# Energy sufficiency: the missing lever to tackle the energy transition

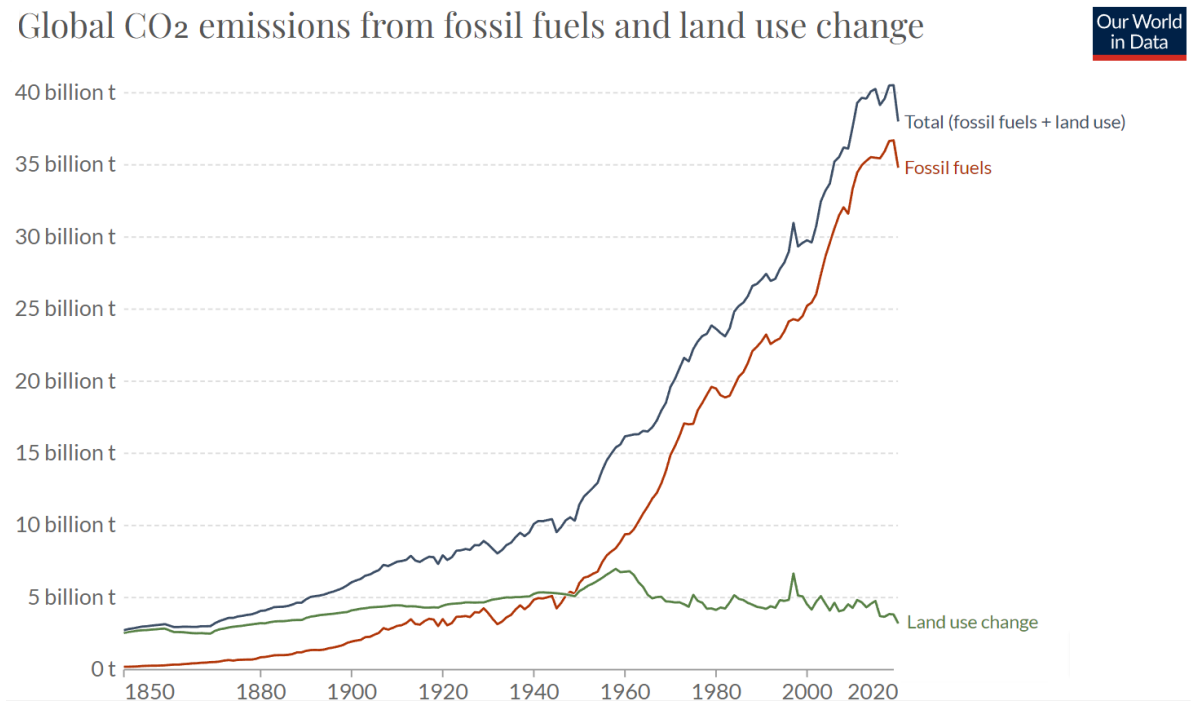
Umair Tareen, Sylvain Quoilin

June 2023

# IPCC AR6

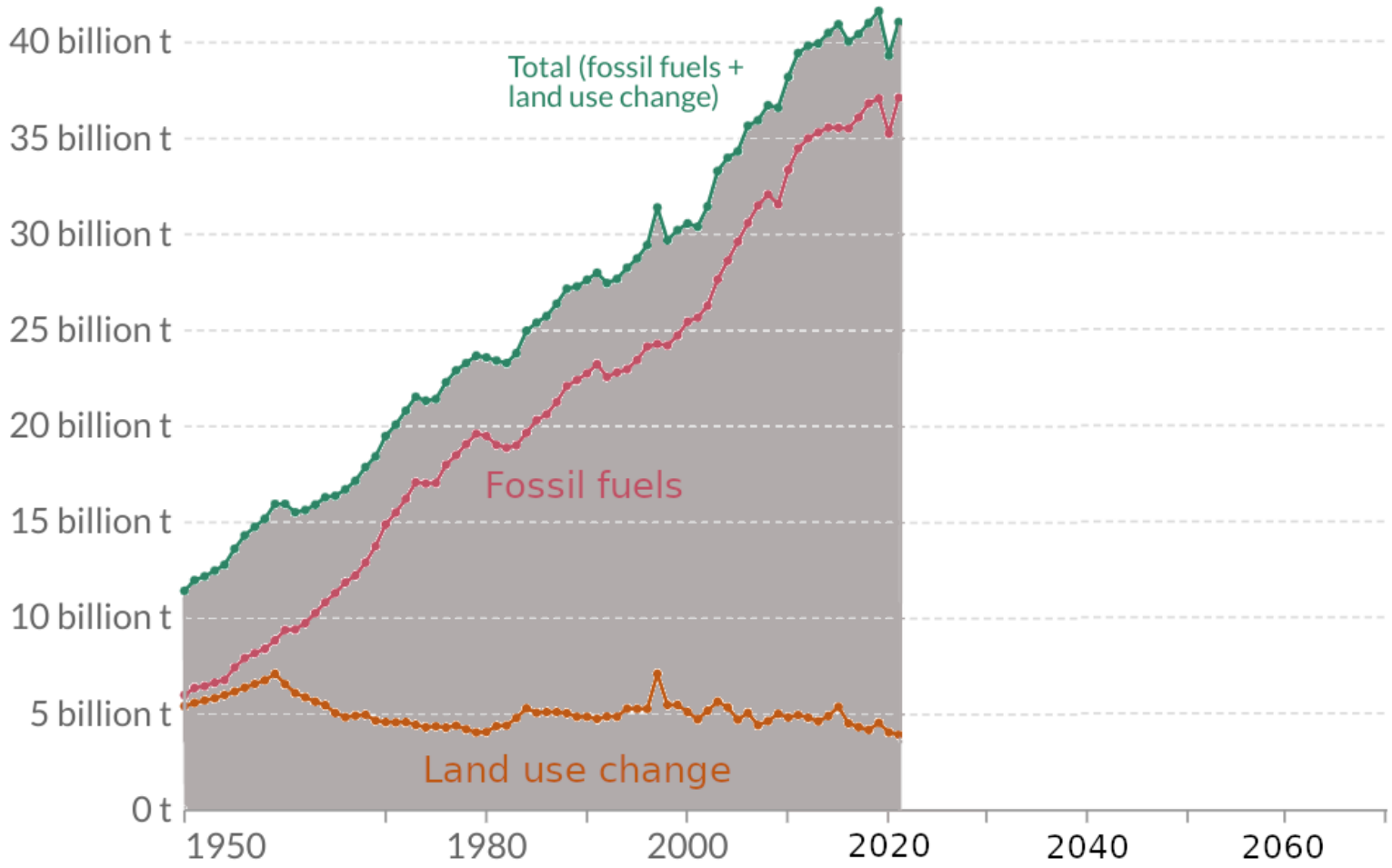
- IPCC definition of sufficiency:
  - *Sufficiency policies are a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being for all within planetary boundaries*
- New in the 6th report for WG3 (energy transition)
  - Much broader representation of social sciences: teams in almost all the chapters (not only climate scientists, economists or engineers)
  - More emphasis on justice and equity. "Just transition" is embedded in multiple chapters.
- Are we on track for 2°C or 1.5 ?
  - Consensus that we are behind on addressing climate change (high confidence)
  - Negative emissions:
    - Most scenarios of 2°C are valid only if we deploy negative carbon technologies globally
    - Technology is studied since more than 50 years, but has not be completely proven yet

# Carbon budget for the world

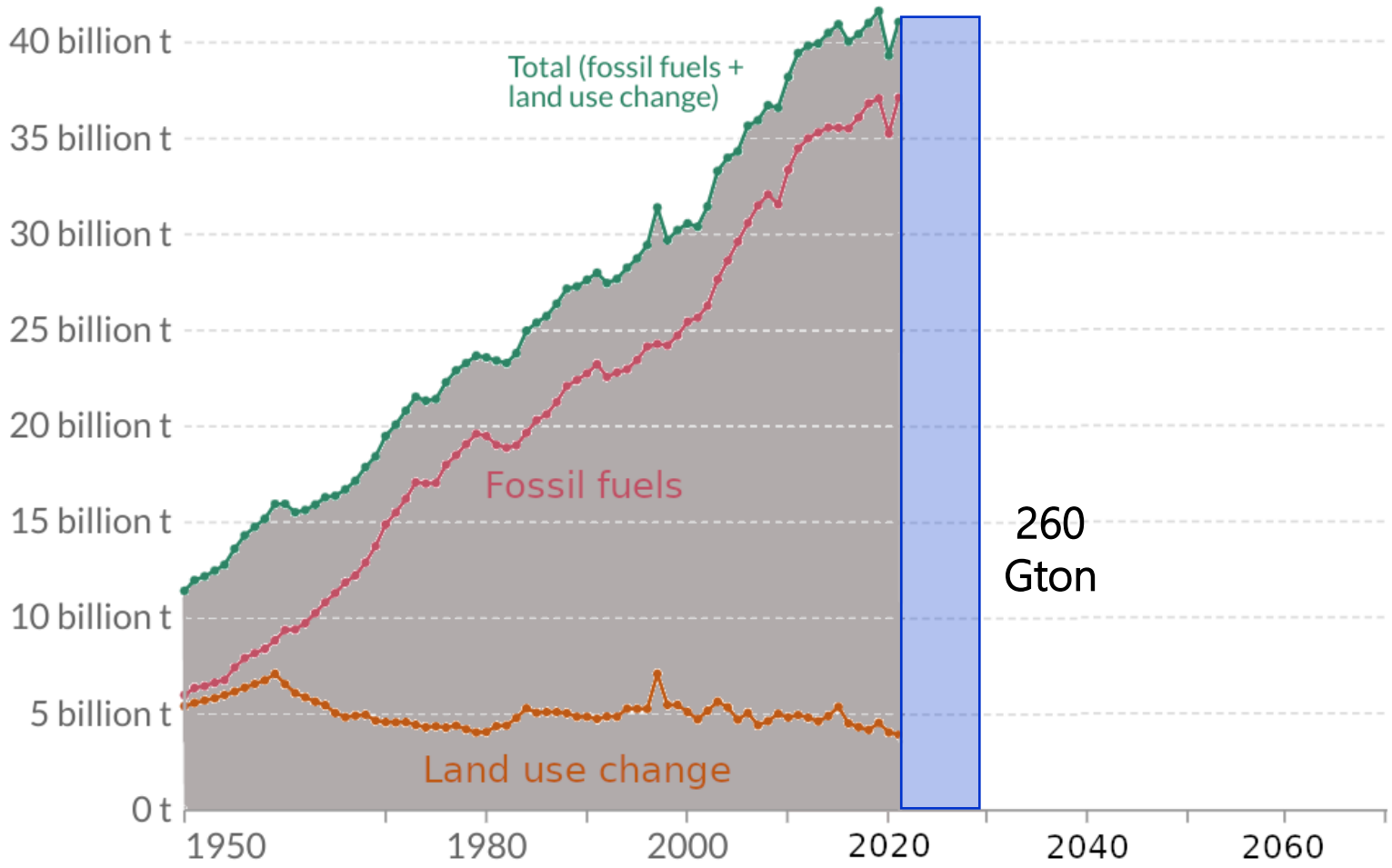



| Likelihood of limiting global warming to temperature limit | Temperature limit of interest compared to preindustrial levels | Estimated remaining carbon bnudget from the beginning of 2020 ($GtCO_2$) | New esttimations in 2023 ($GtCO_2$) |
|---|---|---|---|
| 50%<br>67% | 1.5°C<br>2°C | 510 (IPCC WGIII, 2022)<br>1000 (IPCC WGIII, 2022) | 260<br>950 |

# Carbon emissions

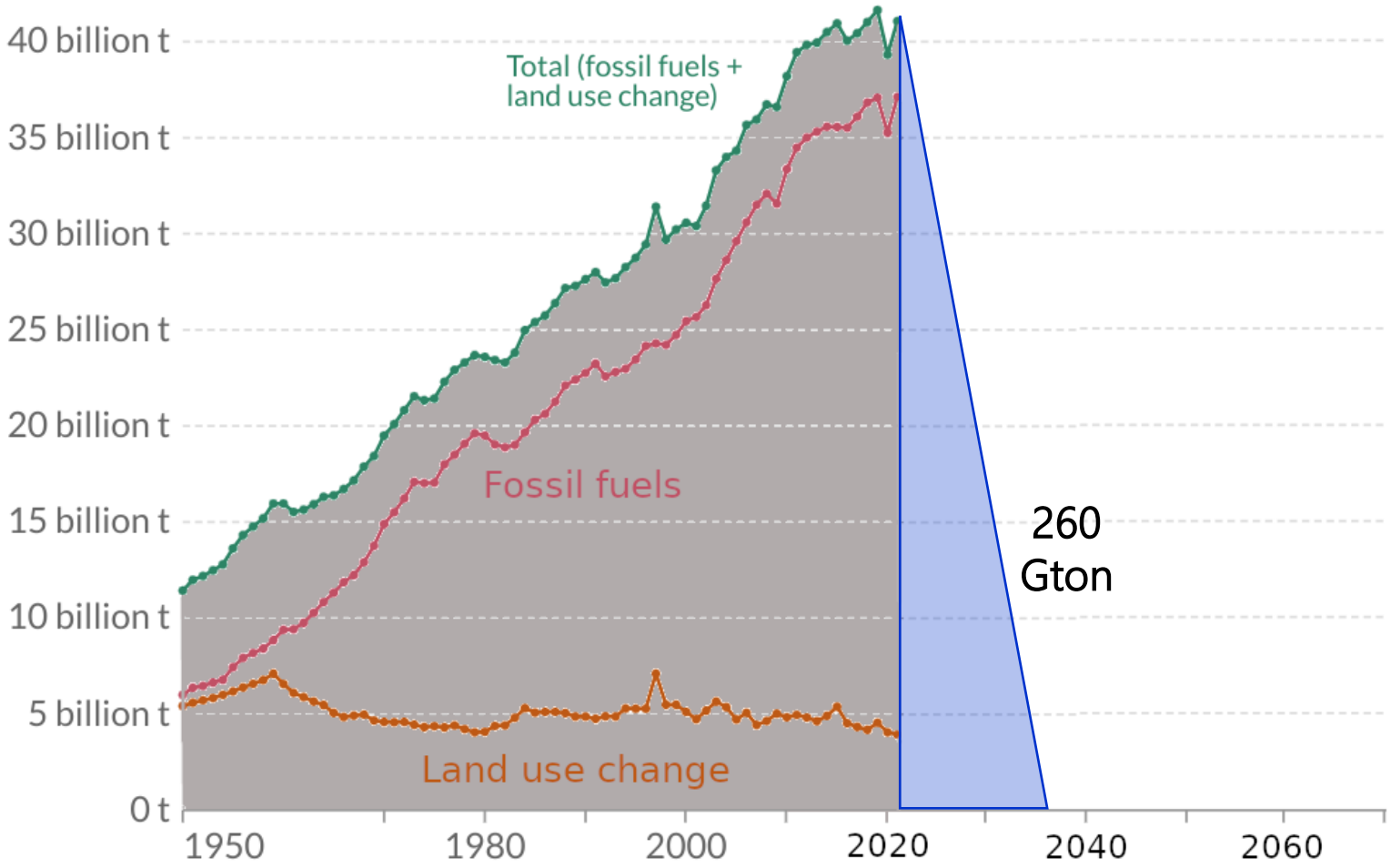


# Carbon Budget



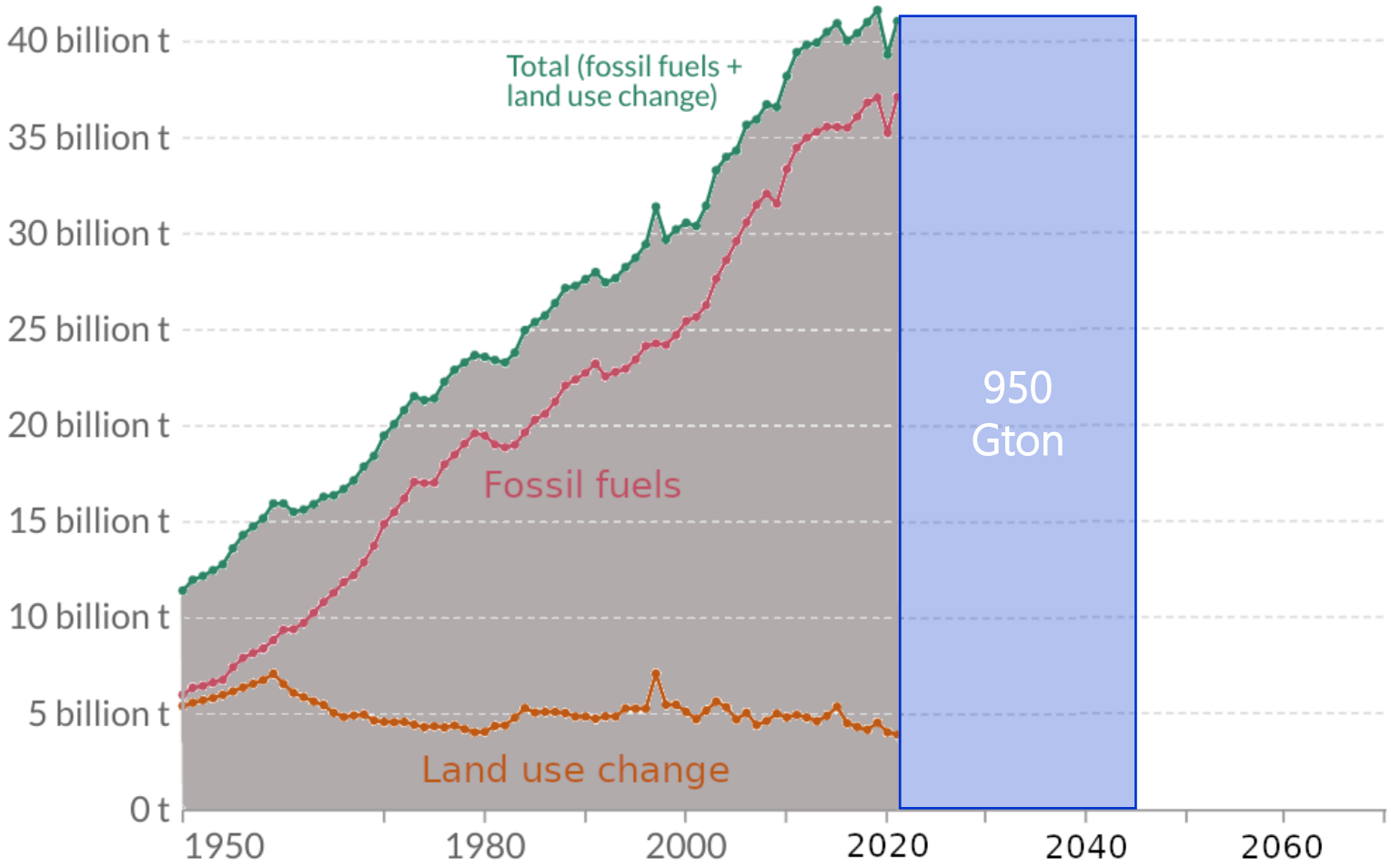

**1.5°C** (with no or limited overshoot)

# Carbon Budget



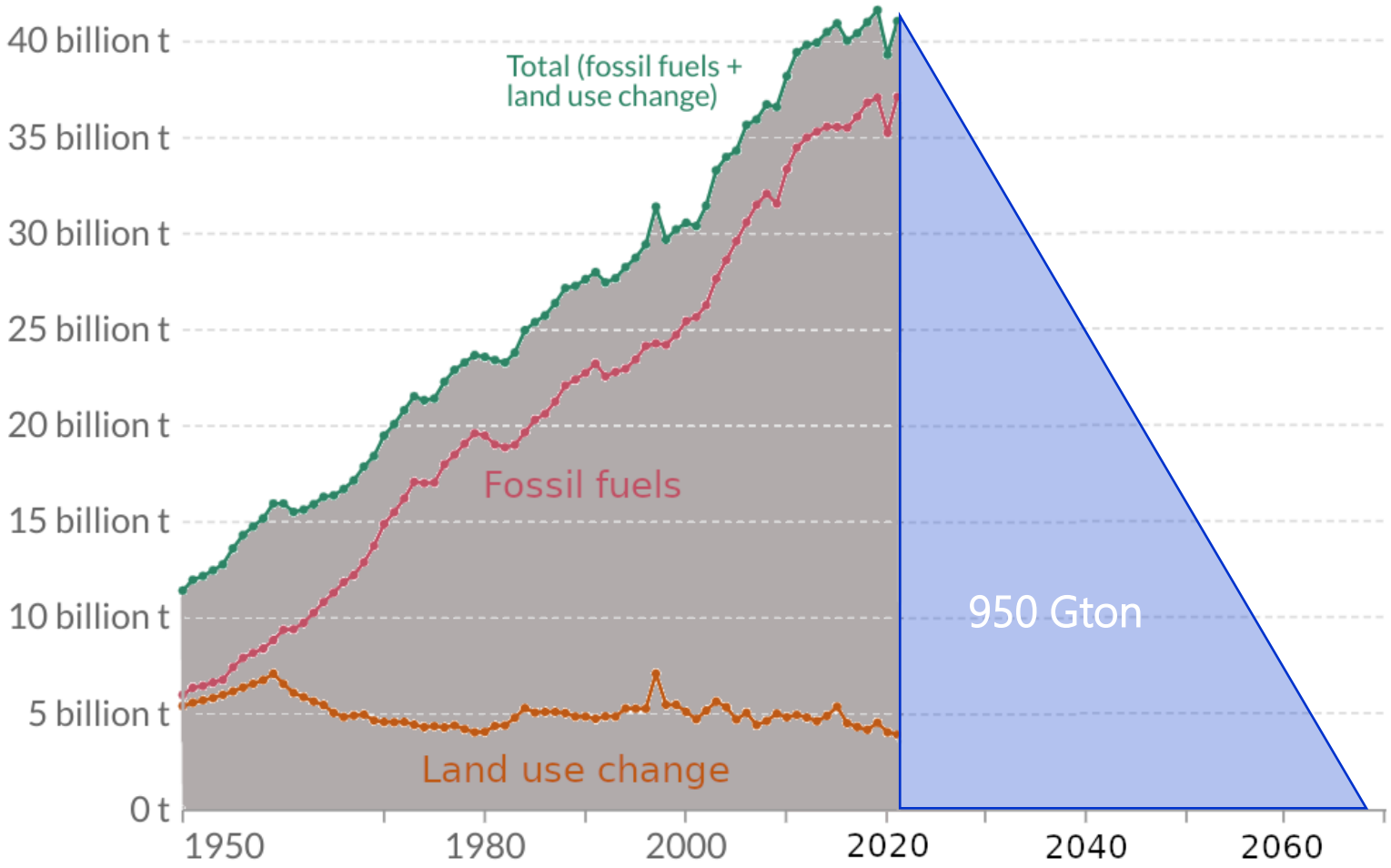

**1.5°C** (with no or limited overshoot)

# Carbon Budget



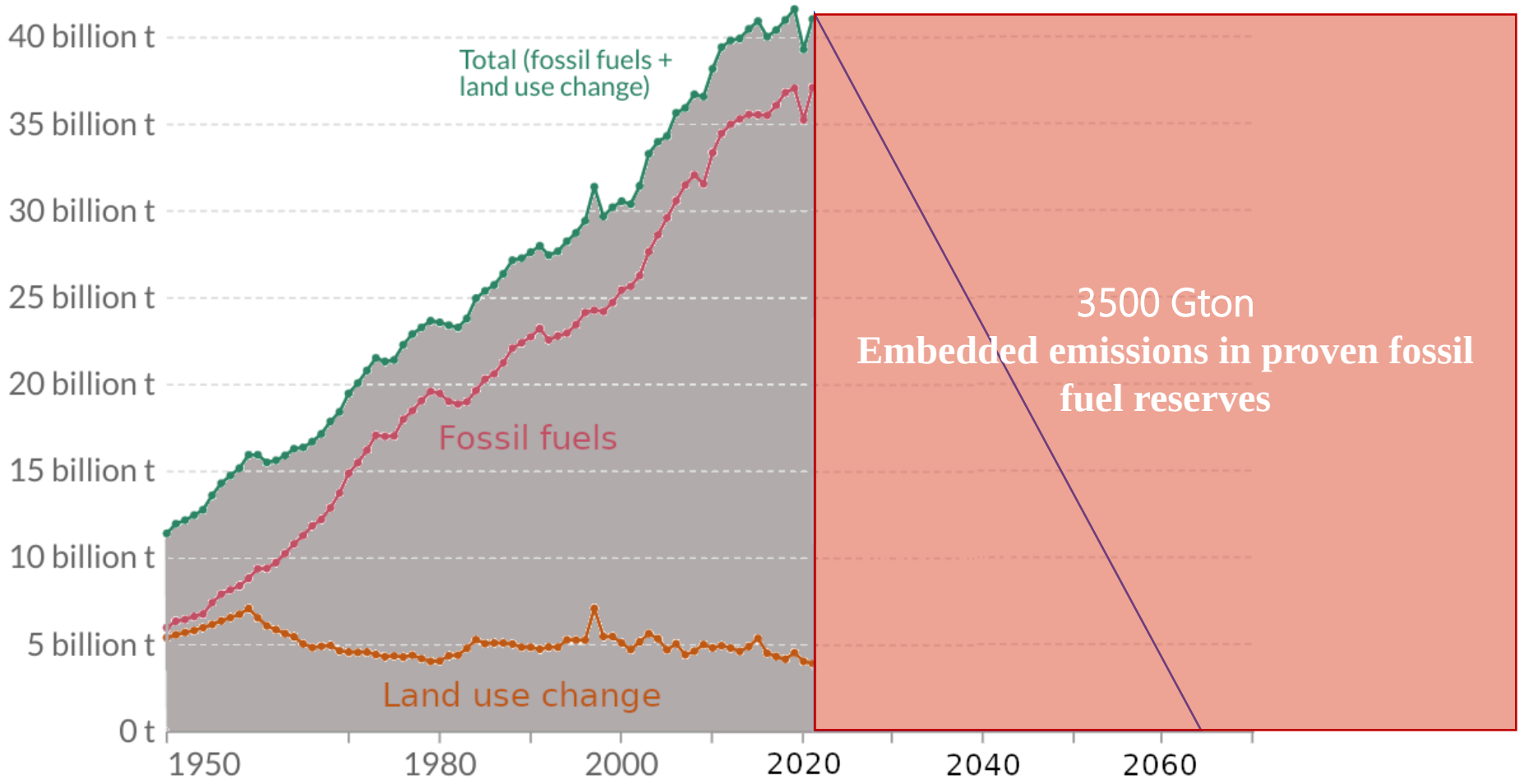

**2°C** (pathway likely limiting warning to)

# Carbon Budget




**2°C** (pathway likely limiting warning to)

# Unburnable carbon

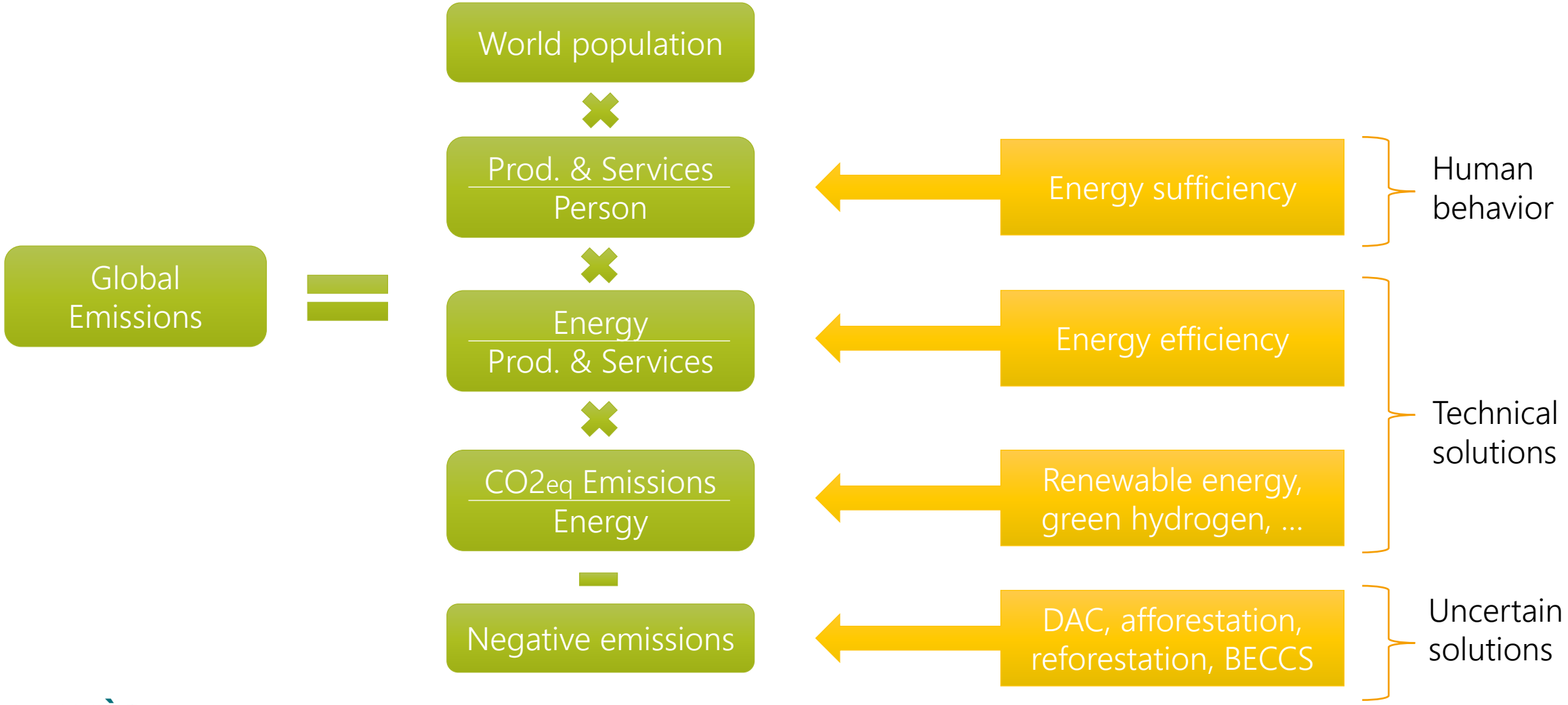



Stranded assets to be retired earlier than expected lifetime (IPCC AR6 WGIII)

Data source: The Global Registry of Fossil Fuels (reported by The Guardian)

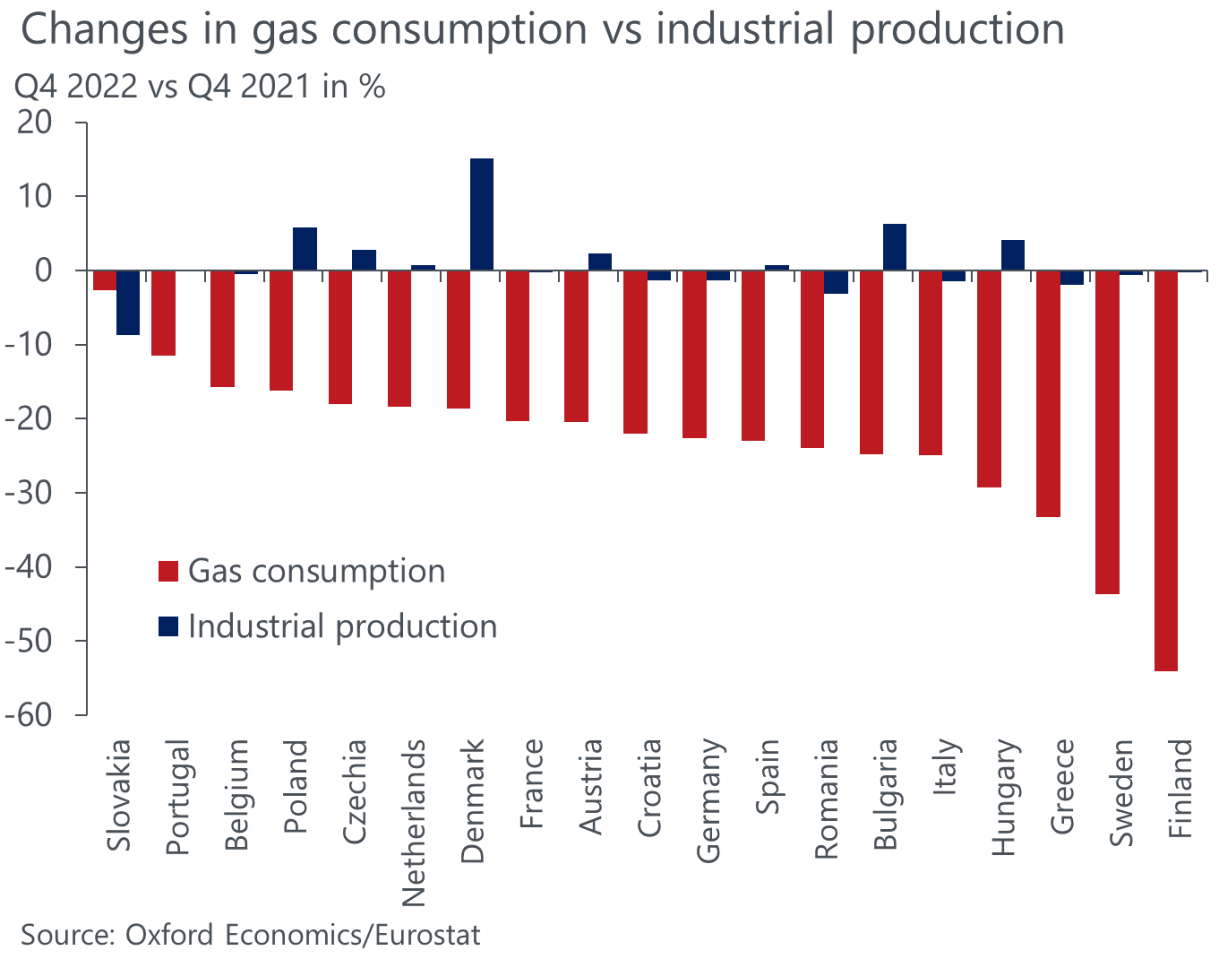
# Kaya's identity

## Energy sufficiency, efficiency and clean techs are complementary!




Adapted from B. Best, Suffizienz in deutschen Energiescenarien, 2021

# Energy sufficiency is has already been tested in 2022!



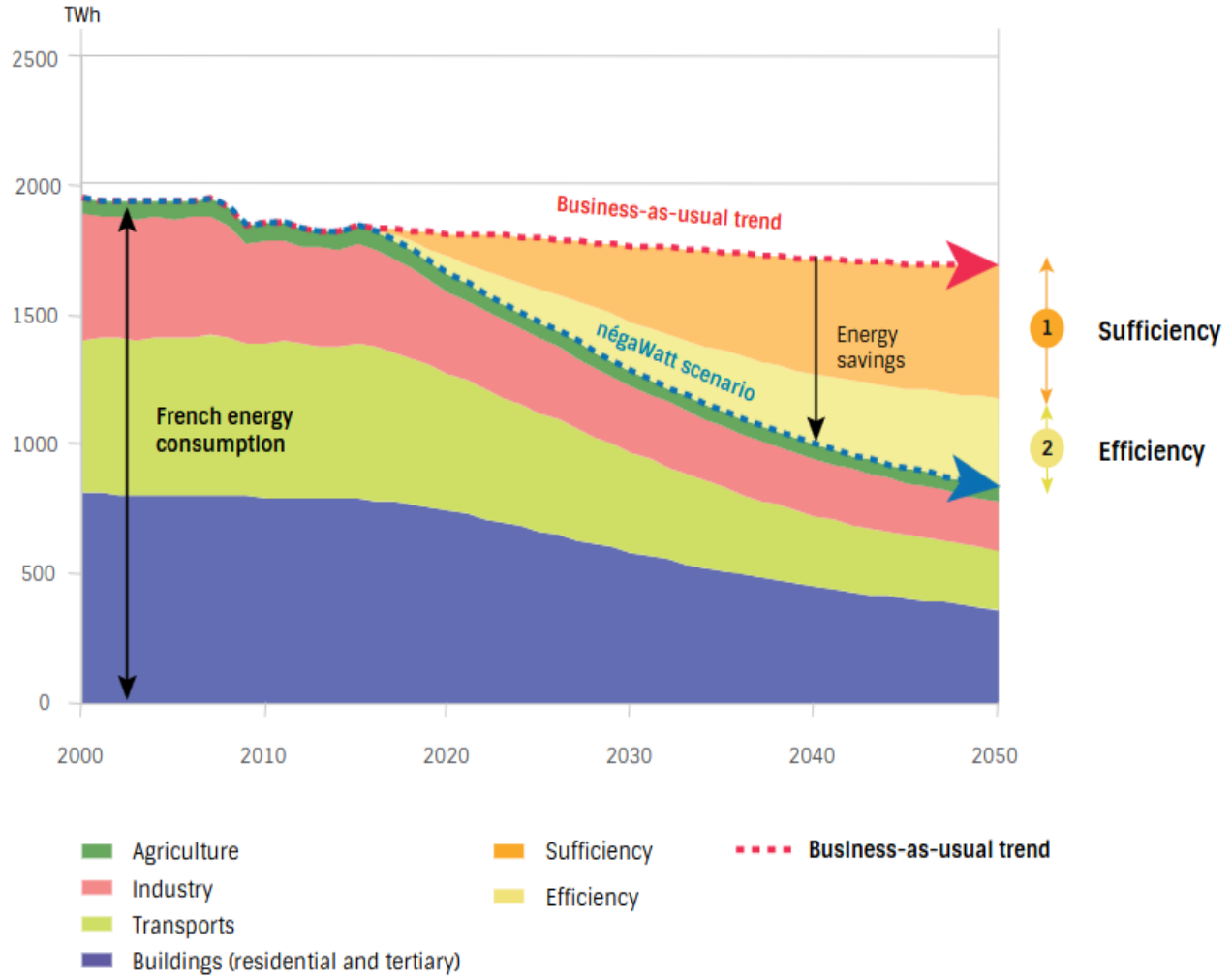
Source: Oxford Economics/Eurostat

LIÈGE université

# EU energy sufficiency scenario

# Energy Sufficiency

- Transition towards climate neutral, sustainable and flexible economies
- Decreasing the overall demands by sufficiency measures (use of smaller cars, lower road speed, lower temperatures for space heating, car-sharing, home office, slow tourism, etc.
- Individual and societal approach to decrease over consumption
- Respecting the planetary boundaries



# The CLEVER Scenario

- Bottom-up approach
- Carbon neutral by 2050 with 100% renewable technologies
- National sufficiency trajectories aggregated into a European pathway
- Quantifying the energy consumption at national level including the sufficiency assumptions
- Defining minimum consumption level on individual basis by prioritizing essential needs
- Carbon budget to reach 1.5C scenario

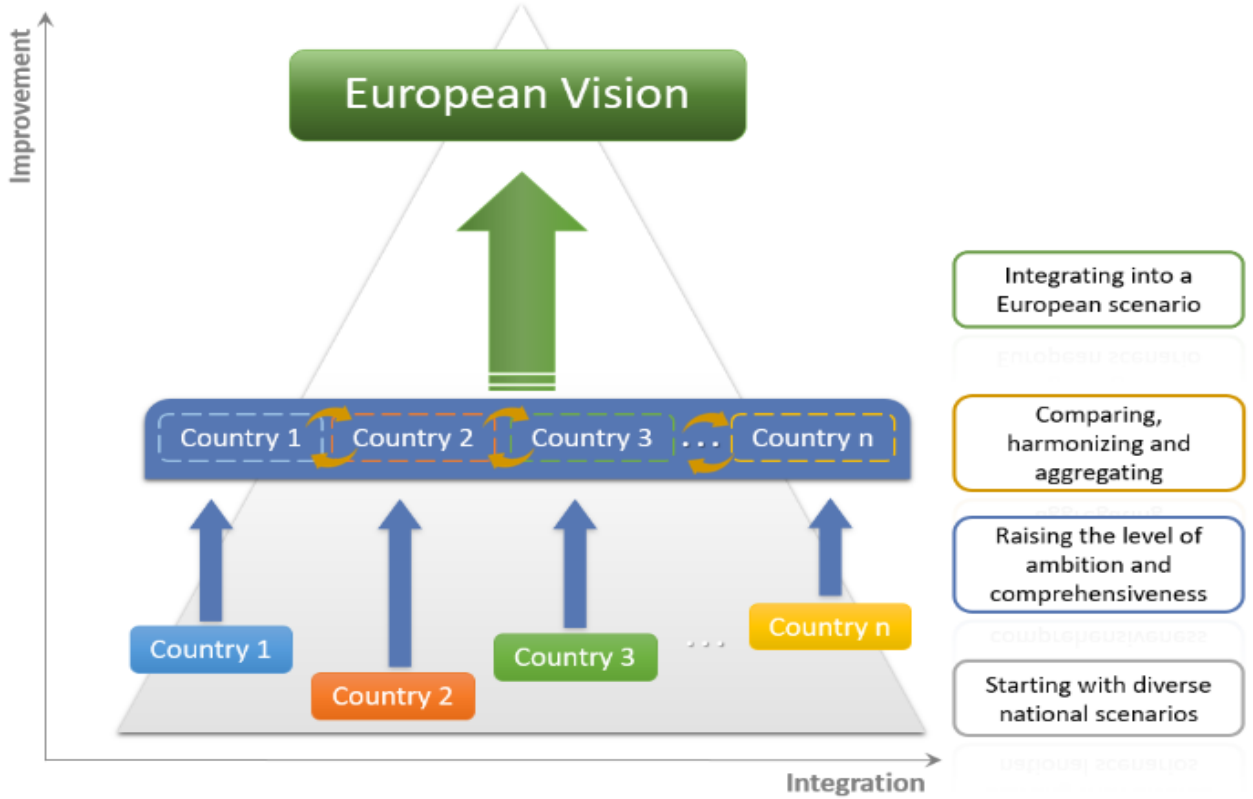
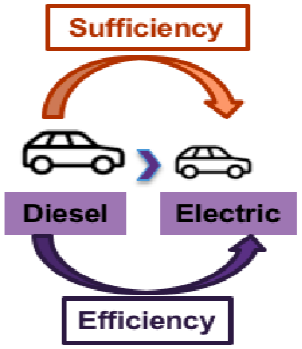
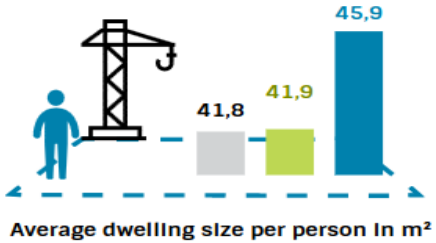
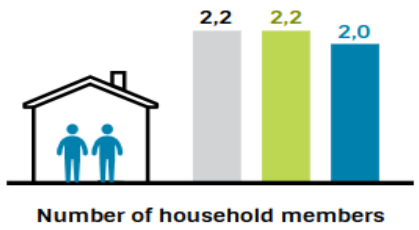



Image credentials: Clever – A Collaborative Low Energy Vision for the European Region – Final Report, June 2023

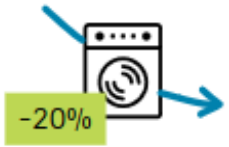
# CLEVER Sufficiency Assumptions

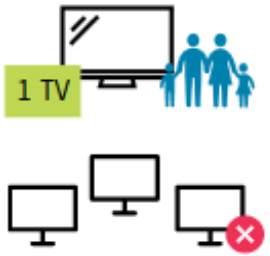


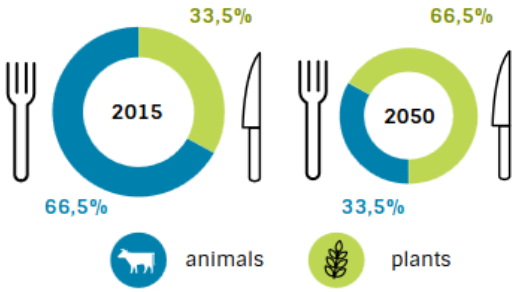

In 2015
In 2050, in the négaWatt scenario
In 2050, business-as-usual

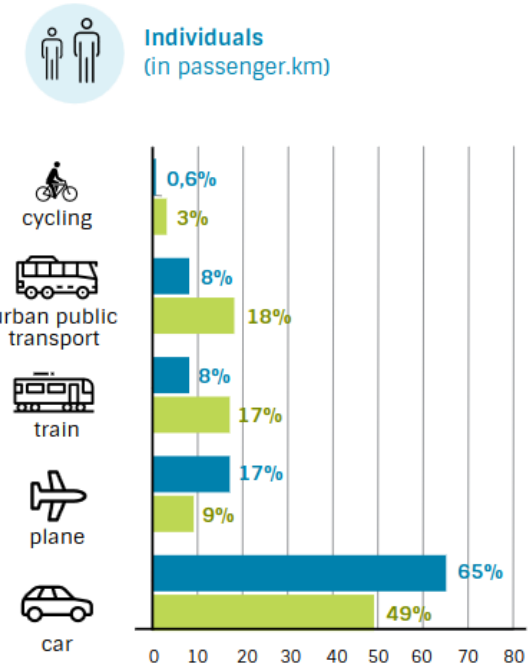


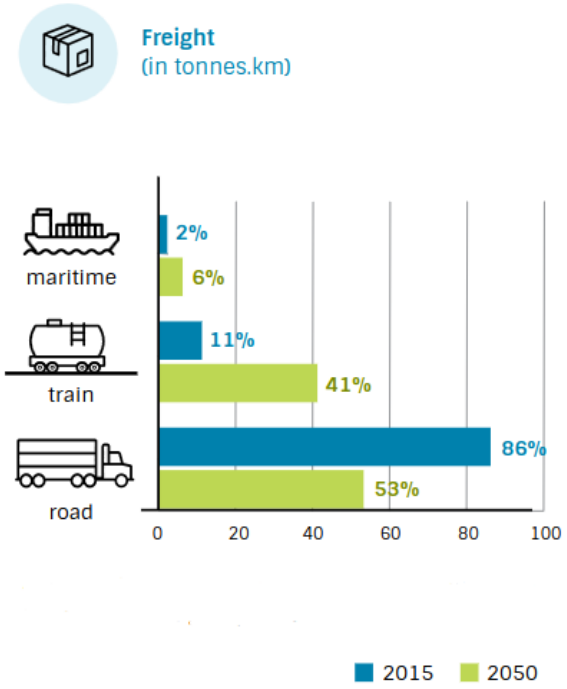





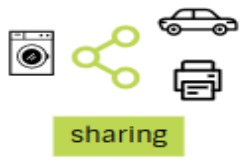




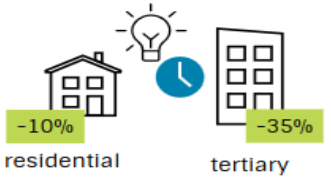



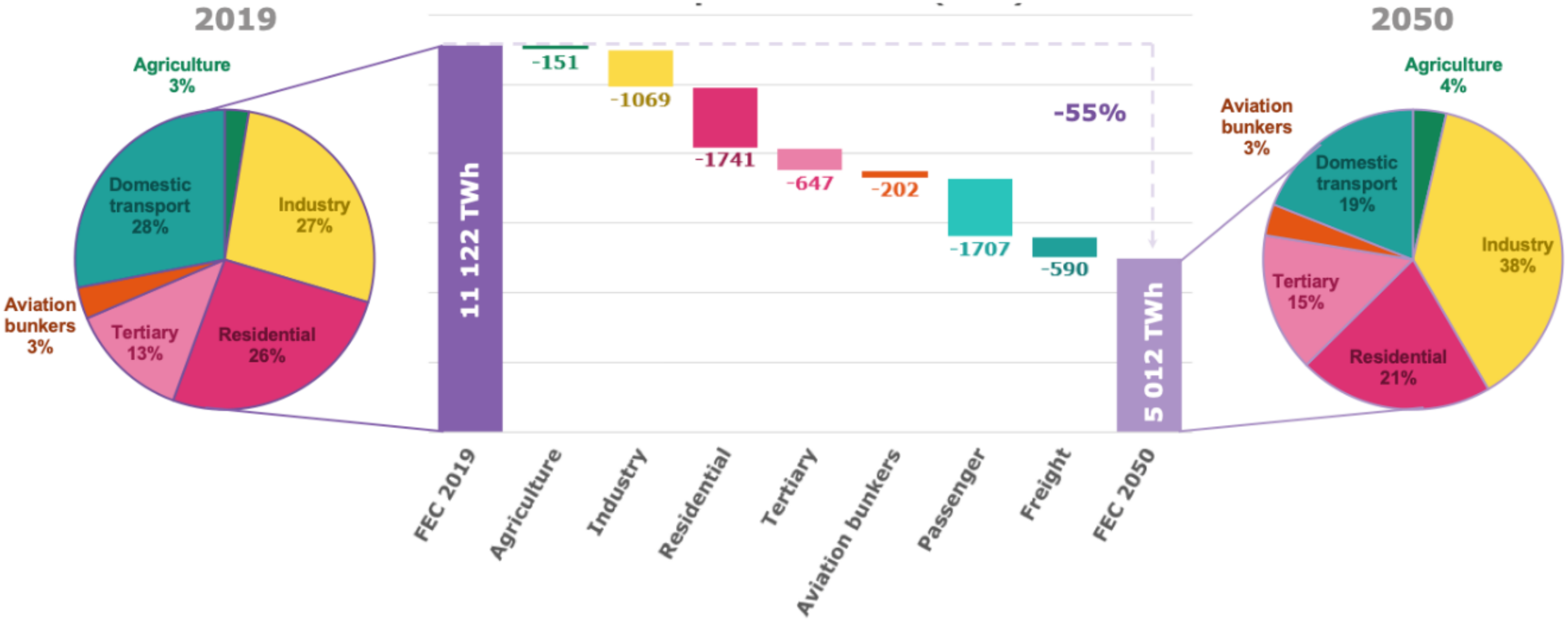






# Demands in 2050



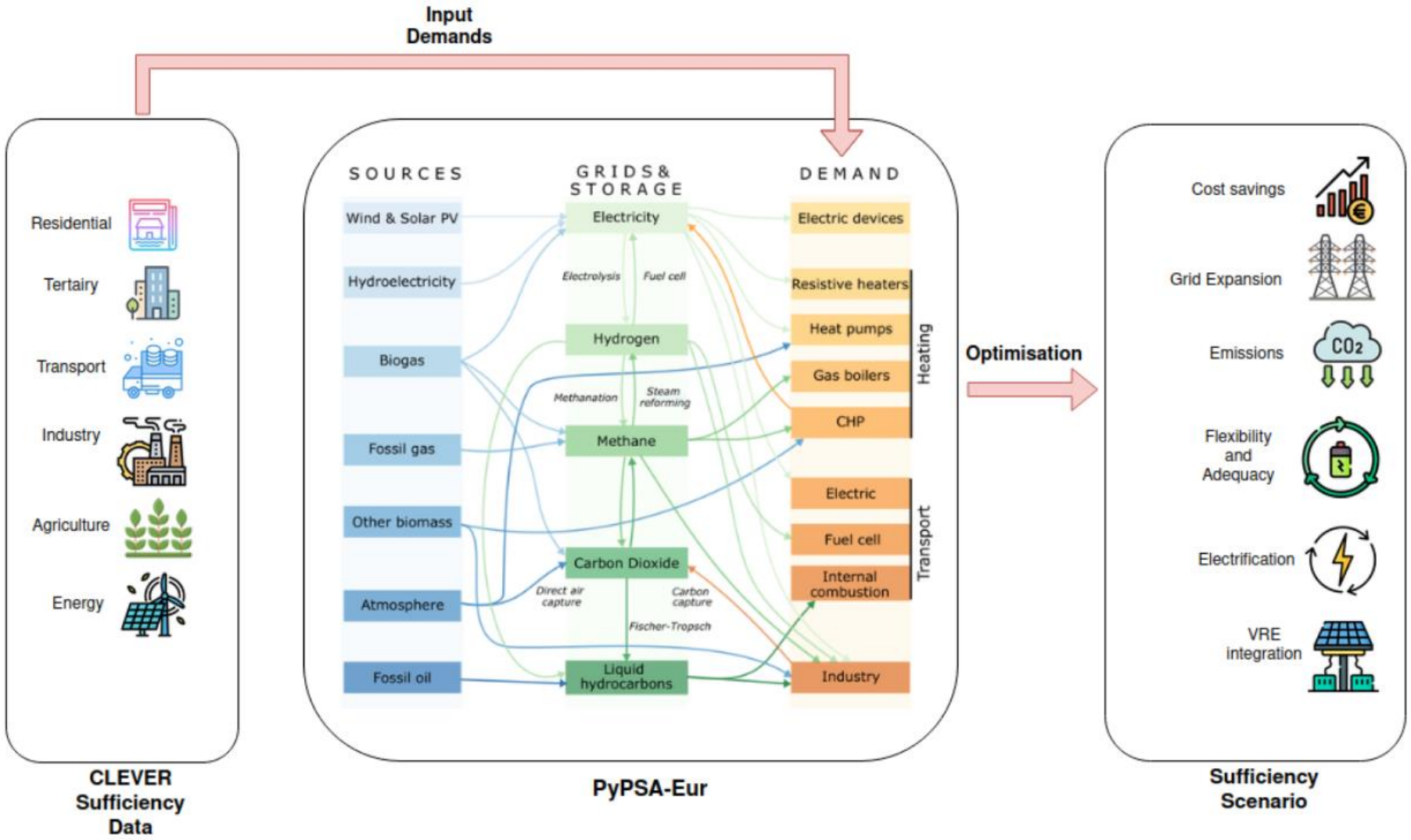

-55% reduction in final energy consumption
-20% to -30% thanks to energy sufficiency

Image credentials: Clever – A Collaborative Low Energy Vision for the European Region – Final Report, June 2023

# Policy instruments: some examples

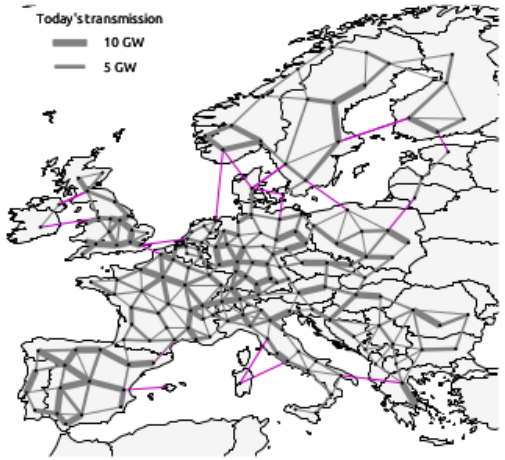
- Cross-sectoral:
  - Progressive tariff systems for energy and water (economic - pricing)
- Agriculture:
  - Vegan/ vegetarian dishes / organic food served at catering kitchens (voluntary agreements);
  - Minimum environmental criteria for collective food procurement and preparation for public administration
- Buildings:
  - 19 °C set point in winter in public buildings (regulation) and
  - awareness raising campaigns for consumers (information),
  - limit land take/soil sealing (regulation),
  - support collective living and encourage swapping of households (fiscal and information).
- Industry:
  - Tax bonus for repairing objects (fiscal - subsidy),
  - prohibit planned obsolescence (regulation),
  - labelling and car emissions regulations (regulation),
  - minimum targets for recycled content in new products and set targets for recycling capacity (regulation),
  - integrating consumption reduction targets for materials (for base and critical raw materials) and limiting the growth of strategic raw materials use
- Moblility
  - Integrated urban planning, promote 15-minutes city model (fiscal - public expenditures for infrastructure),
  - improved rail and active mobility infrastructure (fiscal - public expenditures for infrastructure),
  - promote carpooling (fiscal - subsidy and infrastructures),
  - promote small and light vehicles (regulation),
  - flight bans where a suitable alternative is available (regulation)

# A sector-coupled EU-wide Energy System Model

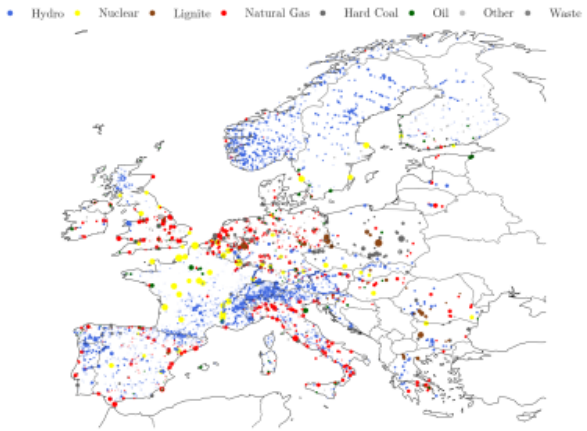


# PyPSA Open data workflows

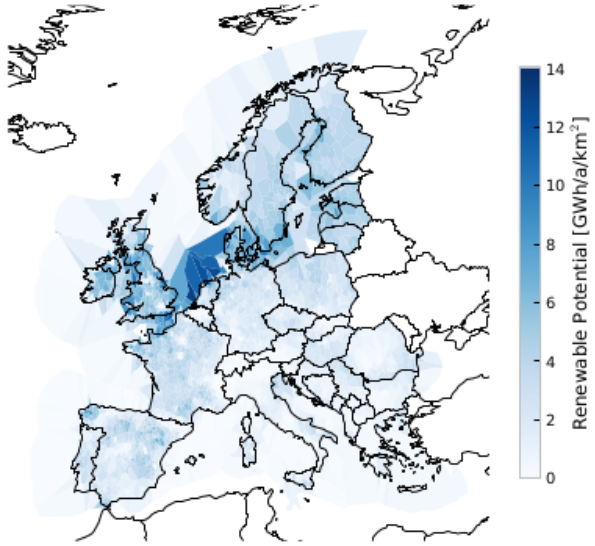
clustered network model



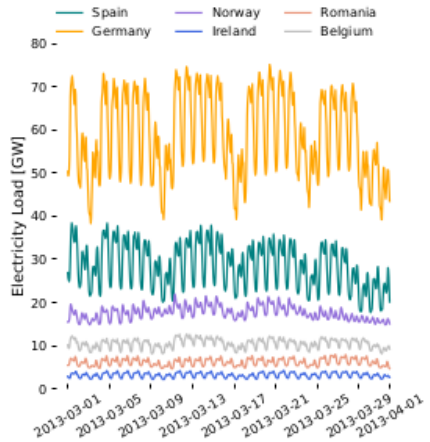

power plants and technology assumptions




renewable potentials and hourly time series for each region




demand projections time series



# Simulations

## Sufficiency Scenario

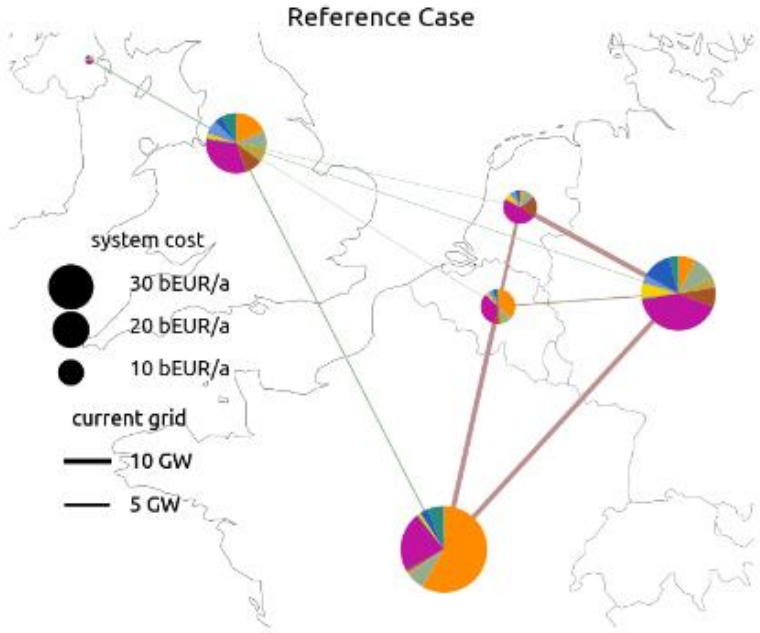
- Sufficiency scenario based on CLEVER sufficiency scenario for Belgium, France, Germany, Netherlands and Great Britain
- Carbon budget for 1,5°C.
- sufficiency measures
  - lower temperatures for space and water heating,
  - less car and air travel and
  - increased rail travel,
  - electrification of heating sector,
  - low oil and gas consumption in industry
  - etc

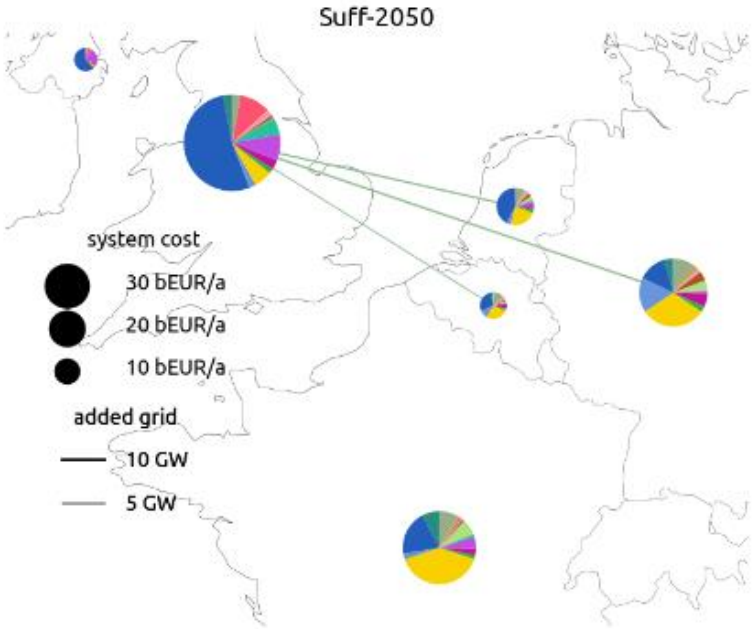
## BAU (reference) Scenario

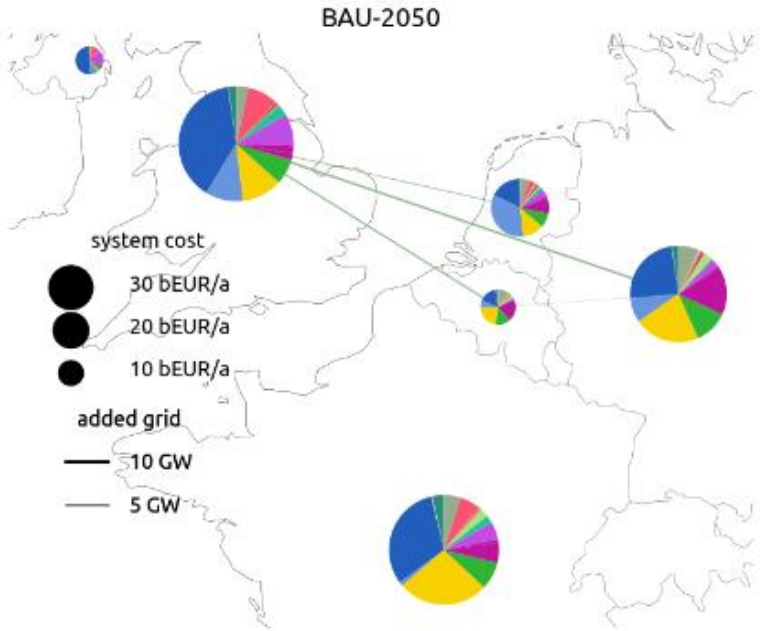
- Baseline scenario based on current energy systems in 5 countries
- Total demands in the sectors based on Eurostat data
- Consideration of already installed technologies

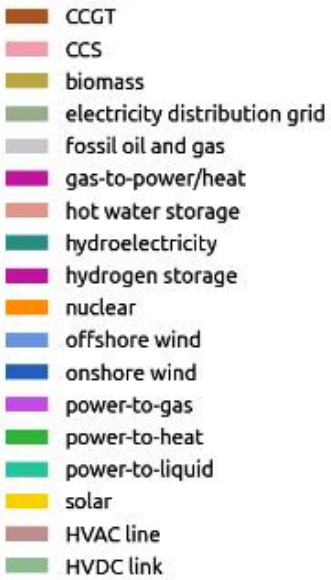
## BAU 2050 Scenario

- Baseline scenario with current demants
- Net zero by 2050

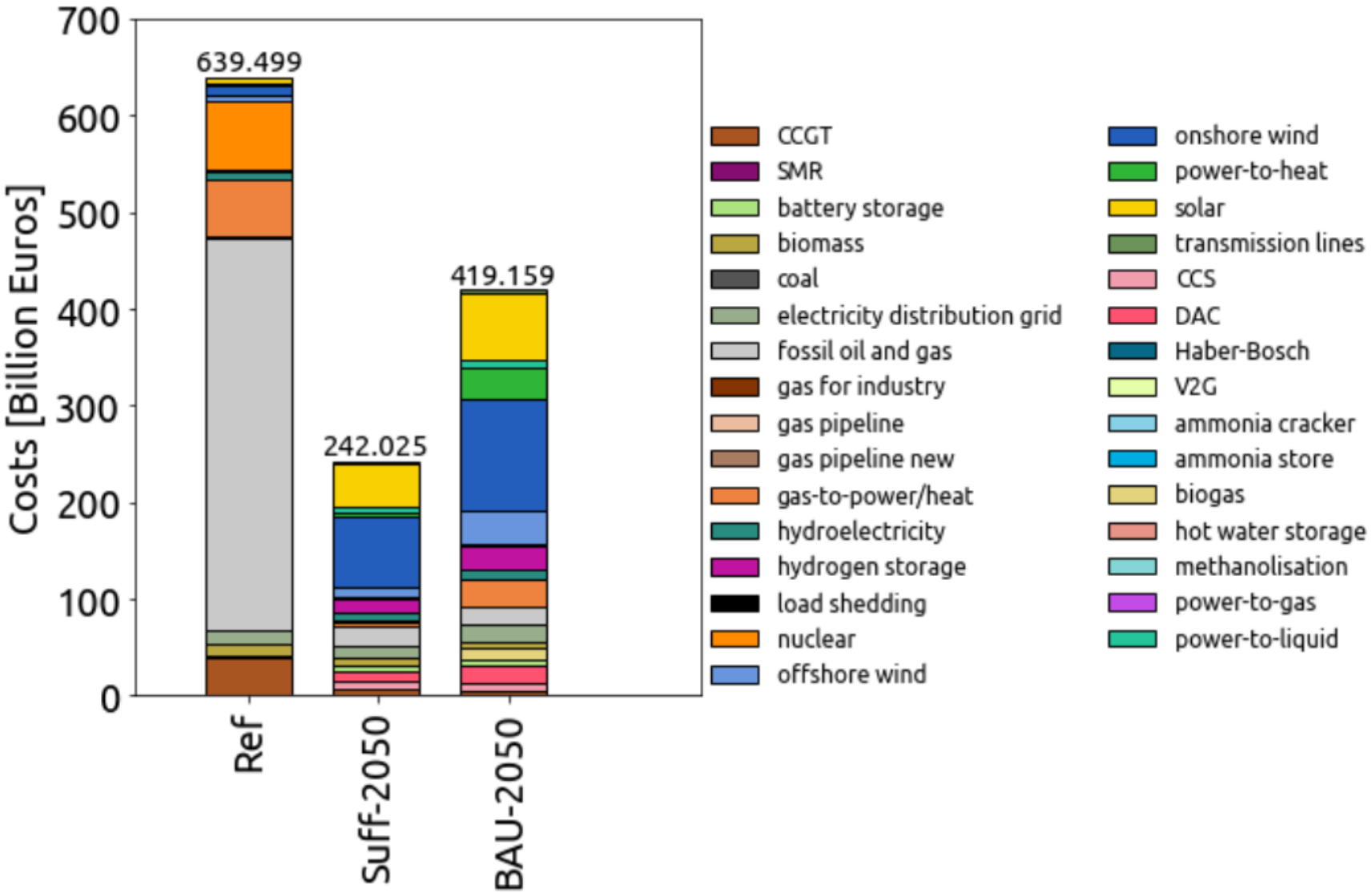

Reference Case
system cost
30 bEUR/a
20 bEUR/a
10 bEUR/a
current grid
10 GW
5 GW


Suff-2050
system cost
30 bEUR/a
20 bEUR/a
10 bEUR/a
added grid
10 GW
5 GW

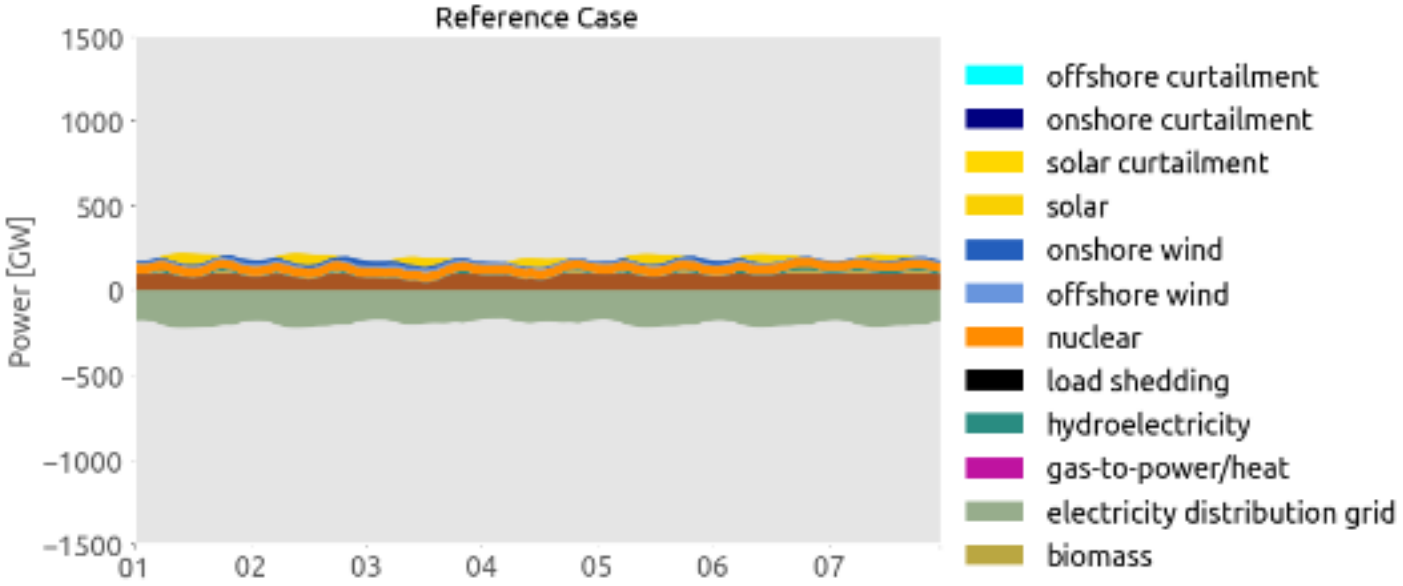

BAU-2050
system cost
30 bEUR/a
20 bEUR/a
10 bEUR/a
added grid
10 GW
5 GW

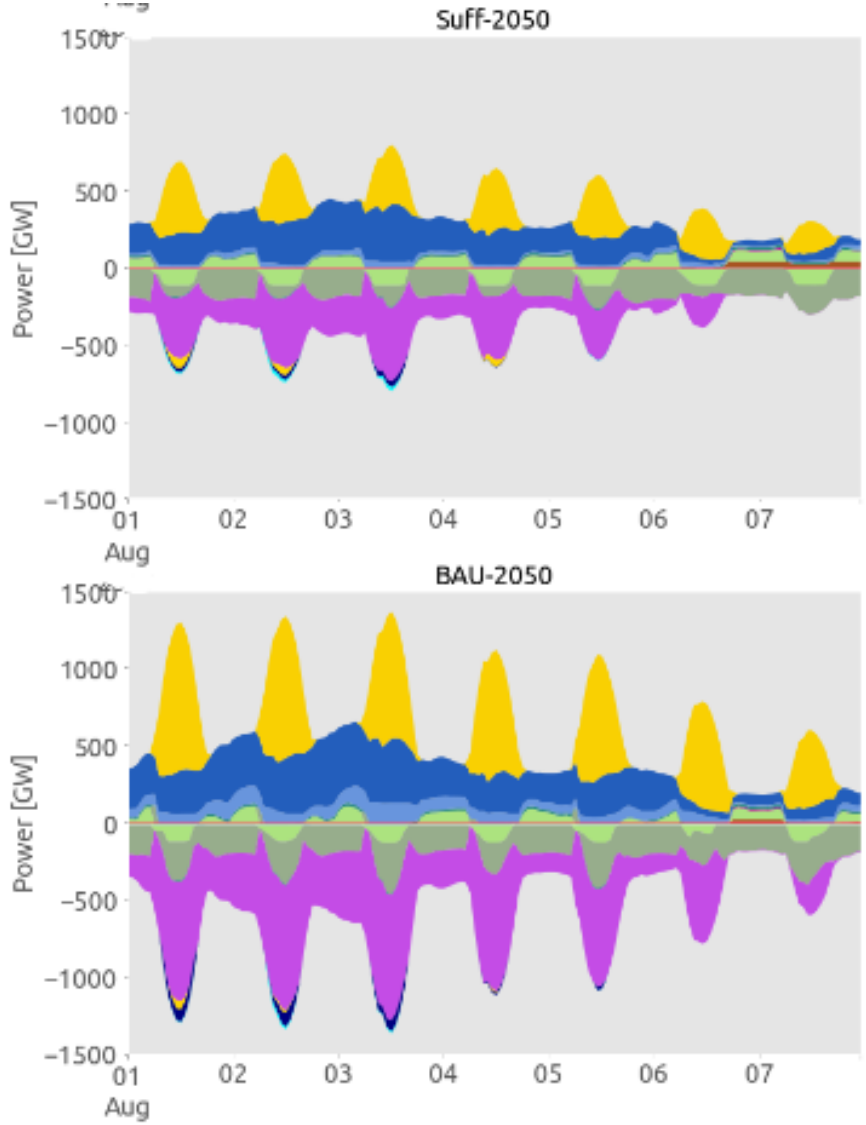

CCGT
CCS
biomass
electricity distribution grid
fossil oil and gas
gas-to-power/heat
hot water storage
hydroelectricity
hydrogen storage
nuclear
offshore wind
onshore wind
power-to-gas
power-to-heat
power-to-liquid
solar
HVAC line
HVDC link

# Total Costs


Costs [Billion Euros]
700
600
500
400
300
200
100
0
639.499
242.025
419.159
Ref
SuFF-2050
BAU-2050
CCGT
SMR
battery storage
biomass
coal
electricity distribution grid
fossil oil and gas
gas for industry
gas pipeline
gas pipeline new
gas-to-power/heat
hydroelectricity
hydrogen storage
load shedding
nuclear
offshore wind
onshore wind
power-to-heat
solar
transmission lines
CCS
DAC
Haber-Bosch
V2G
ammonia cracker
ammonia store
biogas
hot water storage
methanolisation
power-to-gas
power-to-liquid

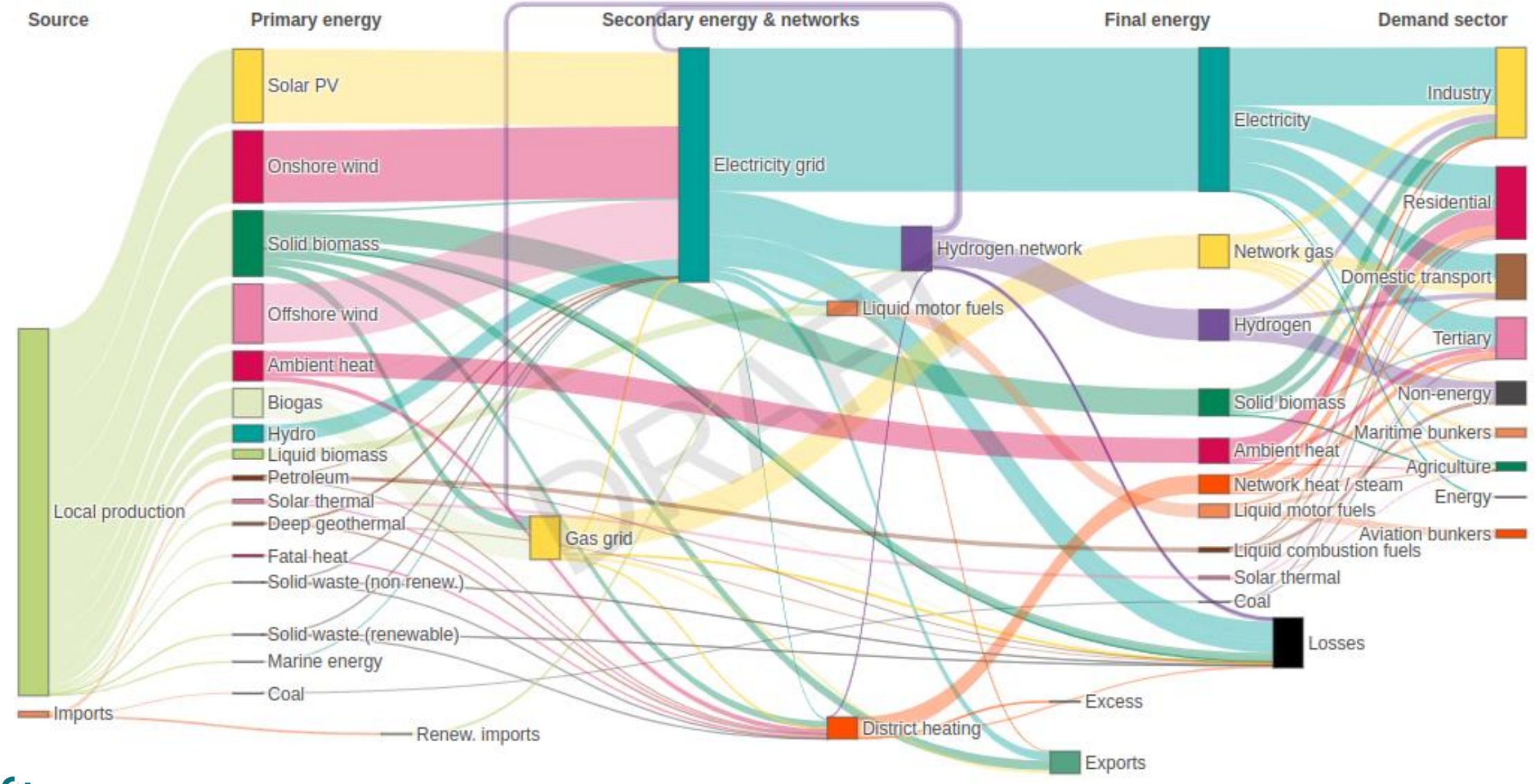
# Electricity Dispatch




Electricity Dispatch in Summer

# Sankey Diagram (Sufficiency Scenario, 2050)



# Conclusions

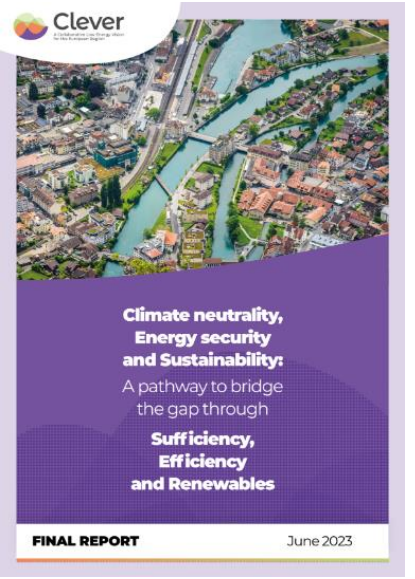
- Do not oppose technology and sufficiency/behavioral changes!
- Sufficiency, efficiency and renewables make new nuclear or CCS avoidable
- Europe can be freed from its dependency on energy imports
- Important cost savings with sufficiency measures
- Increased electrification due to P-to-X technologies and reduced hydro-carbon usage
- Work in progress! Future works will focus on:
  - Refined modeling of EU-28 countries
  - Detailed adequacy and flexibility analysis beyond 2030
  - Include sufficiency data for missing sectors

*Thank you very much for you attention!*

For more information on the topic:

Clever | A Collaborative Low Energy Vision for the European Region

https://clever-energy-scenario.eu/

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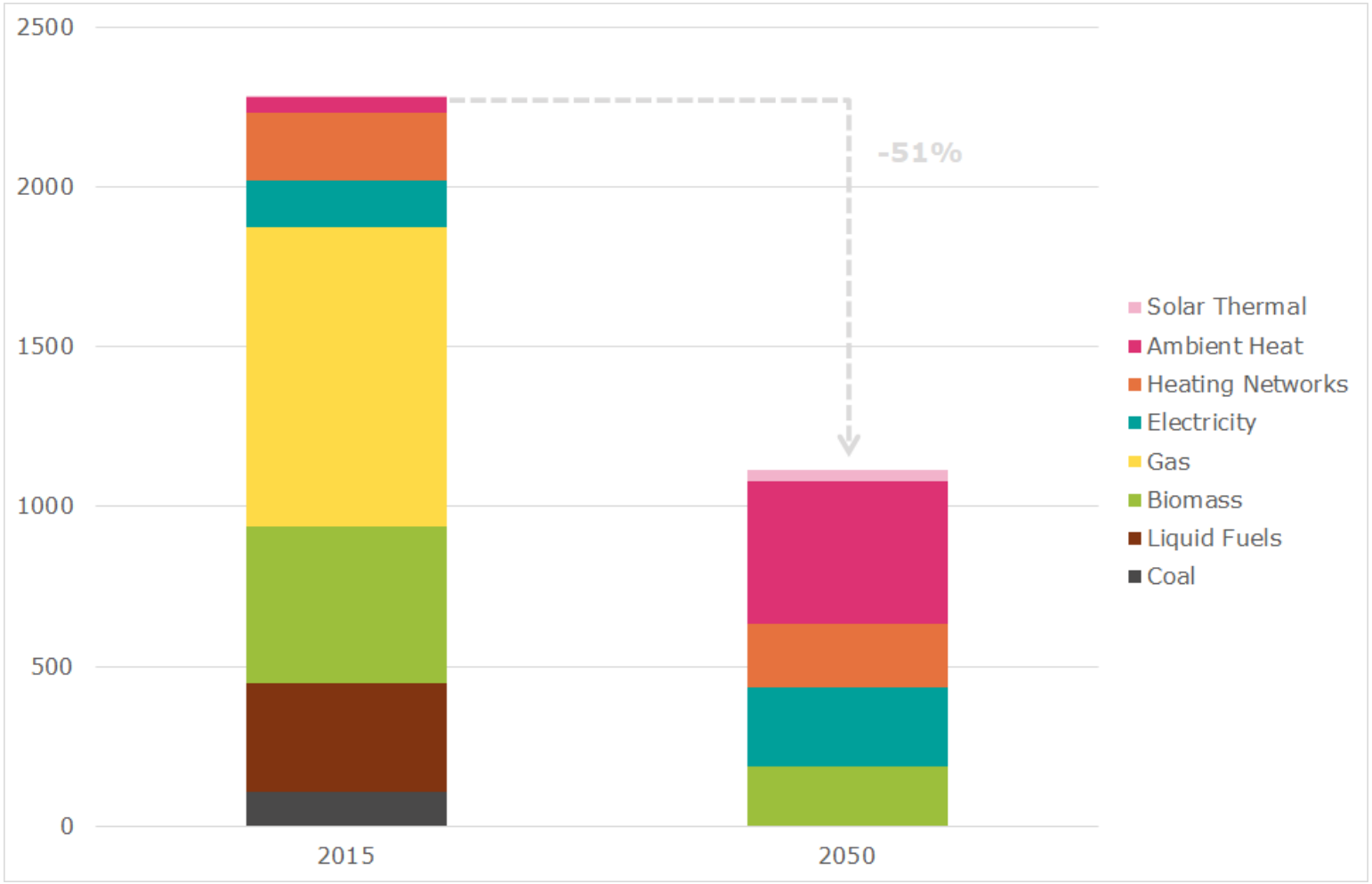
# Contributions (NDCs)

- Emission gap:
  - The contributions have already been watered down.
  - even if we meet the pledges, not on track for 2°C
  - Estimated to 10 to 16 Gton/yr emission gap for 2°C
- Implementation gap:
  - Gap between the NDC and what the countries actually deliver.
  - Estimated to 4 Gton/yr

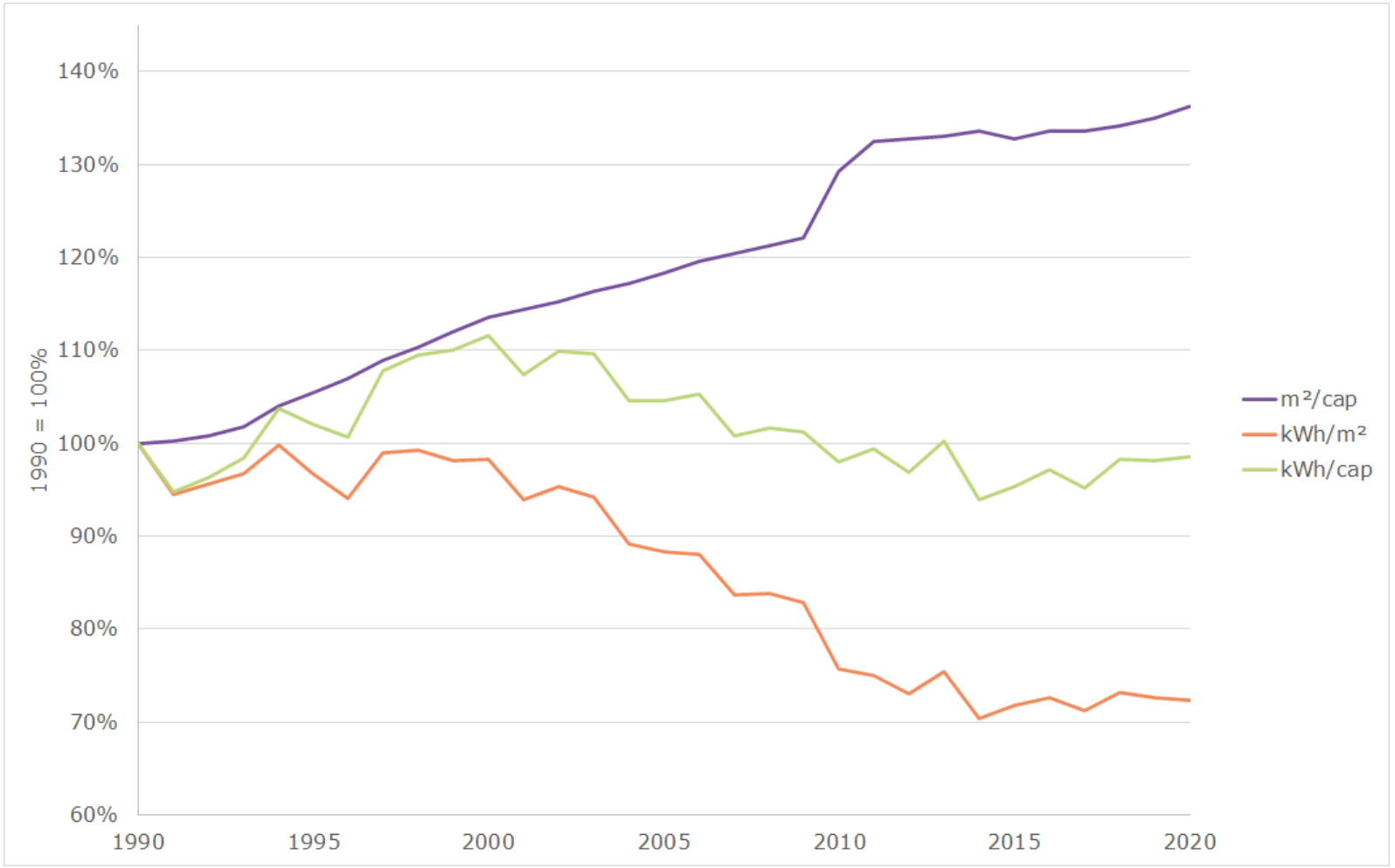
# CCS

- Multiple concepts: CDR (carbon dioxide removal), BECCS, negative emission technologies, LULUCF, Direct air capture
- In 2021, 40 Mt CO2 captured
- Snohvid in Norway: operating since 1996. Displaces oil.
- To date globally, 28 CCS plants are developed to the operational stage
  - 2 are currently suspended
  - 22 using the CO2 captured for enhanced oil/gas recover
  - five of them with integrated dedicated geological storage
- Smokescreen from the oil industry to keep operating?
- BECCS: is biomass carbon neutral?
- Hard-to-abate sectors: interesting but not carbon negative

# Space Heating (TWh)

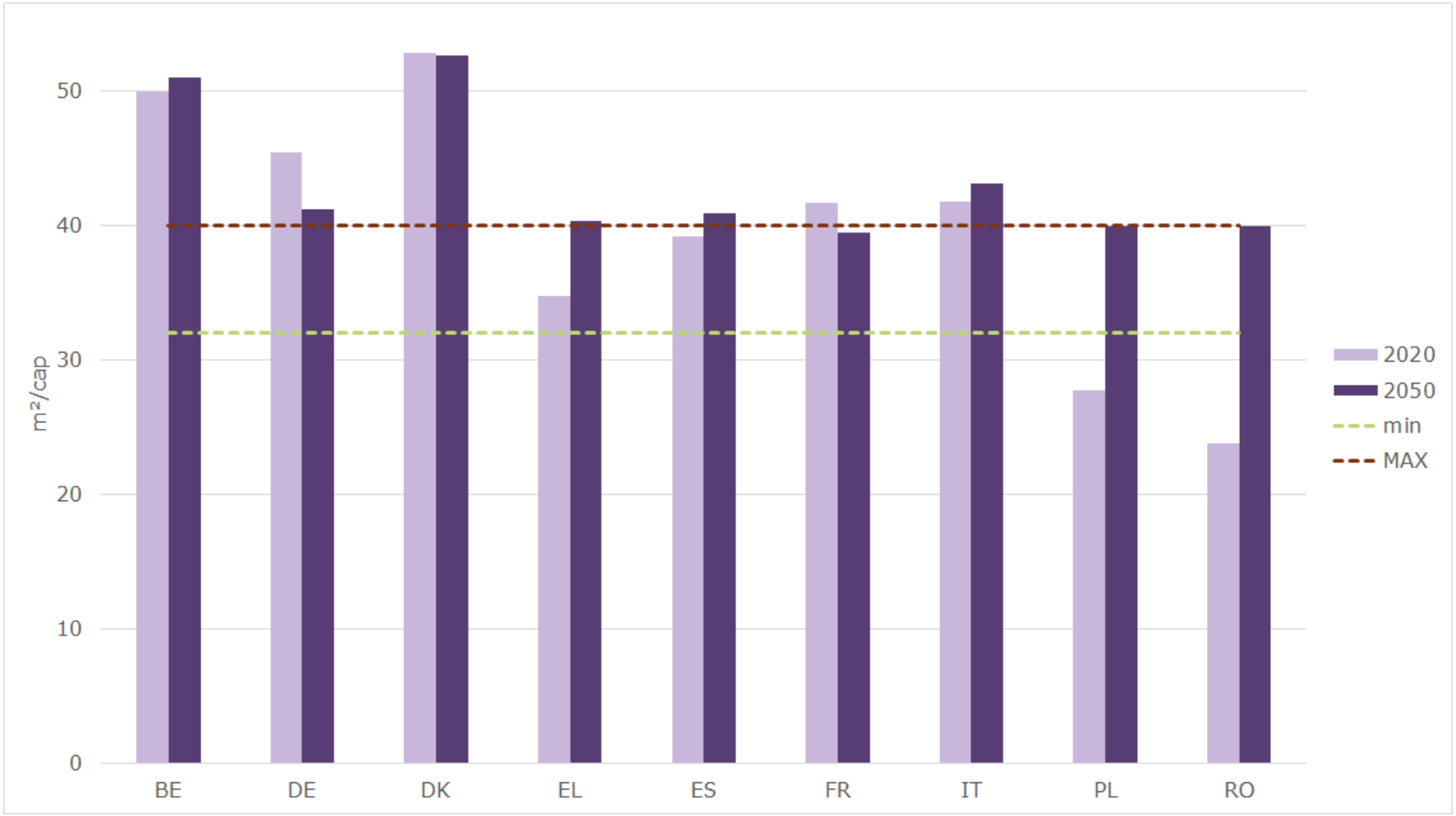


# Living area: historical trends

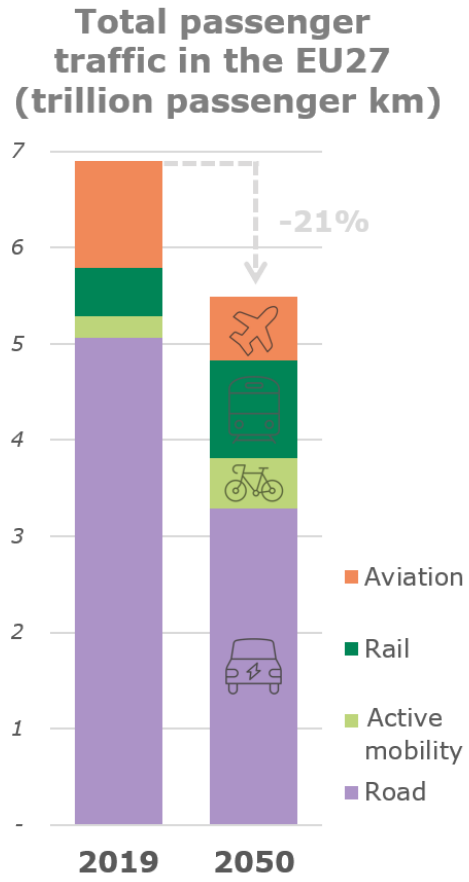


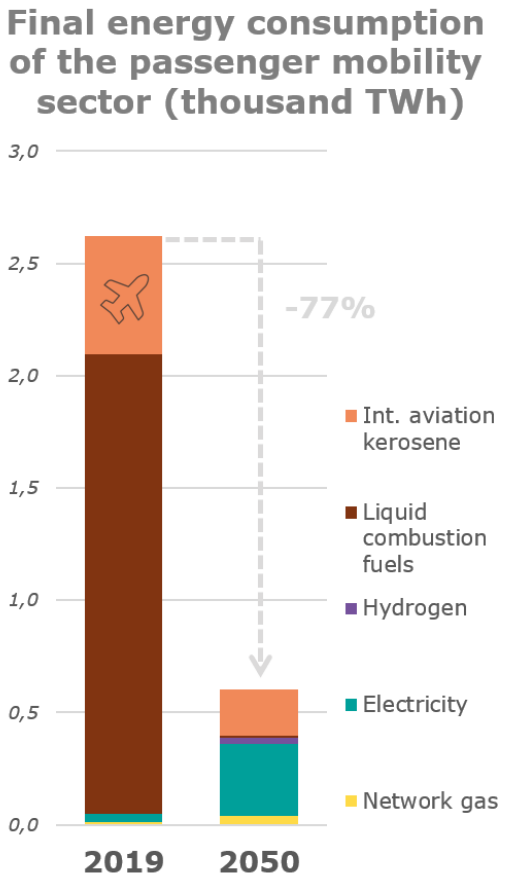

*Evolution of energy consumption and living space per capita in the German residential sector*

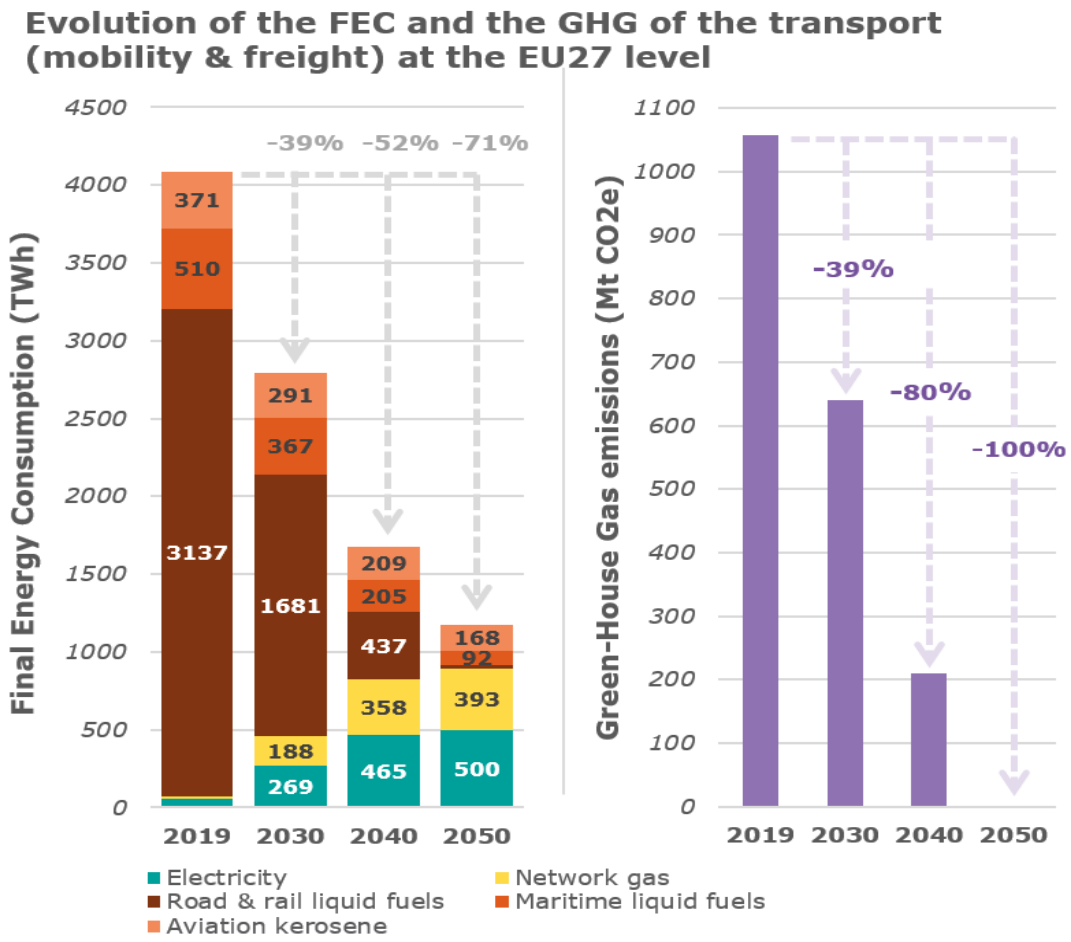
# Evolution of floor area per capita in the CLEVER scenario



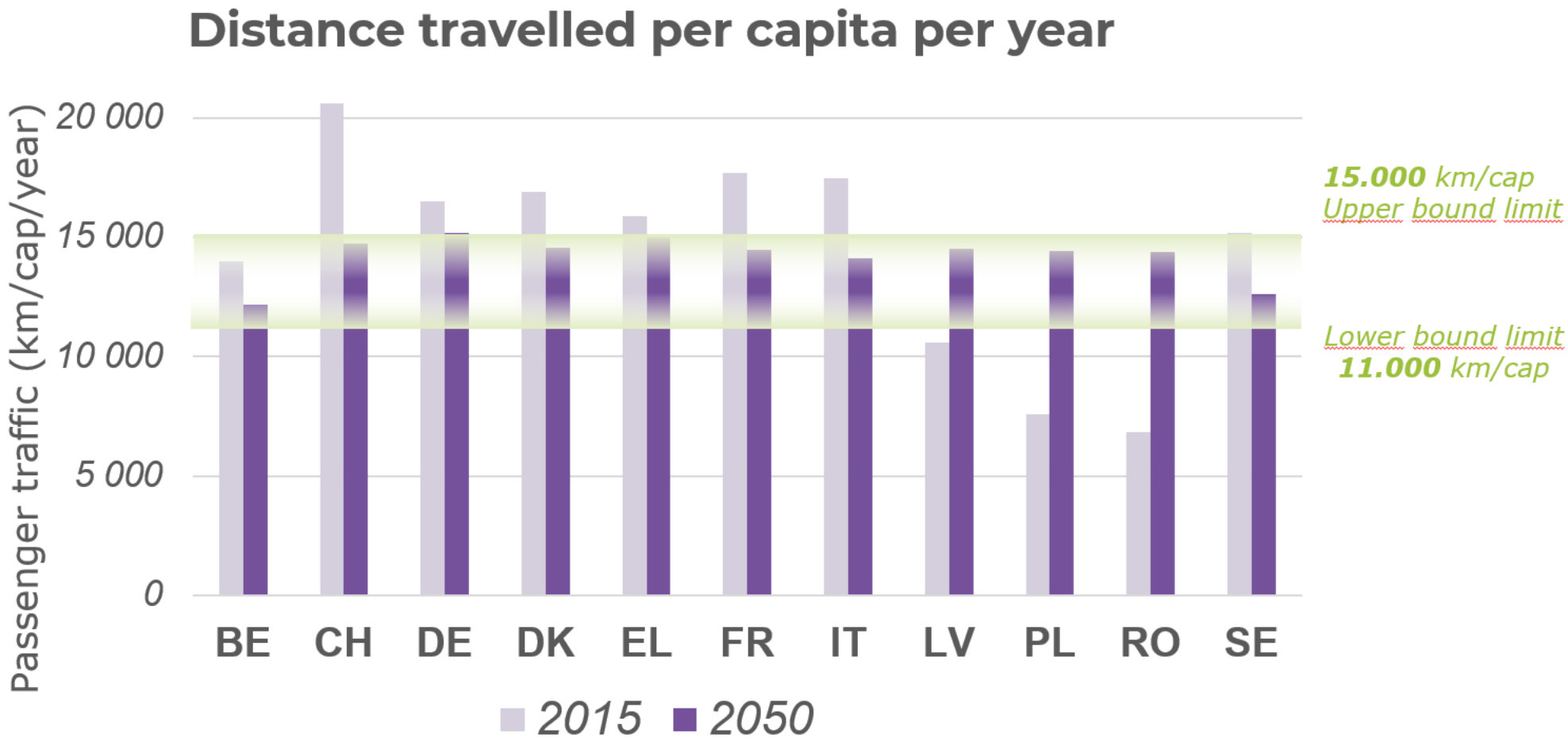
# Transport


Total passenger traffic in the EU27 (trillion passenger km)
7
6
5
4
3
2
1
-
-21%
2019
2050
Aviation
Rail
Active mobility
Road

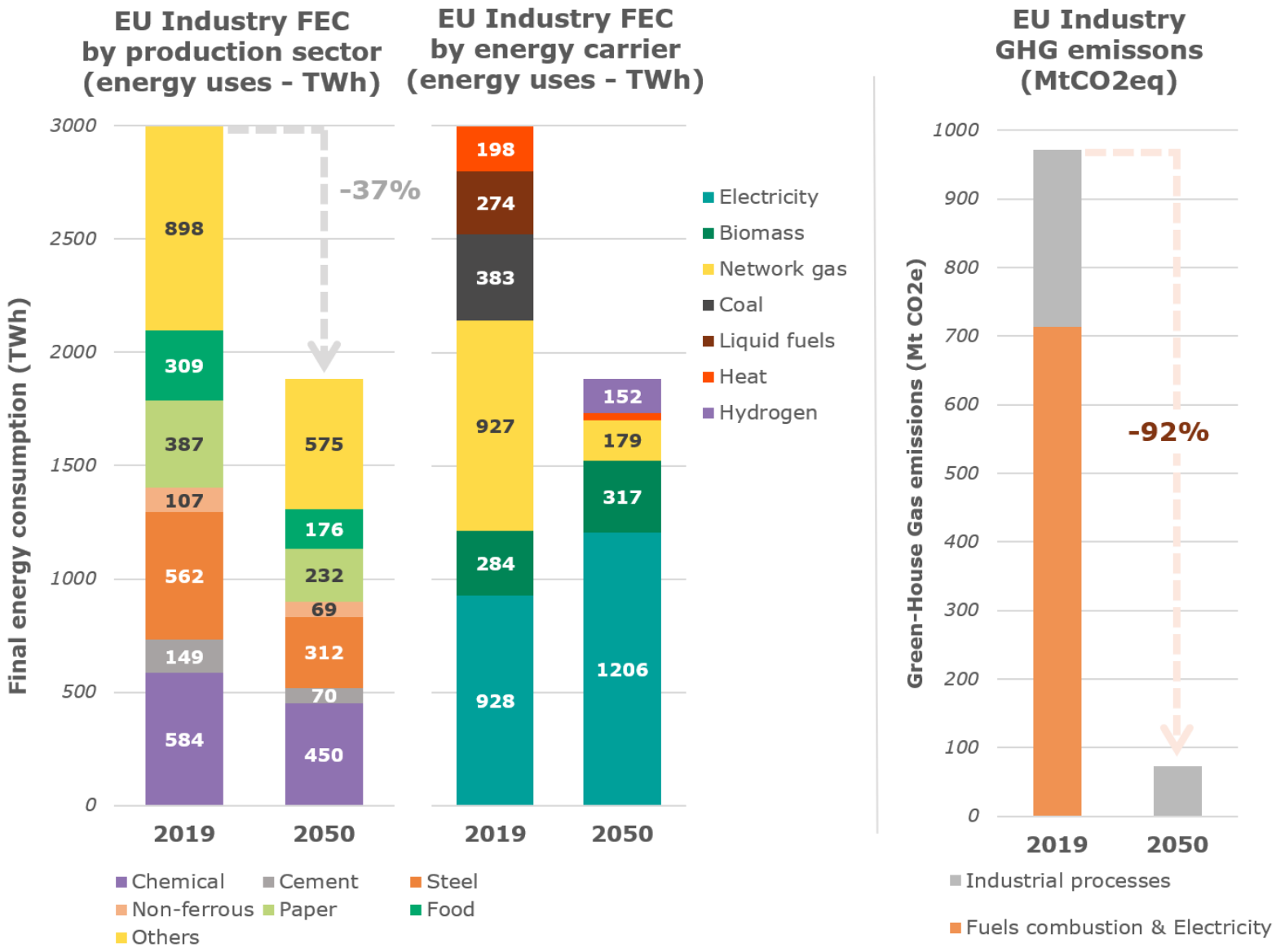

Final energy consumption of the passenger mobility sector (thousand TWh)
3,0
2,5
2,0
1,5
1,0
0,5
0,0
-77%
2019
2050
Int. aviation kerosene
Liquid combustion fuels
Hydrogen
Electricity
Network gas


Evolution of the FEC and the GHG of the transport (mobility & freight) at the EU27 level
Final Energy Consumption (TWh)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-39%
-52%
-71%
371
510
3137
291
367
1681
188
269
209
205
437
358
465
168
92
393
500
2019
2030
2040
2050
Green-House Gas emissions (Mt CO2e)
1100
1000
900
800
700
600
500
400
300
200
100
0
-39%
-80%
-100%
2019
2030
2040
2050
Electricity
Road & rail liquid fuels
Aviation kerosene
Network gas
Maritime liquid fuels

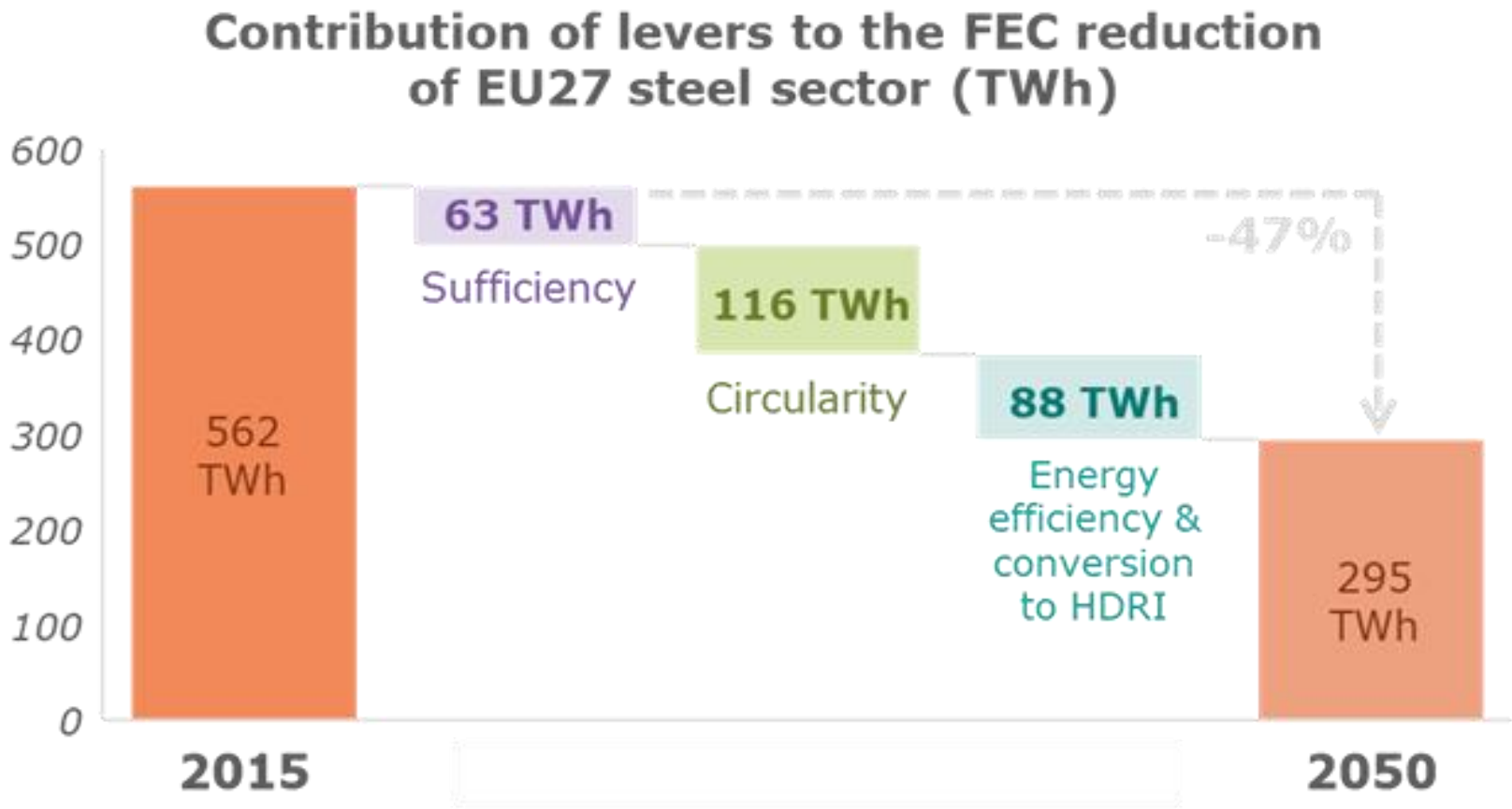
# Transport demand



# Industry


EU Industry FEC by production sector (energy uses - TWh)
EU Industry FEC by energy carrier (energy uses - TWh)
EU Industry GHG emissons (MtCO2eq)
Final energy consumption (TWh)
3000
2500
2000
1500
1000
500
0
-37%
898
309
387
107
562
149
584
575
176
232
69
312
70
450
198
274
383
927
284
928
152
179
317
1206
2019
2050
2019
2050
Electricity
Biomass
Network gas
Coal
Liquid fuels
Heat
Hydrogen
Chemical
Cement
Steel
Non-ferrous
Paper
Food
Others
Green-House Gas emissions (Mt CO2e)
1000
900
800
700
600
500
400
300
200
100
0
-92%
2019
2050
Industrial processes
Fuels combustion & Electricity

# Industry: example with steel



# Electricity mix