

# Energy Transition: resilient energy supply and demand

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# Resume

- MSc Aerospace Engineering TU Delft
- PhD Physics TU Eindhoven
  
- Assistant/Associate professor TU Delft 1992-2010
- Scientific director Geotechnology Laboratory TU Delft 2006-2010
  
- Chair Energy Technology TU Eindhoven
- Scientific director 4TU Resilience Center 2018-2020
- Scientific director 4TU Energy Center since 2020
- Board member Dutch Gas sector

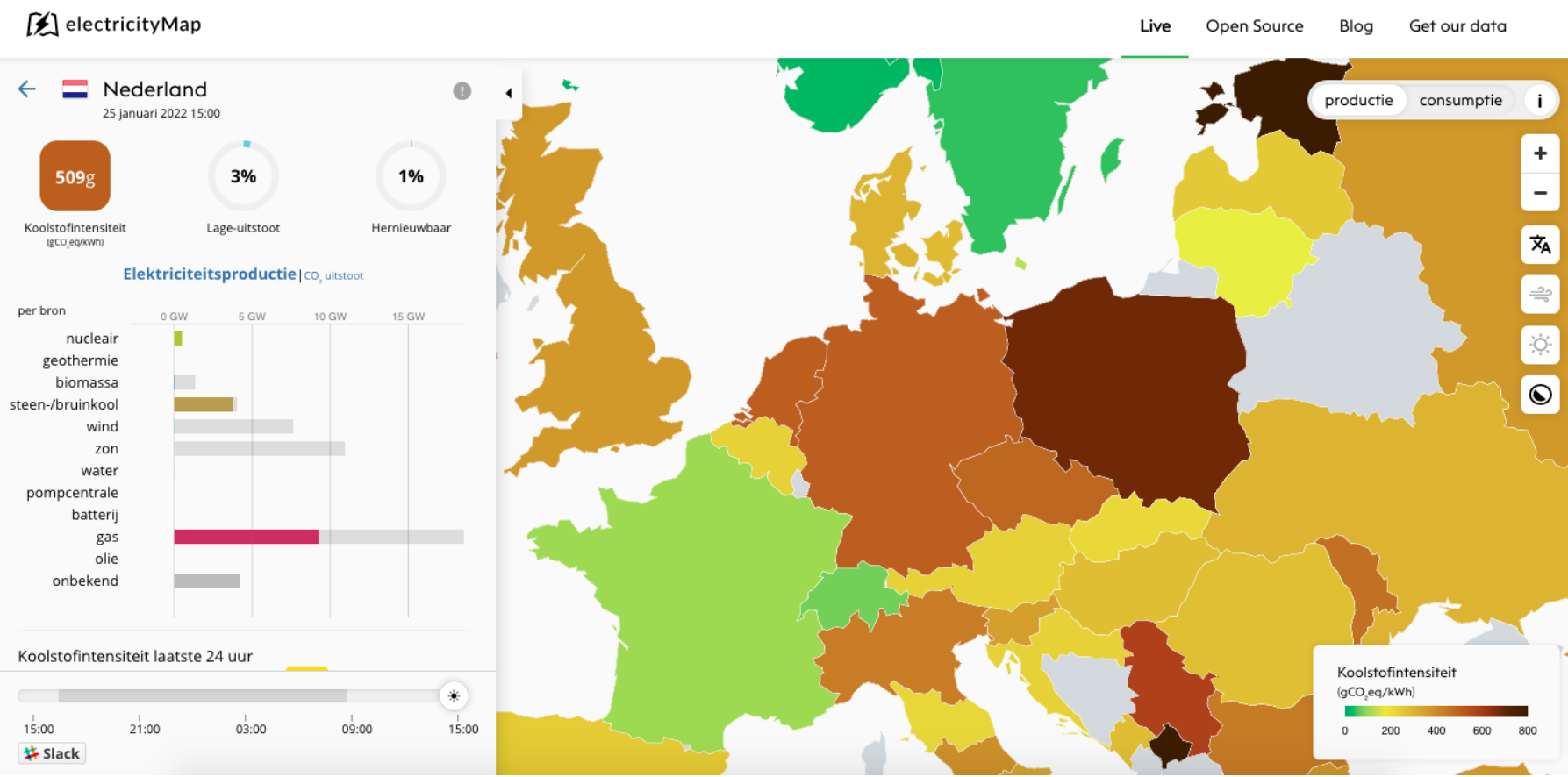


*Resilience* is the ability to withstand adversity and bounce back from difficult events

# Resilient energy design

- Locate project outside hazard area
- Flexible design which allows upgrades (multi-generation aircraft)
- Robust simple systems (intuitive understanding)
- Redundancy (back up, fail-safe)
- Indigenous techniques ('old-fashioned', e.g. thick walls instead of airco)
- .....

# No solar/wind energy on 25 January 2022

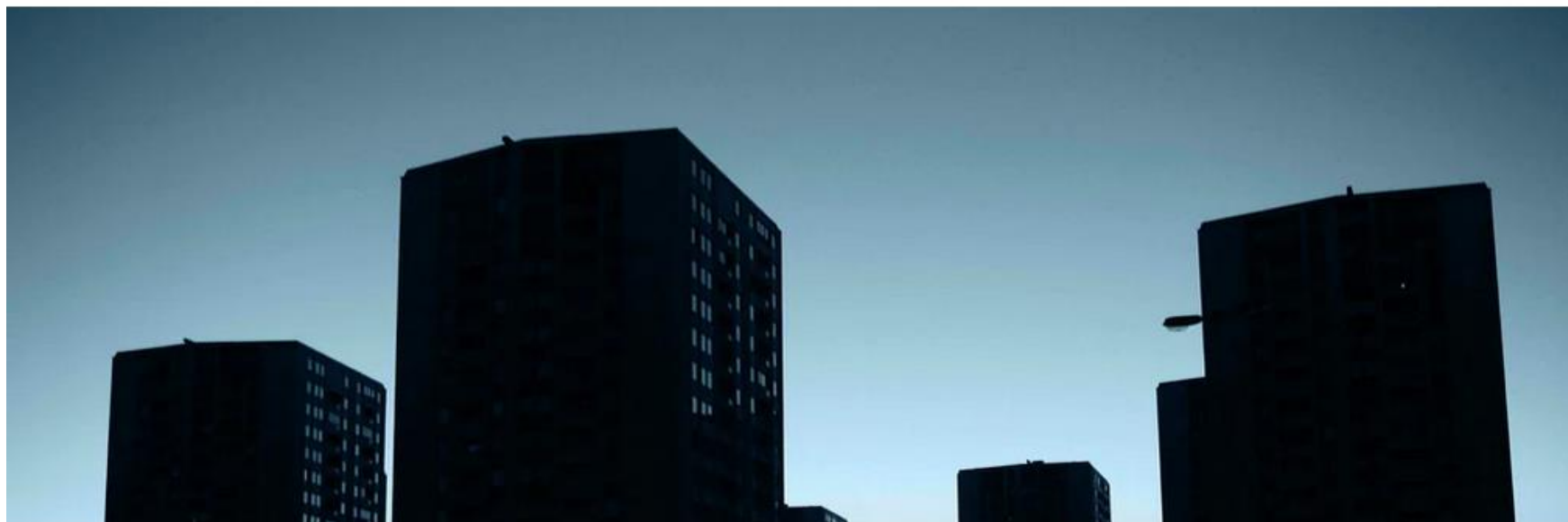


DN DEBATT

# *DN Debatt. "Hela södra Sverige kan bli långvarigt strömlöst i vinter"*



UPPDATERAD 2022-08-12 PUBLICERAD 2022-08-12

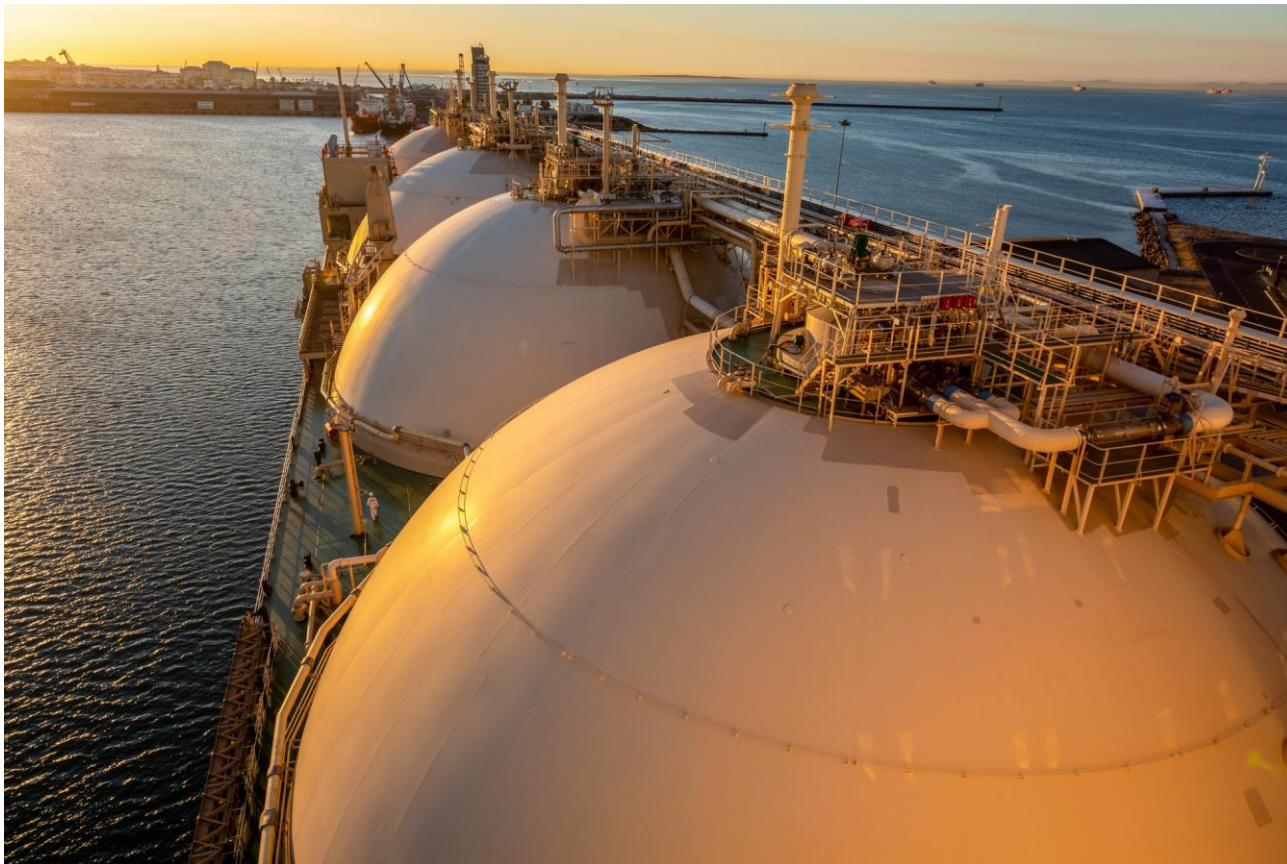


**Business**

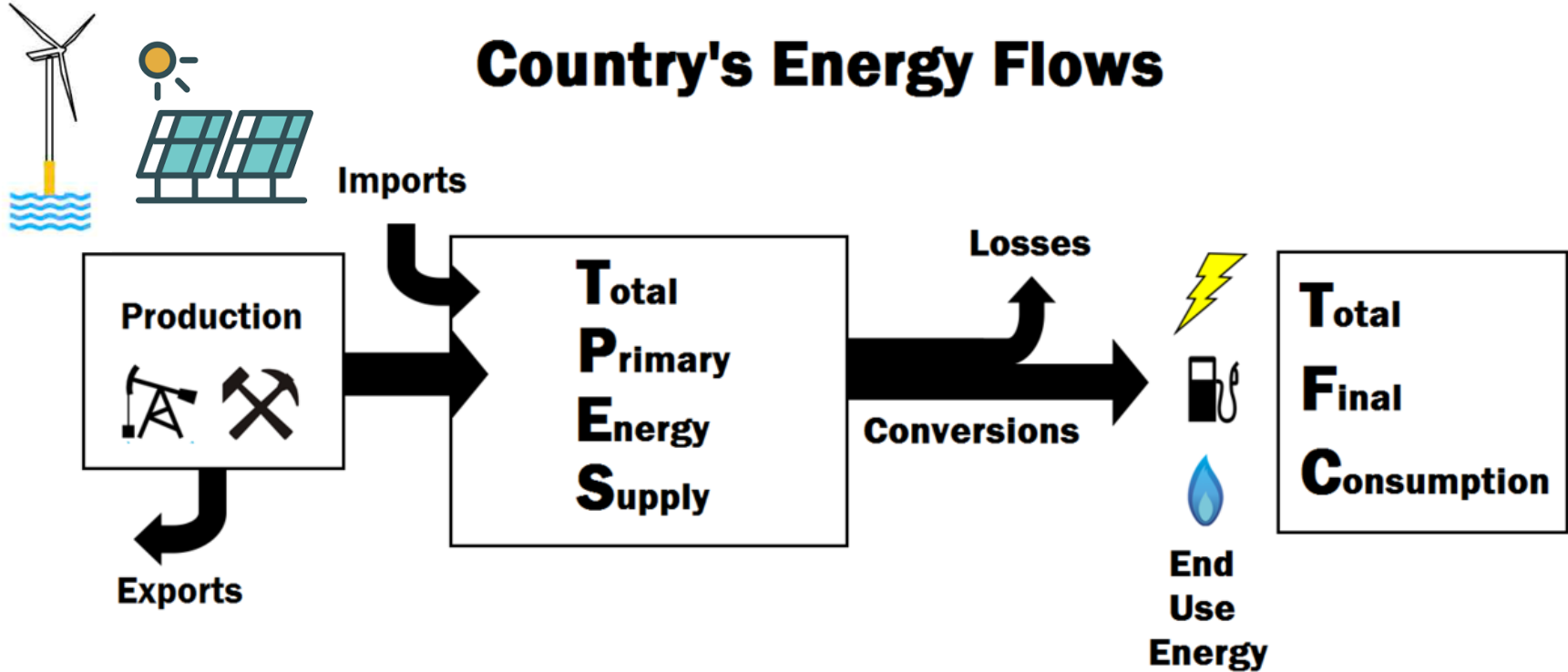
## The Big Take

# Natural Gas Soars 700%, Becoming Driving Force in the New Cold War

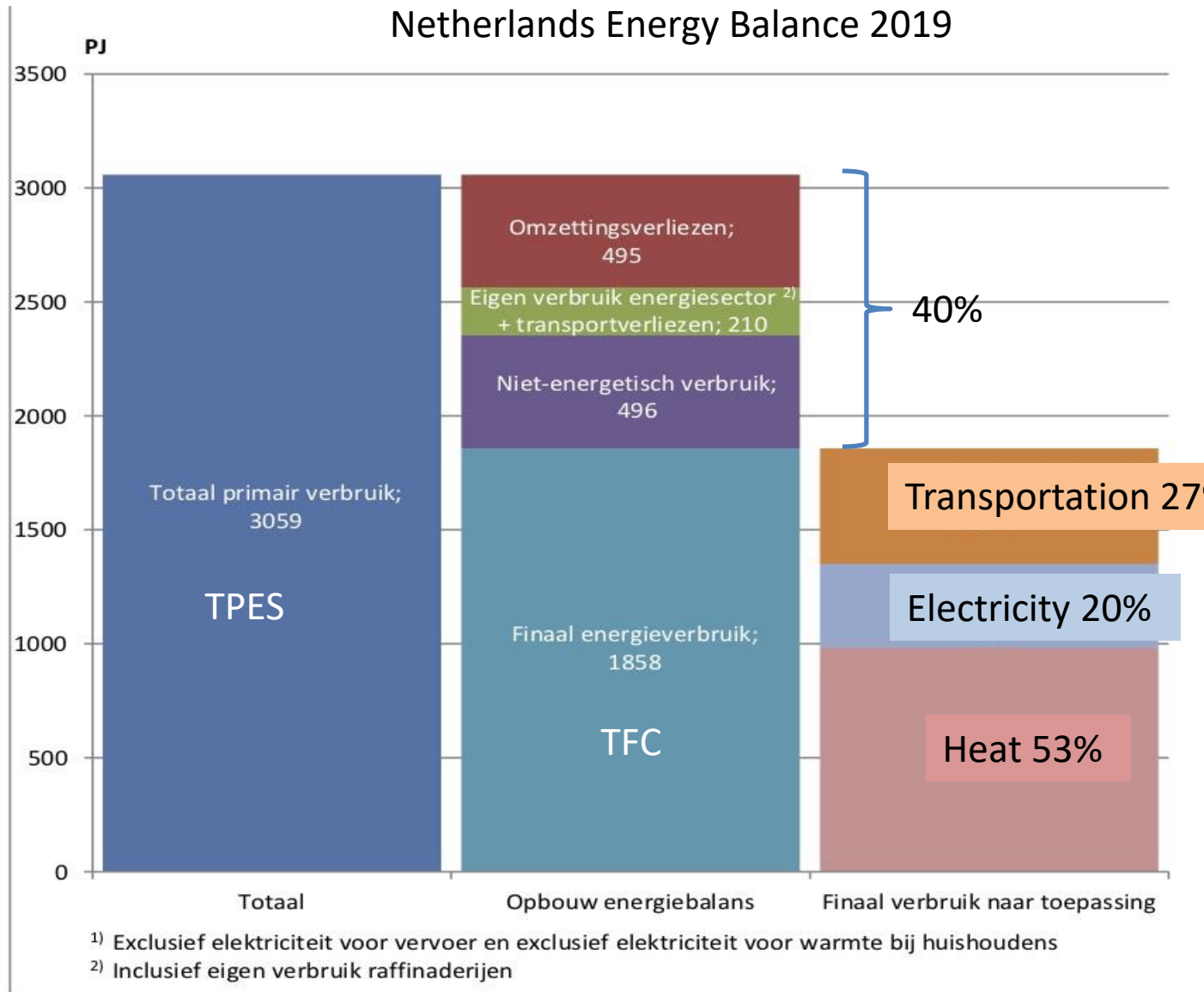
Shortages of the fuel are rippling throughout the global economy, threatening recessions and a further wave of inflation.



# Strategy 1: less consumption







**Figuur 2.1** Opbouw energieverbruik 2019. Bron: CBS

# Strategy 2: Government Pension Fund Global

The fund's market value

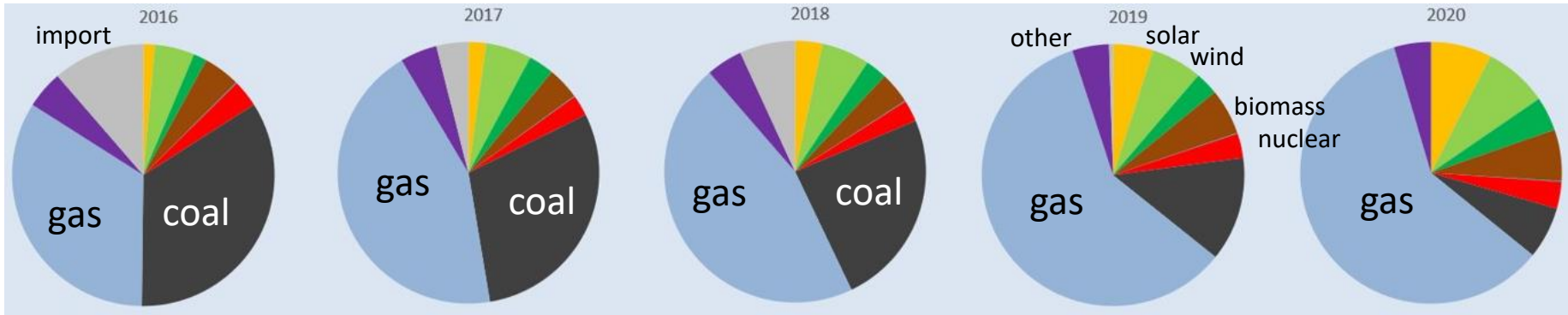
**11 631 193 248 899** NOK

We work to safeguard and build  
financial wealth for future generations

1163 billion €



# Strategy 3: diversification



Source: Martien Visser, Hanze

Not so successful:

We have become more and more dependent on natural gas over the past years for our electricity generation

# Political naivety



# Coal-fired power plants

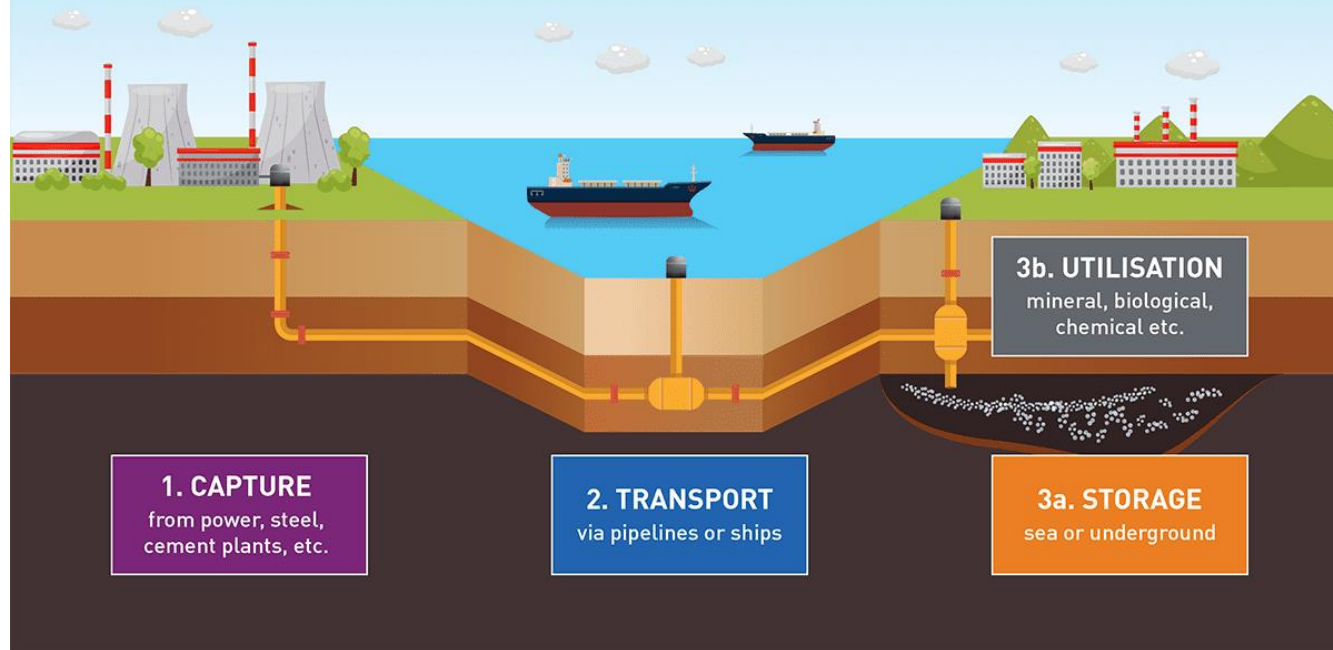
	operational	Under construction
China	1 032	126
USA	296	-
India	291	33
Russia	84	3
Japan	83	15
Germany	77	1
Indonesia	69	23
Poland	50	4
Netherlands	5	-
World	2 459	256

2458 x 6 Mton = 15 Gton = 40% of global CO<sub>2</sub> emissions

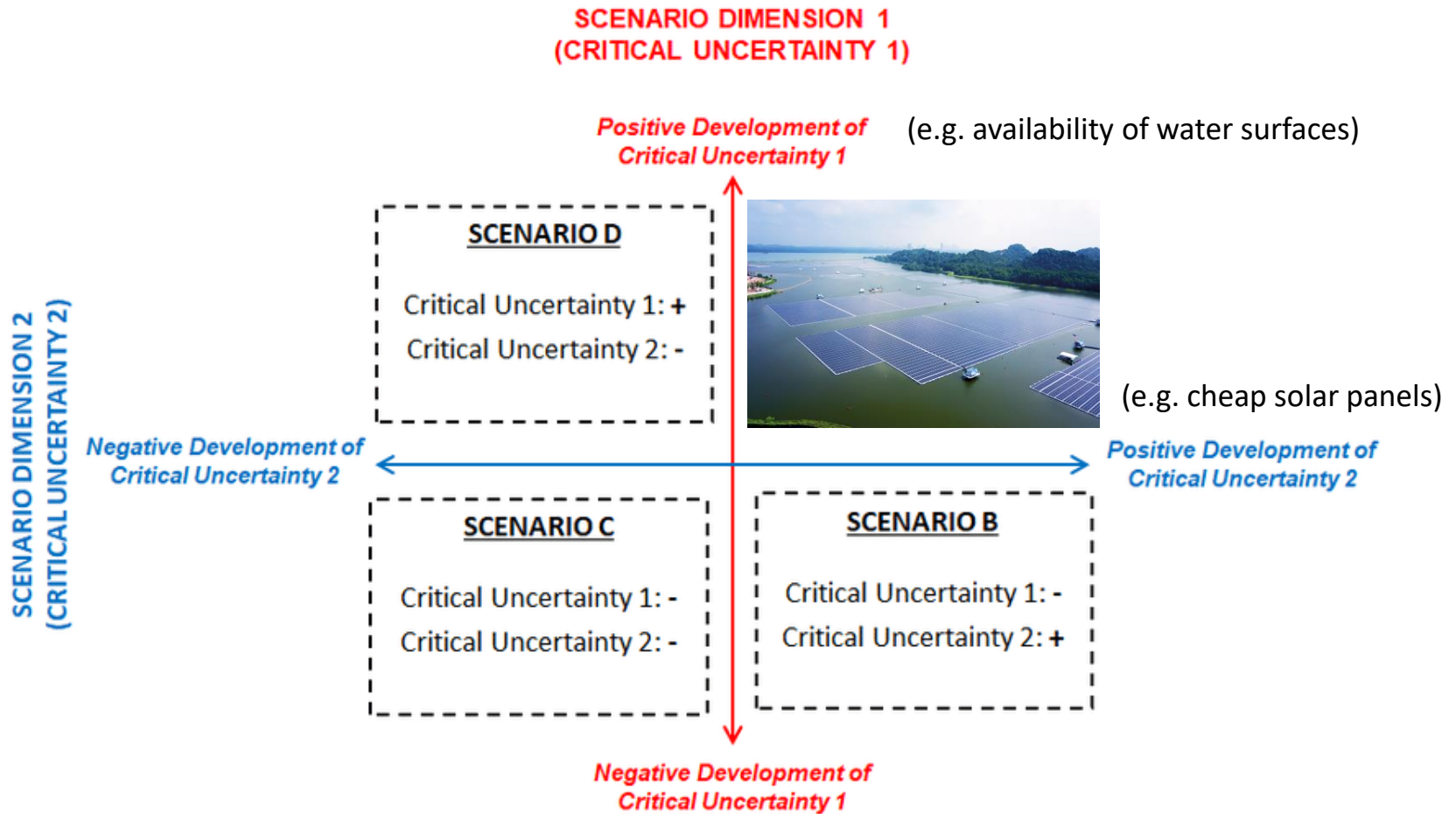
# Mitigate rather than closing down



## The CCUS process



# Strategy 4: scenario thinking, not wishful thinking



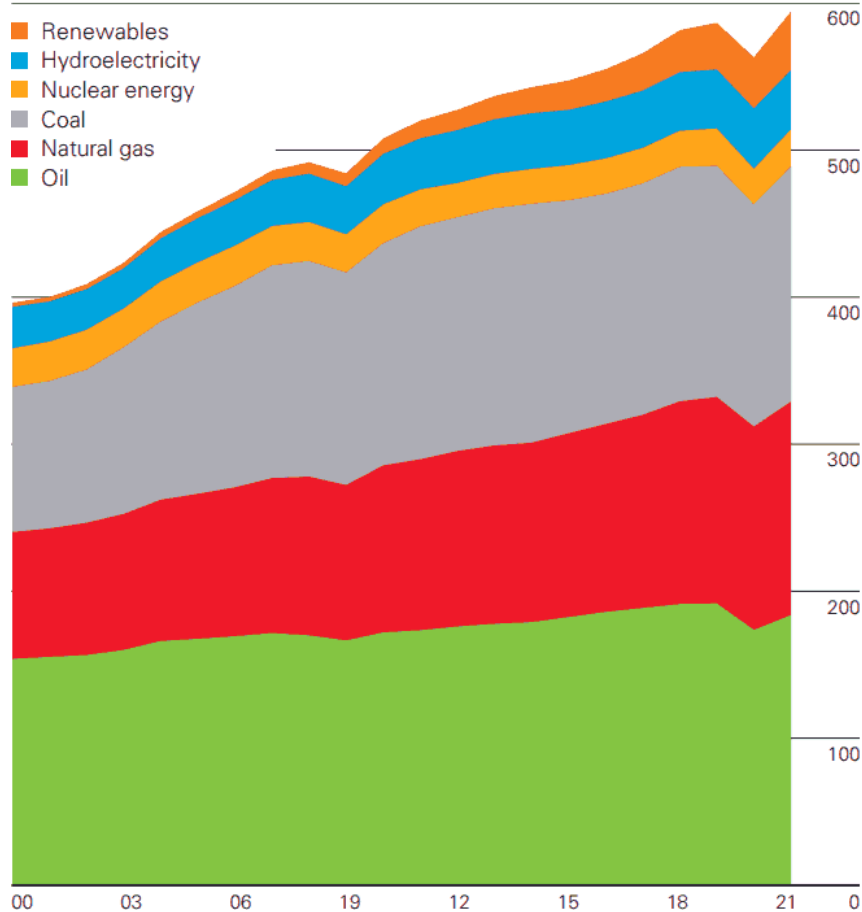
# Sharp rebound in energy demand in 2021

## Fossil fuels: 82%

The level of fossil fuel energy consumption was unchanged between 2019 and 2021, with lower oil demand (-8 EJ) offset by higher natural gas (5 EJ) and coal (3 EJ) consumption.

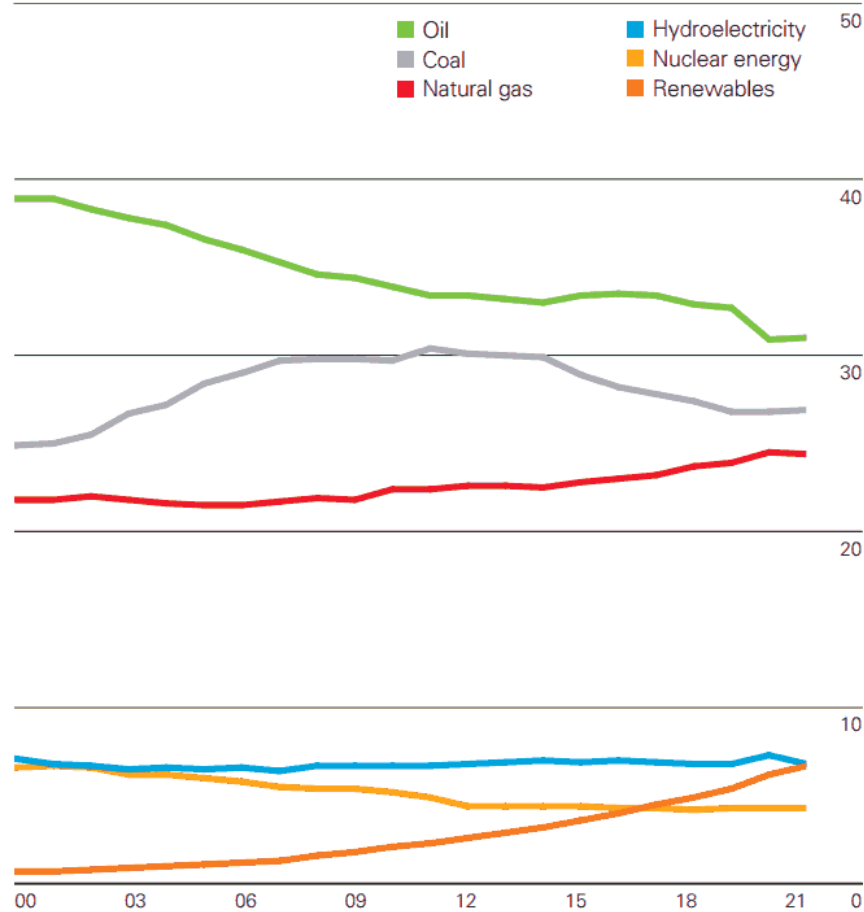
### World consumption

Exajoules



### Shares of global primary energy

Percentage

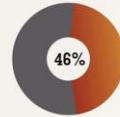




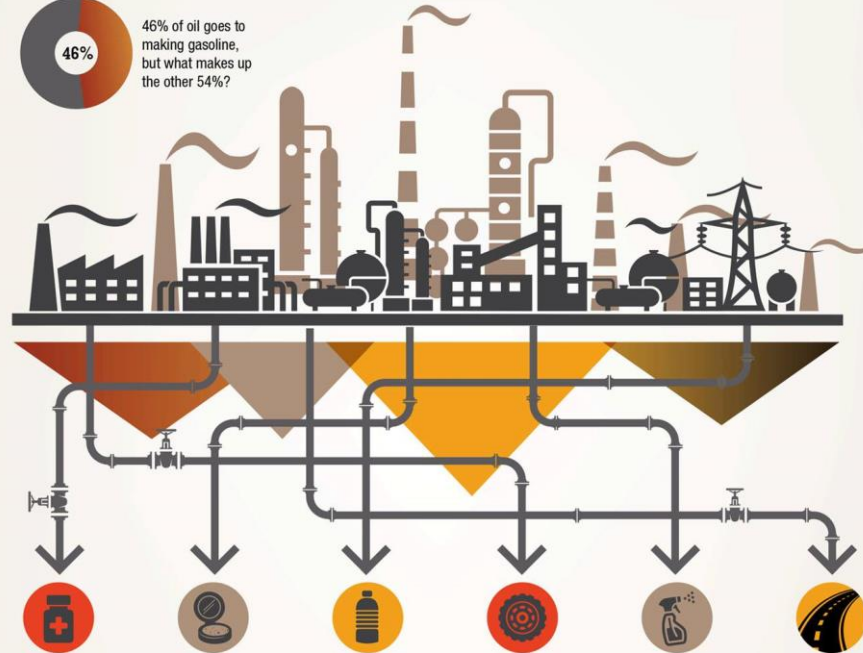
THE BIGGER PICTURE

# Life Without Oil

NOT AS SIMPLE AS YOU MAY THINK



46% of oil goes to making gasoline, but what makes up the other 54%?



**Medicine**

Most over the counter medications, homeopathic products and vitamins are derived from benzene, a product of petroleum.



**Cosmetics**

Makeup and shampoo that has oils, perfumes, waxes and color are all produced with the help of petrochemicals.



**Plastics**

Almost all plastics are made from petrochemicals, from your iPhone to that bottle of water. It is 4-5% of the total petroleum consumption.



**Synthetic Rubber**

Thousands of products rely on rubber such as shoes, tires, wet suits, breast implants, gloves.



**Cleaning Products**

All those ingredients you can't pronounce in the ingredients list, all of which are very poisonous.



**Asphalt**

There are over 11 million miles of paved road in the world. Asphalt aka bitumen is the glue that binds the minerals together.

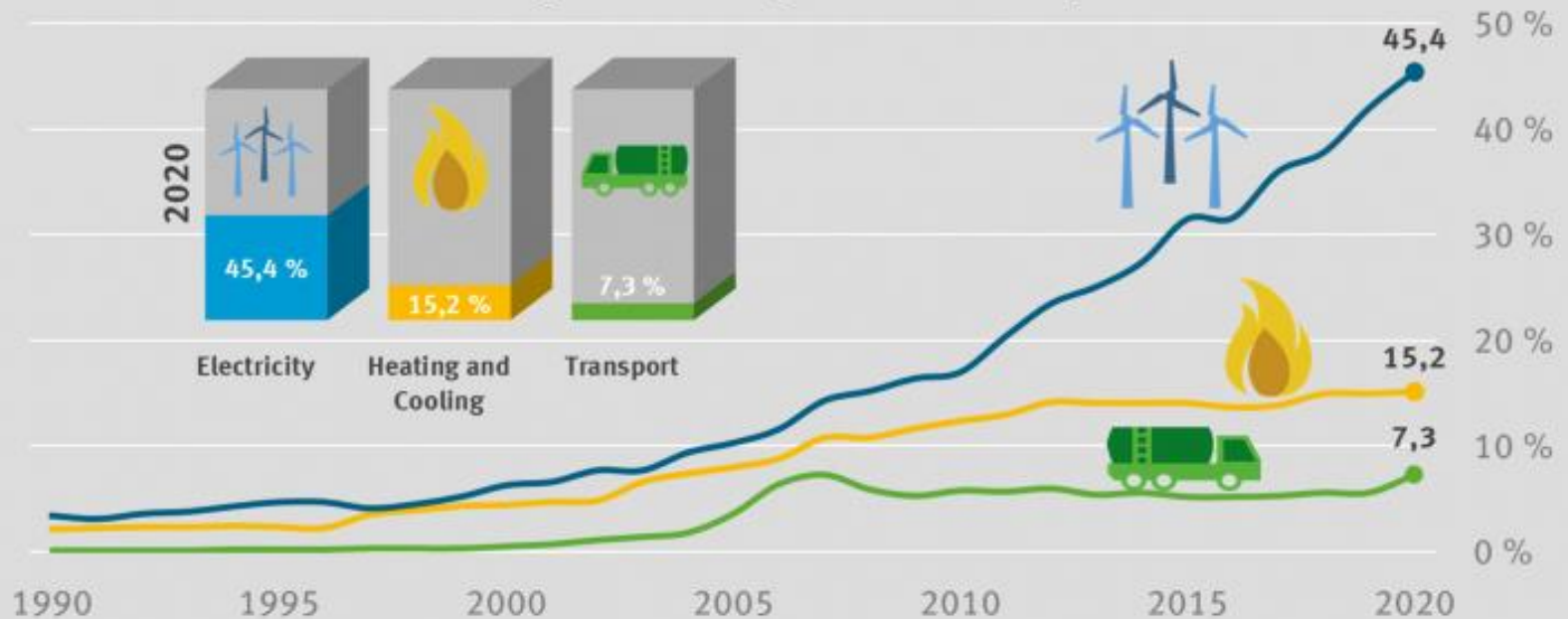
**A few other products made with Oil**

Insecticides, Ink, Floor Wax, Pens, Upholstery, Clothing, Boats, Sports Car Bodies, Nail Polish, Fishing Lures, Bags, Perfumes, Cassettes, Dishwasher Parts, Tool Boxes, Shoe Polish, Helmets, Caulking, Petroleum Jelly, Tape, Washers, Antiseptics, Curtains, Food Preservatives, Basketballs, Soap, Antihistamines, Purses, Dashboards, Cortisone, Deodorant, Footballs, Putty, Dyes, Panty Hose, Refrigerant, Percolators, Life Jackets, Rubbing Alcohol, Linings, Skis, TV Cabinets, Shag Rugs, Electrician's Tape, Tool Racks, Car Battery Cases, Epoxy, Paint, Mops, Slacks, Insect Repellent, Oil Filters, Umbrellas, Yarn, Fertilizers, Hair Coloring, Roofing, Toilet Seats, Fishing Rods, Lipstick, Denture Adhesive, Linoleum, Speakers, Plastic Wood, Electric Blankets, Glycerin, Tennis Rackets, Rubber Cement, Dice, Nylon Rope, Candles, Trash Bags, Paint, Water Pipes, Hand Lotion, Roller Skates, Surf Boards, Shampoo, Wheels, Paint Rollers, Shower Curtains, Guitar Strings, Luggage, Safety Glasses, Antifreeze, Awnings, Eyeglasses, Toothbrushes, Ice Chests, Combs, CD's & DVD's, Brushes, Detergents, Vaporizers, Balloons, Sun Glasses, Tents, Heart Valves, Crayons, Parachutes, Telephones, Enamel, Pillows, Dishes, Cameras, Anesthetics, Artificial Turf, Artificial Limbs, Bandages, Dentures, Model Cars, Folding Doors, Hair Curlers, Cold Cream, Movie Film, Soft Contact Lenses, Drinking Cups, Fan Belts, Car Enamel, Shaving Cream, Ammonia, Refrigerators, Golf Balls, Toothpaste, and of course Solvents, Diesel Fuel, Motor Oil, Bearing Grease etc. etc. etc.

Maybe it isn't as simple as we thought?

# Strategy 5: Respect differences

**Shares of renewable energy sources in the electricity sector,  
for heating and cooling and for transport**



Source: German Environment Agency (UBA) based on Working Group on Renewable Energy Statistics (AGEE-Stat)  
Update: 02/2021

# IN 2016, 1.186 BILLION PEOPLE WERE STILL LIVING WITHOUT ELECTRICITY



22 MIL.  
LATIN AMERICA

634 MIL.  
AFRICA

18 MIL.  
MIDDLE EAST

512 MIL.  
ASIA



SOURCE: IEA, World Energy Outlook 2016

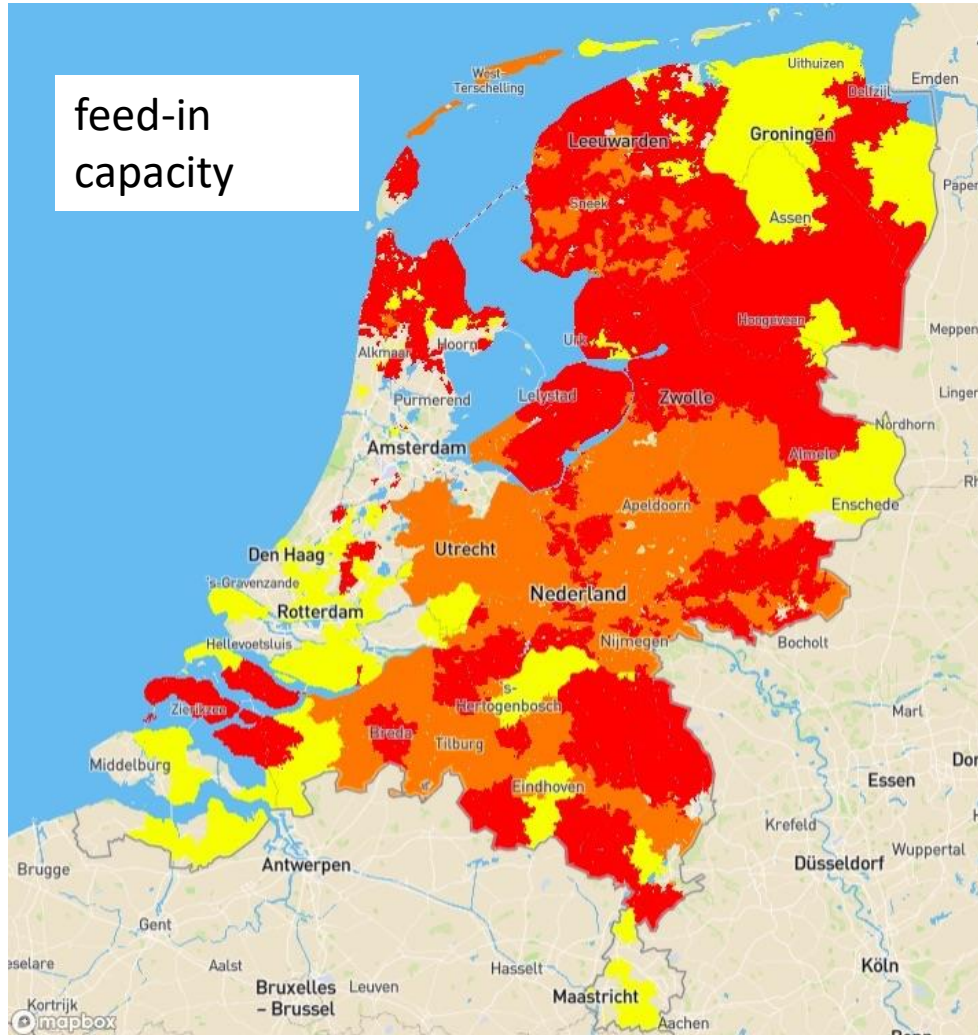
## Strategy 6: Reality checks

source	Power density (W/m <sup>2</sup> )	Load factor (%)
biomass	0.5	90
Onshore wind	2	25
Offshore wind	2.5	50
Solar PV	5	10
CSP	15	Some storage involved
Power plant	10,000	90

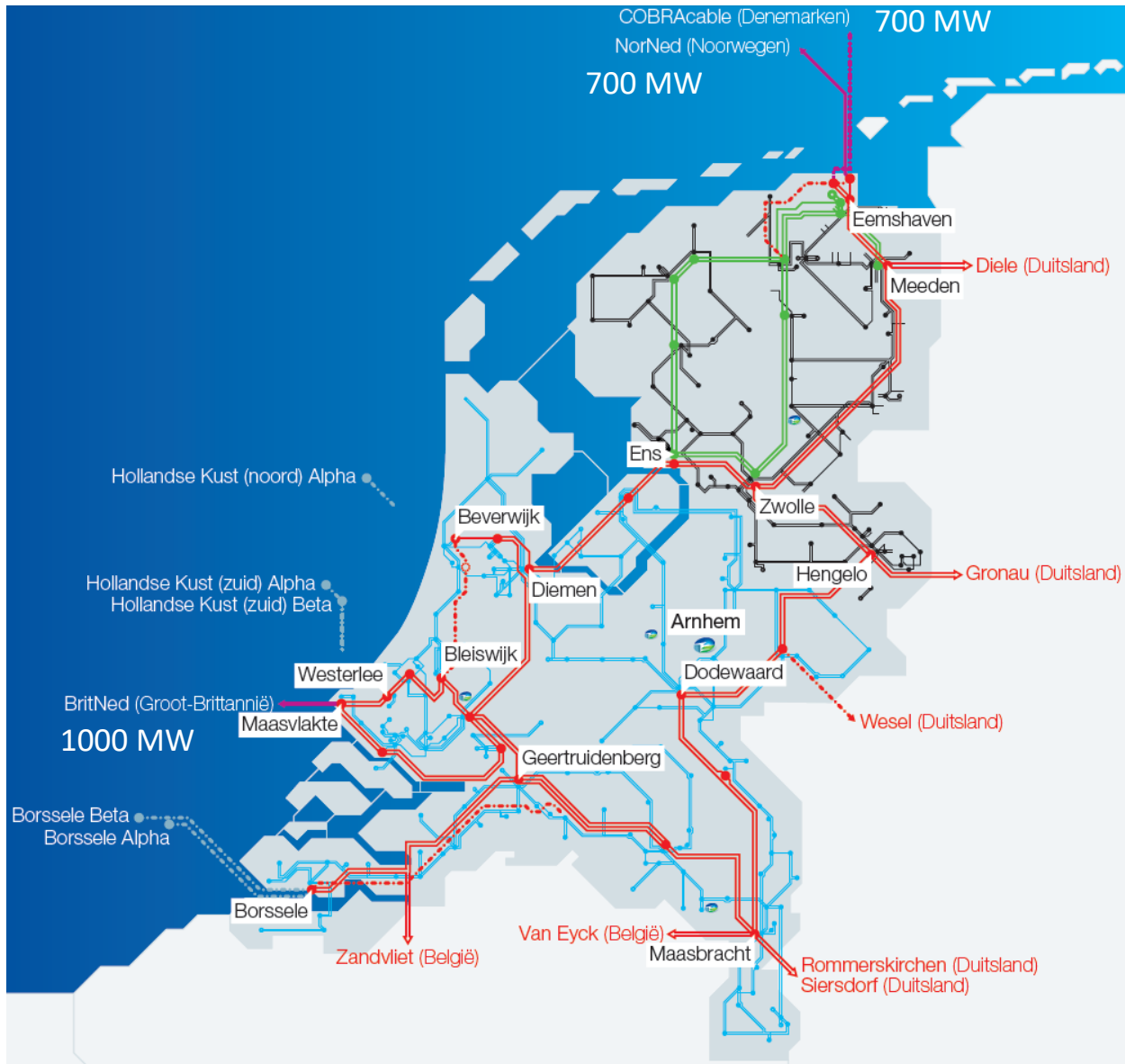
‘We need a lot of space’  
We need a lot of capacity’

‘We need a lot of back-up’  
‘we need a lot of balancing’  
(after prof. Söder)

# Strategy 7: robust networks



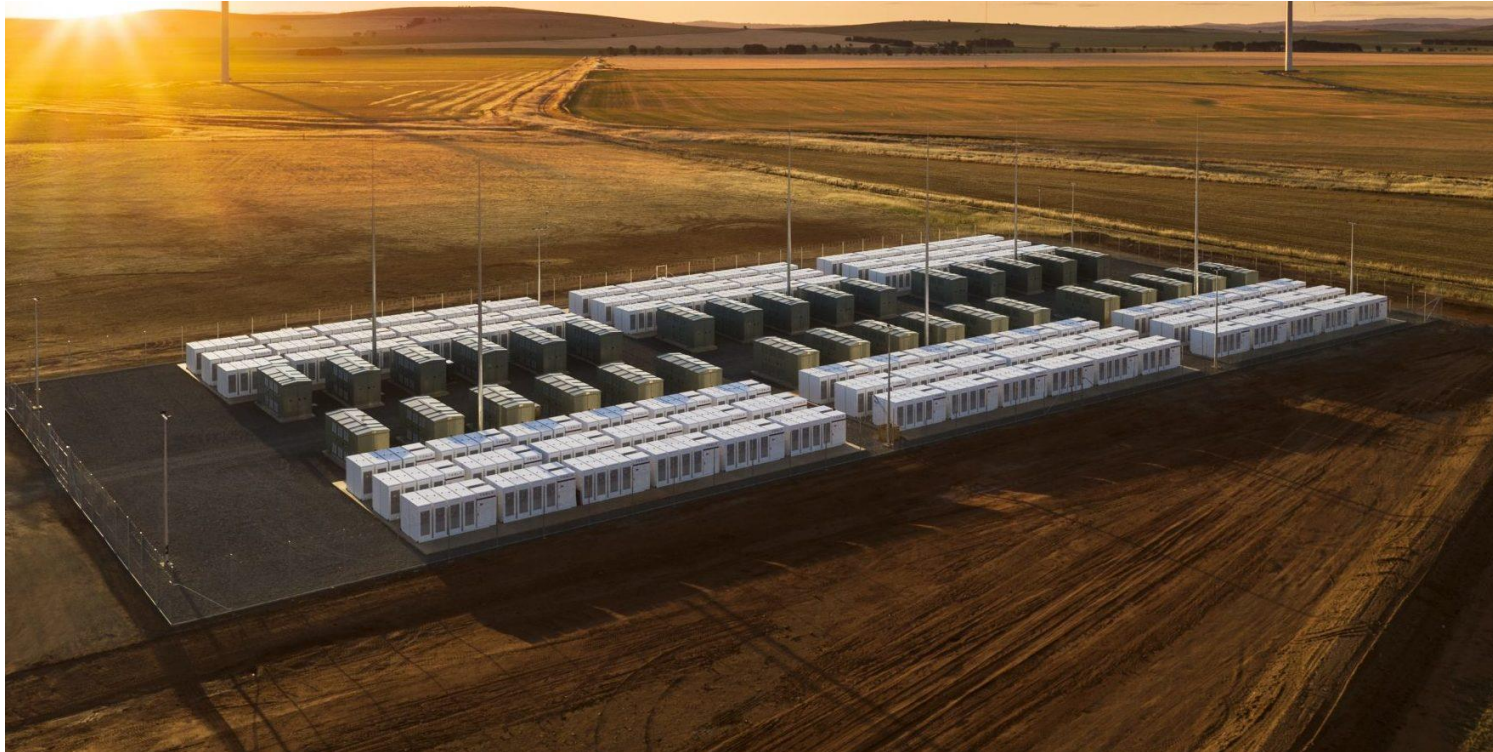
# Interconnectivity (cf. prof. Söder)



# Strategy 8: storing energy



# Hornsedale power reserve



129 MWh (1290 Tesla car batteries)



# Vojens (DK): 37 MW zonnecollectoren en 200.000 m<sup>3</sup> waterbassin



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## HEAT STORAGE PITS

[WWW.RAMBOLL.COM/ENERGY](http://WWW.RAMBOLL.COM/ENERGY)

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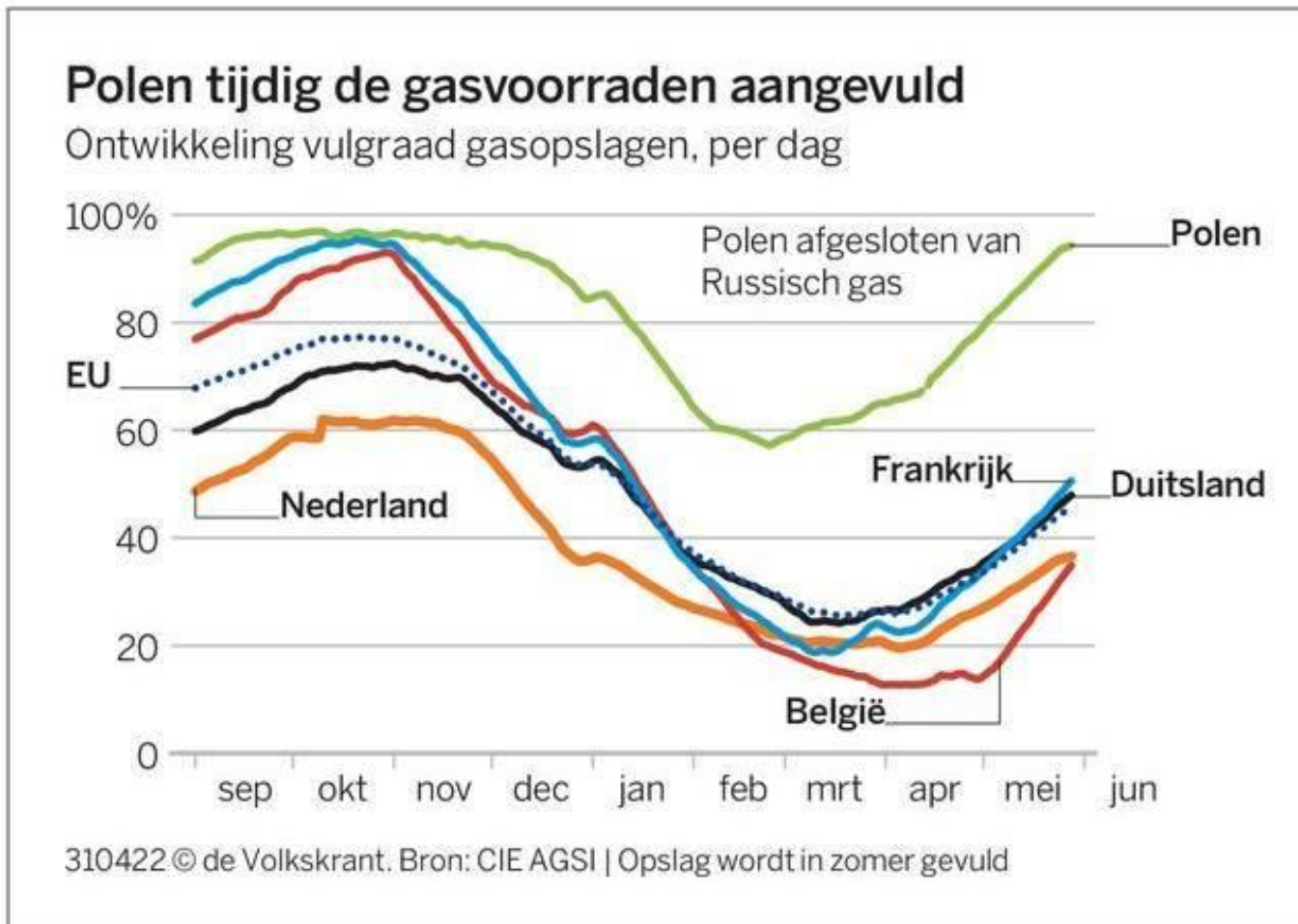
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# Gas storage capacity in Europe

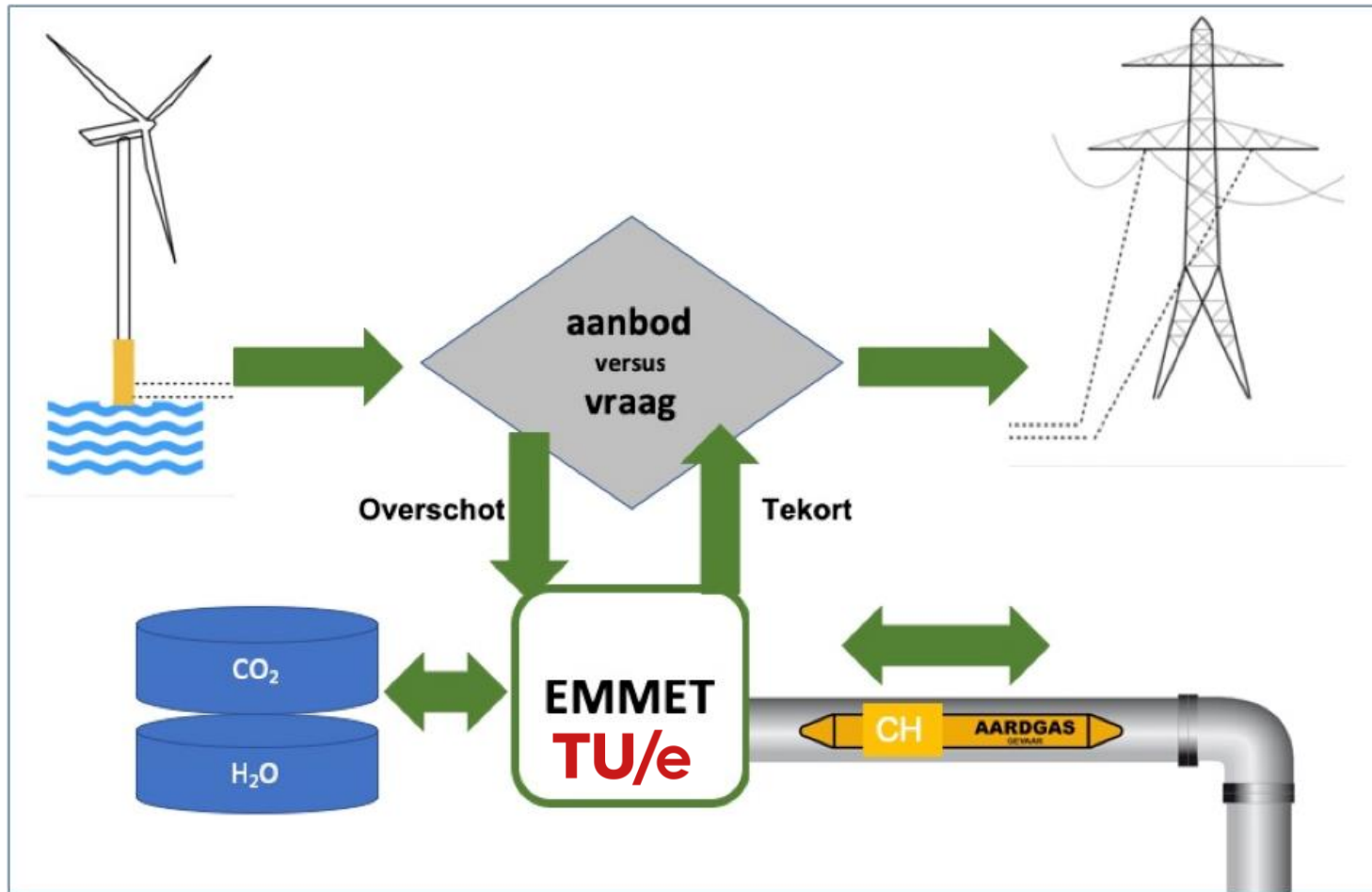
	BCM	TWh
Gas consumption EU 2017	493	4.820
Gas storage capacity EU 2017	89,2	871
Gas storage capacity Germany	21,8	213
Gas storage capacity the Netherlands	13,4	130
Tesla Hornsdale battery		0.000129
EU gas storage capacity/consumption	18%	

Bron: Ad van Wijk

# Filling up the gas reserves



# Synthetic Natural Gas storage



# Geertruidenberg coal plant



# After installation of 1GW EMMET plant



# Energy Transition: strategies for resilient energy supply and demand

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