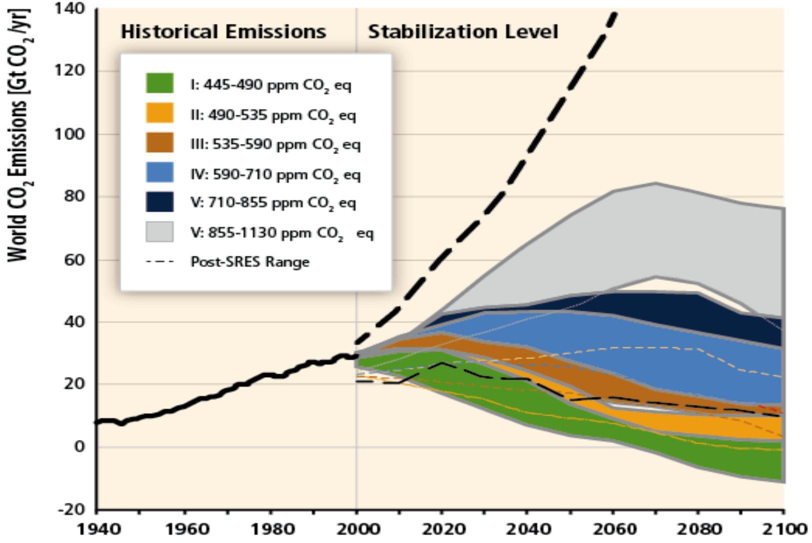
WND Conferentie 2018 – Energietransitie, Noordwijkerhout

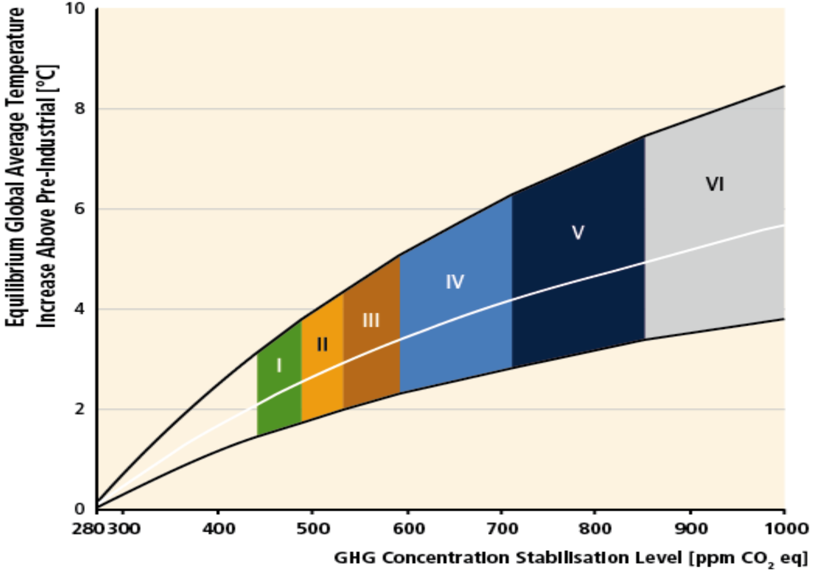
Andre Faaij
Distinguished Professor Energy system analysis, University of Groningen

Director of Science
ECN part of TNO

ECN › TNO innovation for life

ENERGY DEMAND, GHG EMISSIONS AND CLIMATE CHANGE...

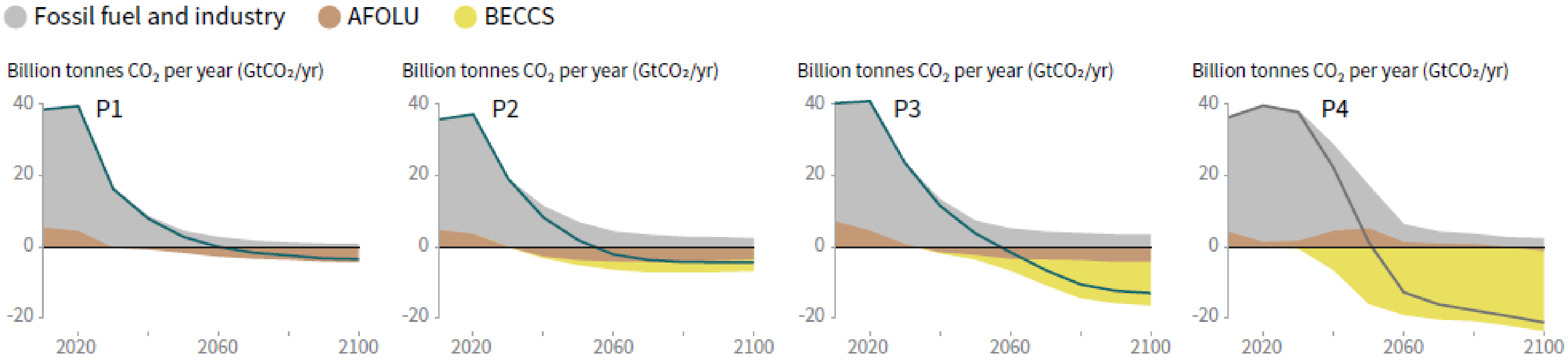




[IPCC]

THE IPCC 1,5 OC REPORT: EMISSION PATHWAYS

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



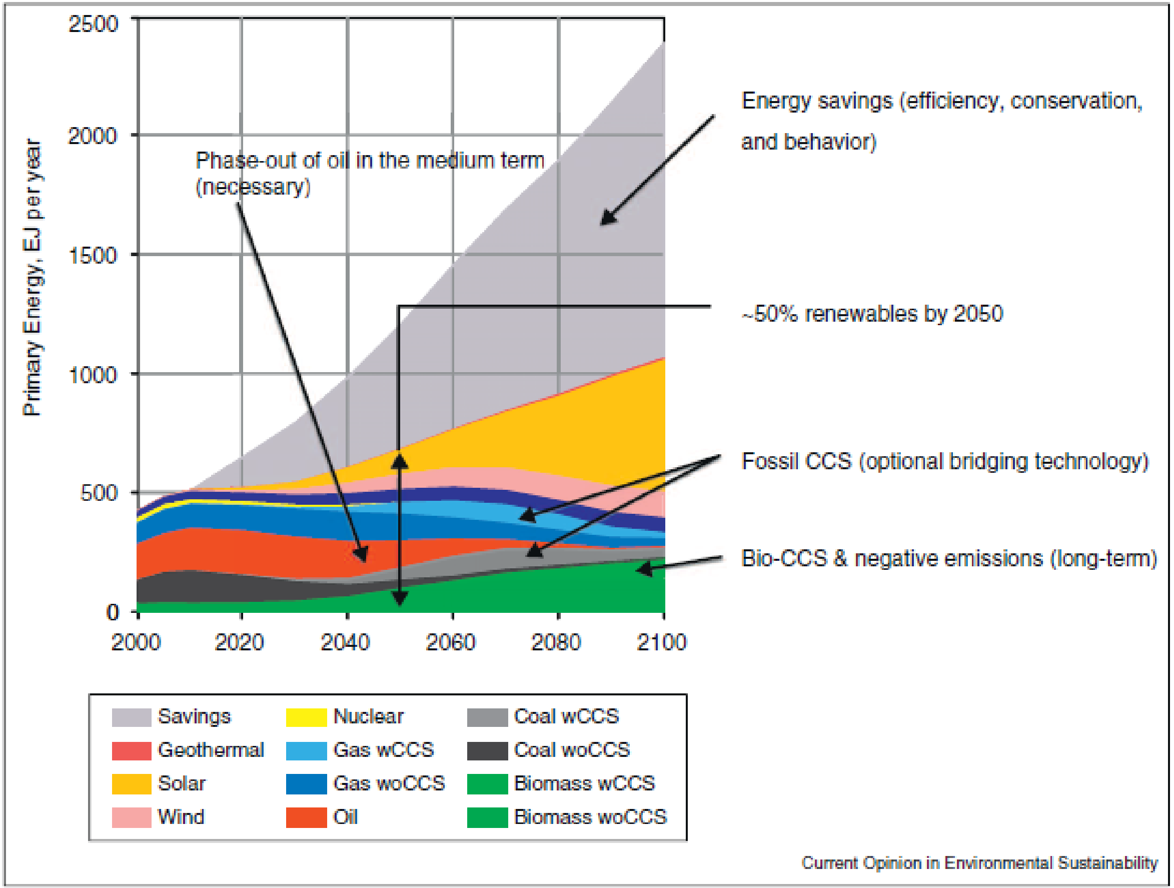
P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

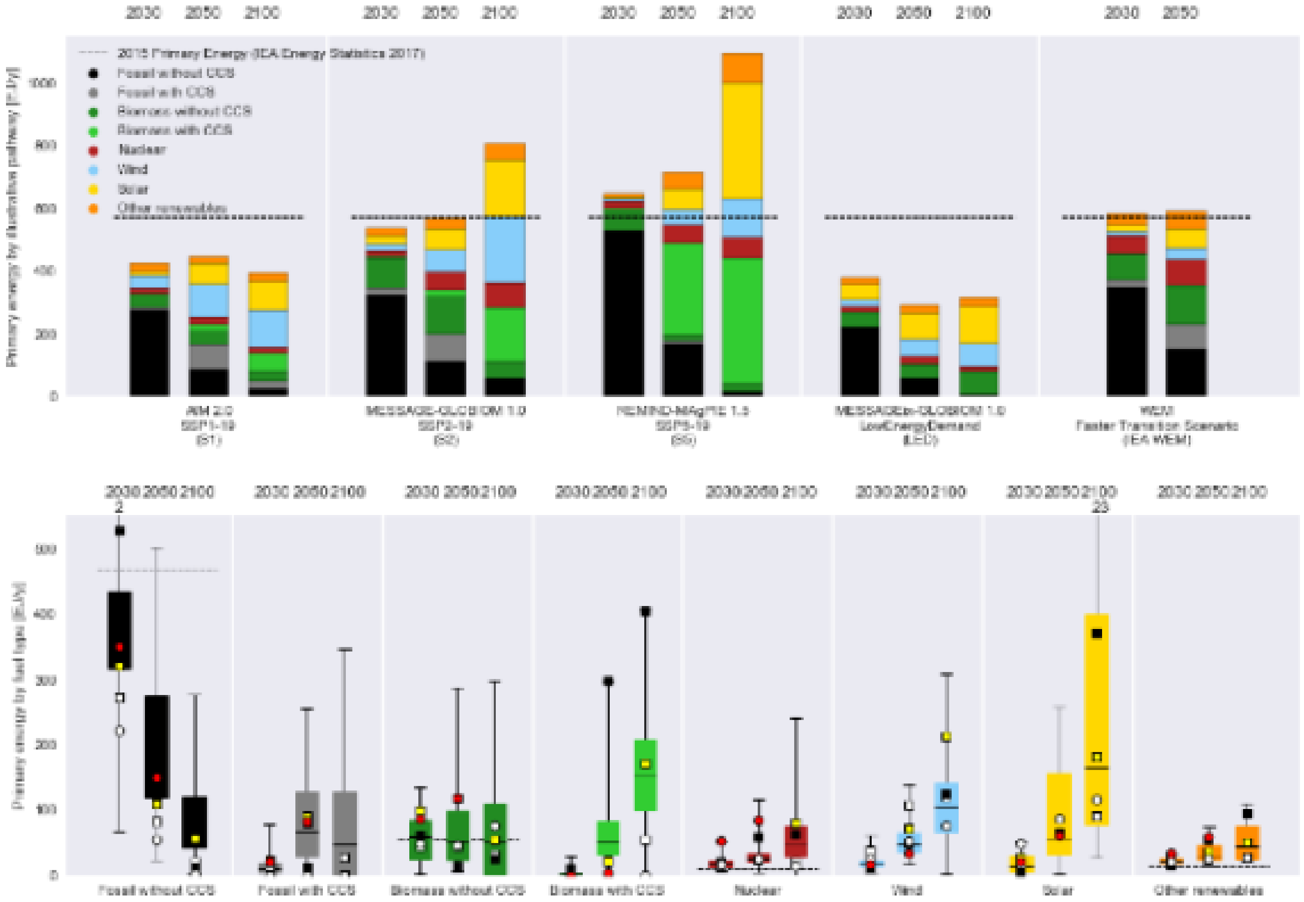
P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

ENERGY SYSTEM TRANSFORMATION...



[GEA/van Vuuren et al CoSust, 2012]



IPCC 1,5 OC REPORT: ILLUSTRATIVE PATHWAYS ACCORDING TO DIFFERENT ACTORS & MODELLING FRAMEWORKS

HISTORICAL AND PROJECTED GLOBAL ENERGY INVESTMENTS (IPCC, 1,5 OC REPORT)

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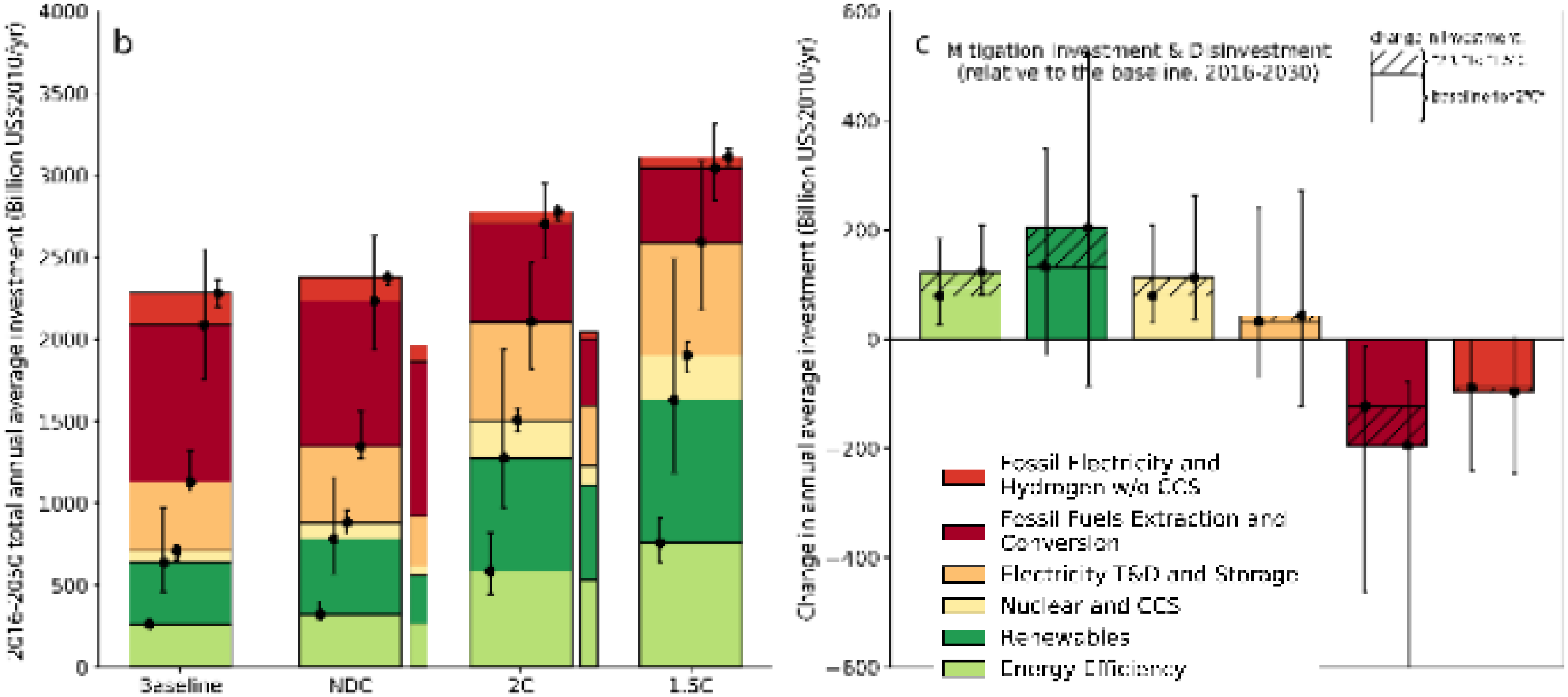
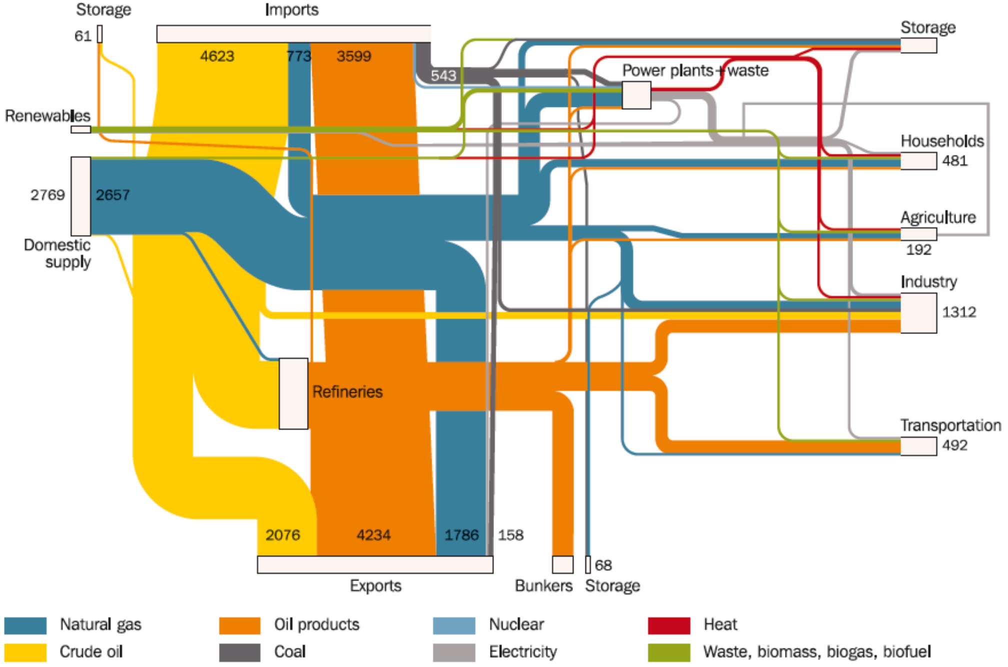


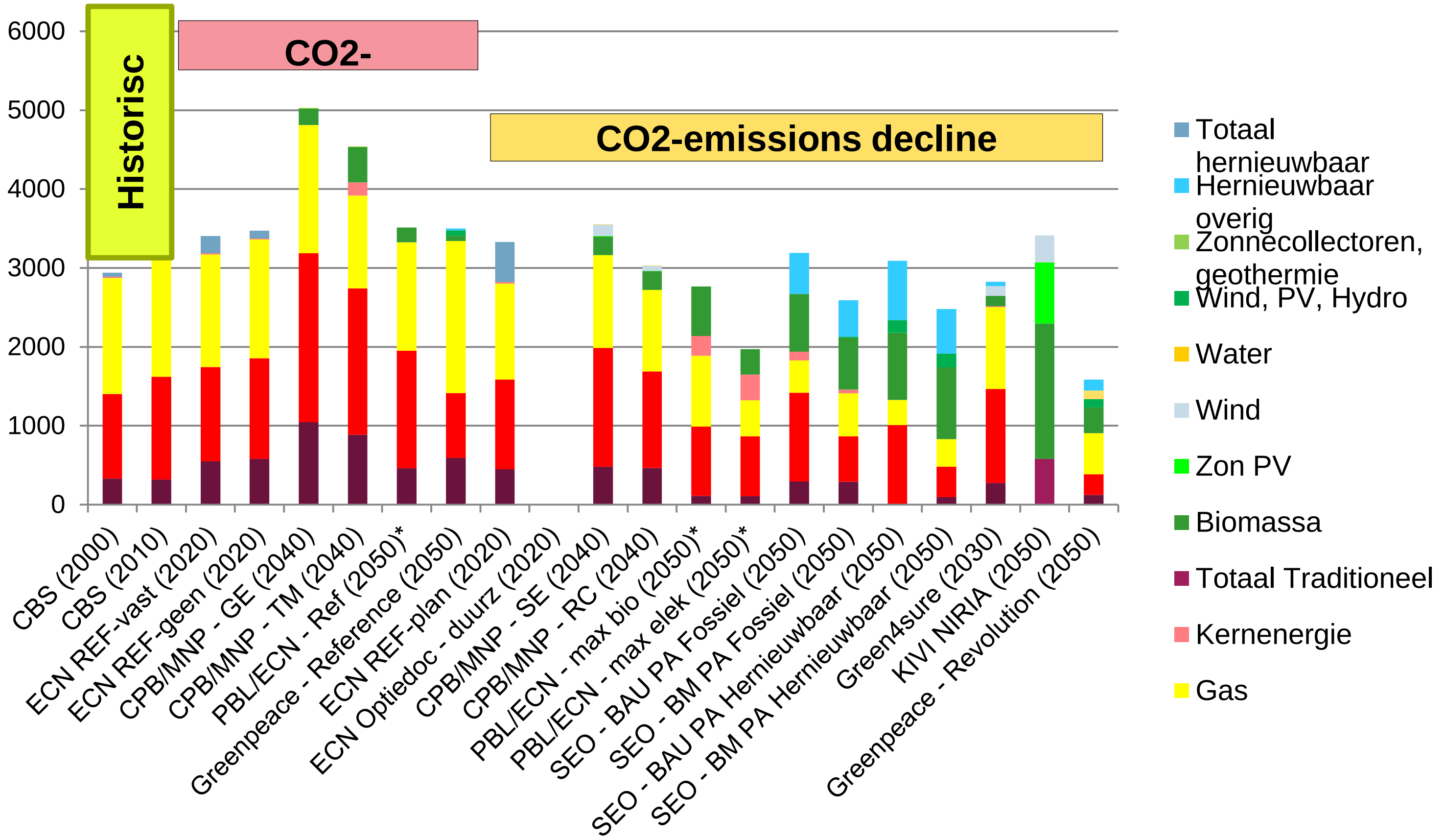
NATIONAL LEVEL…

CURRENT ENERGY SYSTEM OF THE NETHERLANDS; ADVANCED FOSSIL ENERGY INFRASTRUCTURE

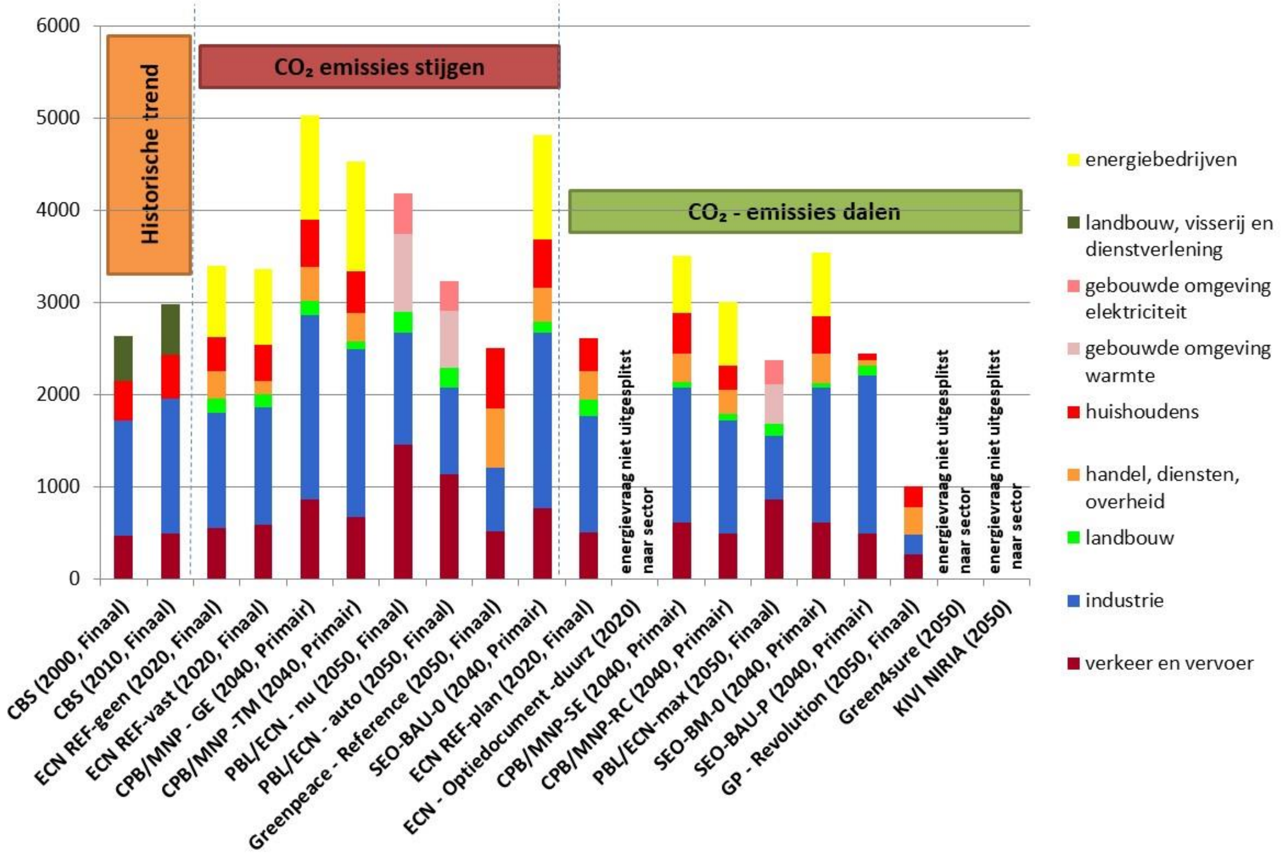


Energiestromen in Nederland (data CBS, 2010).

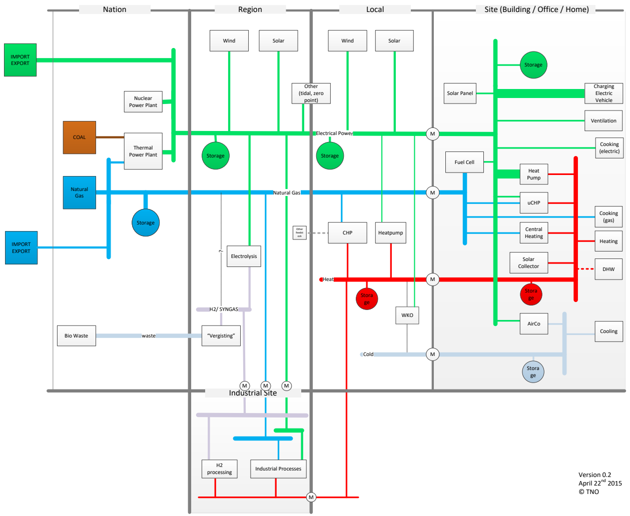
POSSIBLE FUTURE ENERGY SUPPLY NL (PJ/YR)



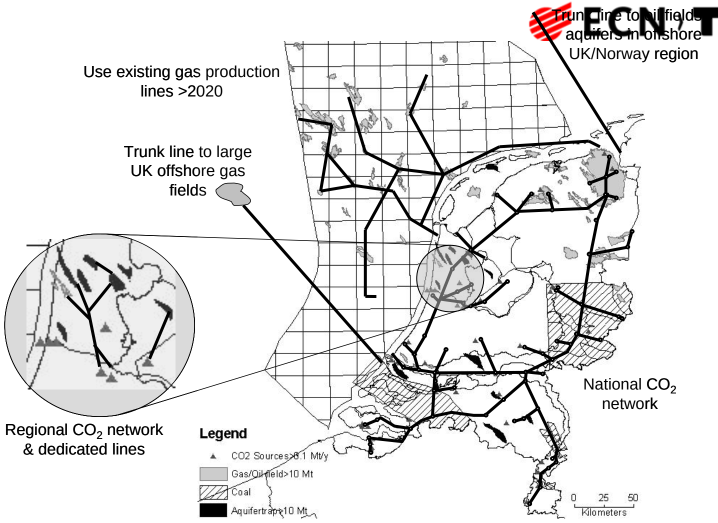
POSSIBLE FUTURE ENERGY DEMAND PER SECTOR THE NETHERLANDS (PJ/YR)



THE FUTURE ENERGY SYSTEM IS COMPLEX…

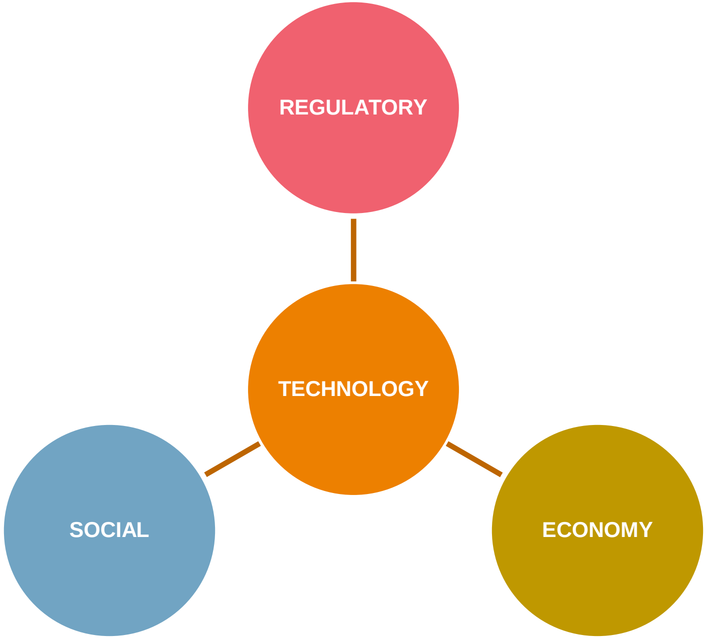


Decentralized, heat networks, energy cooperations, consumer preferences and behaviour, new and more comptetitive energy technologies, incentives, reliability, affordabiliy, new business vs. Current energy sector, regulation…



Possible future configuration
Of CCS infrastructure…

…AND MULTIDISCIPLINARY…



Technology
Energy models
Economic models
Advanced Control Modellen
Forecasting-, simulation- & scenario analyses
…model collaboration!.

Economics
Value chains, business cases

Regulation
Impact of incentives

Social
Societal support
Consumer behaviour and preferences.

Spatial Dimensions: factory - industrial sites – city – province – country – multilateral – Europe – global.

INDUSTRIAL TRANSFORMATION -> ZERO CARBON FOOTPRINT; DAUNTING COMPLEXITY.

- **Industry ~50% of primary energy use.**
- **Many options:**
  - Energy efficiency improvement existing processes
  - New (inherently more efficient) processes
  - Renewable feedstock (biobased industry
  - Renewable energy carriers (green power, green hydrogen)
  - Carbon Capture & Storage (with BECCS negative GHG emissions)
  - Recycling/re-use/circulair value chains
  - Shifts in markets and products.
- **All combined! Over roughly 3 decades; overall one investment cycle!!**
- **Factory level, regional level, structural changes in economy and energy system**

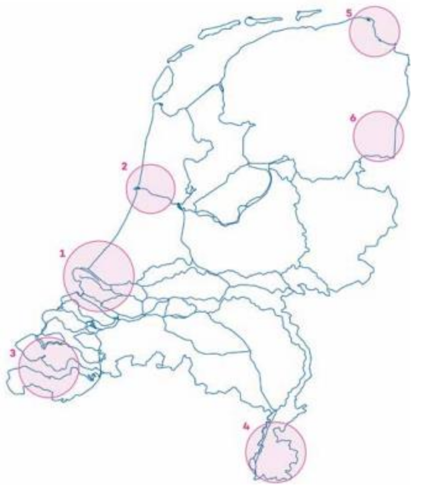


Figure 2 Location and size of the main industrial emission clusters. 1) Rotterdam - Moerdijk (16.9 Mt CO_2); 2) Noordzeekanaalgebied (12.0 Mt CO_2); 3) Zeeland - W-Brabant (7.9 Mt CO_2); 4) Chemelot (4.5 Mt CO_2); 5) Eemsdelta (0.7 Mt CO_2); 6) Emmen (0.5 Mt CO_2).[8,9]

SPATIAL ISSUES... EXAMPLE OF CCS IN RIJNMOND

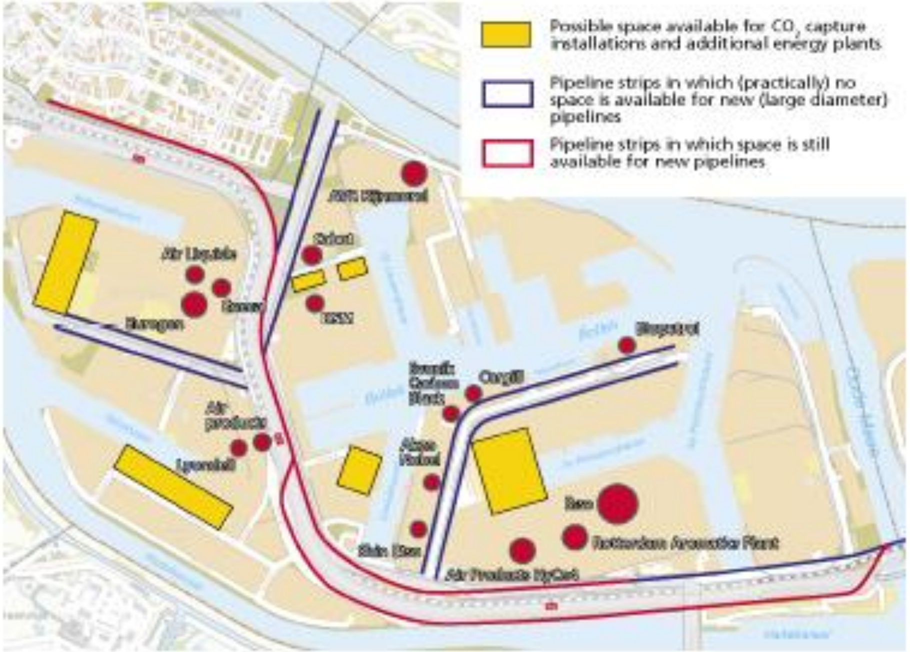
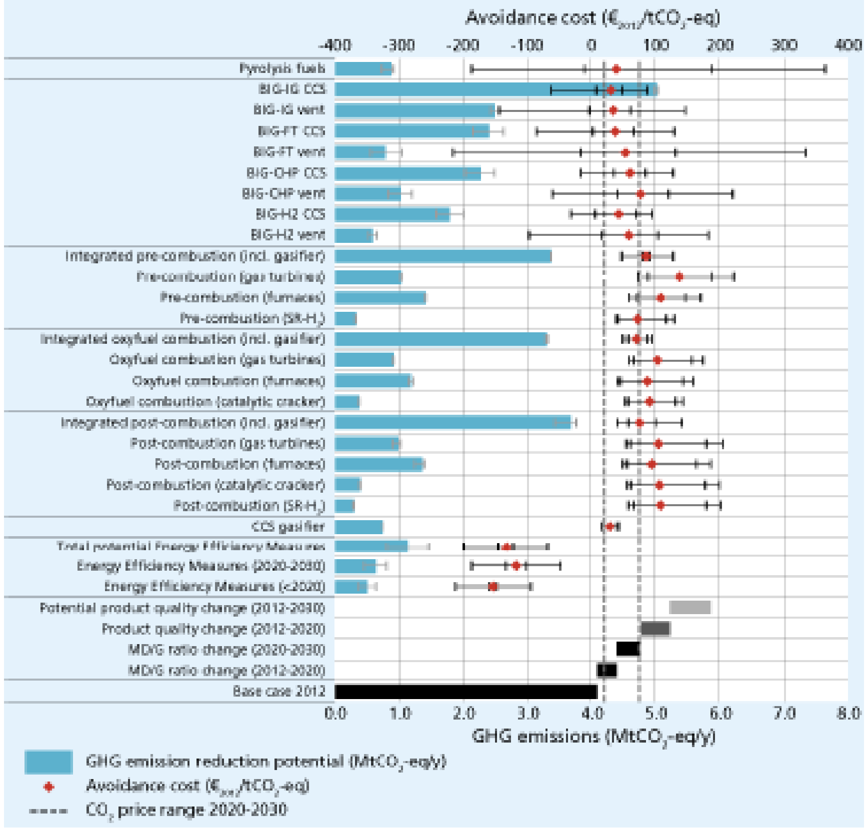


Figure 3.1: Botlek area with industrial plants emitting CO_2 (red circles stars). The size of the circles reflects the annual amount of CO_2 emissions. The high-pressure trunk CO_2 pipeline planned by the Rotterdam Climate Initiative would roughly follow the main pipelines strips on the map that run from the southeast corner to the northwest corner. Map taken from Municipality Rotterdam (2015); information regarding pipelines strips is based on Pipeliner (2012a, 2012b, 2012c).

Berghout et al, 2016

INTEGRATED MITIGATION AT A REFINERY COMPLEX

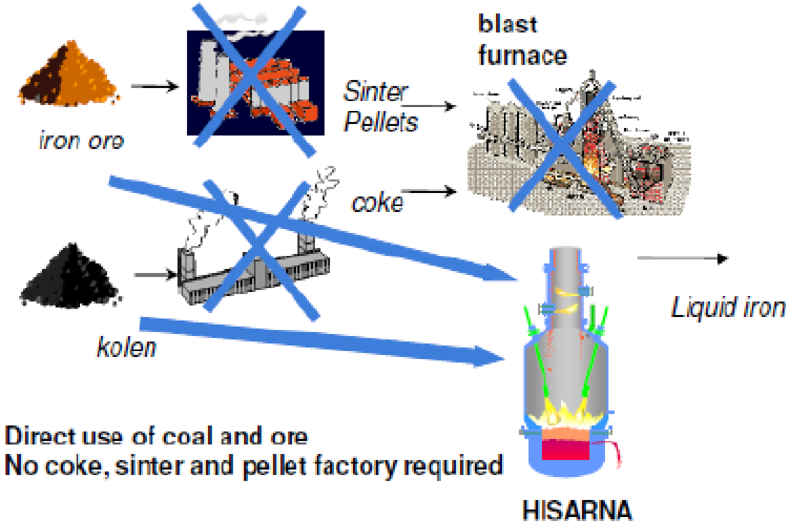


Berghout et al, 2016

Tata Steel in IJmuiden: sustainability (II)

HISARNA – Process innovation

- A **new process** that allows the direct use of **powdered raw material**. No more coke oven or ore processing required
- **Iron ore** is melted in the cyclone reactor
- **Fine coal** is injected directly into the smelter
- By using pure oxygen, we get gases **without nitrogen**
- This makes the combination with **CO_2 recovery & storage (CCS)** easier to realise

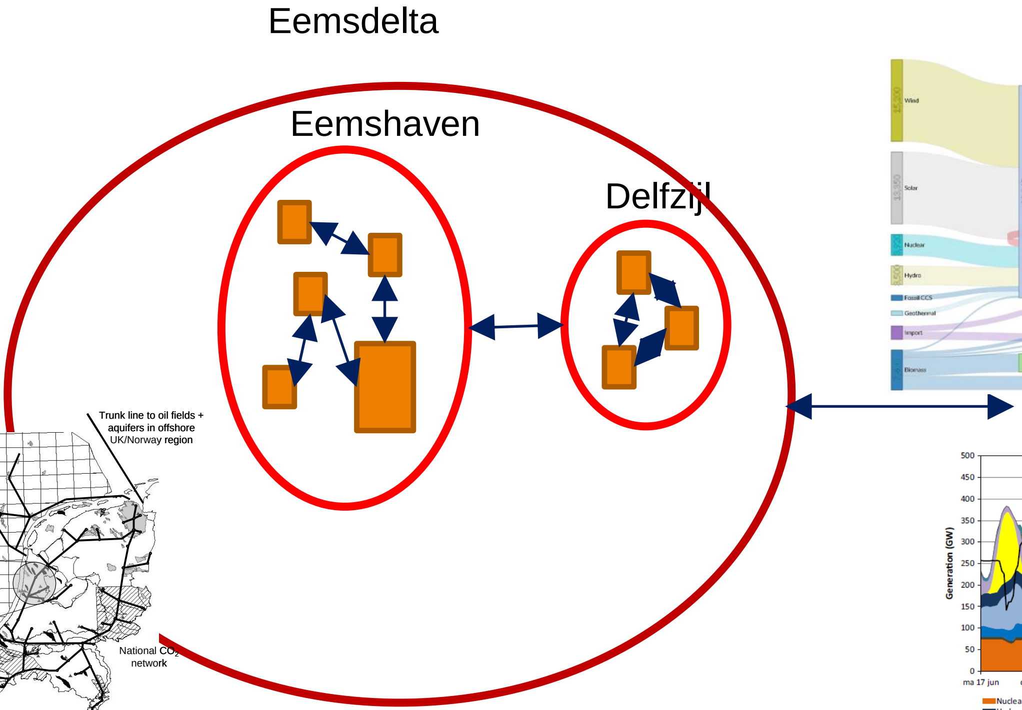


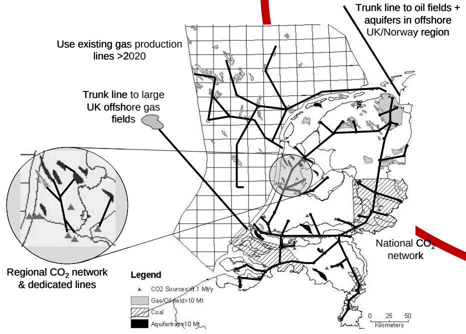
Slide from Hans Kiesewetter, Tata Steel

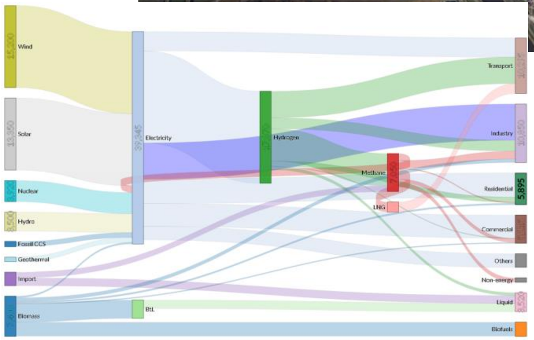
HISARNA technology will produce 20% less CO2 emission in the future with CCS 80%

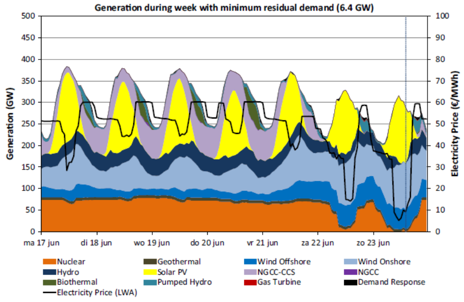
EEMSDELTA/DELFZIJL

(OR ANY OTHER INDUSTRIAL CLUSTER)



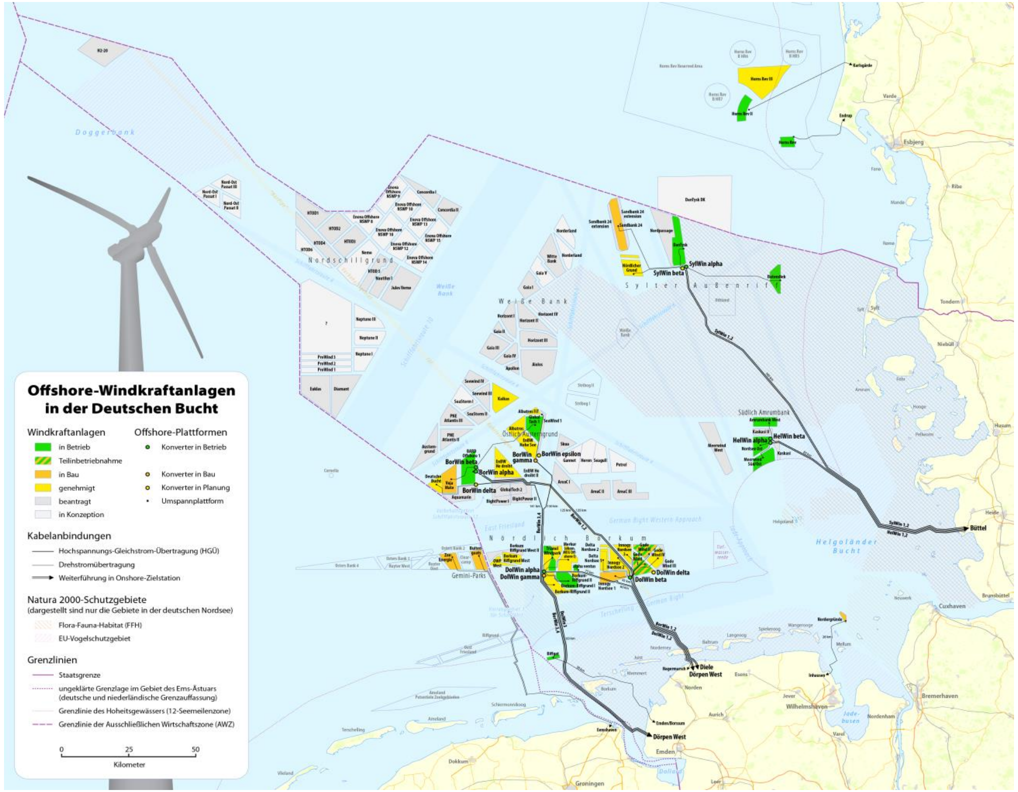






NORTH SEA ENERGY TRANSITION…

BUILD UP WIND OFF-SHORE CAPACITY



CUMULATIVE OFFSHORE WIND CAPACITY NORTH SEA REGION

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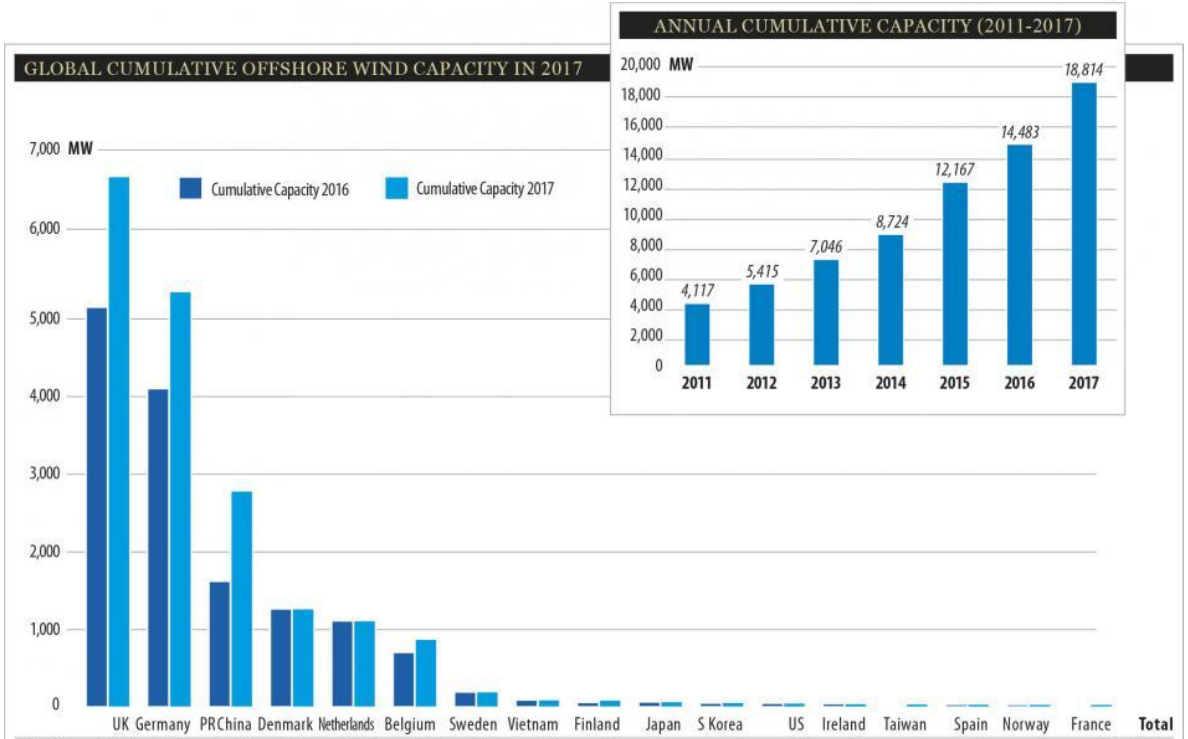


	UK	Germany	PR China	Denmark	Netherlands	Belgium	Sweden	Vietnam	Finland	Japan	S Korea	US	Ireland	Taiwan	Spain	Norway	France	Total
Total 2016	5,156	4,108	1,627	1,271	1,118	712	202	99	32	60	35	30	25	0	5	2	0	14,483
New 2017	1,680	1,247	1,161	0	0	165	0	0	60	5	3	0	0	8	0	0	2	4,331
Total 2017	6,836	5,355	2,788	1,271	1,118	877	202	99	92	65	38	30	25	8	5	2	2	18,814

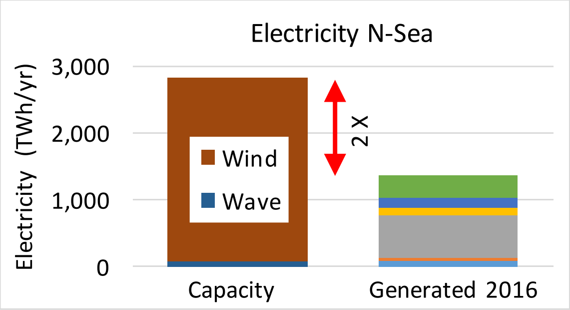
Source: GWEC

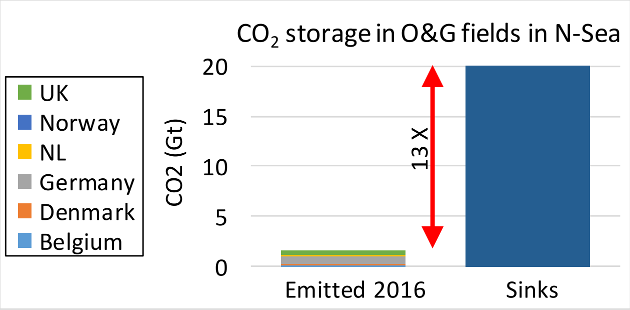
[Wehrman, CLEW, 2018]

NORTH SEA ENERGY POTENTIALS…

- Annually, the Netherlands use 120 TWh electricity and emit 210 Mt CO_2
- Electricity potential doubles this consumption
- Dutch EEZ CO_2 capacity in depleted gas and oil fields equals 13 years

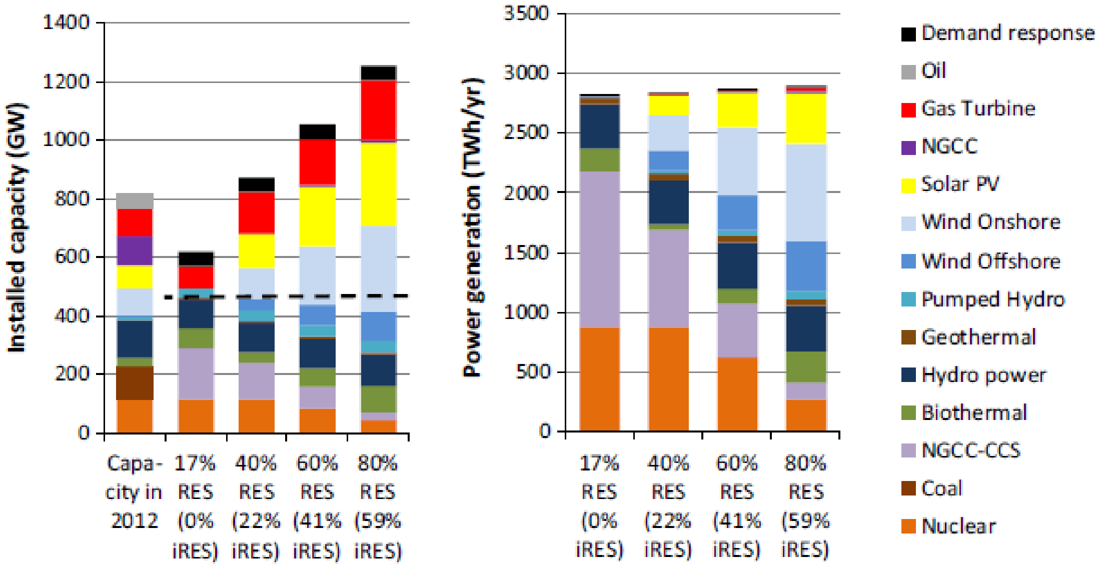
Technical potential	North Sea	Dutch EEZ
Offshore wind	2,765 TWh/yr	240 TWh/yr
Wave	77 TWh/yr	5 TWh/yr
Algae	400 (37,000) PJ/yr	90 (2,800)/yr
CO_2 storage capacity	20 (125) Gt CO_2	1.3 (2.3) Gt CO_2
O&G extraction	137 EJ	





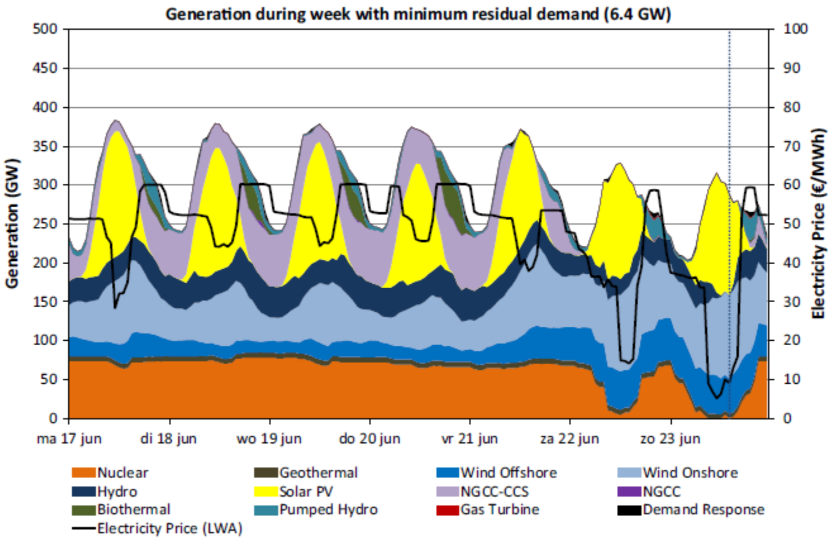
North Sea Energy offshore system integration

POSSIBLE RET DEPLOYMENT NW EUROPE 2050 FOR LOW GHG PATHWAYS (ELECTRICITY ONLY!).



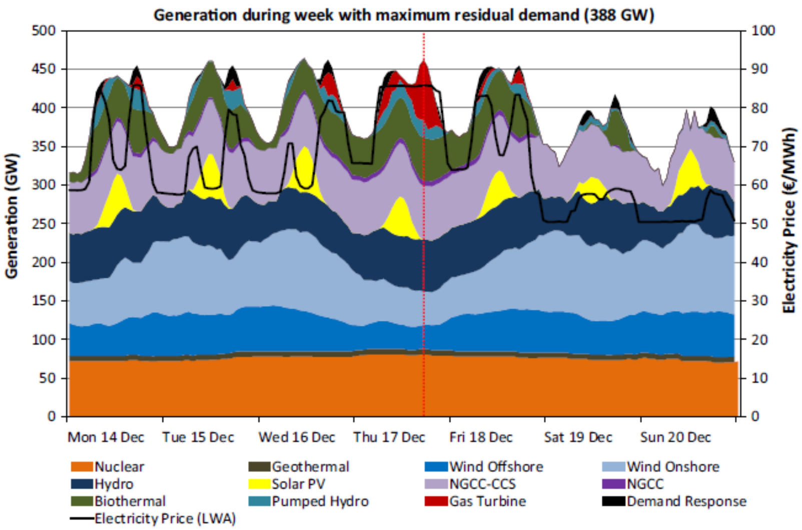
Breakdown of installed capacities and power generation in the core scenarios in the year 2050. The dashed line depicts the peak load in 2050.

[Brouwer et al., Applied Energy, 2016]



System implications!

Electricity system simulations
NW Europe 2050 with 60% iRES
Weeks with maximum and minimum
residual loads during the year.

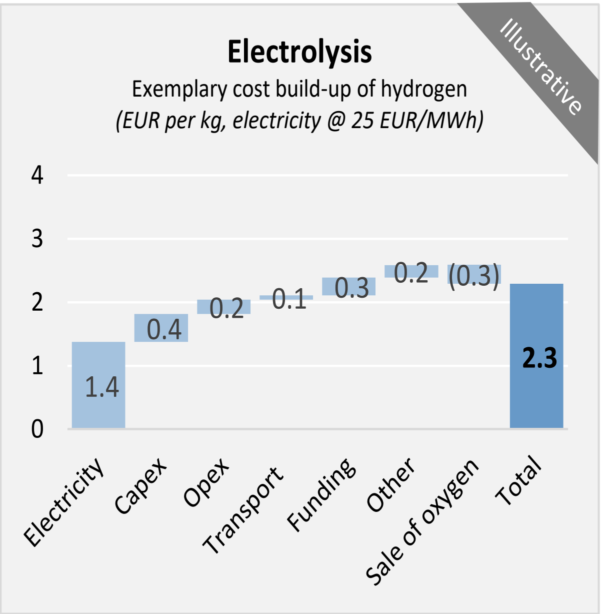


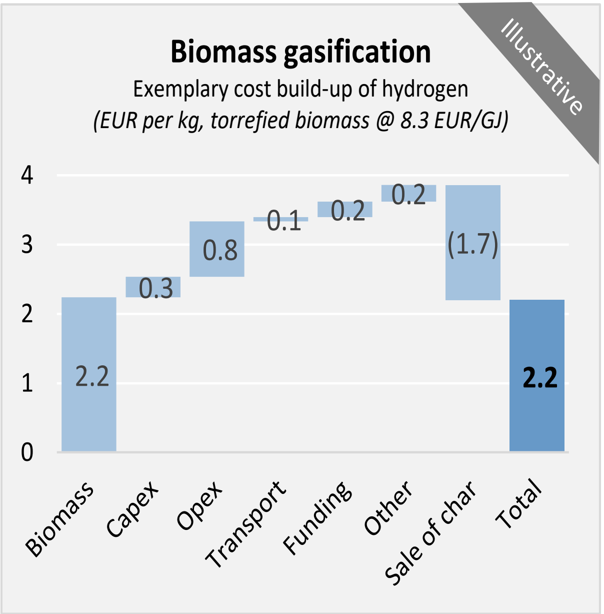
[Brouwer et al., Applied Energy, 2016]

ARTIST IMPRESSION OF TENNET'S VISION FOR A CONCEPT FOR LARGE SCALE WIND ENERGY ON THE NORTH SEA.

source: Tennet

HOPED ECONOMICS HYDROGEN PRODUCTION (NATURAL GAS BASED PRODUCTION: 2-3 EURO/GJ)





Source: Rabobank/NIB H2 roadmap, van Wijk, 2017
However, electricity now some 50 Euro/MWh, surpluses of power minimal during short periods, and infrastructure costs not yet included.

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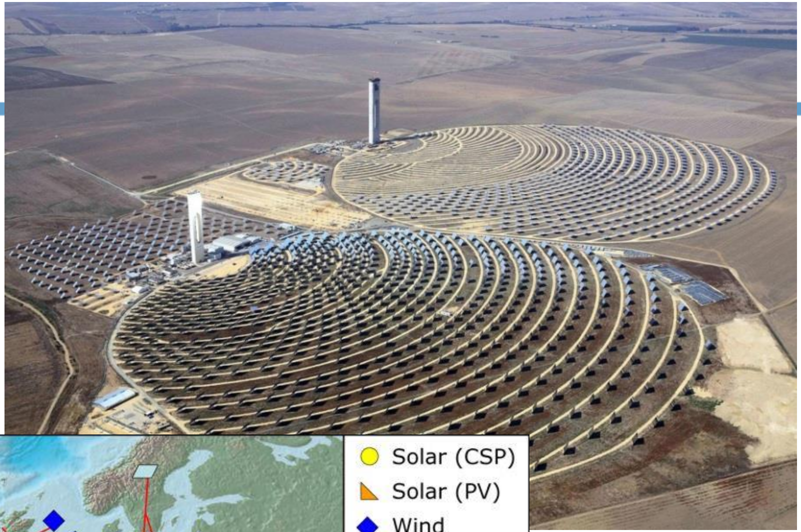
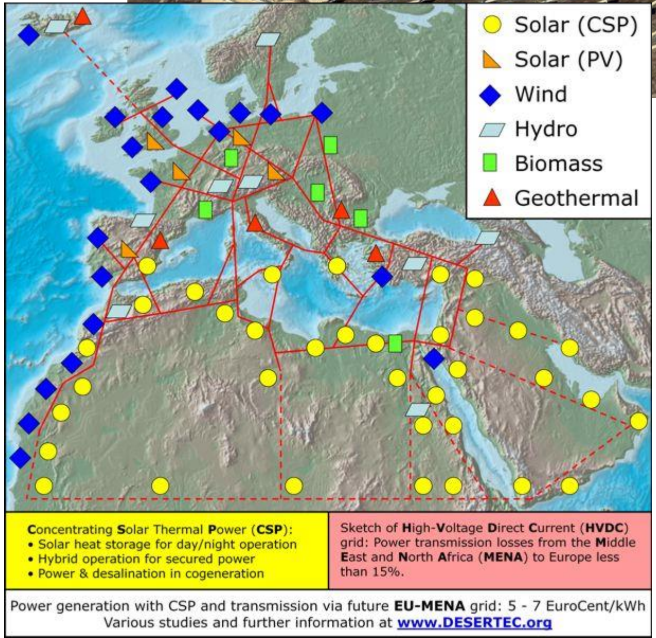
FURTHER ENERGY SYSTEM INTEGRATION...





ADVANCED ENERGY SCENARIO'S FOR EUROPE; COMPETING / BALANCING OPTIONS...

Drivers and barriers for PtM

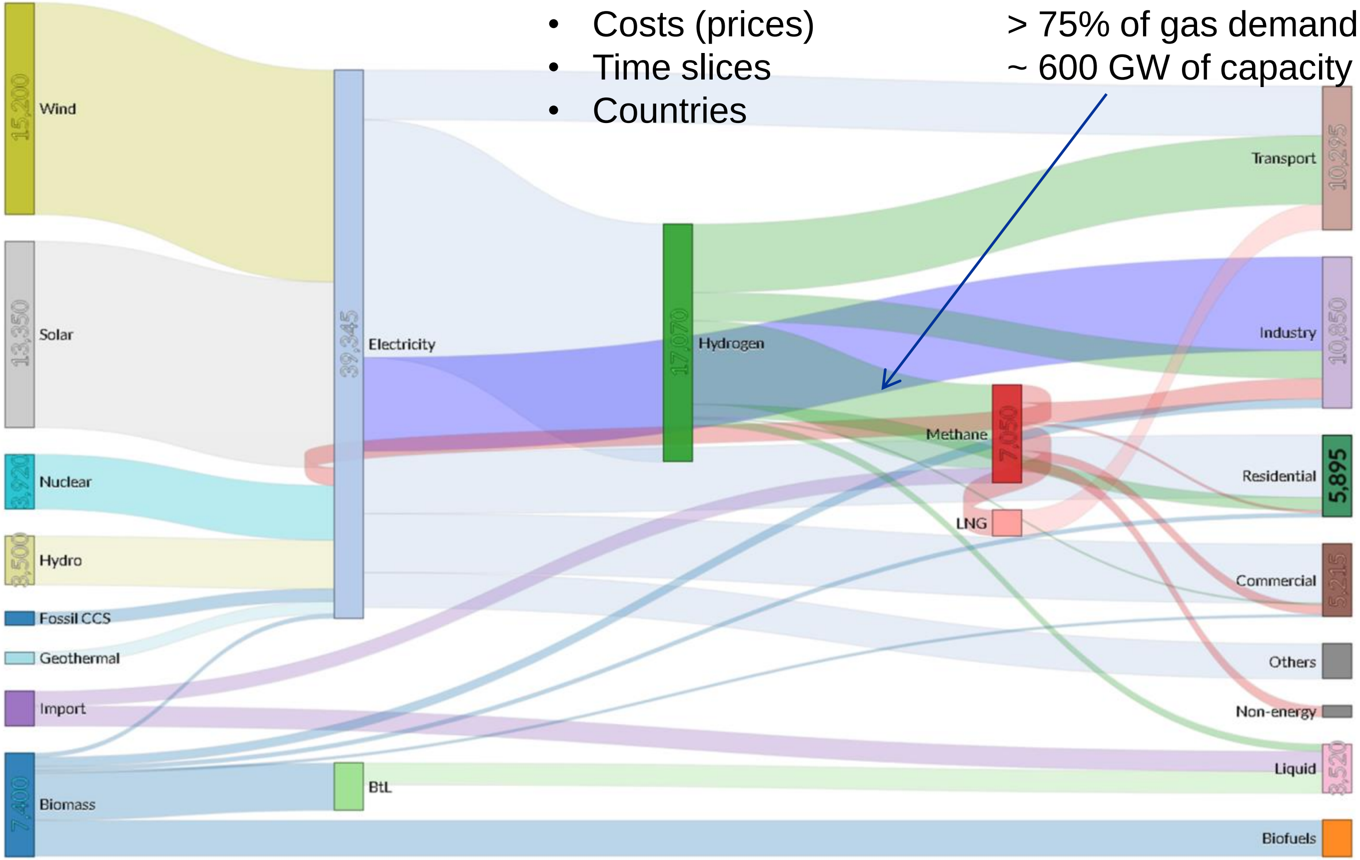
CO_2 target (2050)	914 Mton/y	450 Mton/year	228 Mton/y
CO_2 storage	255 Gton		0 Gton
VRE penetration (%)	0%	60%	97%
PtM Capex	250 €/kW		75 €/kW
PtM Efficiency	85 %		100%
LMG efficiency in ships	25 gCO_2/tnm	18-20 gCO_2/tnm	12 gCO_2/tnm
Biomass potential	25.5 EJ/y	10 EJ/y	7 EJ/y

[Blanco et al., applied Energy 2018]

"Optimistic" scenario

Other dimensions are:
- Costs (prices)
- Time slices
- Countries

PtG
> 75% of gas demand
~ 600 GW of capacity

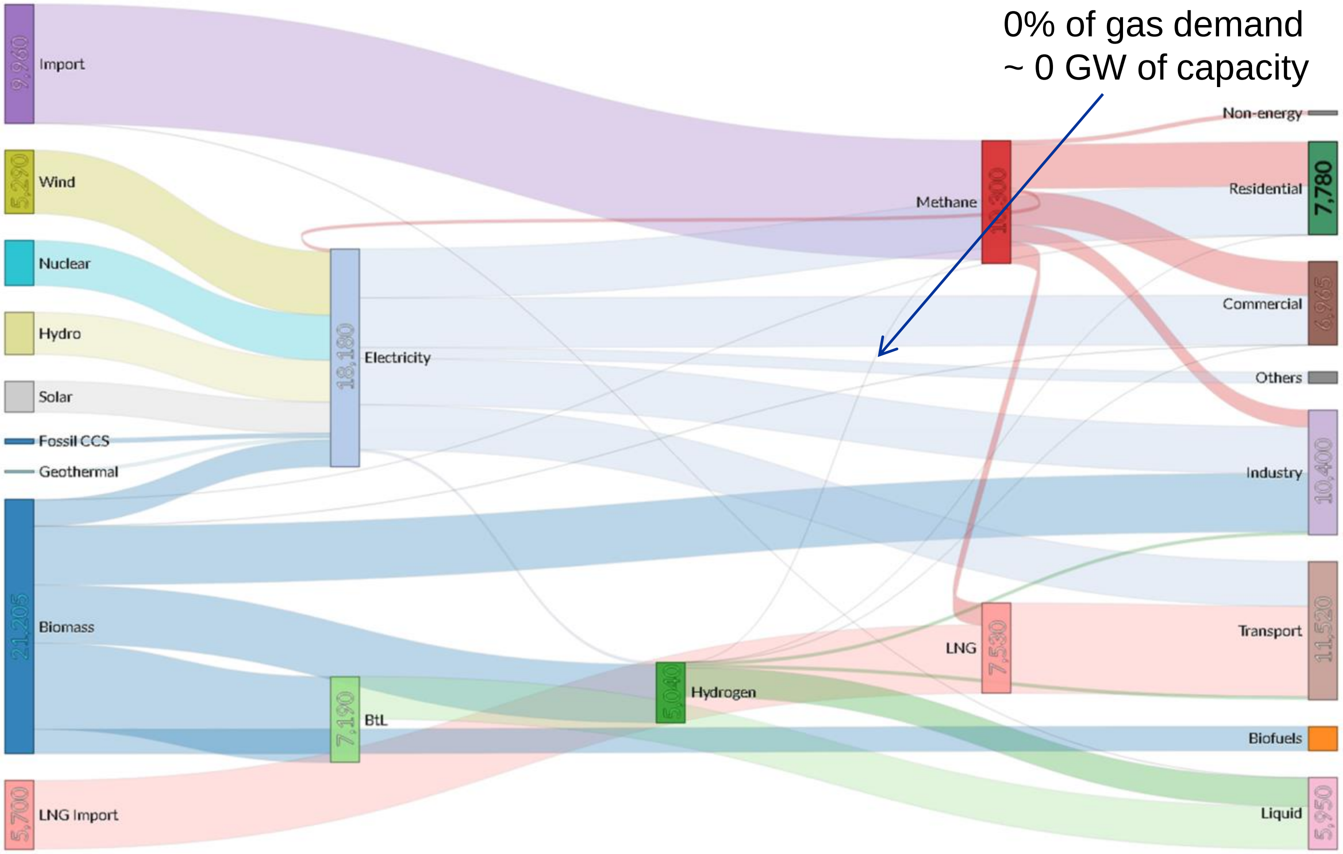


*All values in PJ

[Blanco et al., applied Energy 2018]

"Alternative" scenario

PtG
0% of gas demand
~ 0 GW of capacity

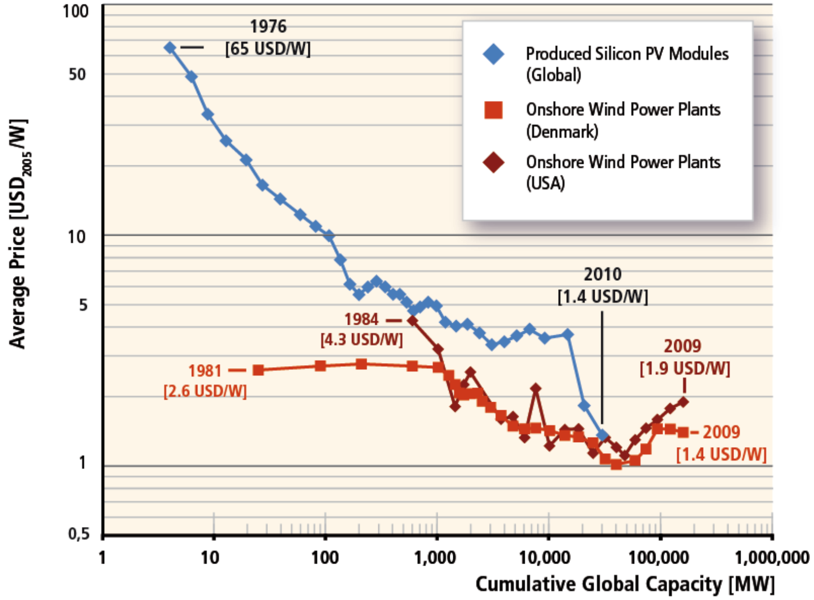


*All values in PJ

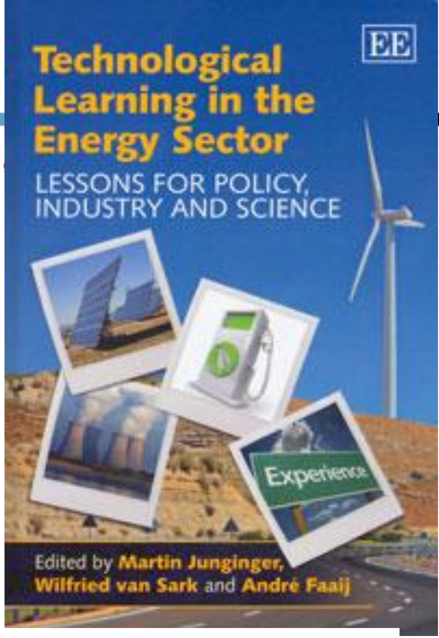
[Blanco et al., applied Energy 2018]

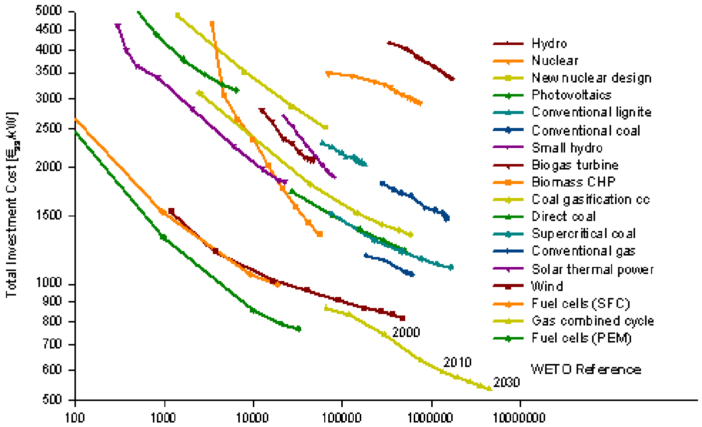
ENERGY TRANSITION = INNOVATION RACE = (TODAYS/FUTURE) BUSINESS.

TECHNOLOGICAL LEARNING = ESSENTIAL



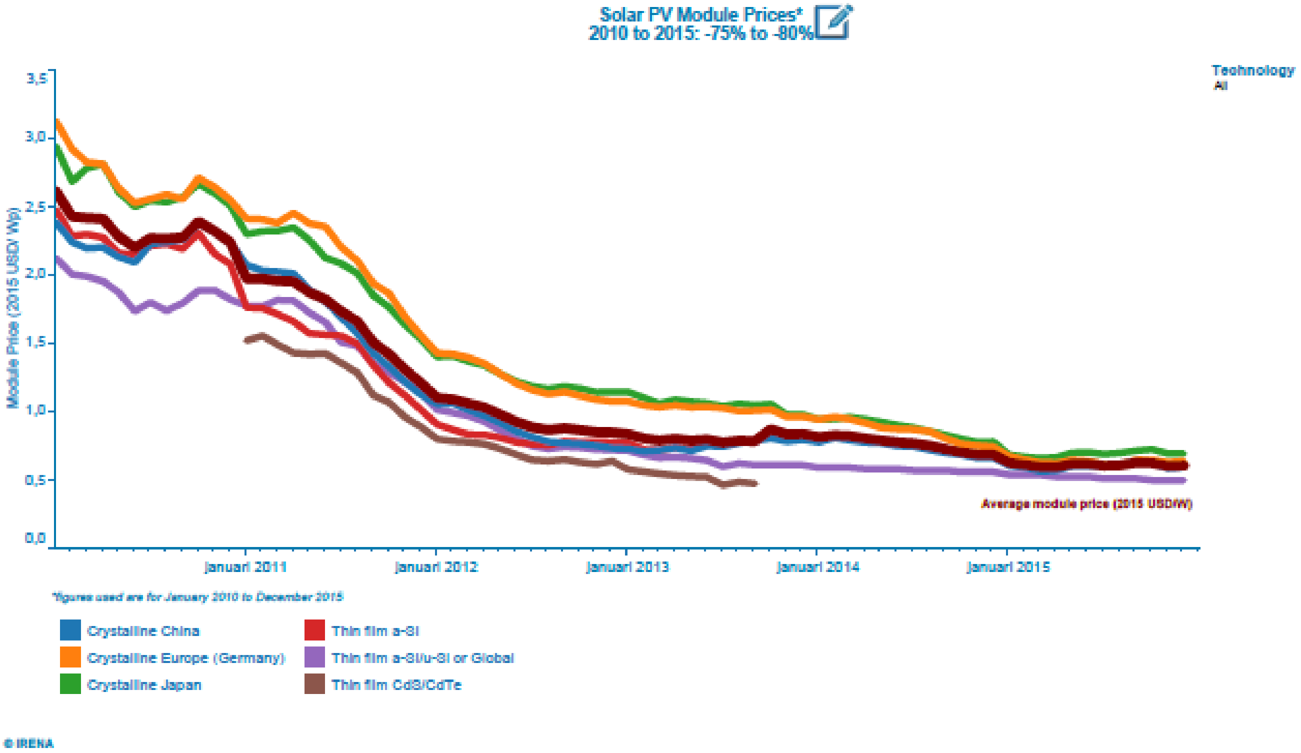
[IPCC-SRREN, 2011]





Learning curve for power generation technologies, historic data and POLES WETO reference projection up to 2030.

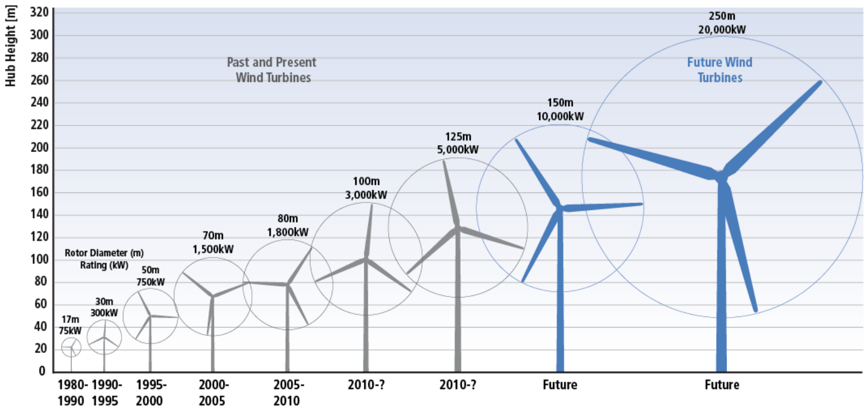
RECENT SOLAR PV MODULE PRICE DEVELOPMENT



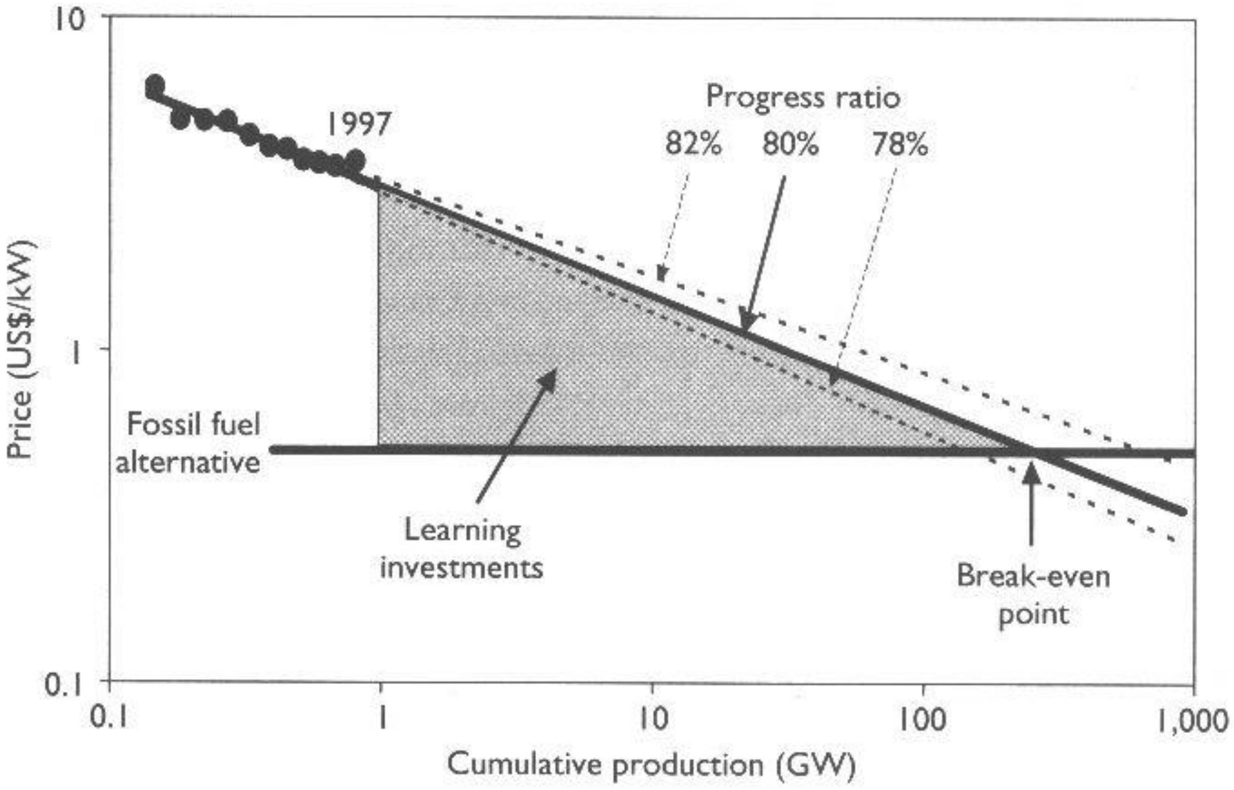
[IRENA]

FACTORS INFLUENCING LEARNING/ UNIT COSTS (EXAMPLE WIND ENERGY)

- Improved siting of wind farms (Learning by doing)
- Development of specific components (gear boxes, generators) and regulating mechanisms (stall/ pitch regulation) (R&D)
- Mass production of wind turbines (economies-of-scale)
- Upscaling of wind turbines (upscaling)

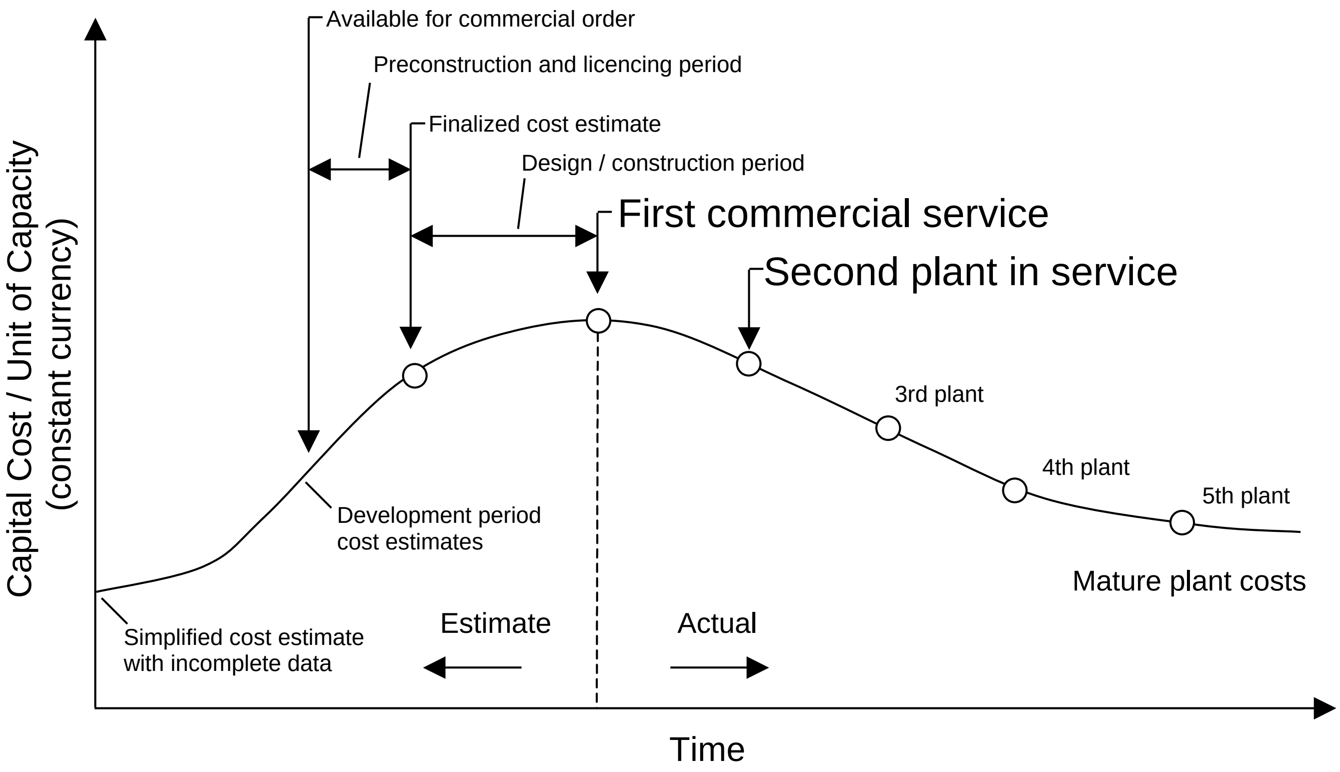


‘LEARNING INVESTMENTS’ – THE COST OF LEARNING

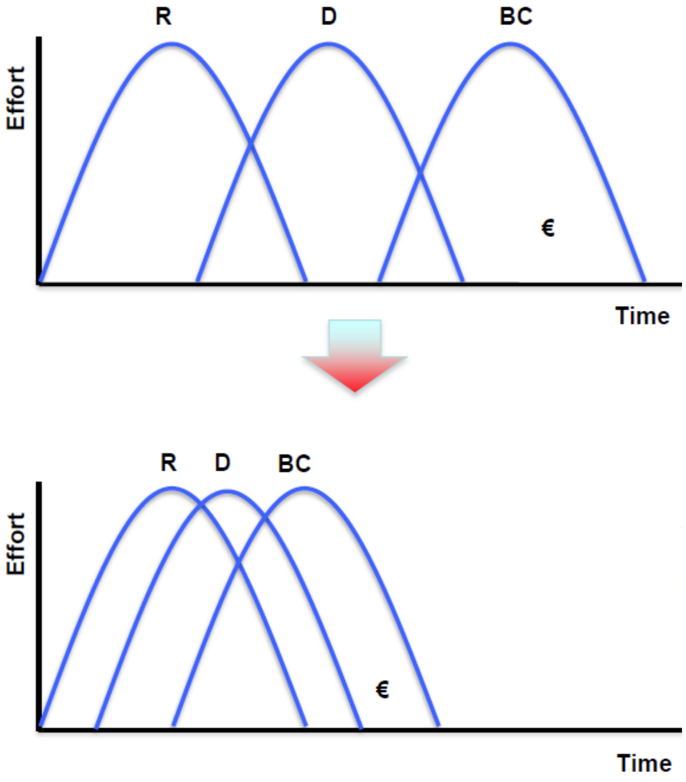


Source: IEA, 2000

MOUNTAIN OF DEATH; "TIME" CAN MEAN DECADES...



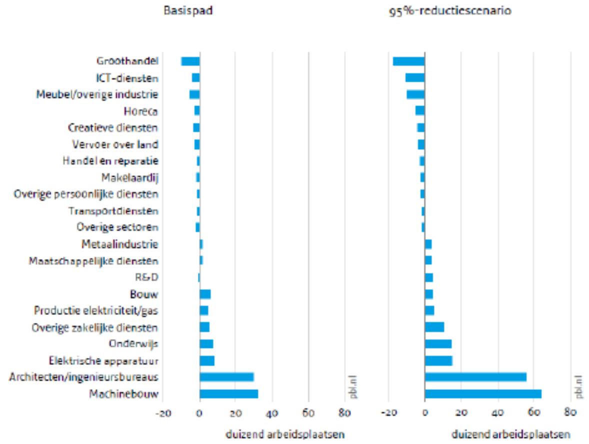
SPEED UP INNOVATIONS; SCIENCE, TECHNOLOGY, MARKET, POLICY...



MAJOR HUMAN CAPITAL AGENDA

- In Europe shortage of skilled workers is a substantial barrier for realizing the ambitious energy transition goals.
- At the same time there is a substantial need for equipping existing energy professionals with up to date skills.
- Required skills and knowledge change fast.
- Increasingly interdisciplinary.

Figuur 4 – Decompositie van potentiële arbeidsvraagveranderingen door energietransitie, naar sector



Uitgangssituatie is 2013, met investeringen ten behoeve van energietransitie, energieproductie en -gebruik in 2030

Bron: Weterings, A. et al. (2018) *Effecten van de energietransitie op de regionale arbeidsmarkt – een quickscan*, PBL, Den Haag, p. 36.

BIGGEST NO-BRAINER IN THE ENERGY FIELD

A.o. IEA (WEO) concluded multiple times that :

- Yes, 450 ppm pathways requires *massive* investments…
- …but will lead to rapid cost reductions of RET's and energy efficient technologies…
- …and less pressure on fossil fuel supplies…
- …leading to an overall lower cost *and* more secure (global) energy supply!

[Vs. external costs of climate change order of magnitude of a few world wars…]

THANK YOU VERY MUCH FOR YOUR ATTENTION