NGO perspective on CCS

@mariusholm

ZERO

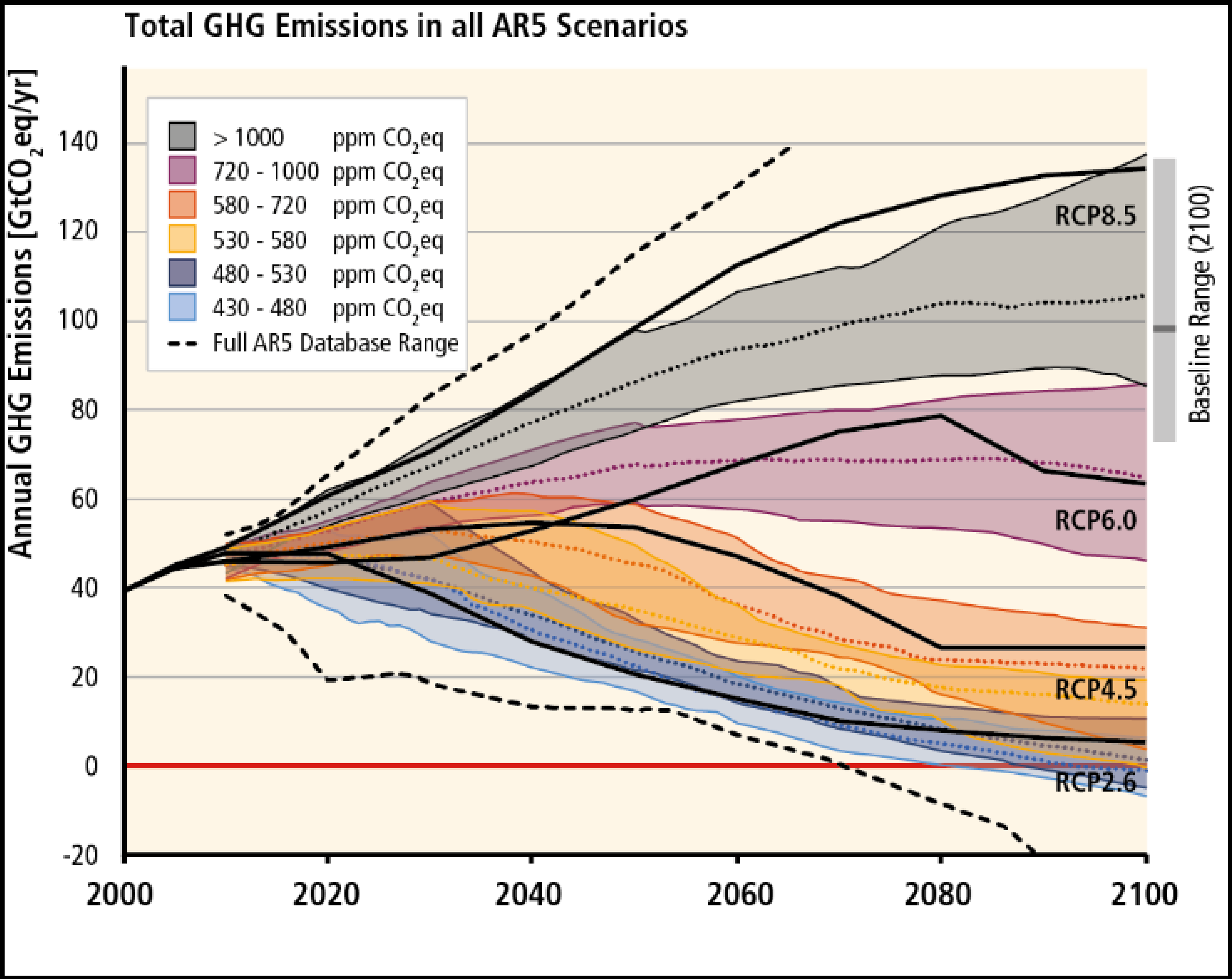
Total GHG Emissions in all AR5 Scenarios
Annual GHG Emissions [GtCO2eq/yr]
140
120
100
80
60
40
20
0
-20
2000
2020
2040
2060
2080
2100
> 1000 ppm CO2eq
720 - 1000 ppm CO2eq
580 - 720 ppm CO2eq
530 - 580 ppm CO2eq
480 - 530 ppm CO2eq
430 - 480 ppm CO2eq
Full AR5 Database Range
RCP8.5
RCP6.0
RCP4.5
RCP2.6
Baseline Range (2100)

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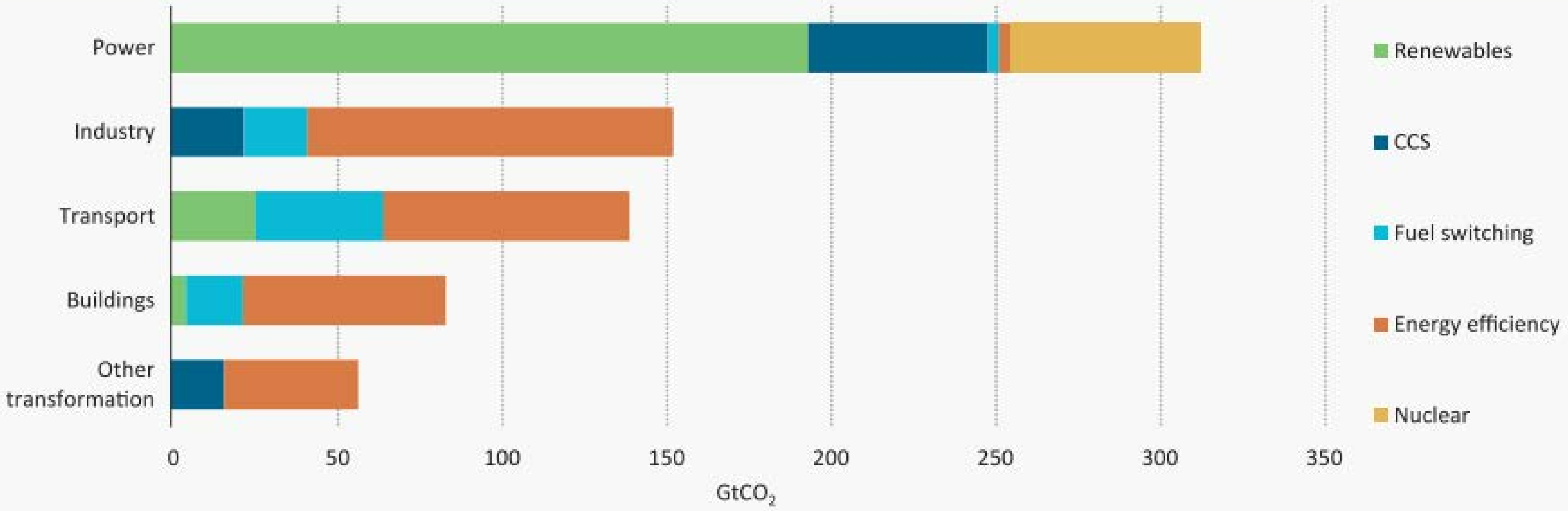
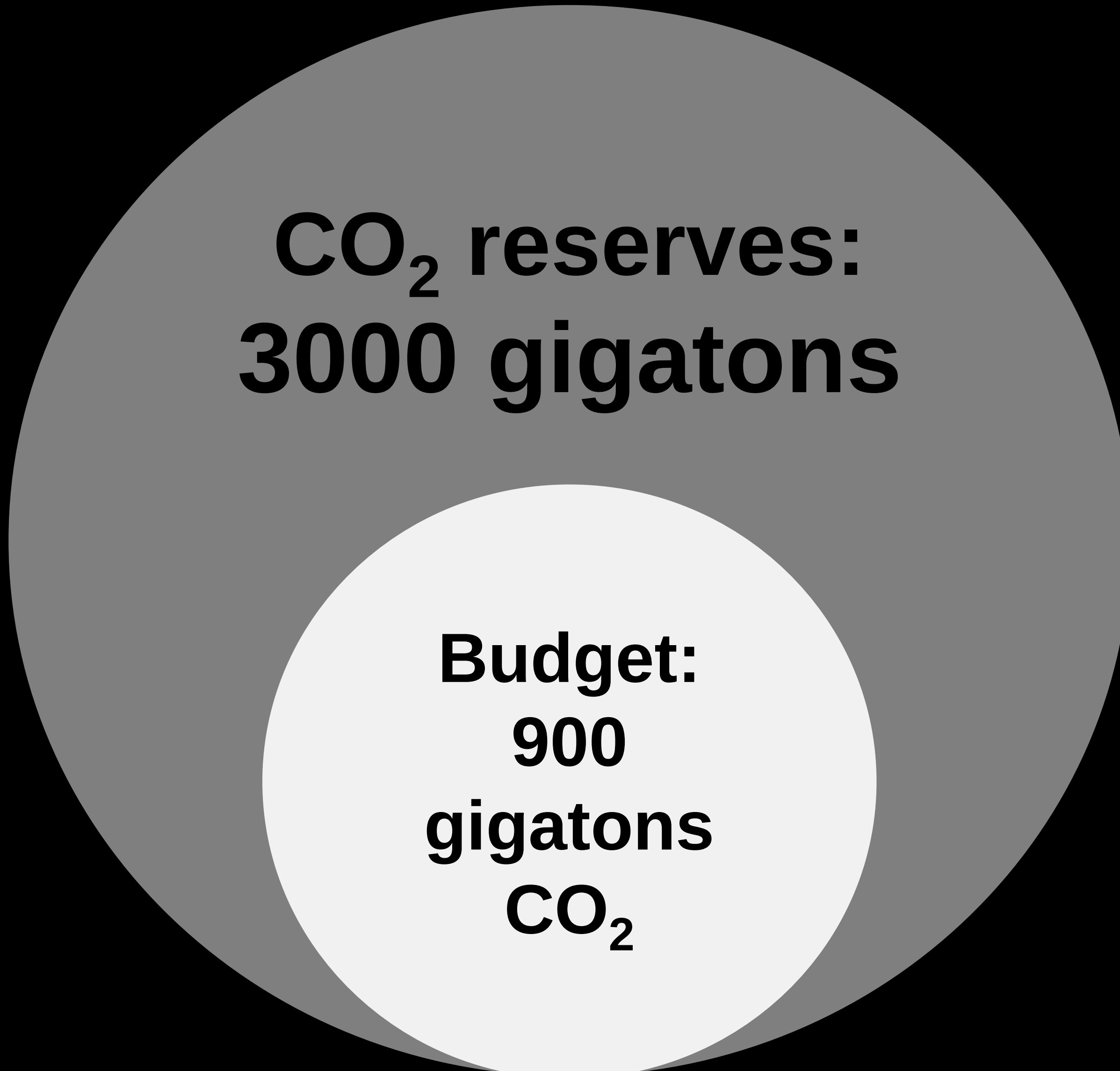
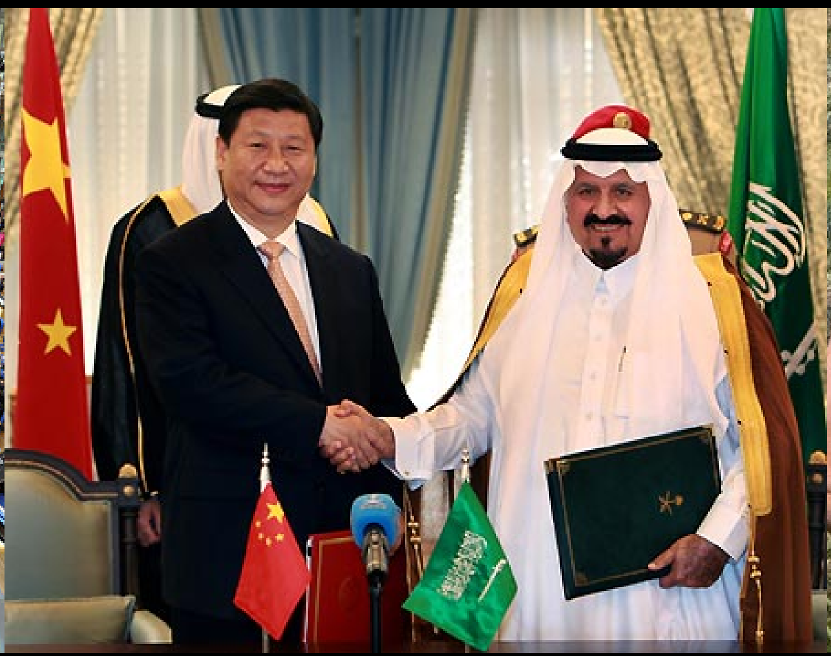
Figure I.1 Cumulative CO_2 reductions by sector and technology in the 2DS to 2050



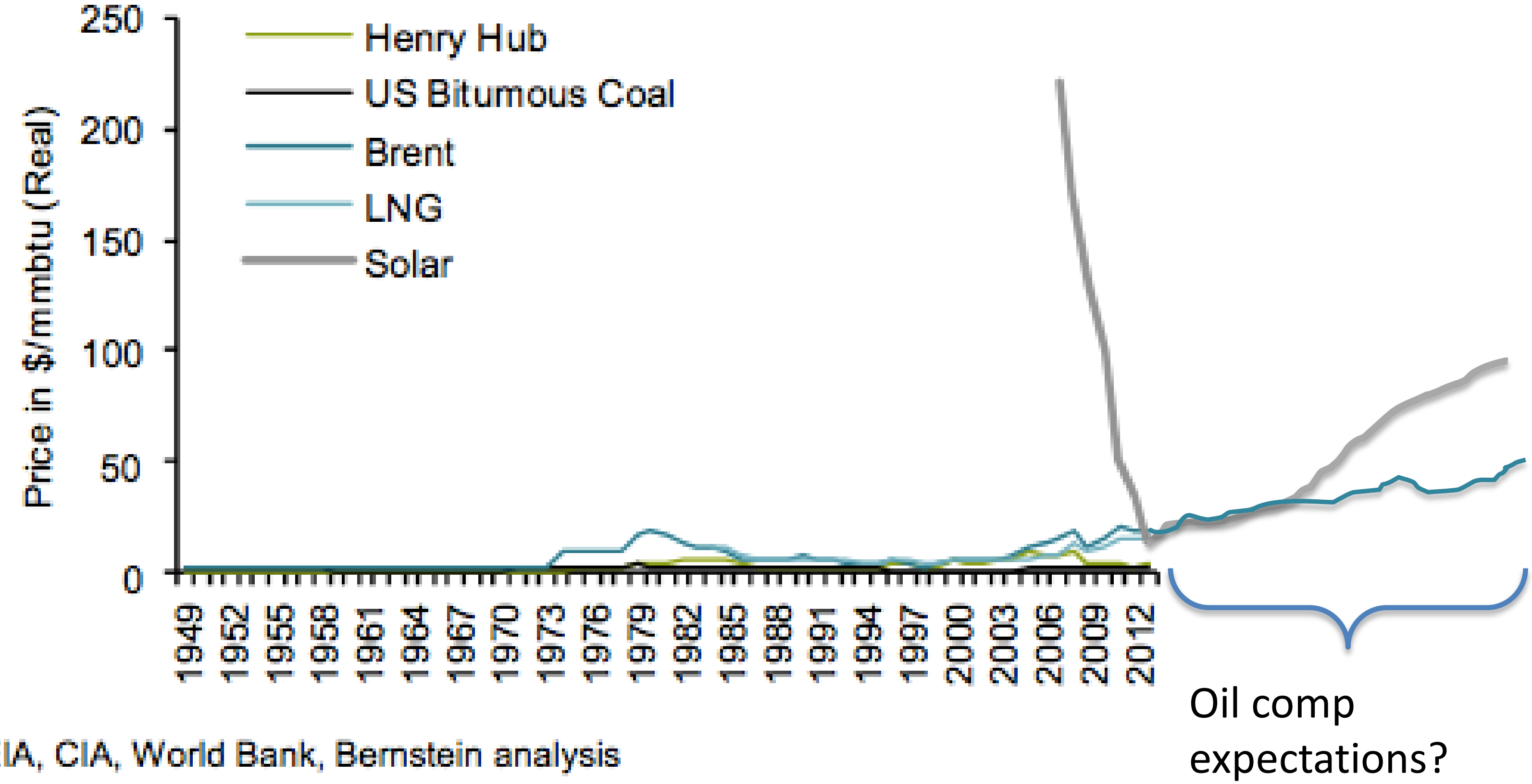
Key point *A portfolio of low-carbon technologies is needed to reach the 2DS; some solutions will be broadly applicable, while others will need to target specific sectors.*


CO_2 reserves:
3000 gigatons
Budget:
900
gigatons
CO_2

Limitations on fossil fuels? - «Highly unlikely»

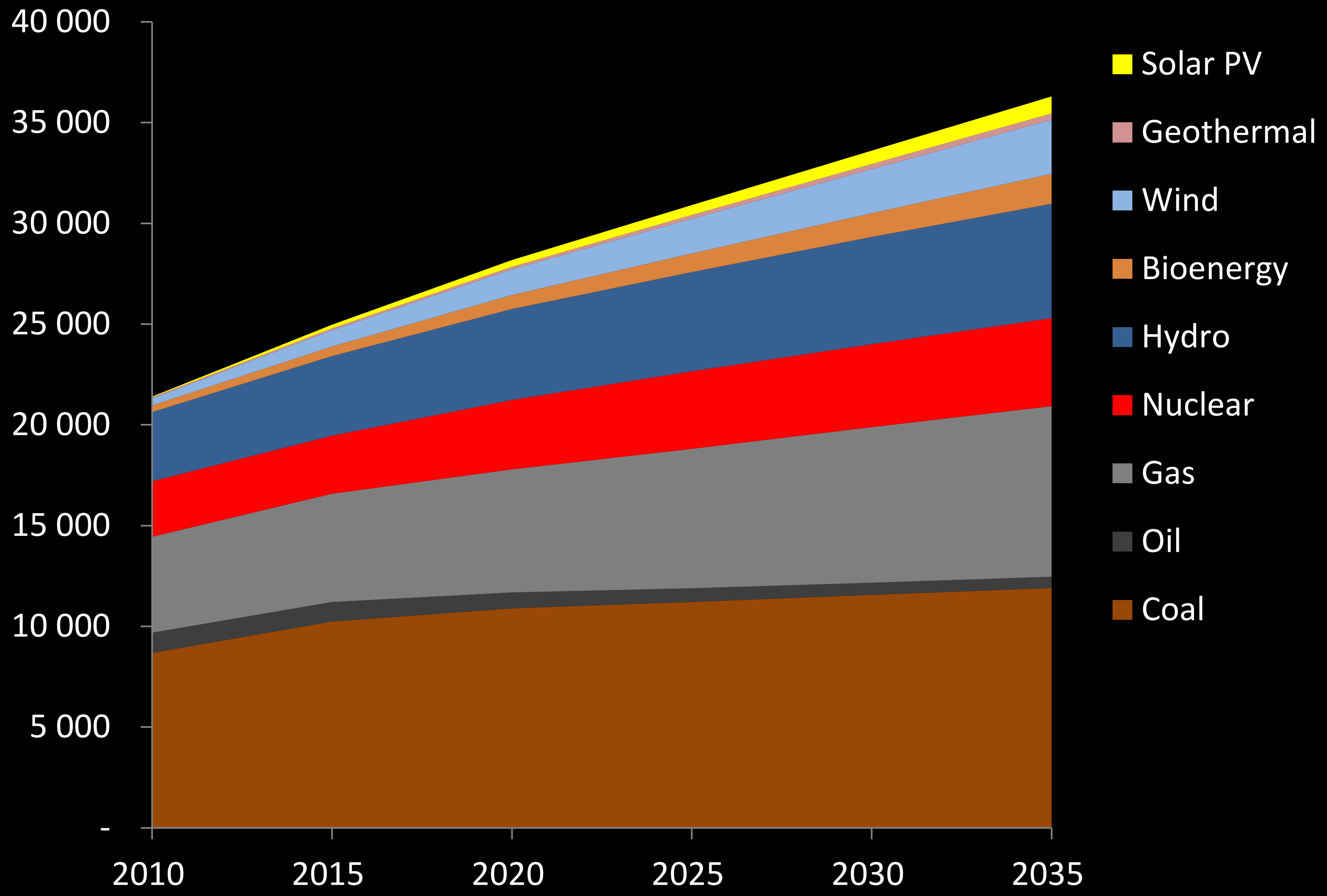


But what is «likely» in energy markets?

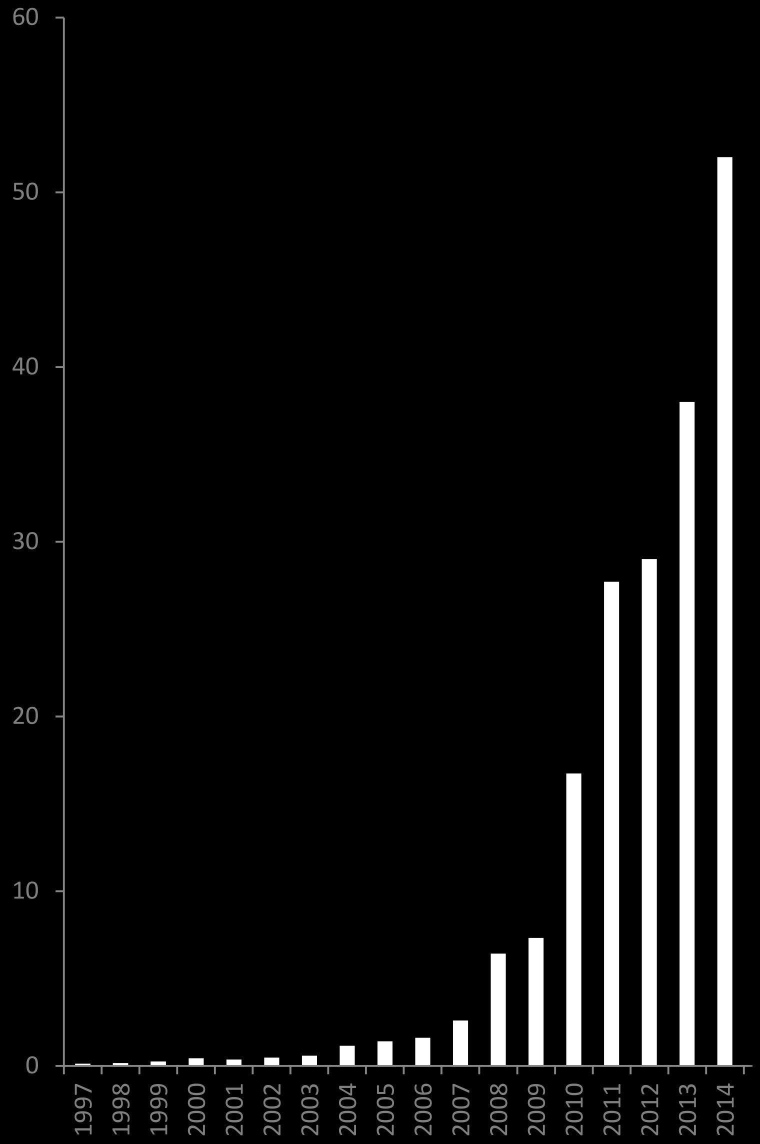


Source: EIA, CIA, World Bank, Bernstein analysis

IEA – New policies scenario: Electricity generation (TWh)



Annual installation of solar PV (GW)



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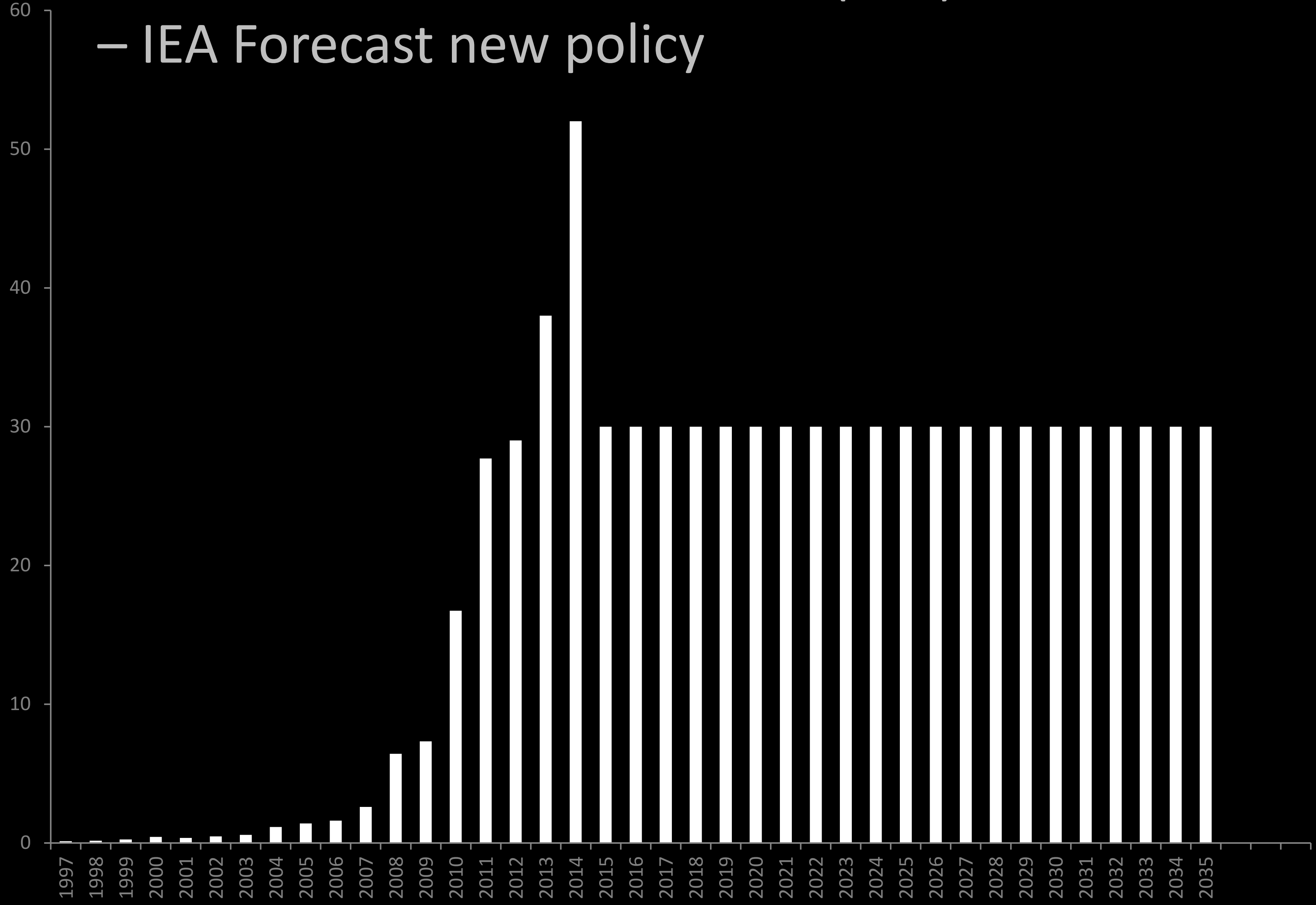
Annual installation of solar PV (GW) – IEA Forecast new policy



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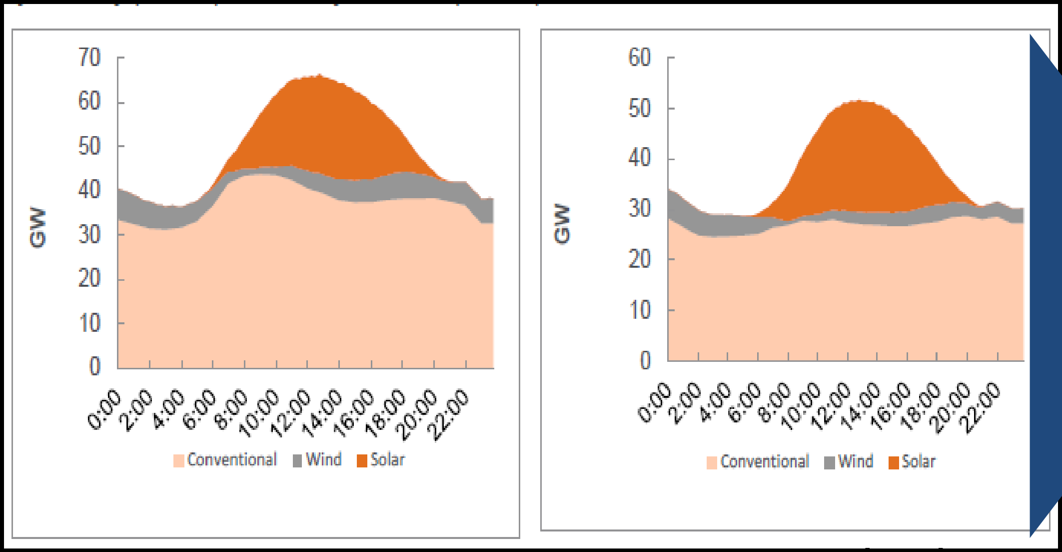
Germany: From “displacing peak” to “disrupting base load”

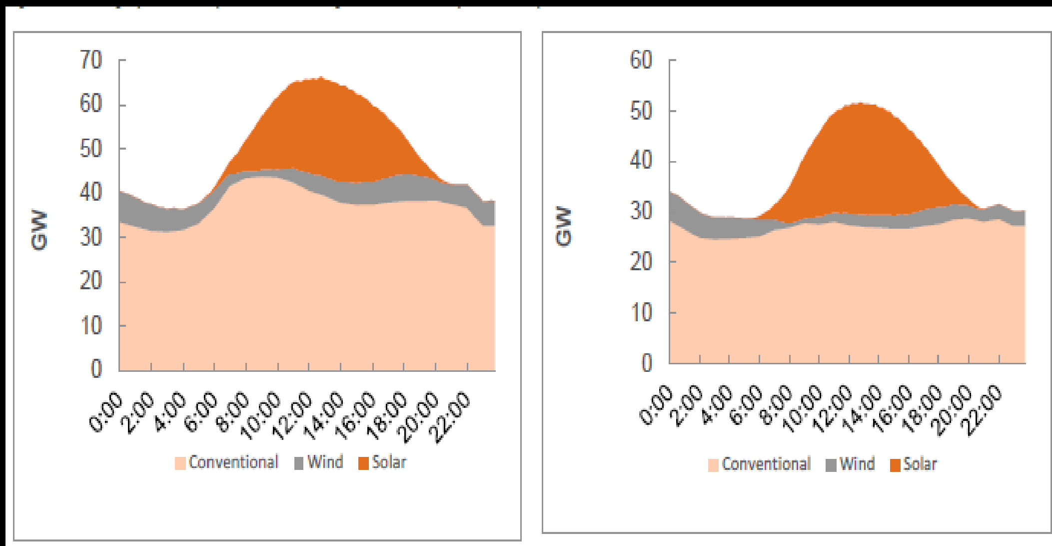


"Today"
Solar PV displacing gas-powered peaking power

ZERO

Scatec
Scandinavian Advanced Technology

Germany: From “displacing peak” to “disrupting base load”



"Today"
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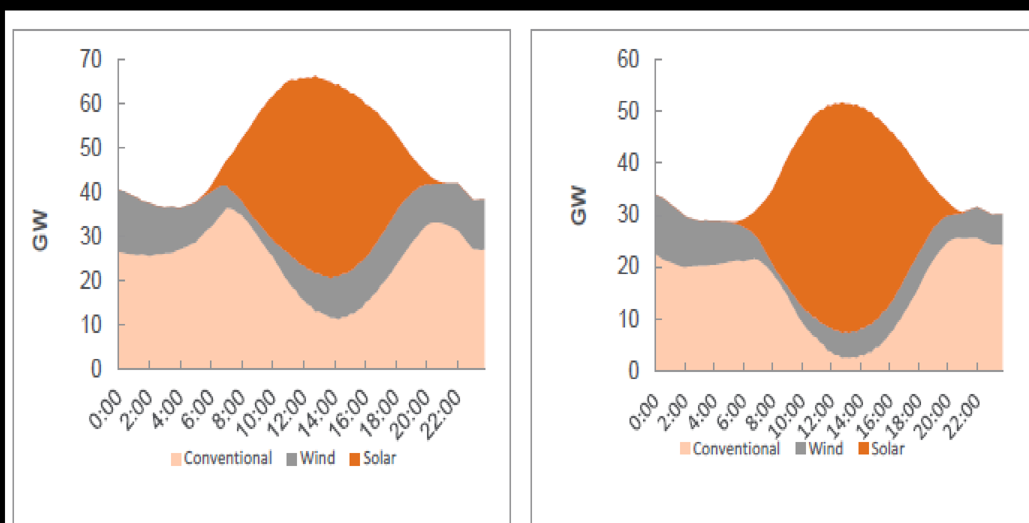
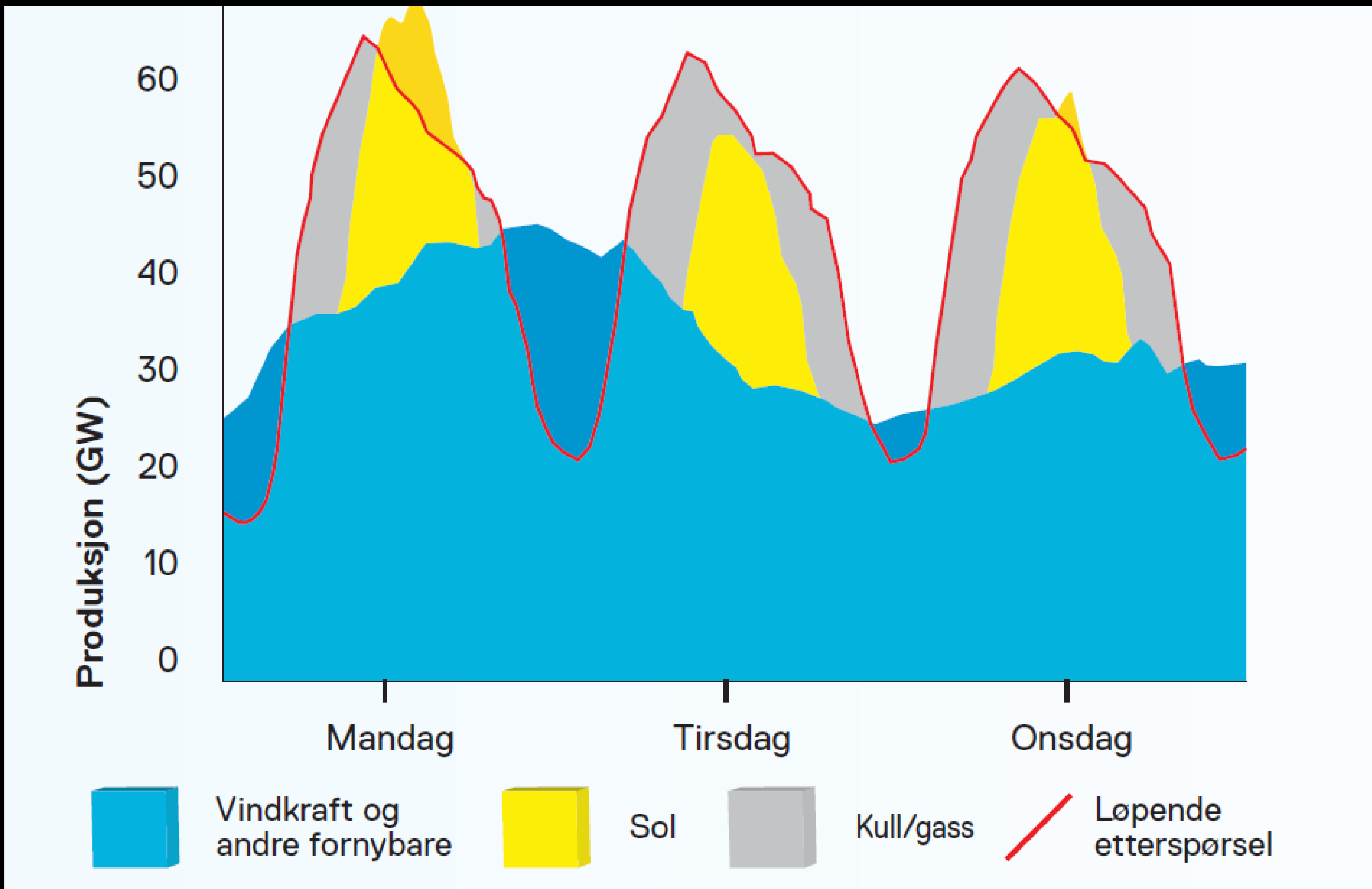


Solar PV disrupting base load

Scatec

Solar energy insufficient alone



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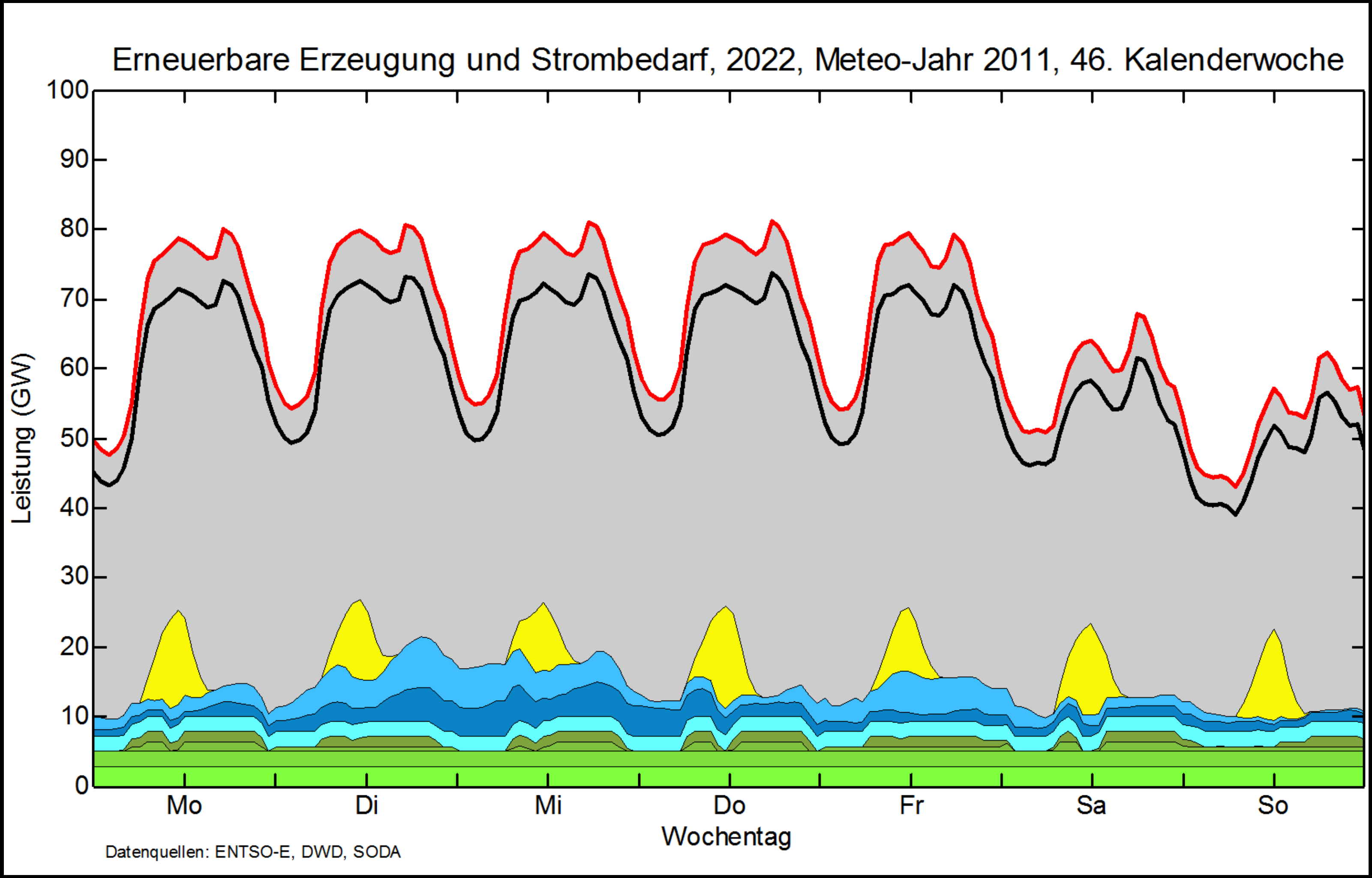
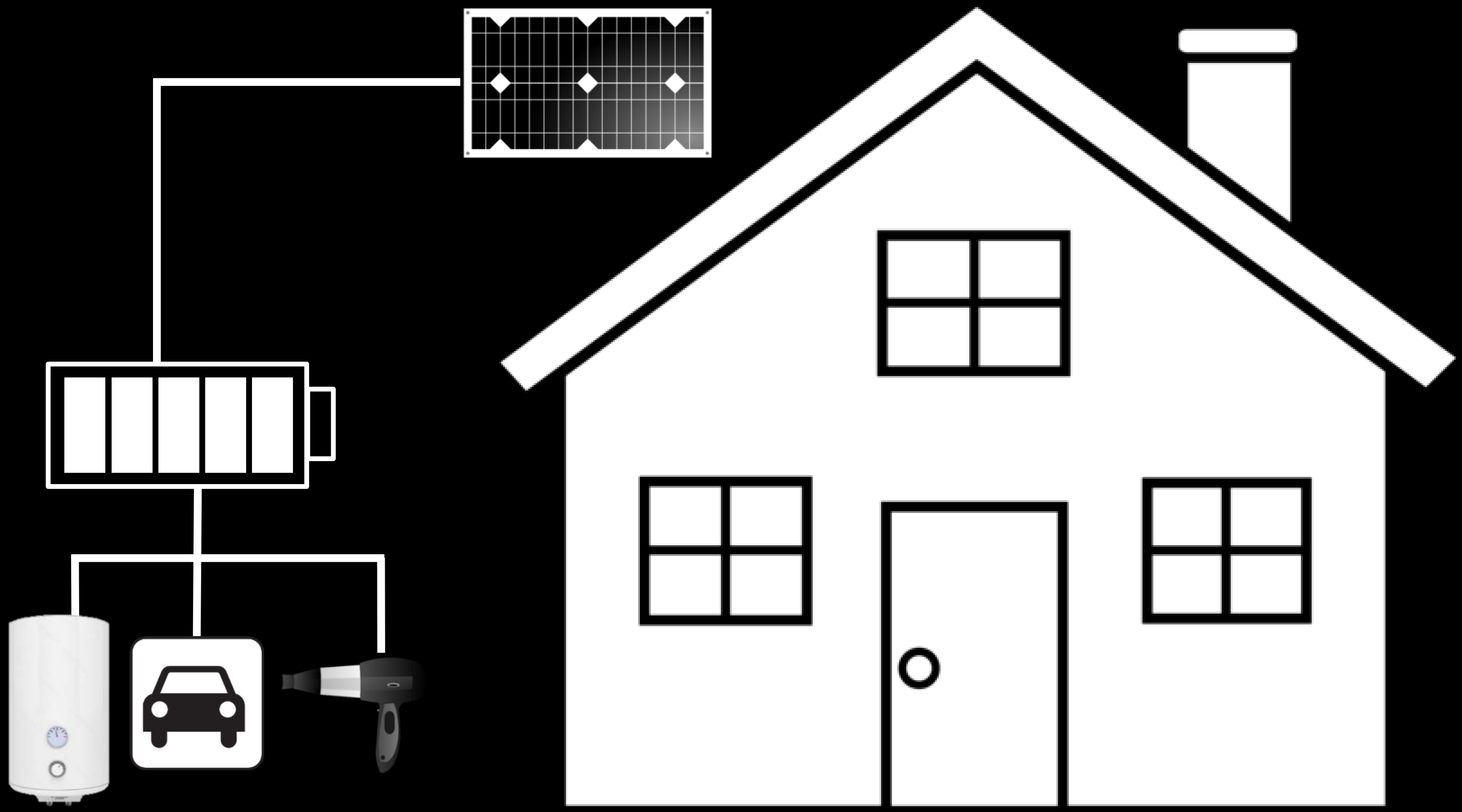
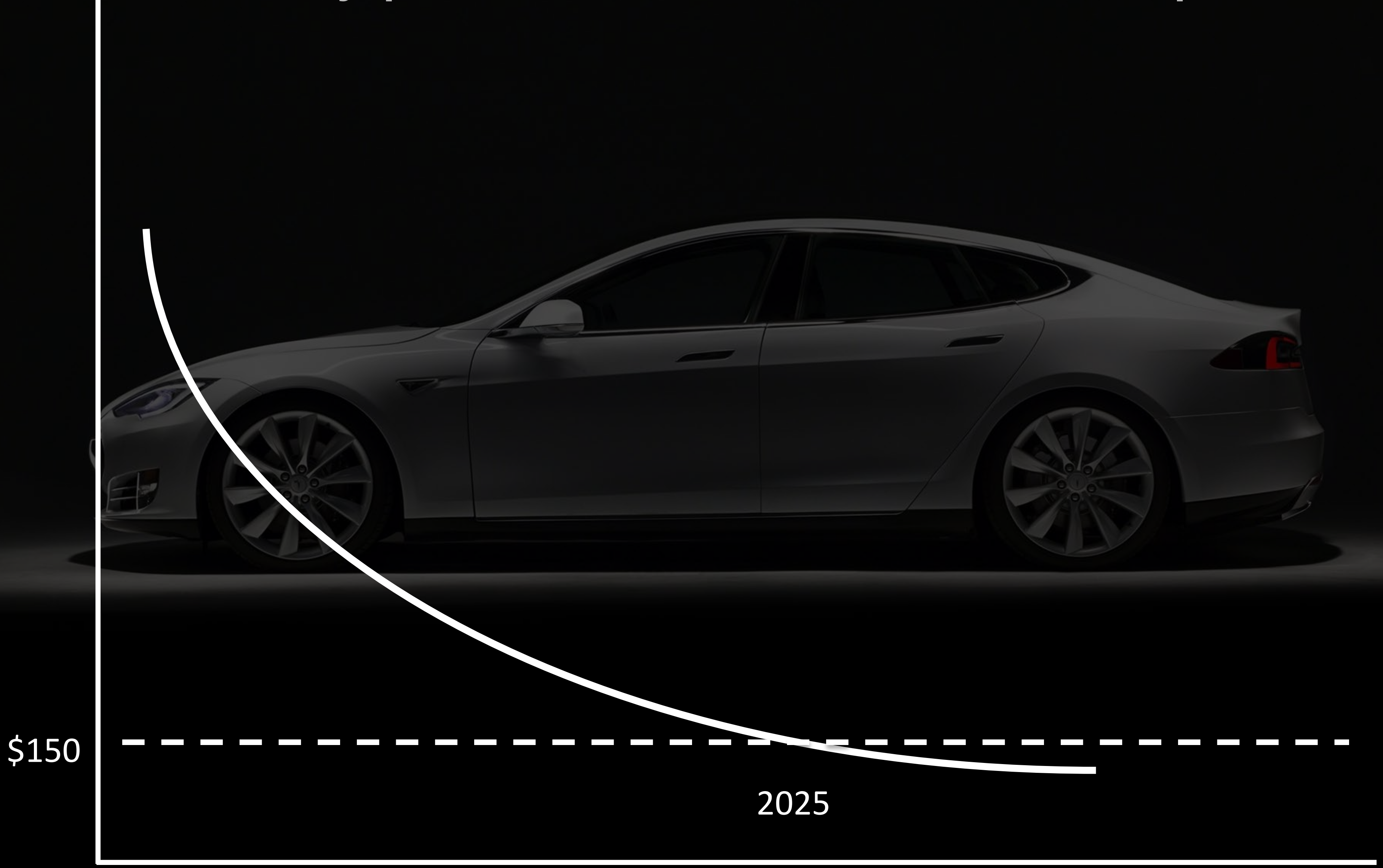


Erneuerbare Erzeugung und Strombedarf, 2022, Meteo-Jahr 2011, 46. Kalenderwoche
Leistung (GW)
0
10
20
30
40
50
60
70
80
90
100
Mo
Di
Mi
Do
Fr
Sa
So
Wochentag
Datenquellen: ENTSO-E, DWD, SODA

ZERO

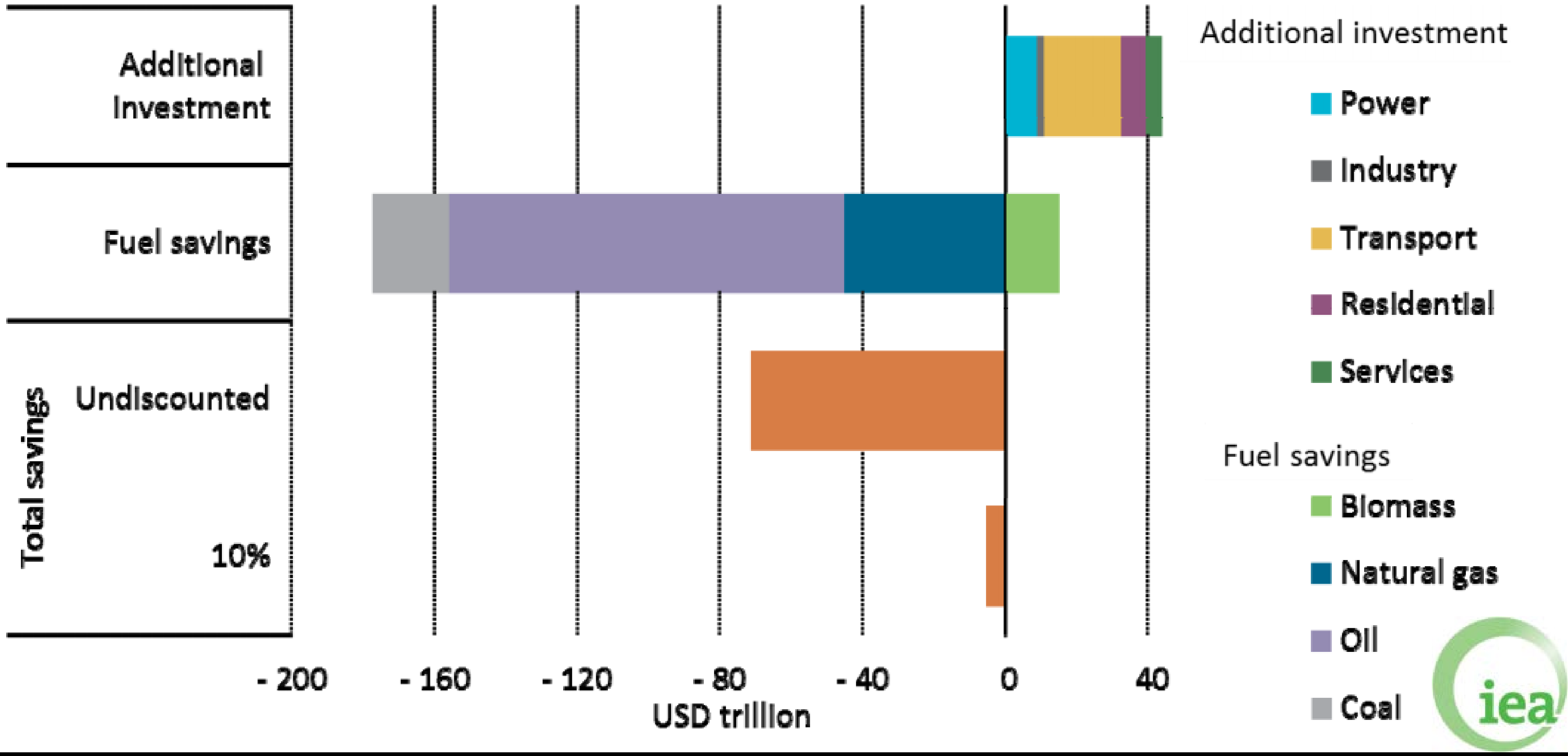


Battery prices down from $750 to $125 per kwh

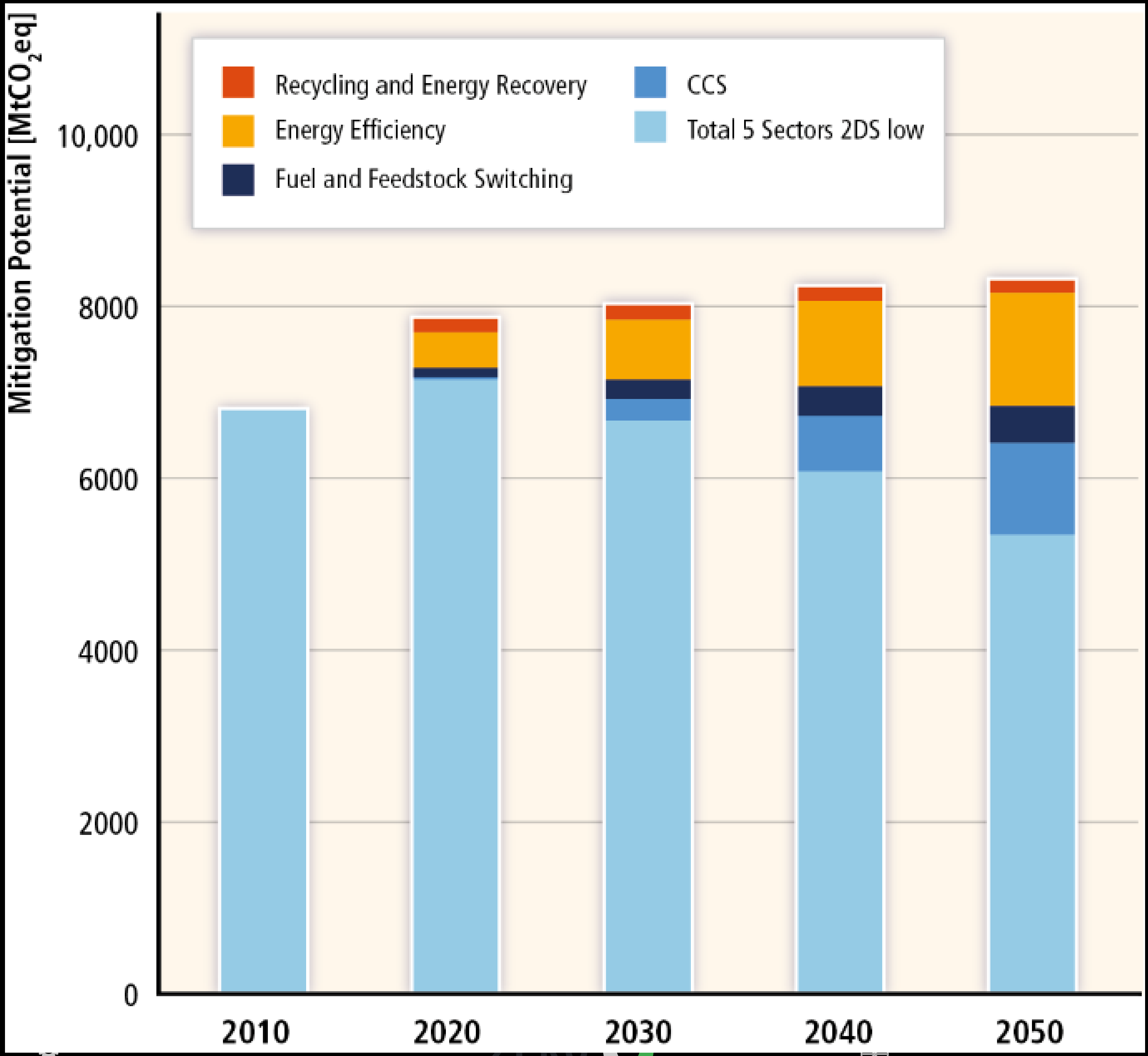


The input was hydrocarbons

The input will be capital



Additional investment
Fuel savings
Total savings
Undiscounted
10%
- 200
- 160
- 120
- 80
- 40
0
40
USD trillion
Additional investment
Power
Industry
Transport
Residential
Services
Fuel savings
Biomass
Natural gas
Oil
Coal
iea


Mitigation Potential [MtCO2eq]
10,000
8000
6000
4000
2000
0
2010
2020
2030
2040
2050
Recycling and Energy Recovery
Energy Efficiency
Fuel and Feedstock Switching
CCS
Total 5 Sectors 2DS low

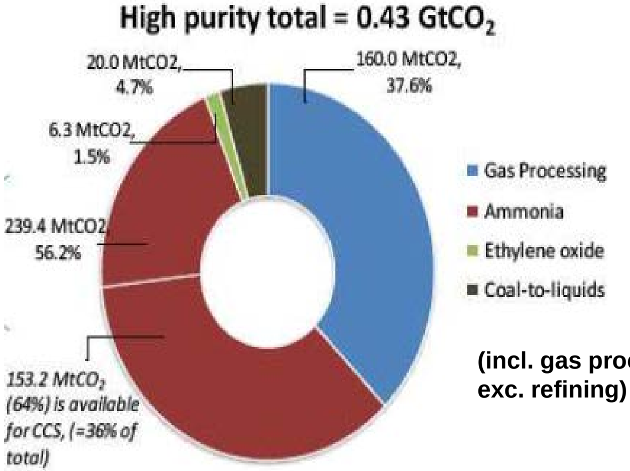
Case 1: Industry, concentrated CO_2

- CO_2 emission volume: 0,7 - 4,5 Mt/y
- CO_2 concentration typically 30 - 100 %

Examples:
- Fertilisers/ammonia
- Hydrogen production
- Chemical industry

Advantages:
- Lower capture cost
- Stable CO_2 source
- Located in industrial clusters/coastal locations => possible lower transport cost
- Industrial experience from commercial use
- Excess energy for CO_2 capture

CCS Potential



(incl. gas processing, exc. refining)

Example:

Ammonia plant, Yara Norway

- *~1,2 Mt CO_2/y*
- *0,8 Mt captured*
- *~0,2-0,3 Mt sold*
- *Rest is emitted*

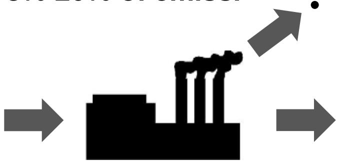
Case 2: Petroleum industry

Refinery:

H_2 production
- CO_2: 100%
- 5%-20% of emiss.

Boilers&furnaces
- CO_2: 15-20 %
- 30-60 % of emiss.

Crude oil

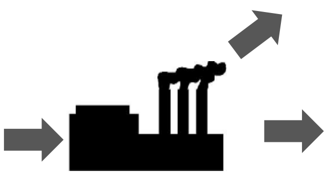


Refined oil products

Natural gas cleaning (“Sweetening”):

CO_2: 96-99%

Natural gas
2-70 % CO_2



Treated gas:
Pipeline <2,5 % CO_2
LNG: <0,2 % CO_2

CCS potential:

Gas processing
~160 Mt/y

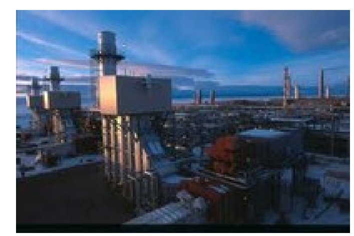
Oil refining
~ 1.1 $GtCO_2$
(McKinsey (2008)

Advantages:

- High CO_2 concentration = lower capture cost
- Long experience in capture and injecting CO_2
- Several CCS projects in operation (natural gas sweetening)
- High geological experience relevant for CO_2 storage
- Excess energy can be used for CO_2 capture
- But: Complicated industrial process could lead to higher costs

Examples:

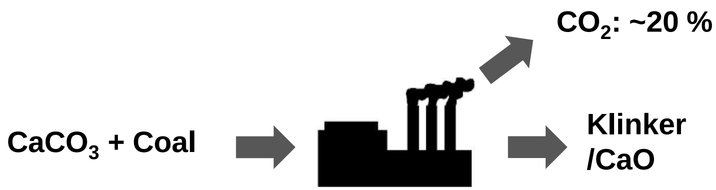
Scotford Upgrader.
Quest CCS project
Shell, Canada.



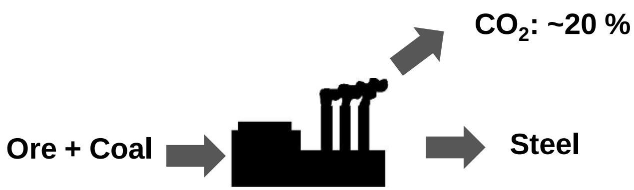
Shute Creek gas processing plant, Wyoming.

Case 3: Industry, very large emissions

Cement:



Steel:



CCS potential:

- Iron and steel: ~2,3 Gt/y (30 % of industry emissions)
- Cement: ~2 Gt/y (26 % of industry emissions)

Advantages:

- High CO_2 concentration = lower capture cost
- Excess heat can be used for CO_2 capture
- CCS only mitigation option for the process emissions
- But: Steel need new built/refurbished plant to get high concentrated CO_2 for suitable/cheaper CO_2 capture.

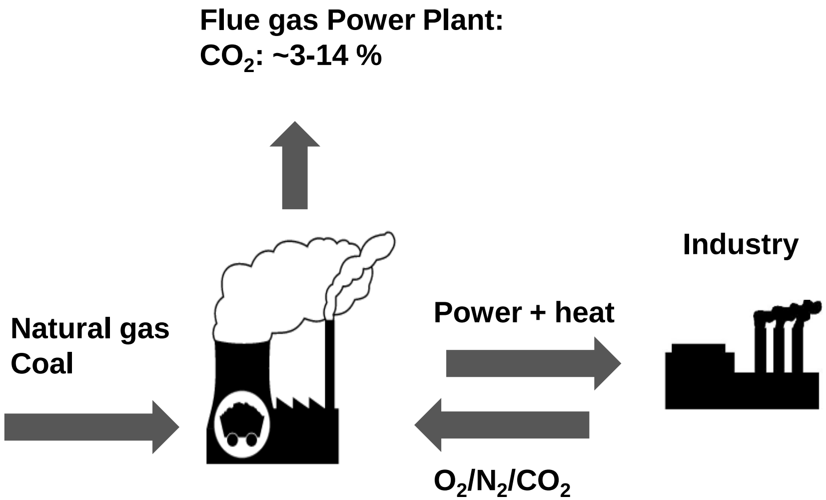
Examples:

Norcem Heidelberg cement plant, Norway

ArcelorMittal/ULCOS CCS demo project

Case 4: Integrated CCS, supply to energy-intensive industry

1. **Energy intensive cluster, with heat as a major supply**
2. **Power intensive industry (aluminium)**



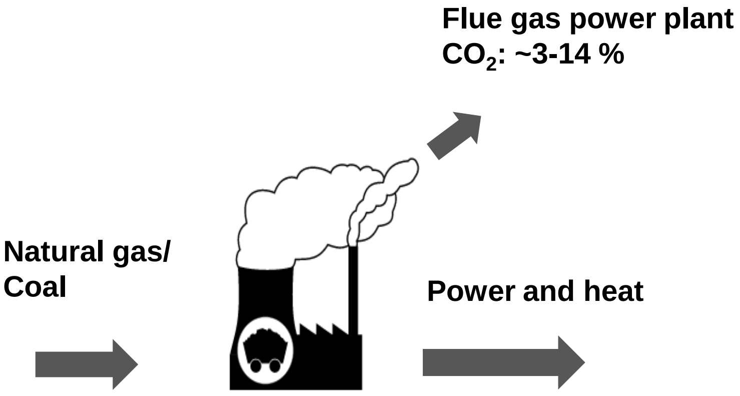
Advantages:

- **High base load power and heat demand**
- **Excess heat from industry for CO_2 capture process**
- **Large emissions in small area gives lower cost for transportation and storage**
- **Existing industry infrastructure can give lower cost for building, operations and utilities**
- **But: Energy is major cost & competition factor for these industries. Higher energy cost with CCS**

Examples:

Qatalum Aluminium and CCGT Qatar

Case 5: Power plants where no renewable alternatives exist



Technical limitations:

- Limited grid capacity for power transfer
- Limited renewable potential compared to energy need
- Volatile renewable production *can* need fossil base load/backup for security of supply

Political limitations:

- Political inertia for changes delaying fossil fuel phase-out.
- Large fossil resources/economic investments/ jobs, delaying renewable implementation

Advantages:

- No alternative or high cost for other mitigations options can give good conditions for CCS.
- Large fossil (coal) reserves with no/low alternative value, can give high willingness to invest in CCS
- But: Political inertia for changes can be challenging for large CCS investments.
- Flexible fossil production as backup/peak power can give increased cost for CCS

Examples:

Boundary dam CCS, Canada

Case 6: Bio-CCS

Bioethanol

Biomass (sugar cane ++) → → Bioethanol

CO_2: ~100 %

Bioenergy

Biomass → → Heat and power

CO_2: ~15 %

Pulp and Paper

Biomass (wood) → → Cellulose/ paper

CO_2: 13-14 %

CCS potential

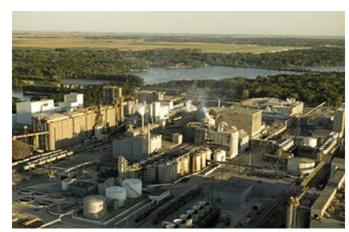
Bioethanol: ~69 MtCO_2, 190 sources, mainly Brazil.

Pulp&Paper: Global estimated ~540 Mt/y

Advantages:

- **Bioethanol: Pure CO_2 cons give low cost for CCS.**
- **BioCCS gives "negative" emissions. Can do large scale removal of CO_2 from atmosphere**
- **Co-firing biomass gives (less than) zero CO_2 from a coal with CCS, not just 70-80 % reductions as regular coal CCS.**
- **Biomass is important renewable source for energy and raw materials replacement of fossil.**
- **But: Bioethanol plants located near field. Uncertainty for storage sites**

Examples:

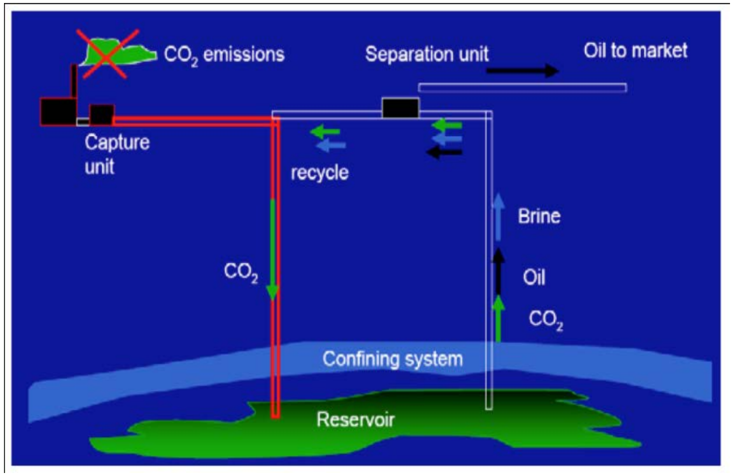


Illinois Bioethanol with CCS

Södra Cell Värö

ZERO

Case 7: CO_2 EOR



Advantages:

- CO_2 EOR been in use commercial in US for more than 40 years
- EOR has been the single largest driver for CCS so far (in US, Canada)
- Value for CO_2 to EOR in the range of 30-40 $/ton CO_2
- But: Geographically and volume limitations for how much CO_2 potentially to be used for EOR

CCS potential:

- 50 largest oil basins can store 140 Gt CO_2 with "state-of-the-art" CO_2-EOR technology.
- Large potential income covers CCS cost: 470 bn barrels of added oil
- Applied to smaller fields:
  - 320 Gt CO_2 storage
  - >1 trillion barrels of oil

Examples:

>100 ongoing CO_2 EOR projects in USA

Policy recommendations - globally

Mandatory certificate system

EPS for power plants
(and industry)

Government funding /
involvement for storage

The certificate system

Carbon up = Carbon down

A mandatory market mechanism

Politically decided volume

Making profit on CO_2 uptake = buying certificates

Capturing and storing CO_2 = awarded certificates

The certificate system