



International Institute for
Applied Systems Analysis



UNECE



Energy Modelling and Scenario Analysis to Inform Policy Decisions for the 2030 Energy Transition

Regional Scenario Results

Exploring and facilitating the transition to sustainable energy systems



Models? Not crystal balls!

Processing data and assumptions

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- Models are mathematical representations of real-world relationships, calibrated with historical data
- Assumptions required to parameterize models
 - Future rates of technological development
 - Socioeconomics
 - Policy changes
- The model solves the mathematical relationships, given the input assumptions
- Scenarios explore different assumptions about inputs
- Policies can be defined through changes to model assumptions or specific policy goals

Using models

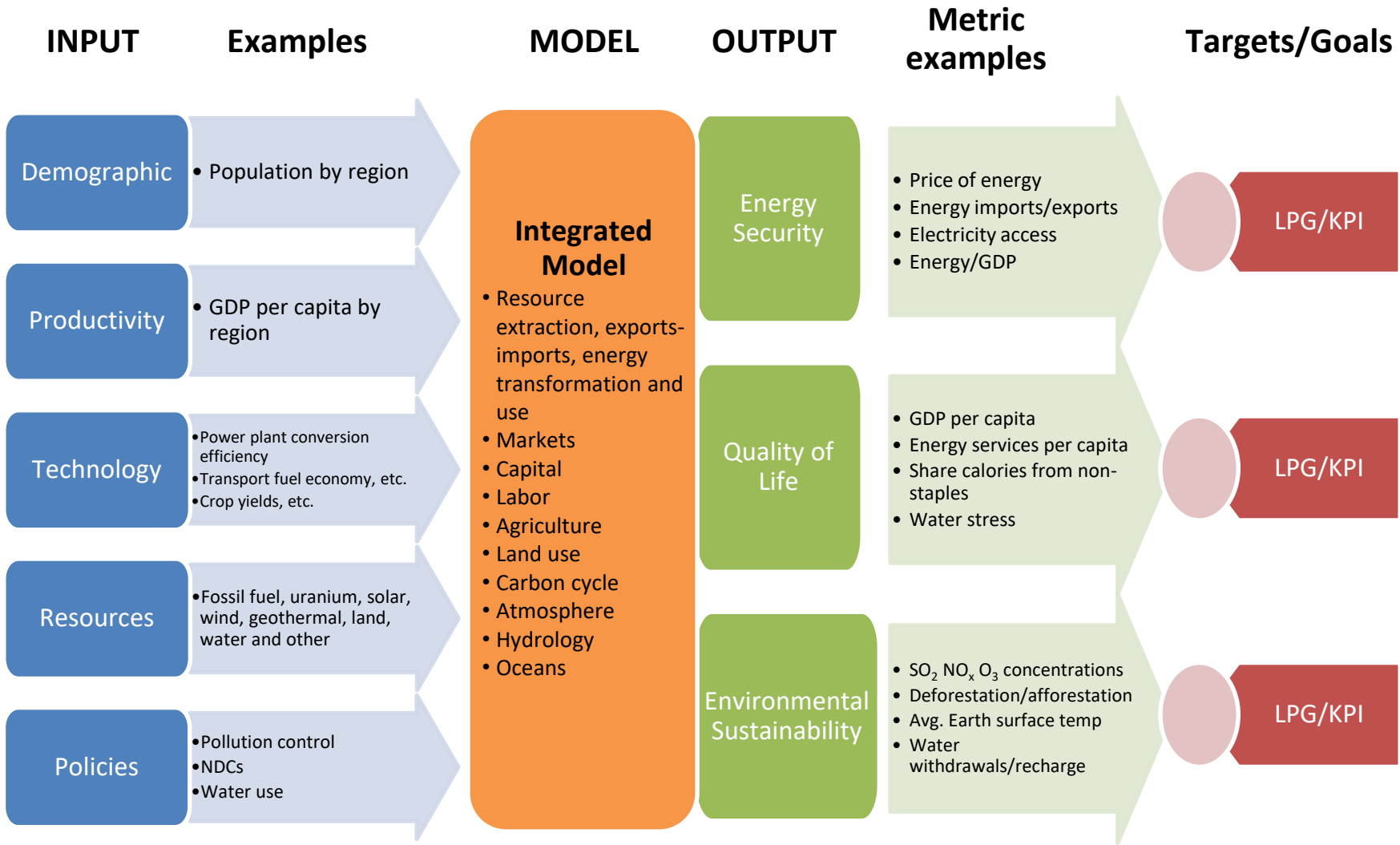
Models **can** inform policy makers on the implications of proposed domestic or international policies

Models **cannot** determine the “best” technology or policy options

Scenario development

Illustration of scenario design

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Scenario Analysis

Three sequential steps

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I. Reference Scenario

Based on SSP 2* as point of departure, i.e., without dedicated sustainable energy or climate policies.

II. NDC scenario

A scenario that implements by 2030 the NDCs under the Paris Agreement but maintains the NDCs beyond 2030 – *kind of NDCs forever*. It also includes other current policies towards sustainable energy

III. Designing pathways towards sustainable energy - Paris to 2°C -

One key component of SE is the 2°C target of the Paris Agreement by 2100 (Environment pillar). The other two pillars “energy security” and “quality of life” to follow – but models require quantified targets (similar to Paris to 2°C)

SSP: Shared Socio-economic pathway to 2100. Pathway 2 is a middle of the road future

Note: Metrics and KPIs will inform and quantify trade-offs between the three pillars

Modeling Results: Demand & supply

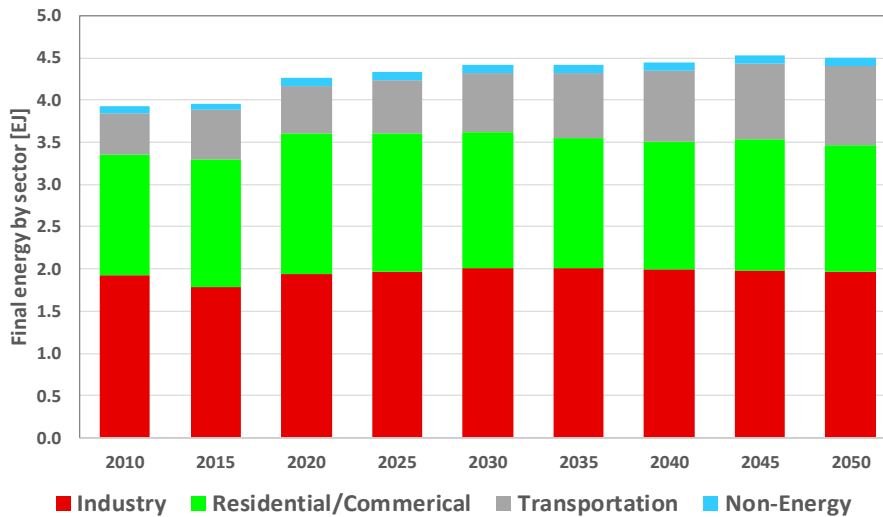
Final energy: CAS

ENERGY

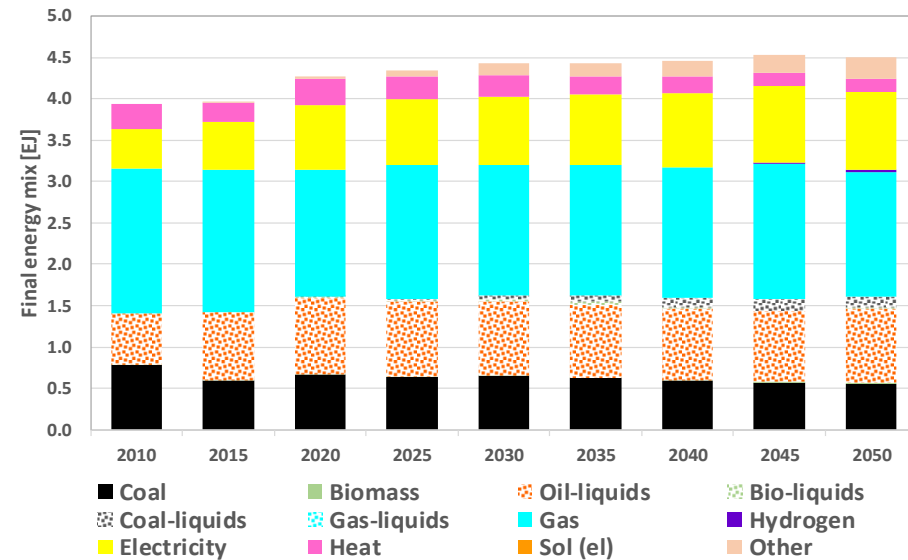


Central Asia (CAS) - REF Scenario

Final energy demand by sector



Final energy supply mix by fuel



Modeling Results: Demand & supply

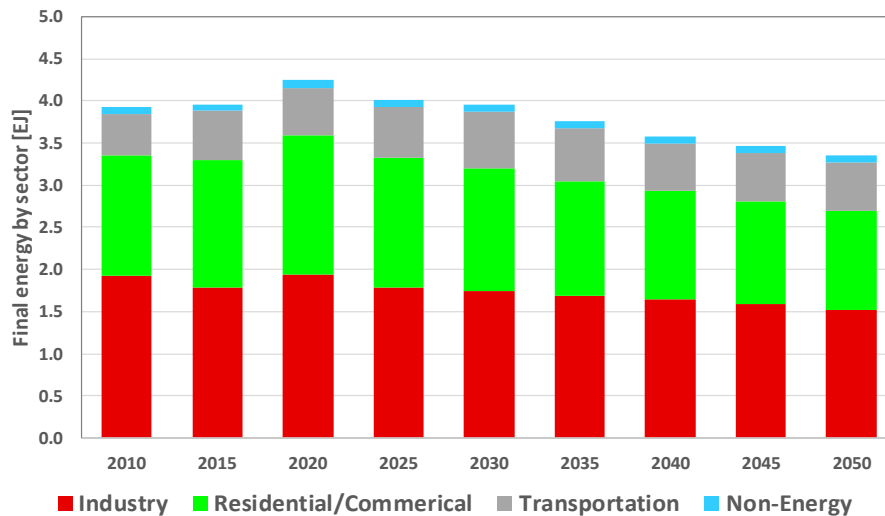
Final energy: CAS

ENERGY

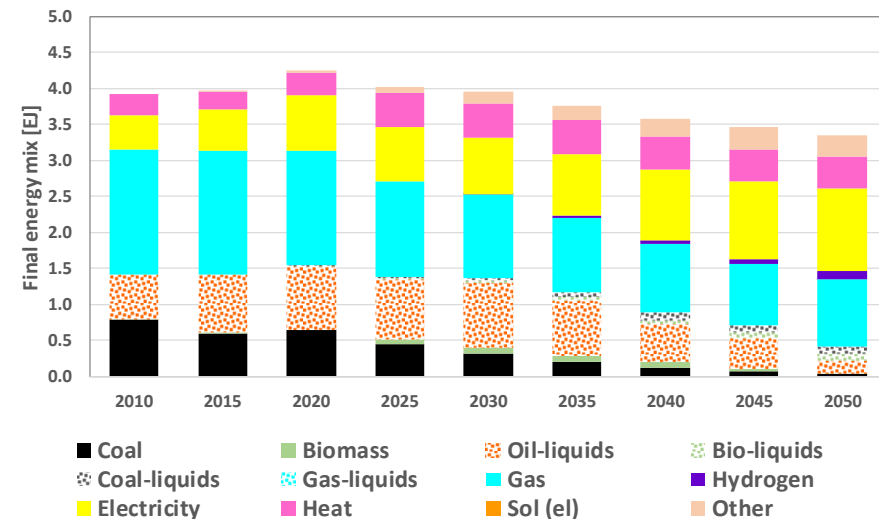


Central Asia (CAS) - P2C Scenario

Final energy demand by sector



Final energy supply mix by fuel



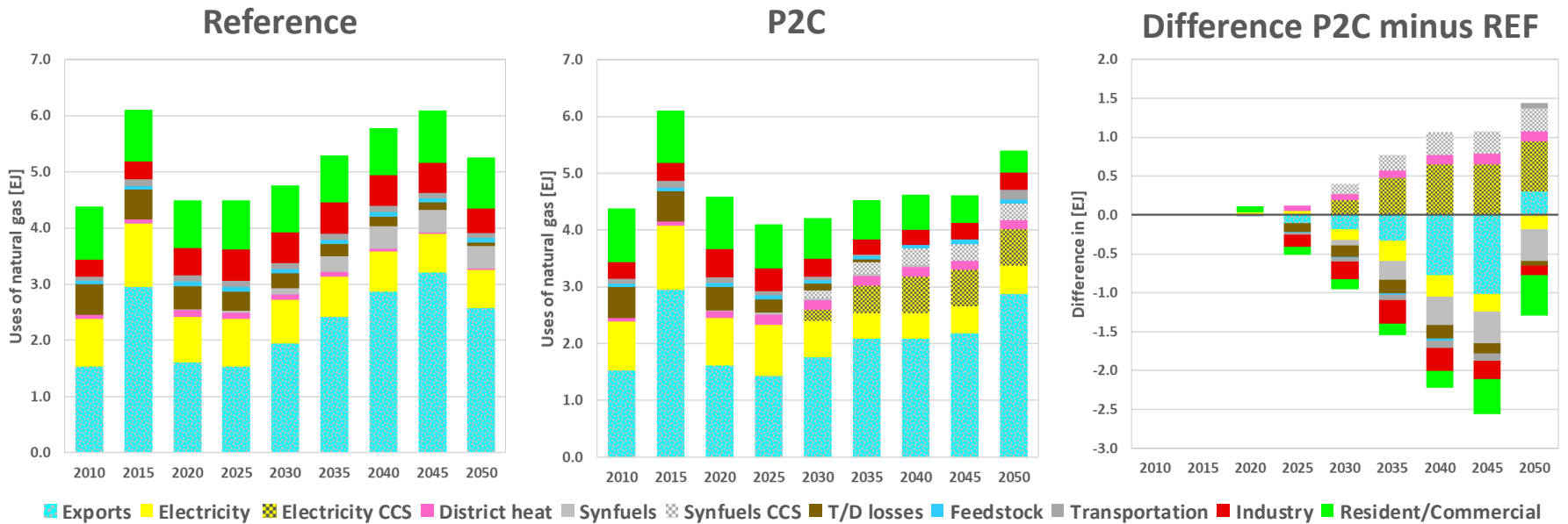
Modeling Results: Energy system transformation

Natural gas markets: CAS

ENERGY



Uses of natural gas in the CAS Region



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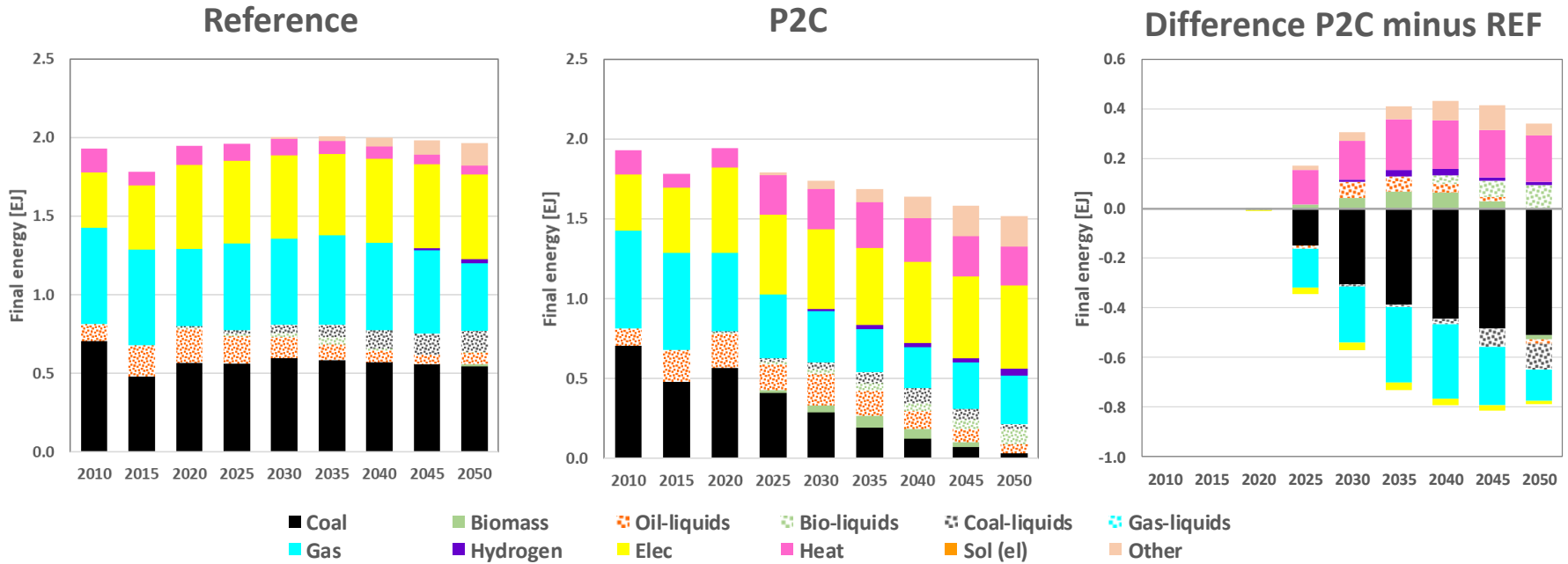
Modeling Results: Sectors

Final energy use: CAS

ENERGY



Industry: CAS Region



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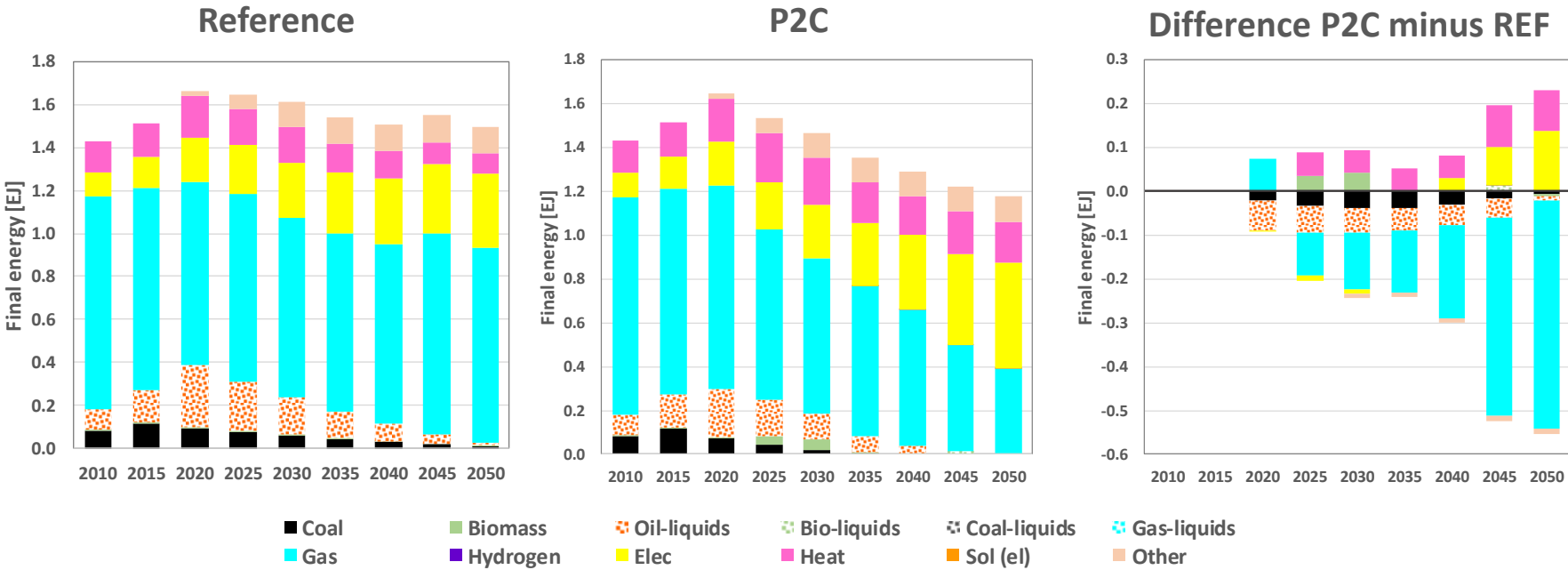
Modeling Results: Sectors

Final energy: CAS

ENERGY



Residential/Commercial sector: CAS Region



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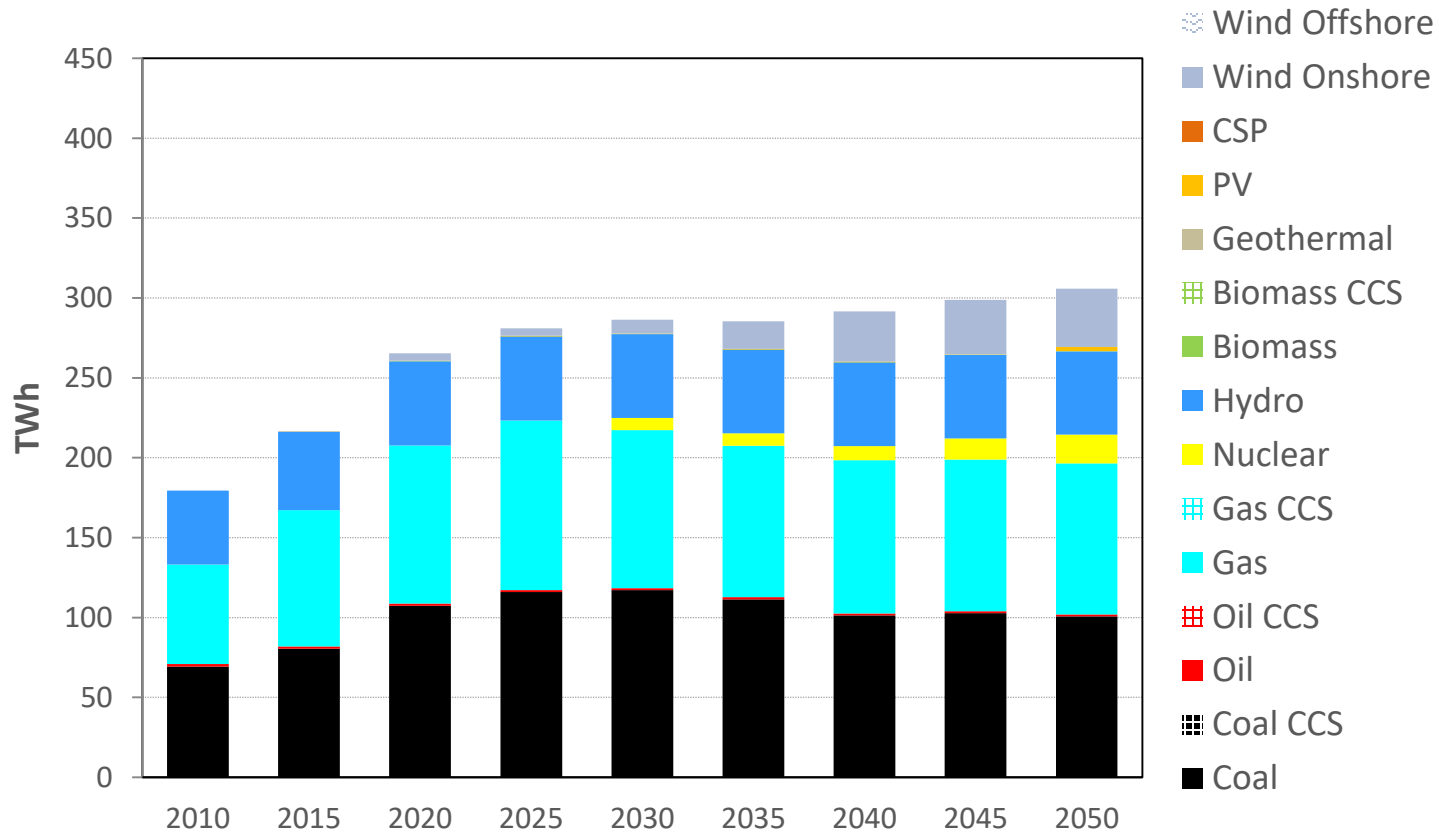
Modeling Results: CAS

Electricity Generation

ENERGY



Electricity generation by technology and fuel - CAS REF Scenario



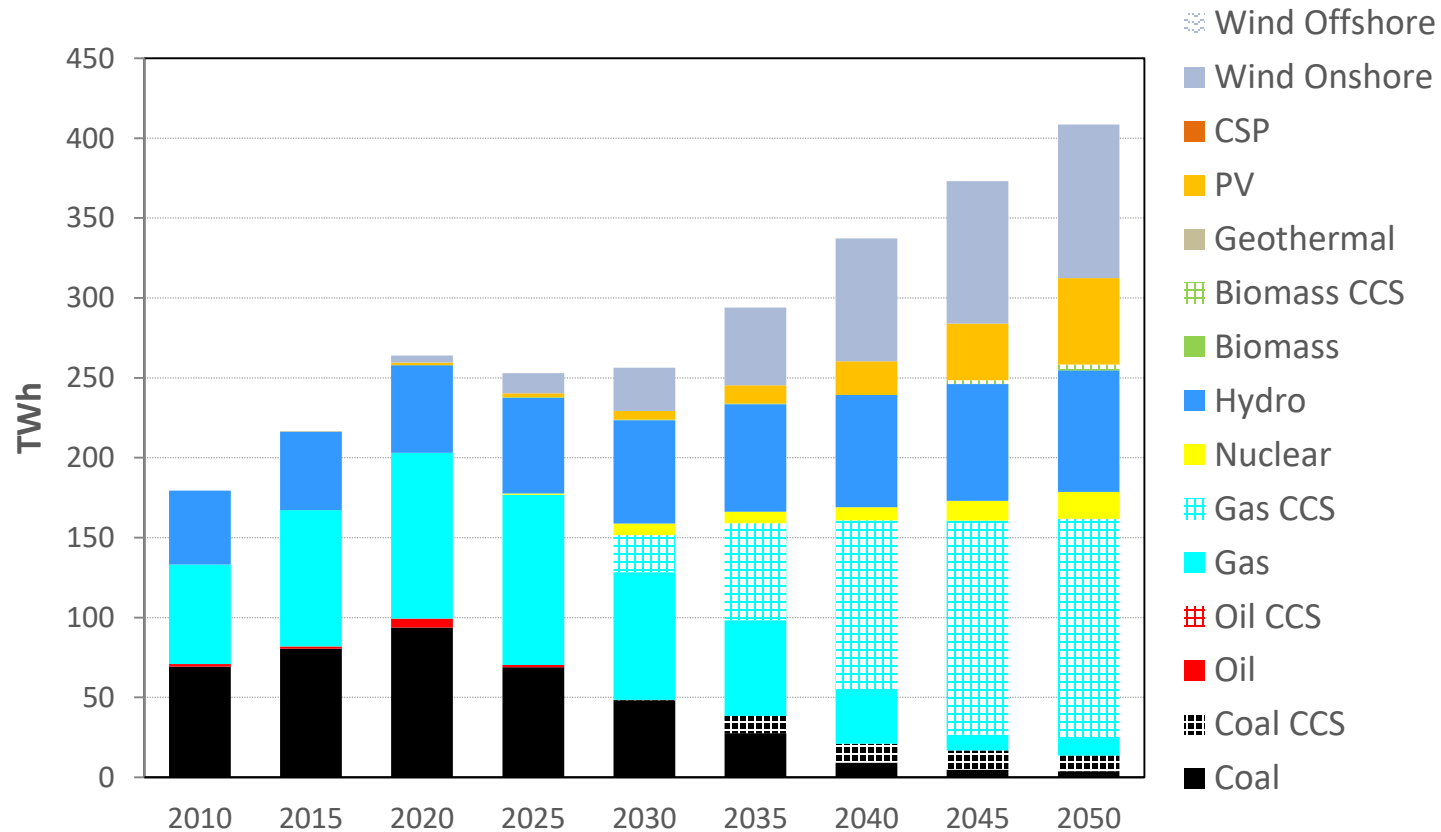
Modeling Results: CAS

Electricity Generation

ENERGY



Electricity generation by technology and fuel - CAS P2C Scenario



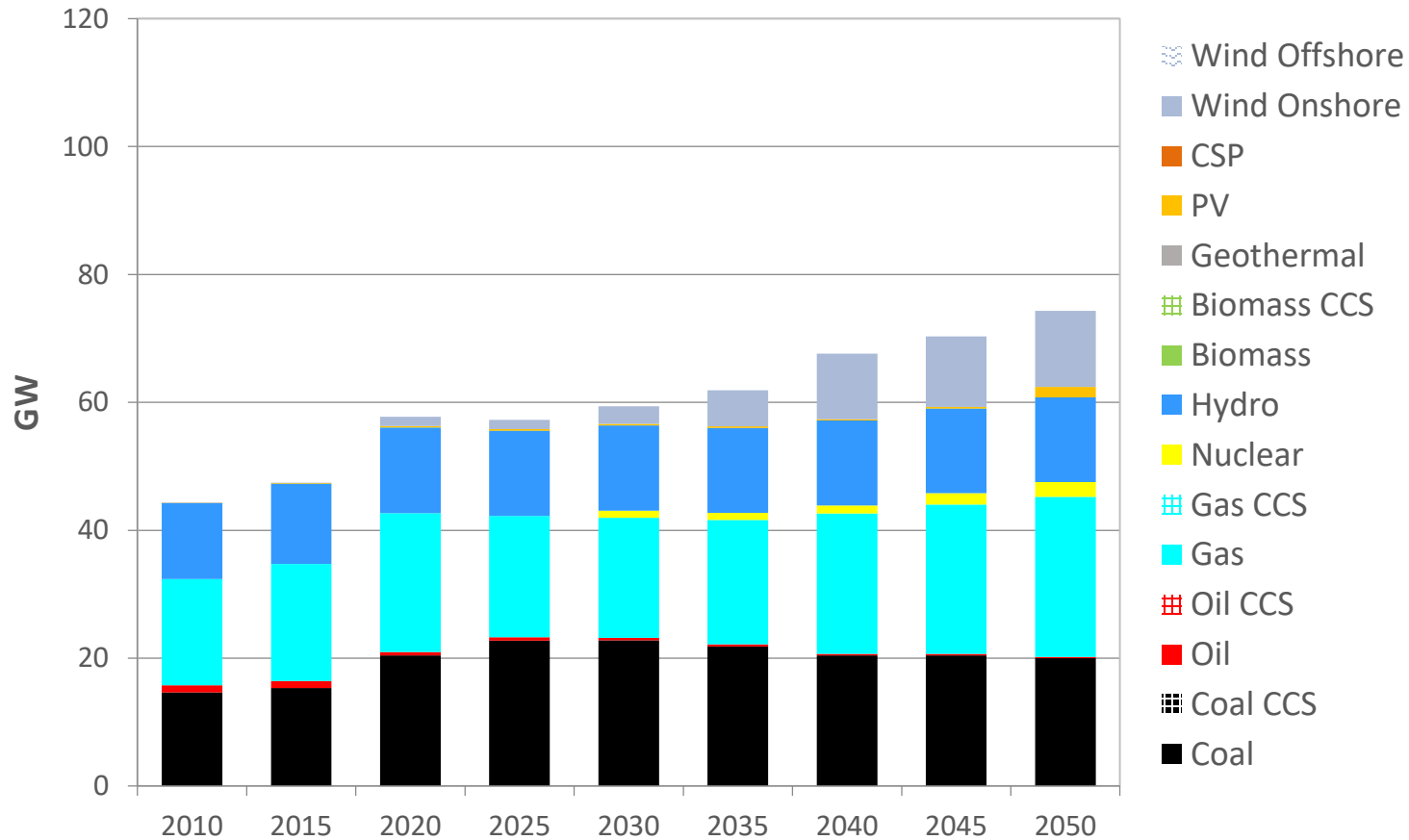
Modeling Results: CAS

Electricity Generation

ENERGY



Generating capacities by technology - CAS REF Scenario



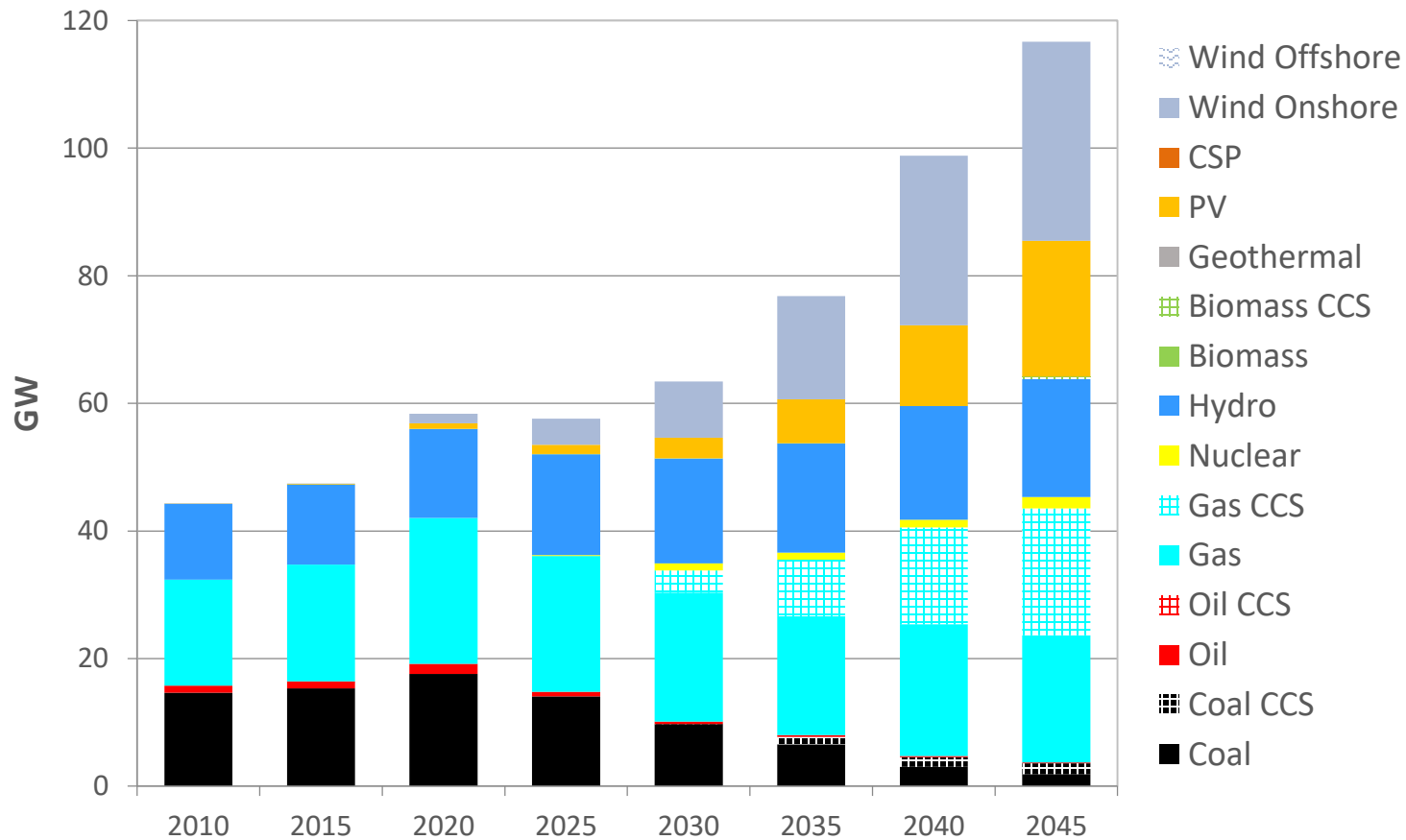
Modeling Results: CAS

Electricity generating

ENERGY



Generating capacities by technology - CAS P2C Scenario



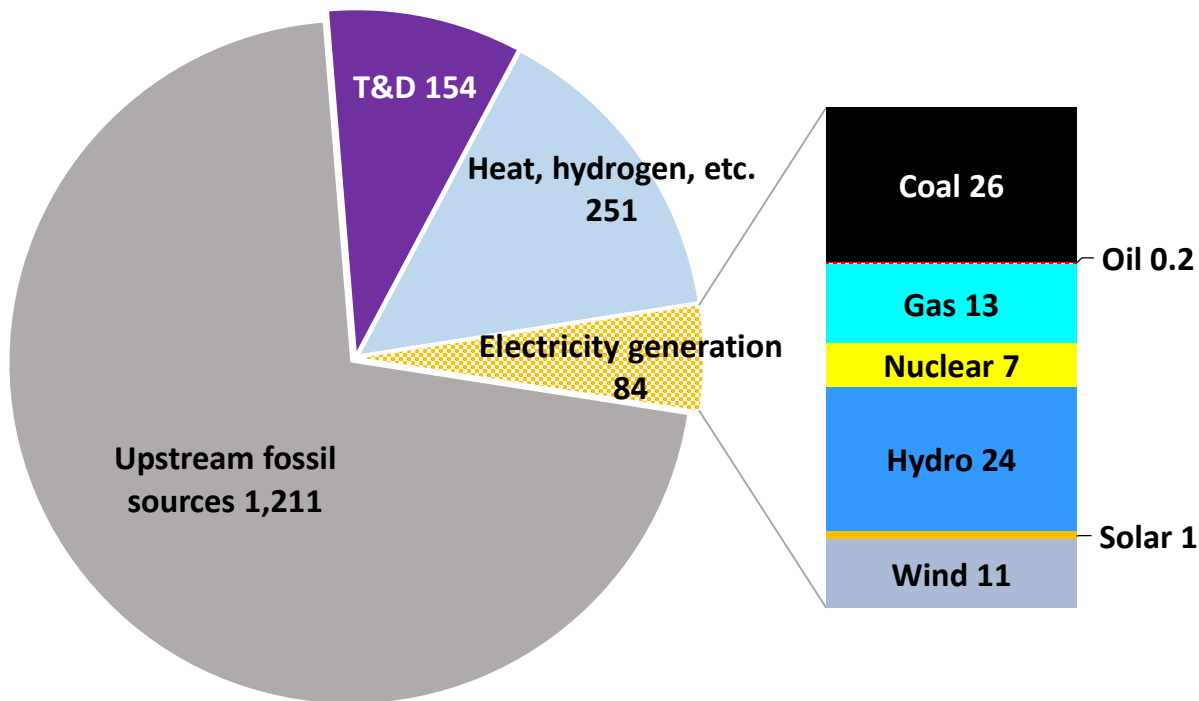
Modeling Results: Indicators

Investment needs: CAS

ENERGY



Cumulative investments 2020-2050: *1,700 billion US\$*
REF – CAS Region



- Upstream fossil sources
- T&D
- Heat, hydrogen, etc.
- Energy efficiency
- Coal
- Coal CCS
- Oil
- Oil CCS
- Gas
- Gas CCS
- Nuclear
- Hydro
- Biomass
- Biomass CCS
- Geothermal
- Solar
- Wind

- T&D: transmission and distribution of electricity and district heat
- Investments in US\$ at 2010 prices and exchange rates

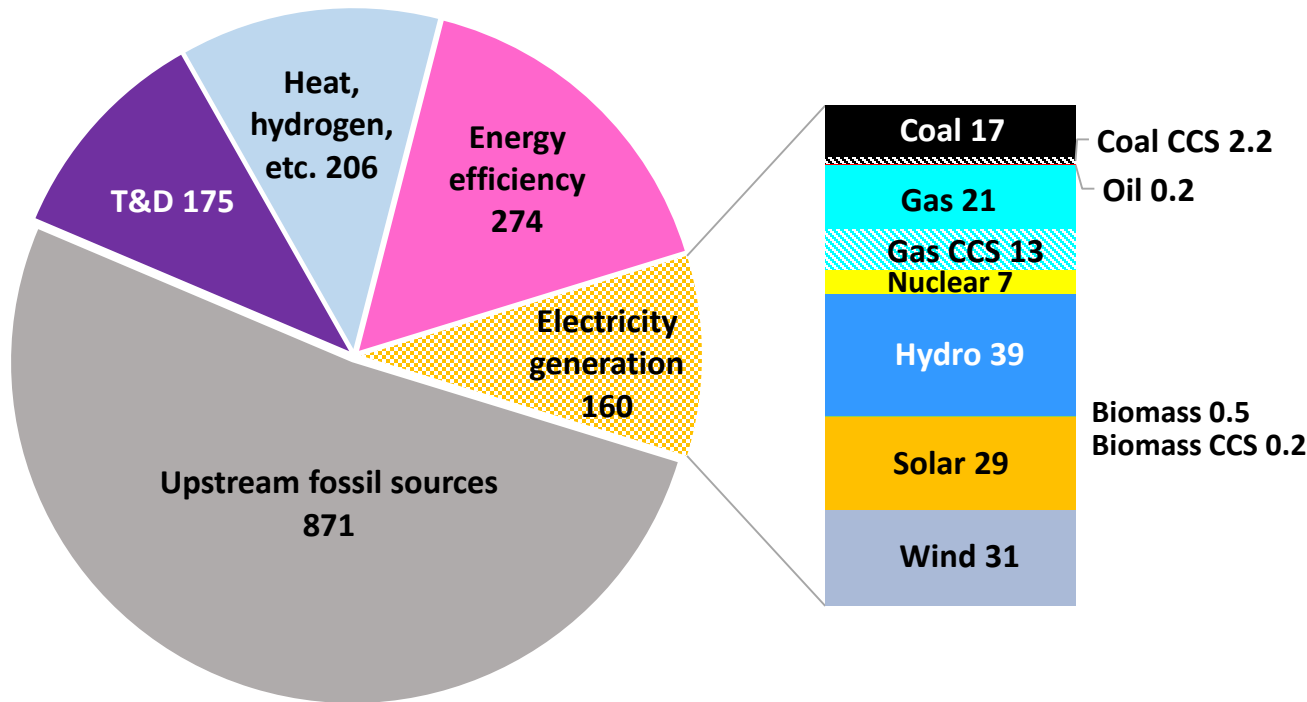
Modeling Results: Indicators

Investment needs: CAS

ENERGY



Cumulative investments 2020-2050: **1,686 billion US\$**
P2C – CAS Region



- Upstream fossil sources
- Oil
- Biomass
- T&D
- Oil CCS
- Biomass CCS
- Heat, hydrogen, etc.
- Gas
- Geothermal
- Energy efficiency
- Gas CCS
- Solar
- Coal
- Nuclear
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- Coal CCS
- Hydro

- T&D: transmission and distribution of electricity and district heat
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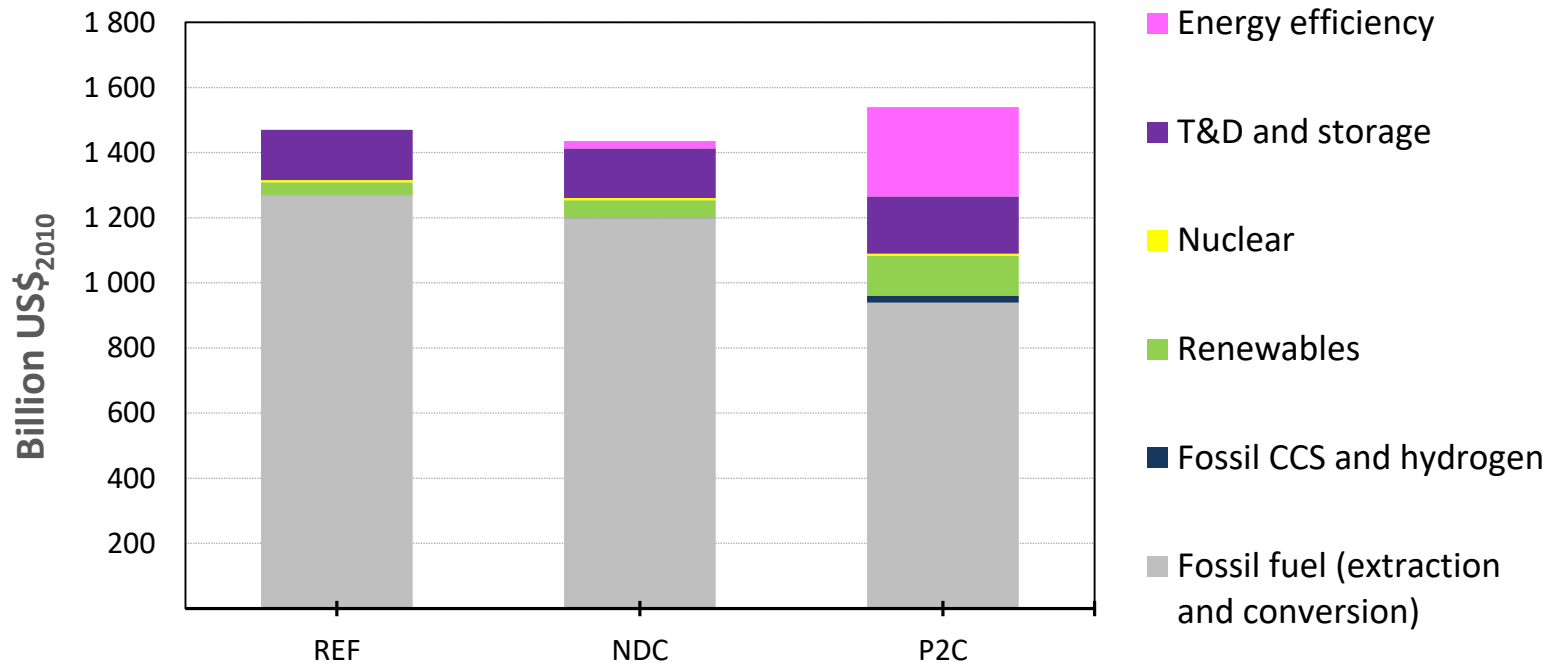
Modeling Results: Indicators

Investment needs: CAS

ENERGY



Comparing investment requirements - CAS REF, NDC and P2C scenarios



- T/D&S: transmission, distribution and storage of electricity and district heat
- CCS: carbon capture and storage
- H2: hydrogen
- BAT: Best available technology

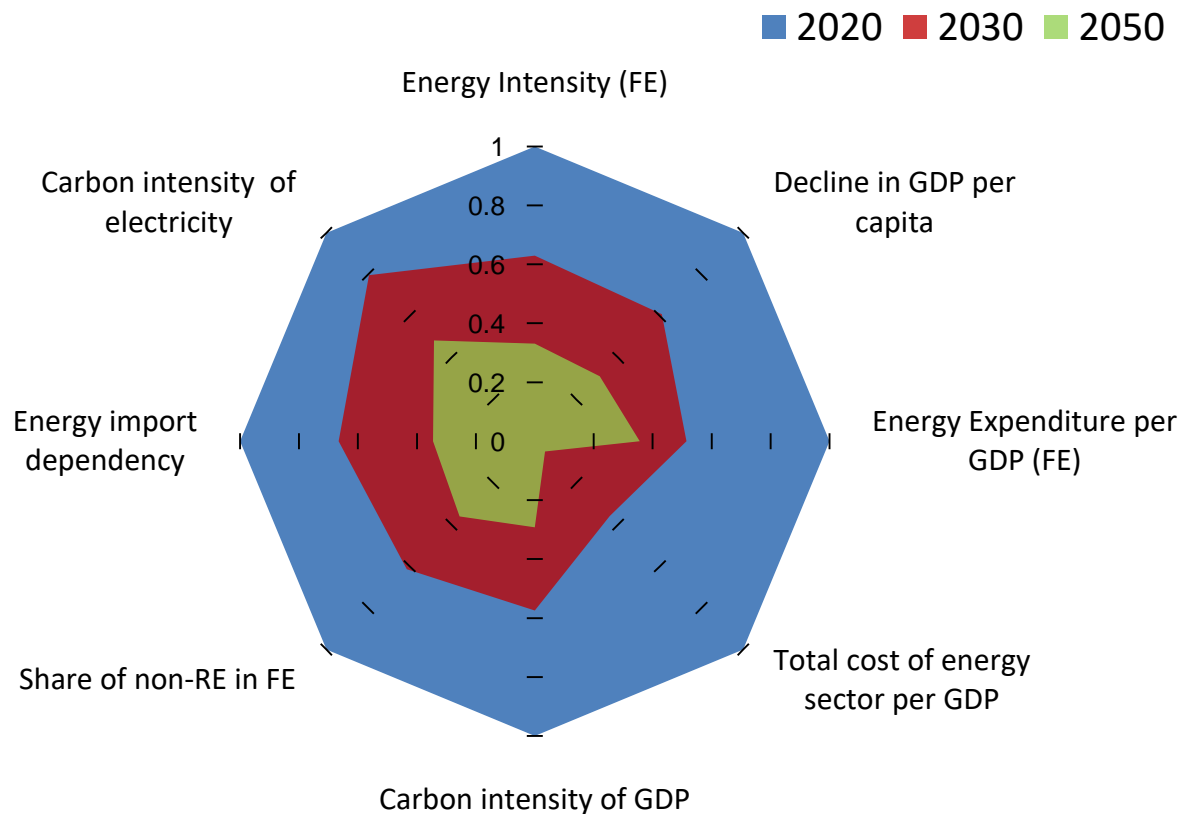
Modeling Results: Indicators

Tradeoffs and synergies: CAS

ENERGY



Indicators: Energy security, environment, quality of life CAS - REF Scenario



- Final energy intensity improves as aging infrastructure is being replaced and economies undergo structural change
- Energy expenditures per GDP decline by 2030 but slow down thereafter
- Carbon intensity of GDP declines faster than CO_2/MWh as the economy undergoes modernization and shifts to the production of higher value added goods and services
- Share of RE declines until 2030; thereafter expands slower compared to most other regions
- CAS turns from a net importing region to an exporter by 2050

- Indicators are scaled relative to 2020 (2020=1); an improvement in any indicator will result in values lower than 1
- If the shape of polygon becomes smaller compared to 2020, it shows improvements in the indicators

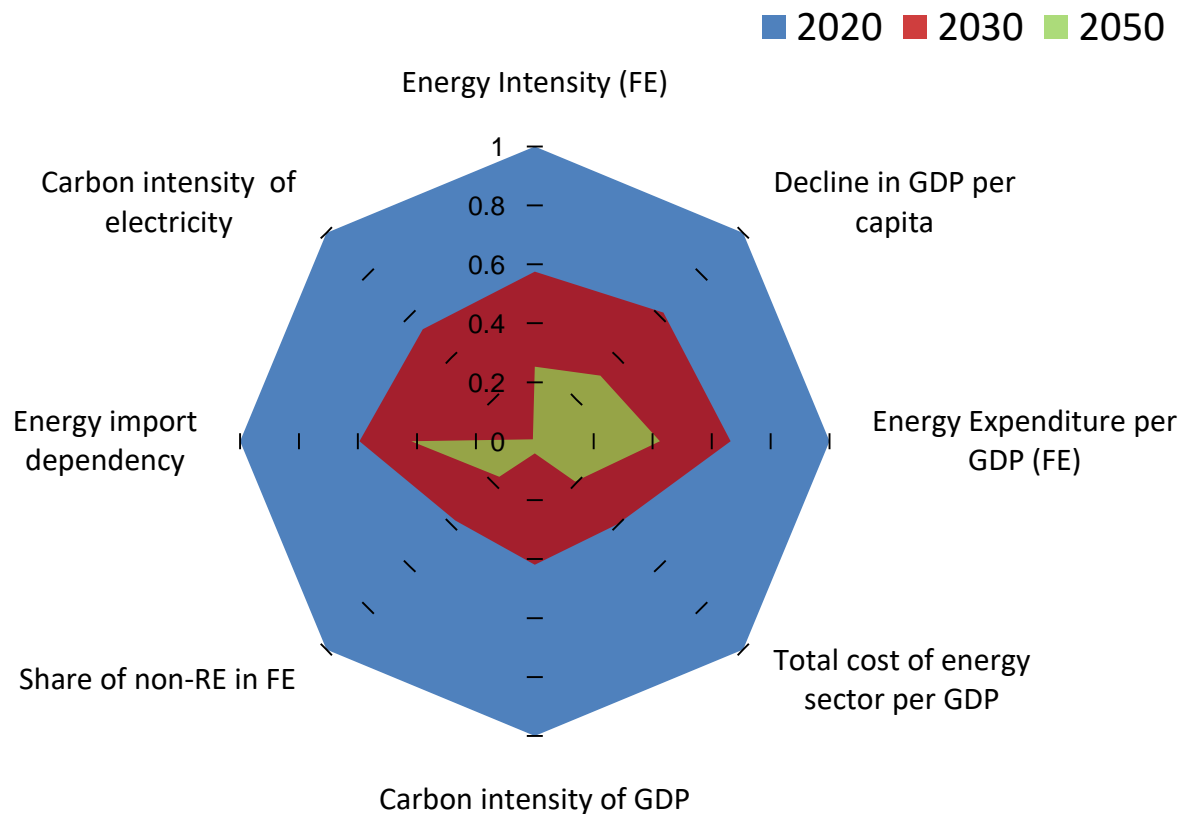
Modeling Results: Indicators

Tradeoffs and synergies: CAS

ENERGY



Indicators: Energy security, environment, quality of life CAS – P2C Scenario



- *Energy system transformation clearly discernible by 2050*
- *Significant change in energy expenditures by 2030 (> 1) and remain thereafter at substantially higher level than in REF and NDC*
- *Drastic improvement of the CO₂/MWh indicator (>95% compared to 2020) outpacing carbon intensity of GDP*
- *Energy intensities decline along with the unprecedented investments in efficiency measures*
- *Total energy sector costs reduced due to higher non-fossil domestic energy use and increased gas exports*

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Modeling Results: Demand & supply

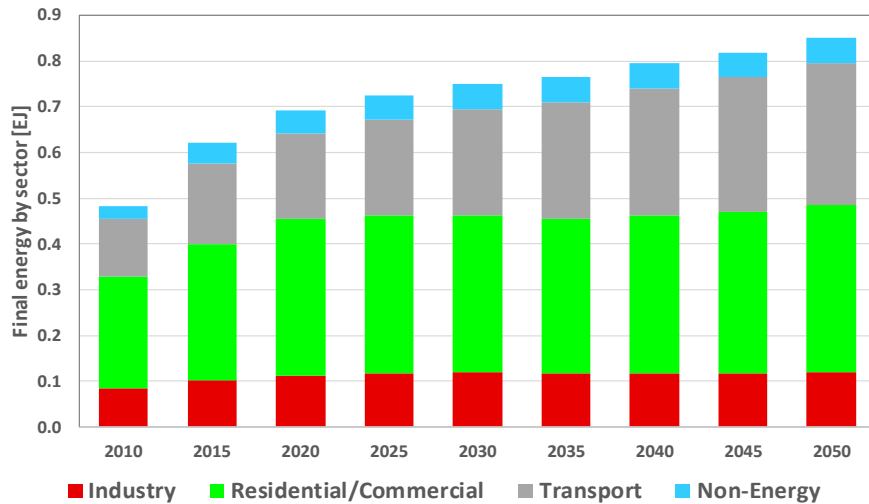
Final energy: SCS

ENERGY

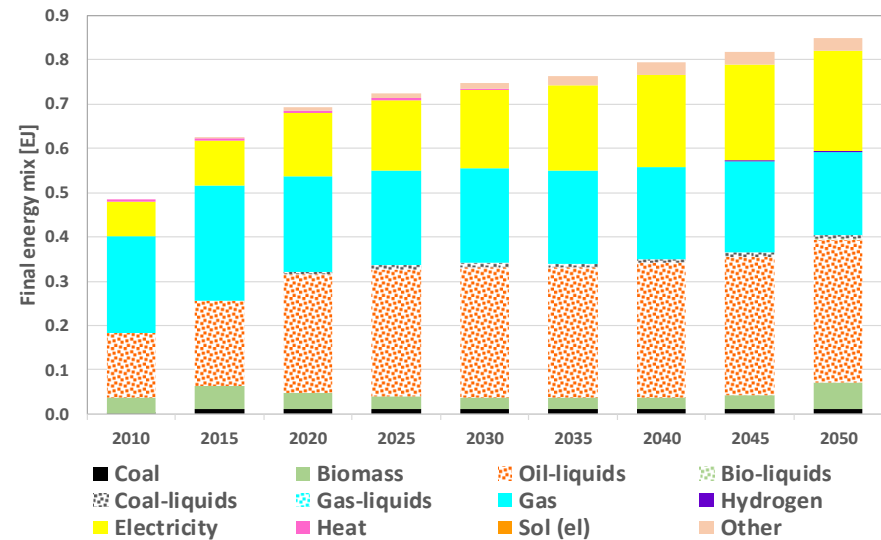


South Caucasus (SCS) - REF Scenario

Final energy demand by sector



Final energy supply mix by fuel



Modeling Results: Demand & supply

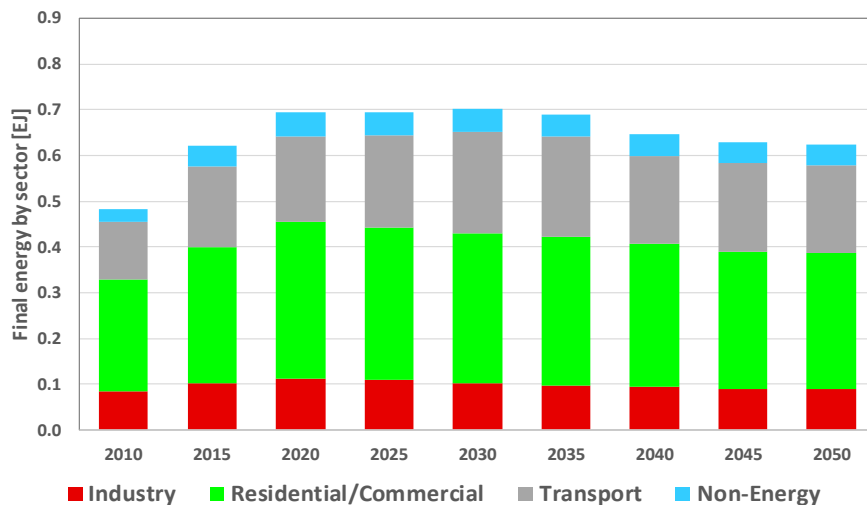
Final energy: SCS

ENERGY

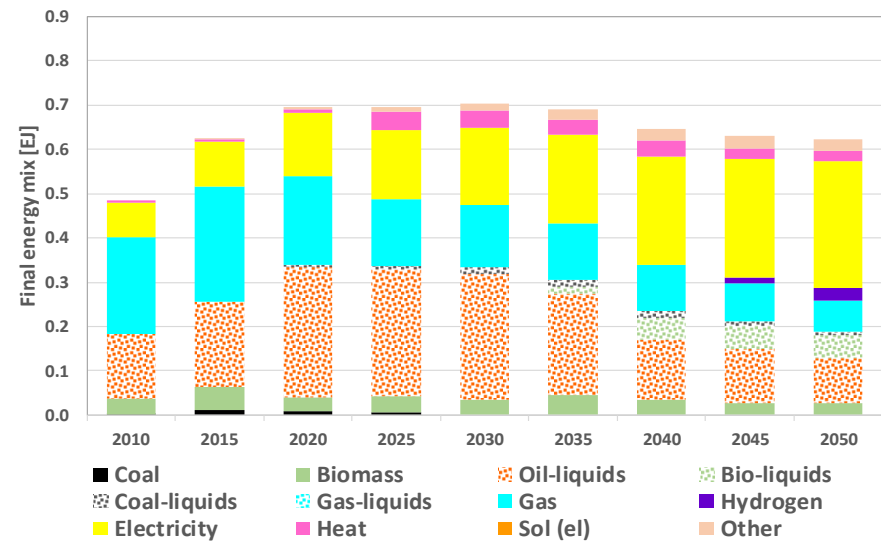


South Caucasus (SCS) - P2C Scenario

Final energy demand by sector



Final energy supply mix by fuel



Modeling Results: Fuel markets

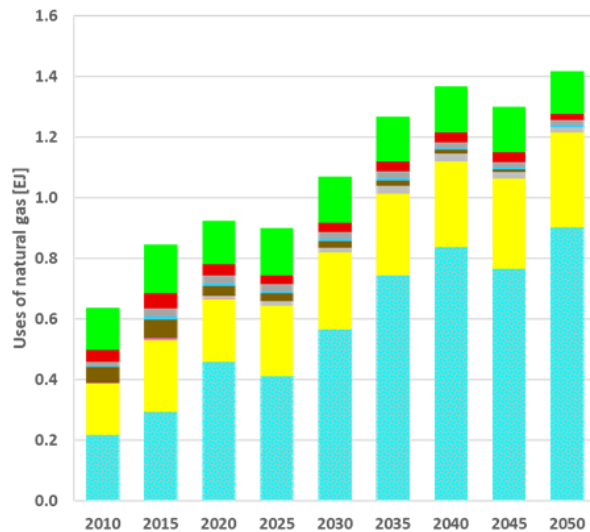
Natural gas markets: SCS

ENERGY

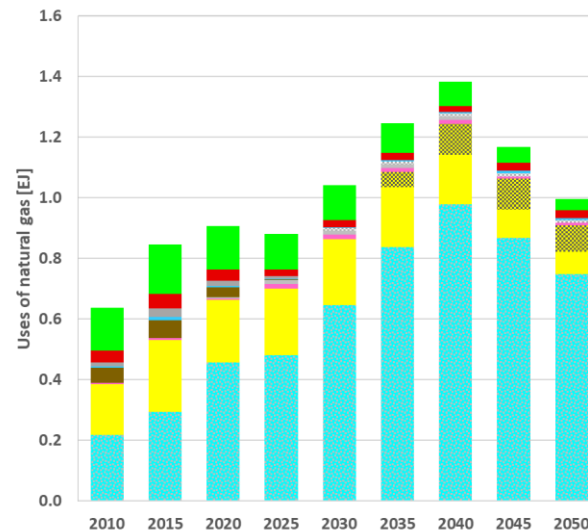


Uses of natural gas in the SCS Region

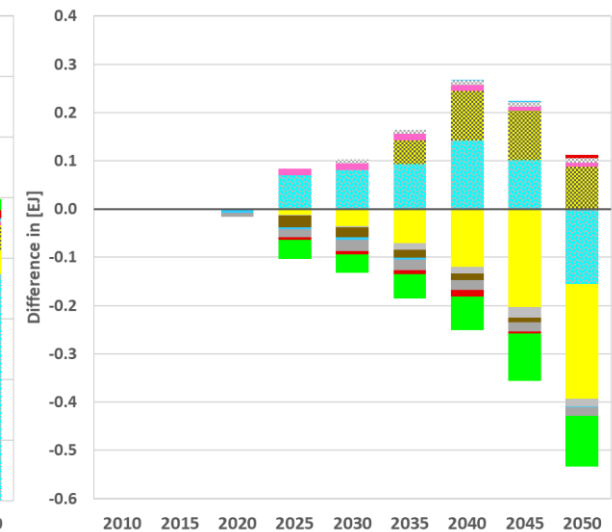
Reference



P2C



Difference P2C minus REF



■ Exports
 ■ Electricity
 ■ Electricity CCS
 ■ District heat
 ■ Synfuels
 ■ Synfuels CCS
 ■ T/D losses
 ■ Feedstock
 ■ Transportation
 ■ Industry
 ■ Resident/Commercial

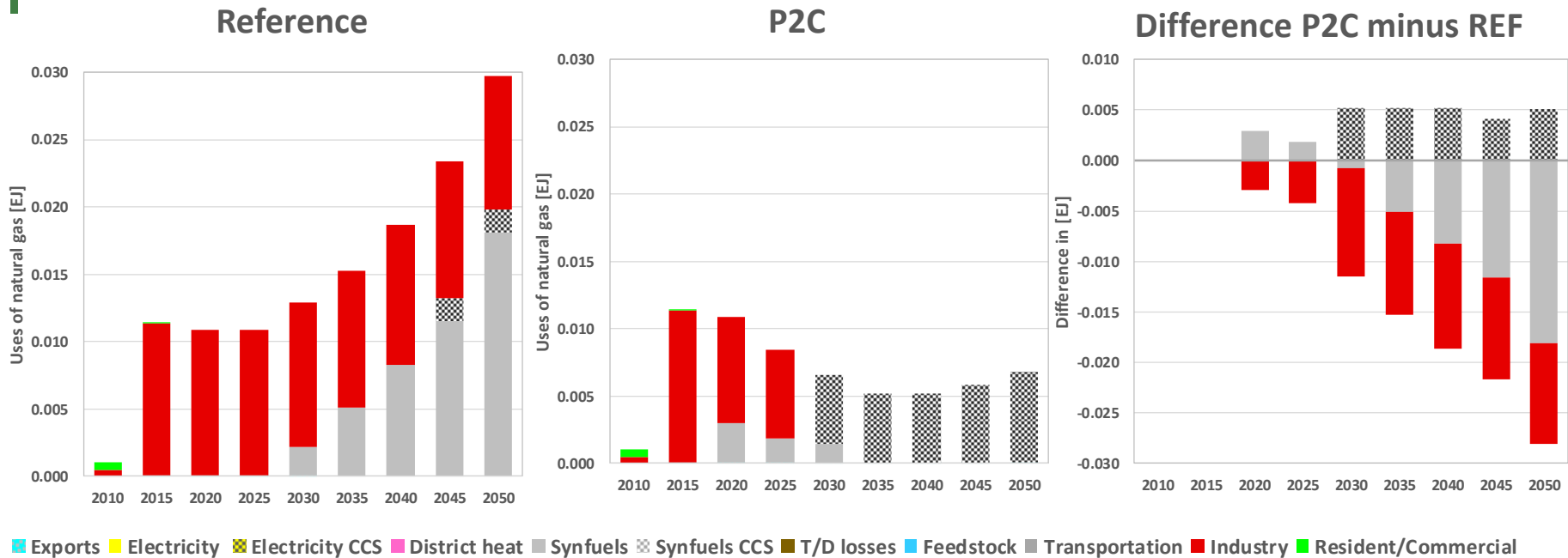
Modeling Results: Fuel markets

Coal markets: SCS

ENERGY



Uses of coal in the SCS Region



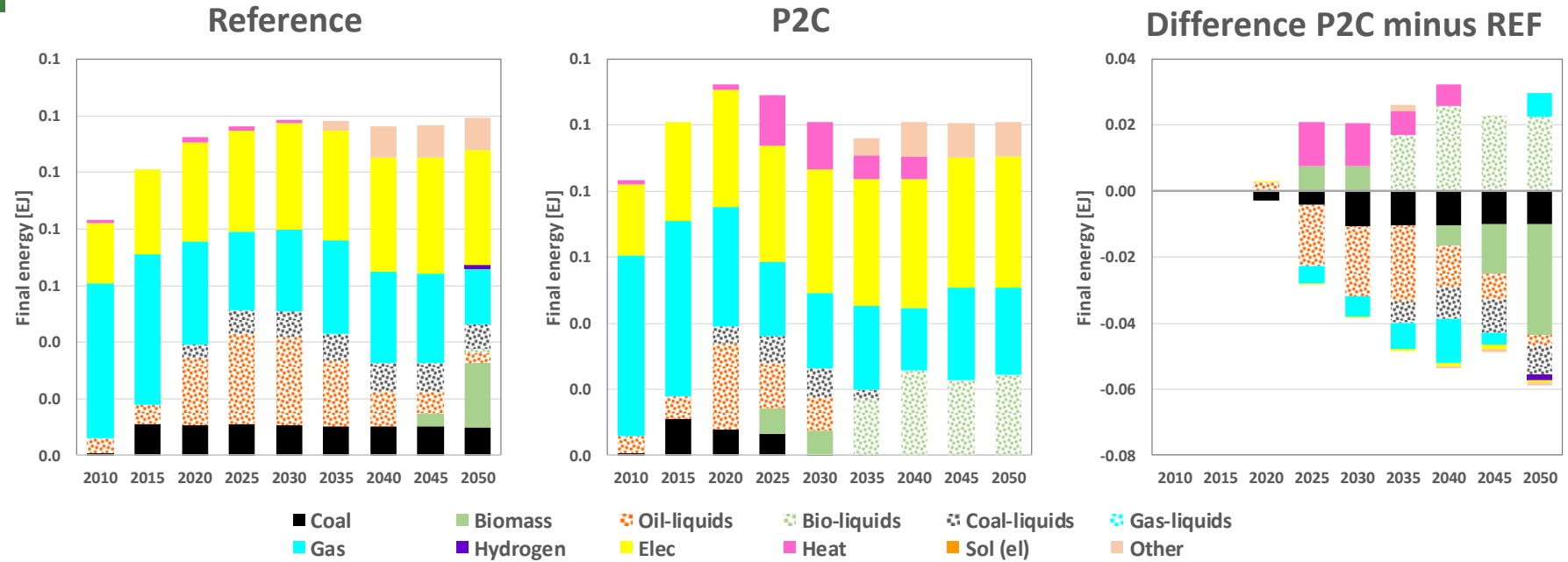
Modeling Results: Sectors

Final energy use: SCS

ENERGY



Industry: SCS Region



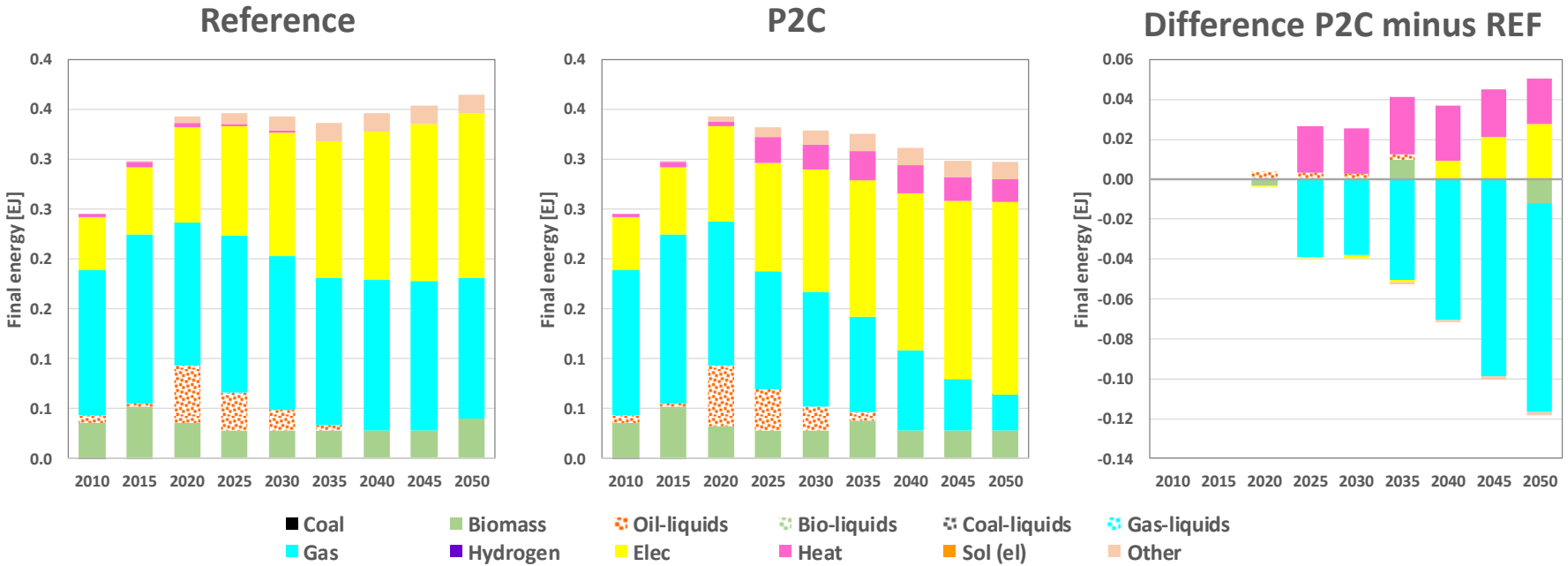
Modeling Results: Sectors

Final energy use: SCS

ENERGY



Residential/Commercial sector: SCS Region



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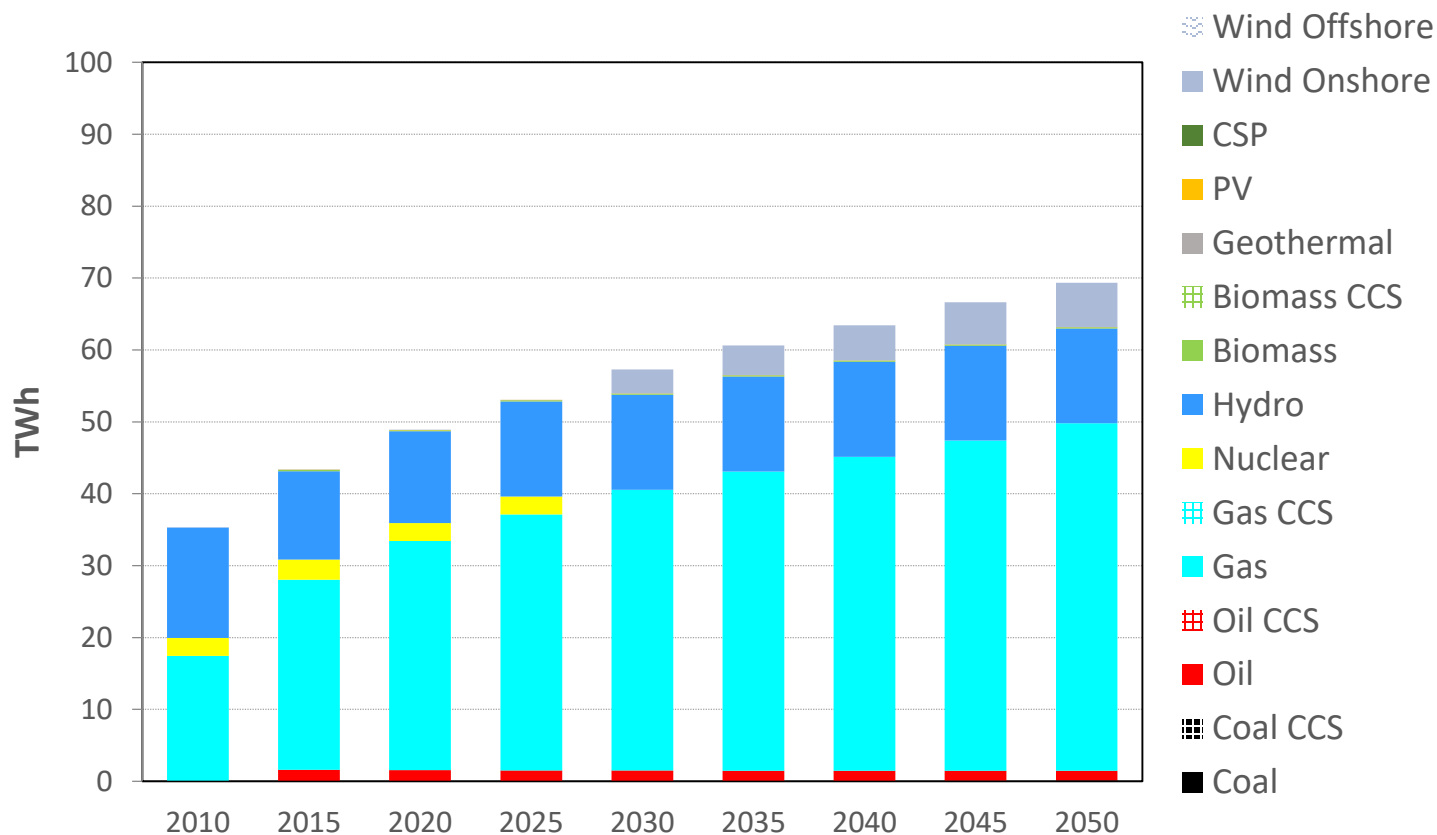
Modeling Results: SCS

Electricity Generation

ENERGY



Electricity generation by technology and fuel - SCS REF Scenario



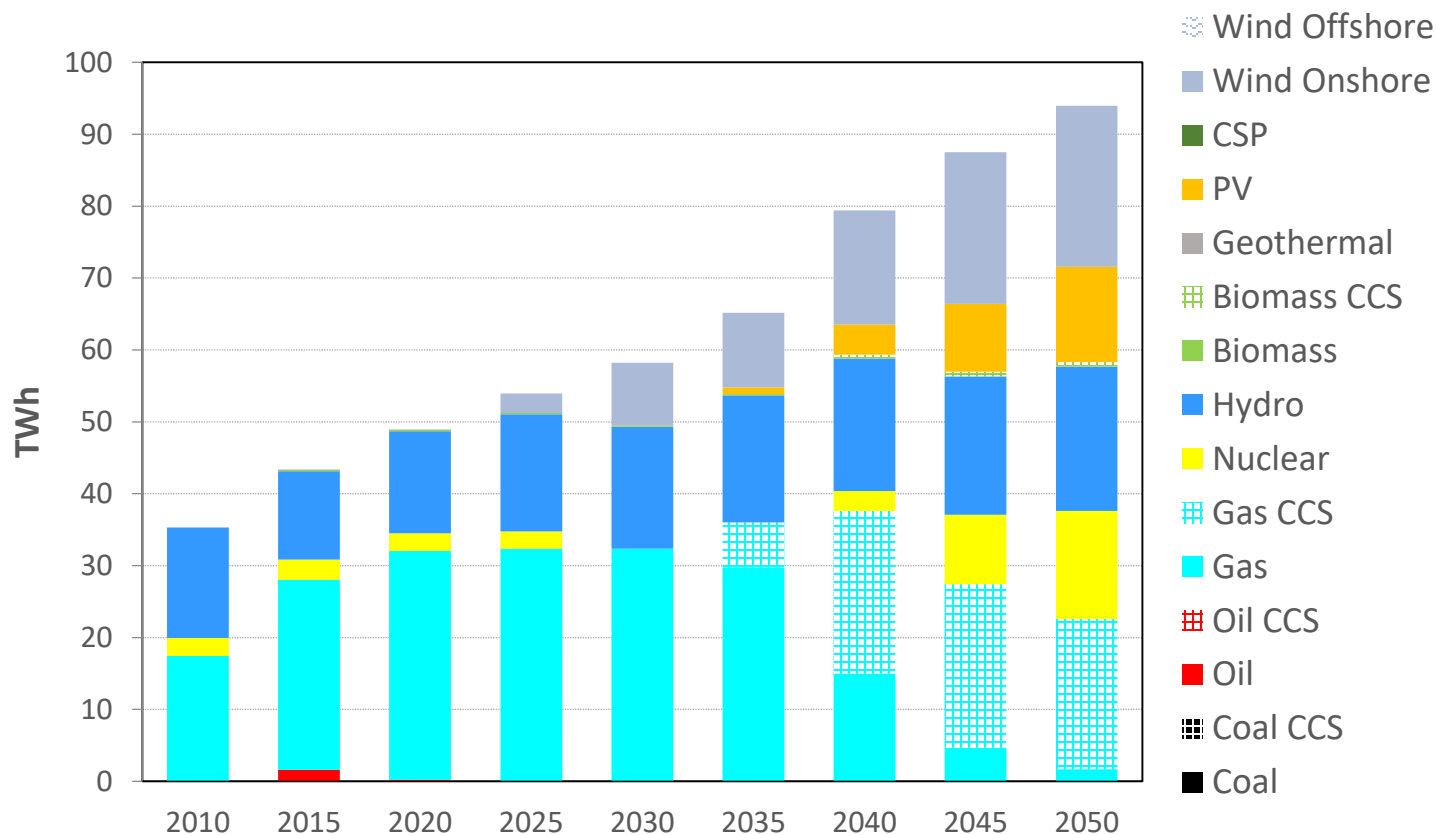
Modeling Results: SCS

Electricity Generation

ENERGY



Electricity generation by technology and fuel - SCS P2C Scenario



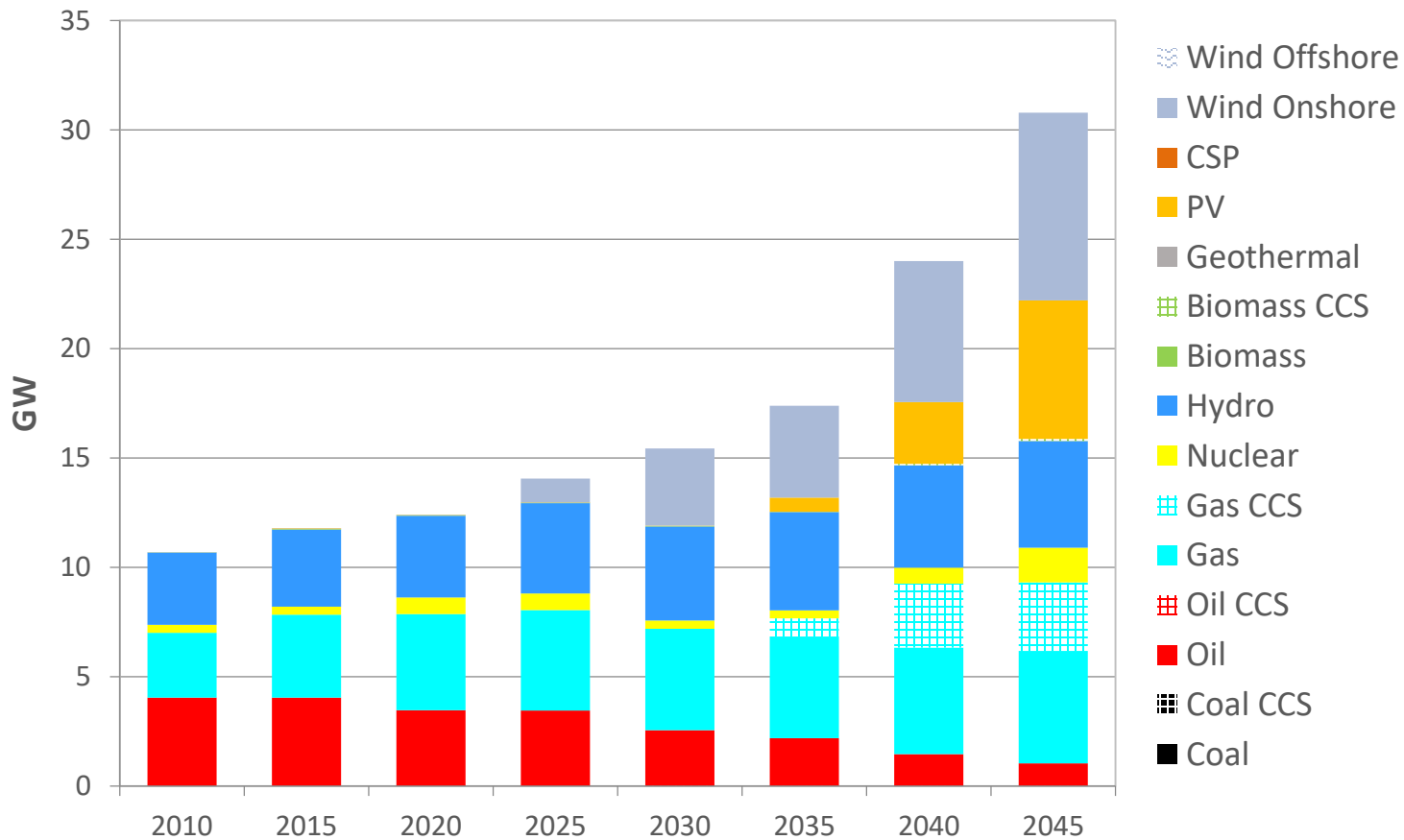
Modeling Results: SCS

Electricity Generation

ENERGY



Generating capacities by technology - SCS P2C Scenario



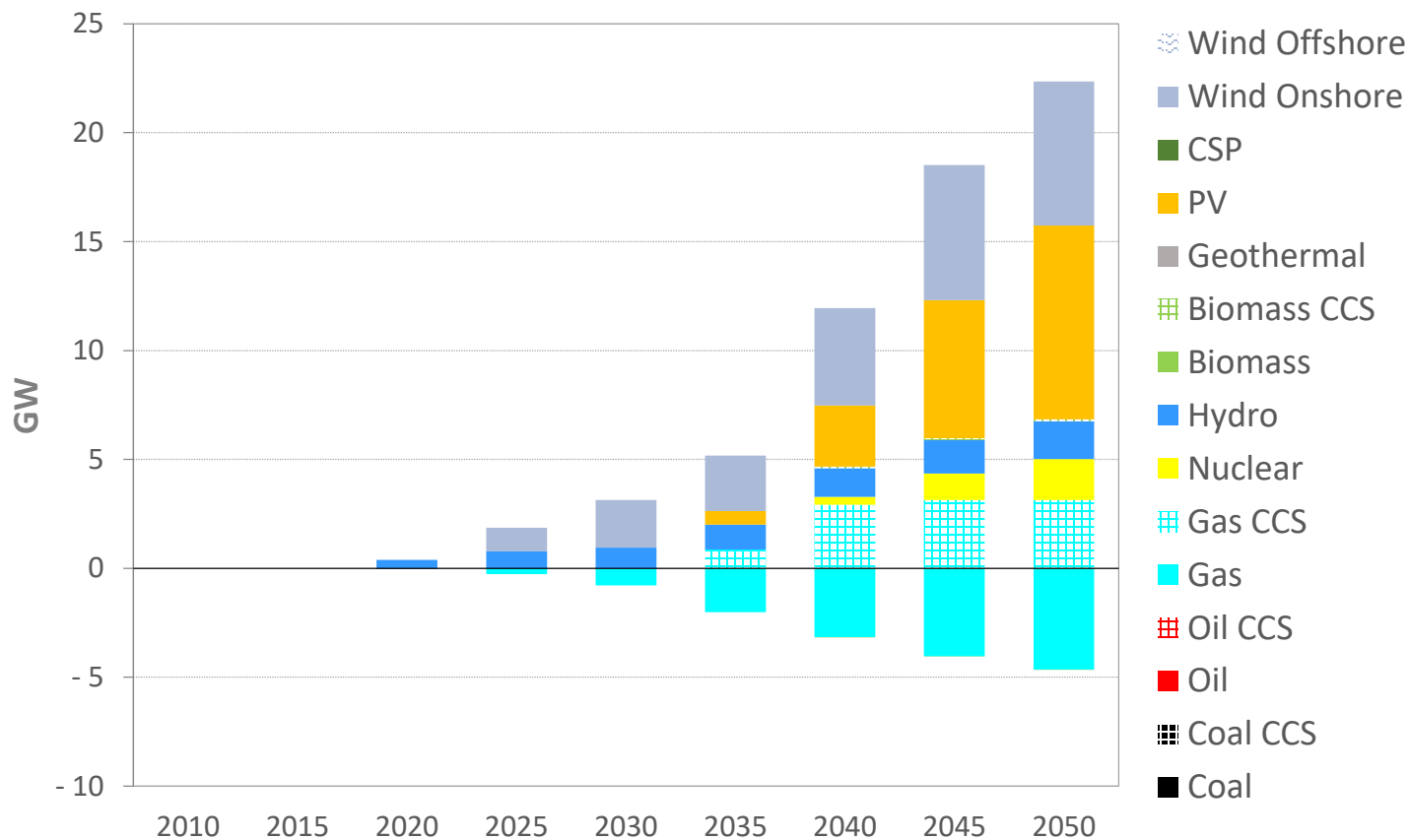
Modeling Results: SCS

Electricity Generation

ENERGY



Difference in electricity generation – SCS: P2C versus REF Scenario



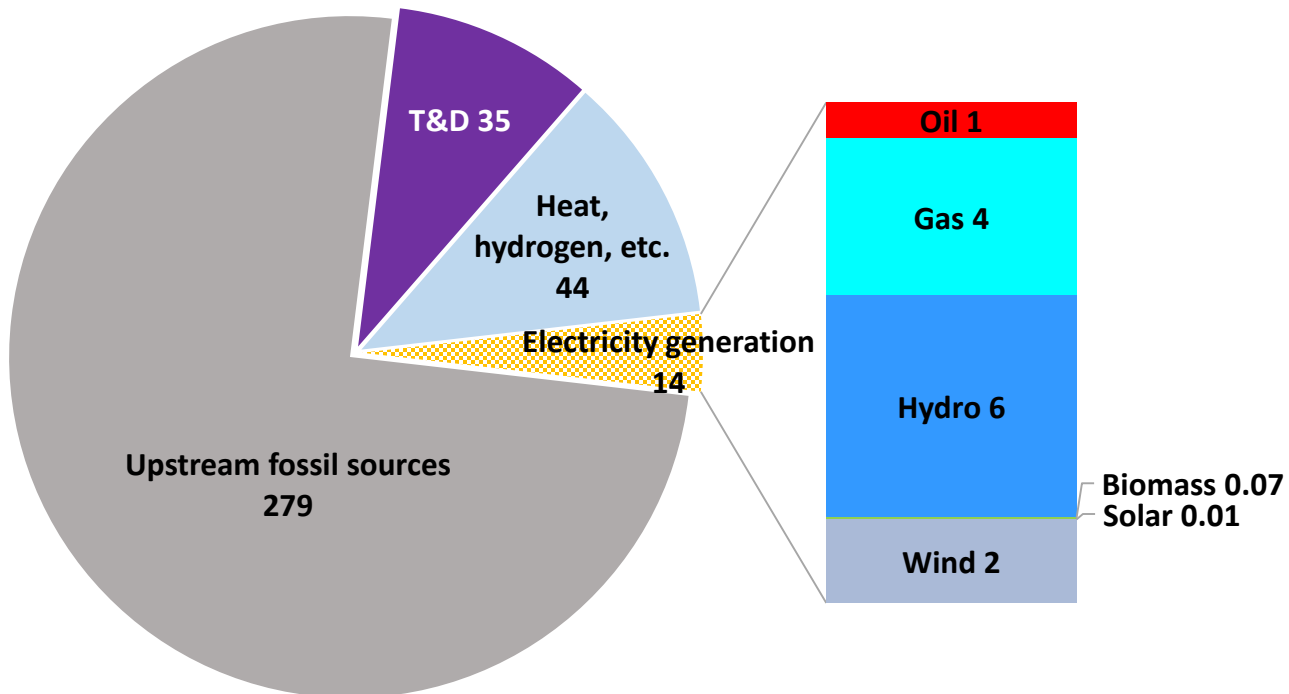
Modeling Results: Indicators

Investment needs: SCS

ENERGY



Cumulative investments 2020-2050: *371 billion US\$*
REF – SCS Region



- Upstream fossil sources
- Oil
- Biomass
- T&D
- Oil CCS
- Biomass CCS
- Heat, hydrogen, etc.
- Gas
- Geothermal
- Energy efficiency
- Gas CCS
- Solar
- Coal
- Nuclear
- Wind
- Coal CCS
- Hydro

- T&D: transmission and distribution of electricity and district heat
- Investments in US\$ at 2010 prices and exchange rates

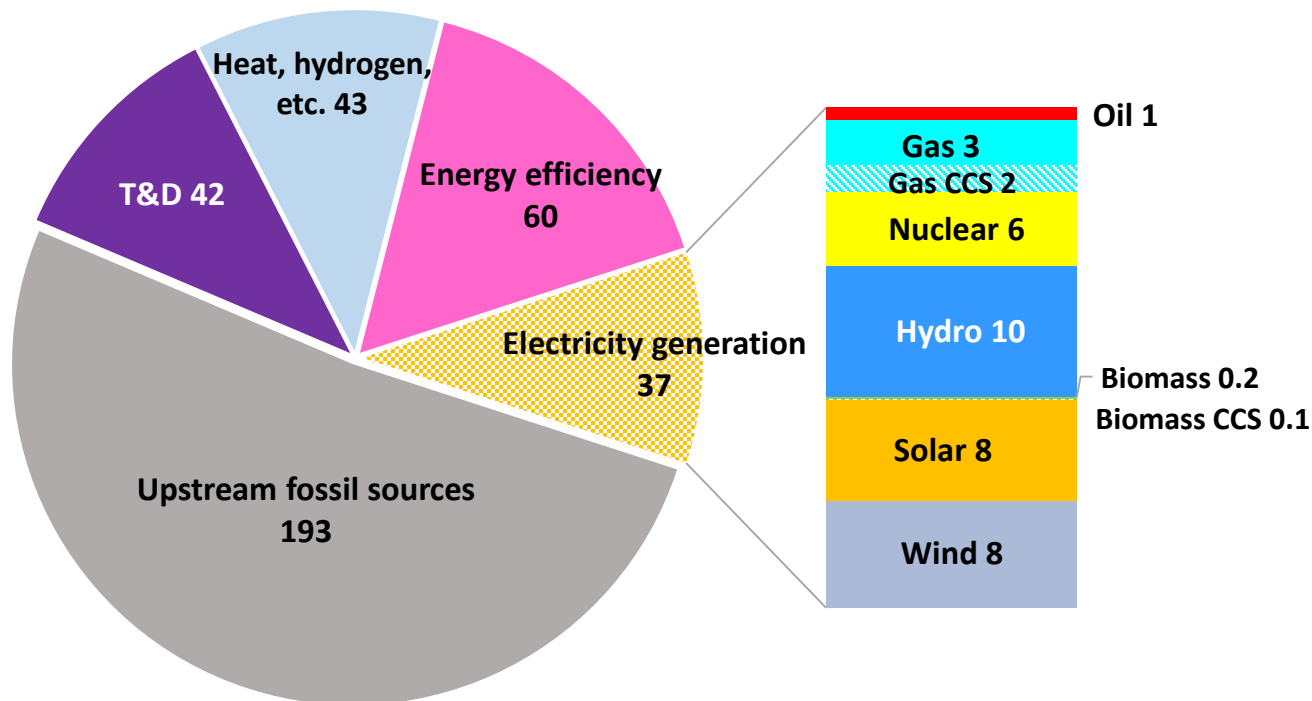
Modeling Results: Indicators

Investment needs: SCS

ENERGY



Cumulative investments 2020-2050: *375 billion US\$*
P2C – SCS Region



- Upstream fossil sources
- Oil
- Biomass
- T&D
- Oil CCS
- Biomass CCS
- Heat, hydrogen, etc.
- Gas
- Geothermal
- Energy efficiency
- Gas CCS
- Coal
- Nuclear
- Solar
- Coal CCS
- Hydro
- Wind

- T&D: transmission and distribution of electricity and district heat
- Investments in US\$ at 2010 prices and exchange rates

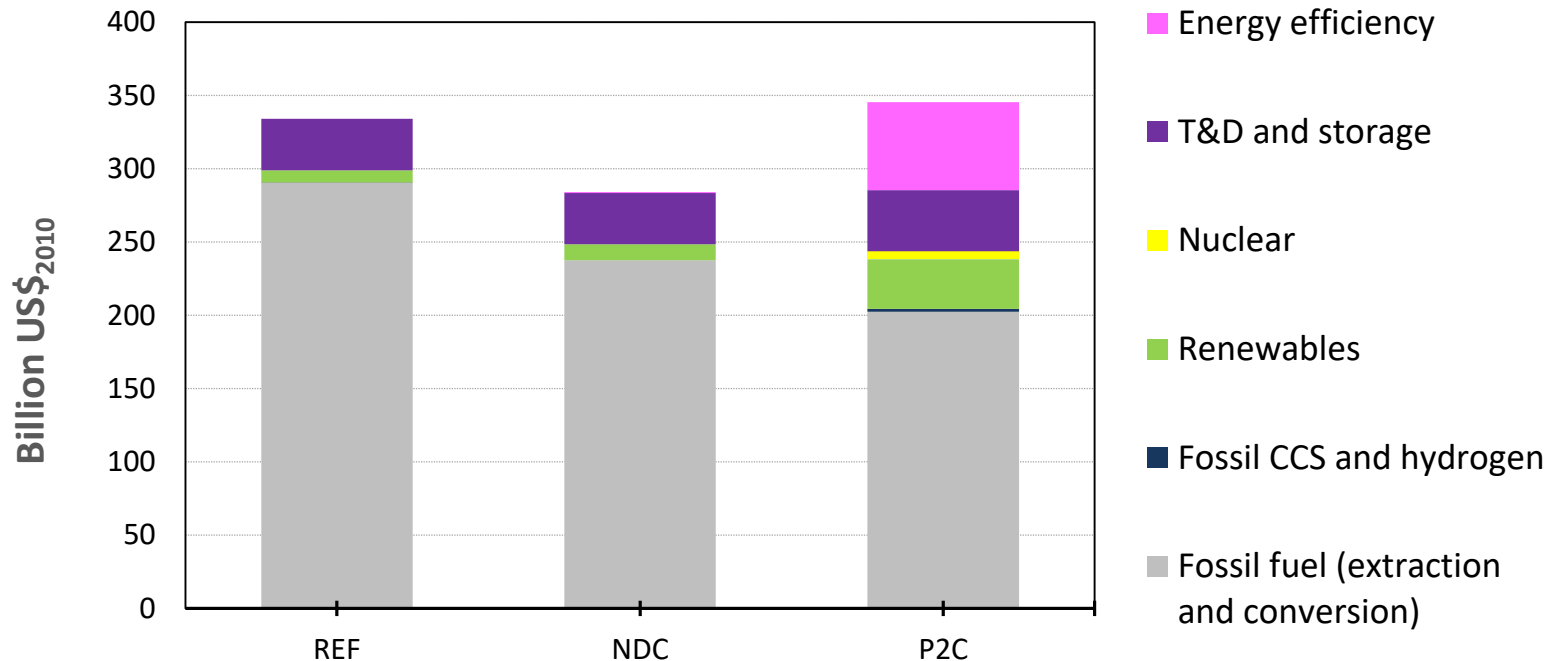
Modeling Results: Indicators

Investment needs: SCS

ENERGY



Comparing investment requirements - SCS REF, NDC and P2C scenarios



- T/D&S: transmission, distribution and storage of electricity and district heat
- CCS: carbon capture and storage
- H₂: hydrogen
- BAT: Best available technology

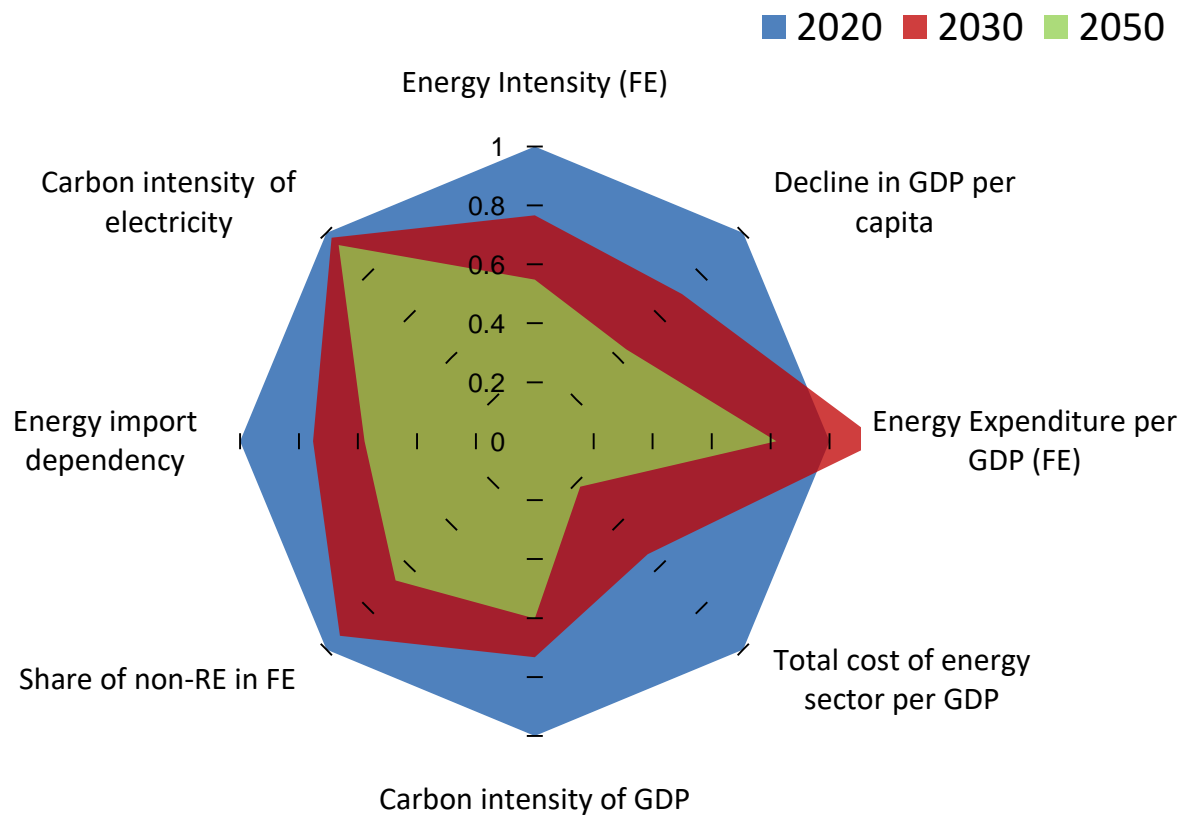
Modeling Results: Indicators

Tradeoffs and synergies: SCS

ENERGY



Indicators: Energy security, environment, quality of life SCS - REF Scenario



- Indicators are scaled relative to 2020 (2020=1); an *improvement in any indicator will result in values lower than 1*
- If the shape of polygon becomes smaller compared to 2020, it shows improvements in the indicators

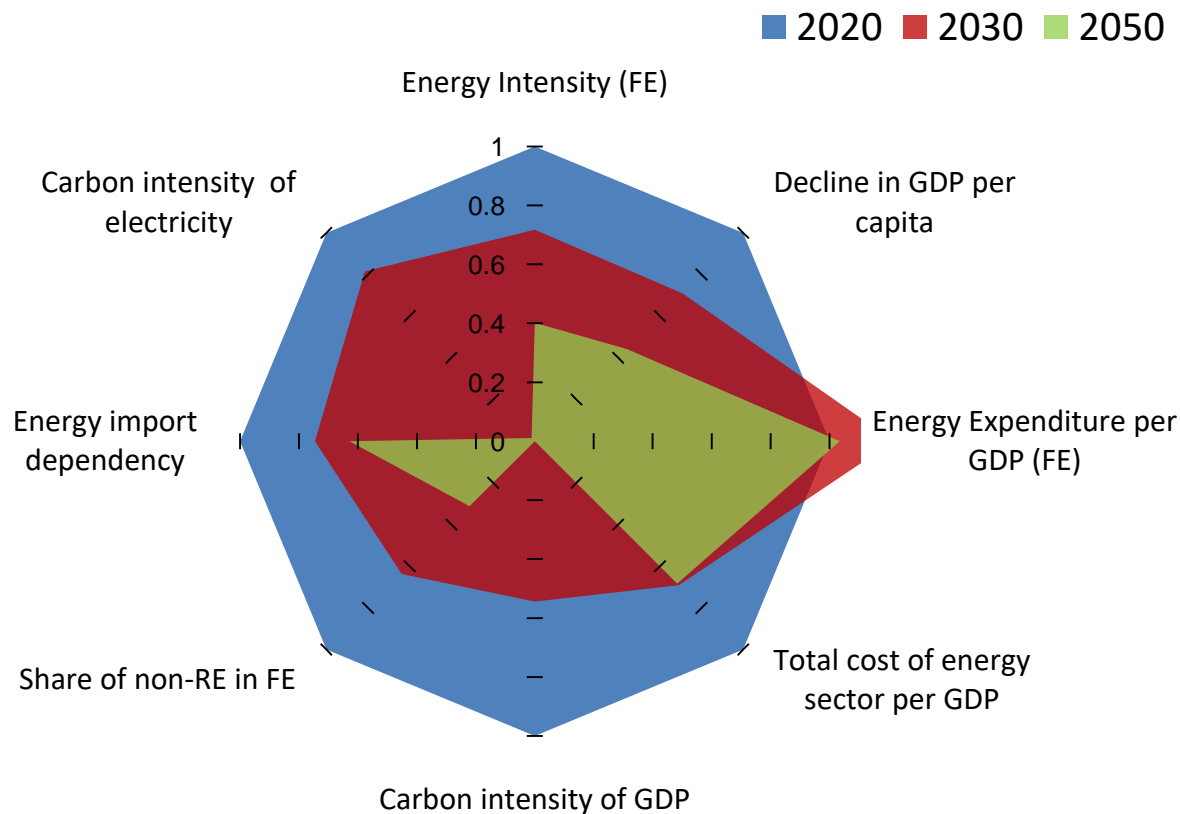
Modeling Results: Indicators

Tradeoffs and synergies: SCS

ENERGY



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Modeling Results: Demand & supply

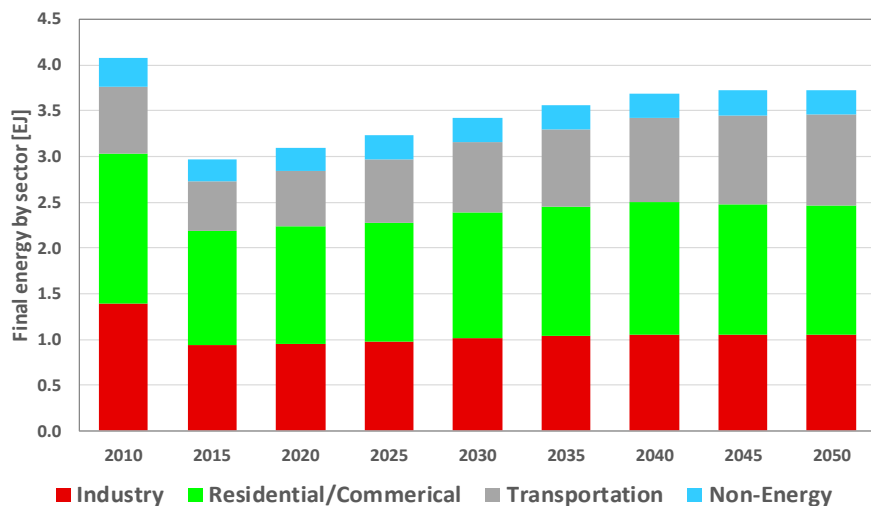
Final energy: BMU

ENERGY

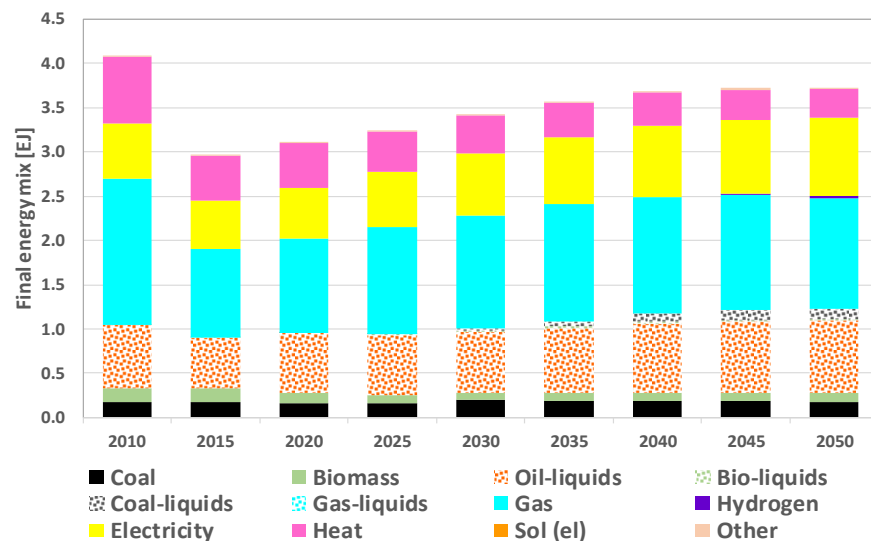


Belarus, Moldova and Ukraine (BMU) - REF Scenario

Final energy demand by sector



Final energy supply mix by fuel



Modeling Results: Demand & supply

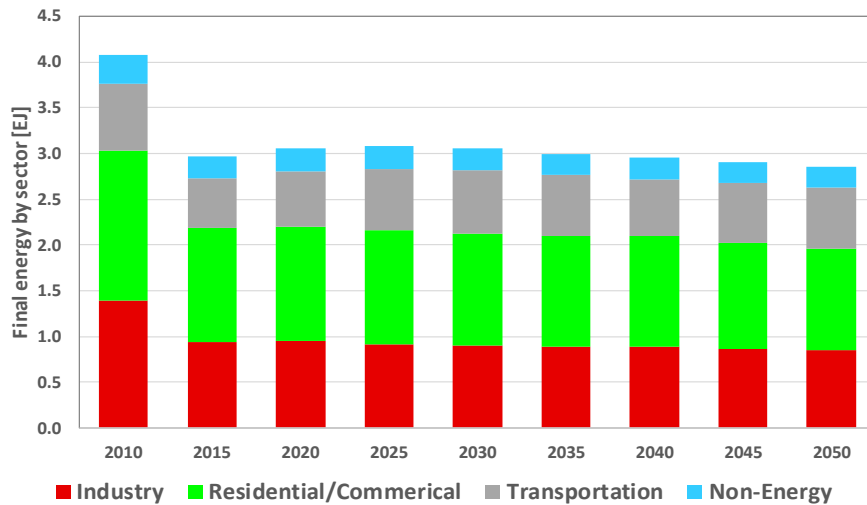
Final energy: BMU

ENERGY

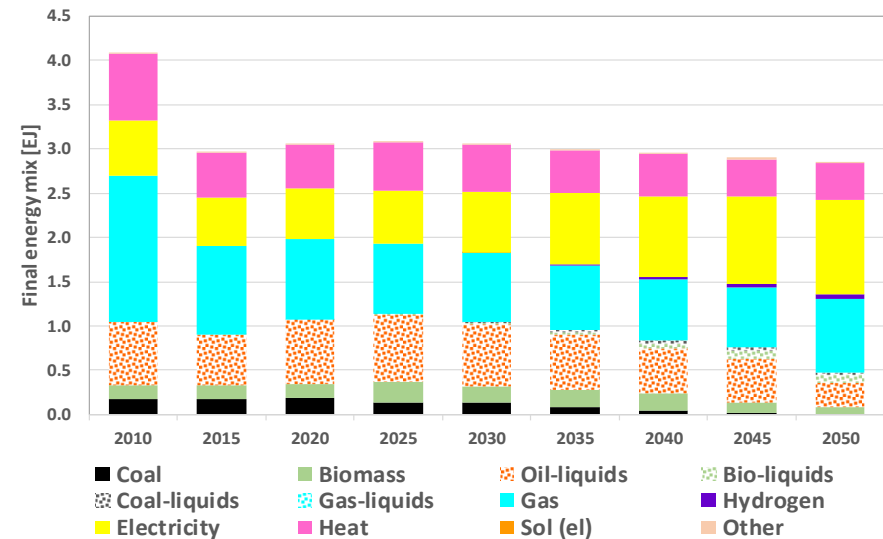


Belarus, Moldova and Ukraine (BMU) - P2C Scenario

Final energy demand by sector



Final energy supply mix by fuel



Modeling Results: Fuel markets

Natural gas markets: BMU

ENERGY

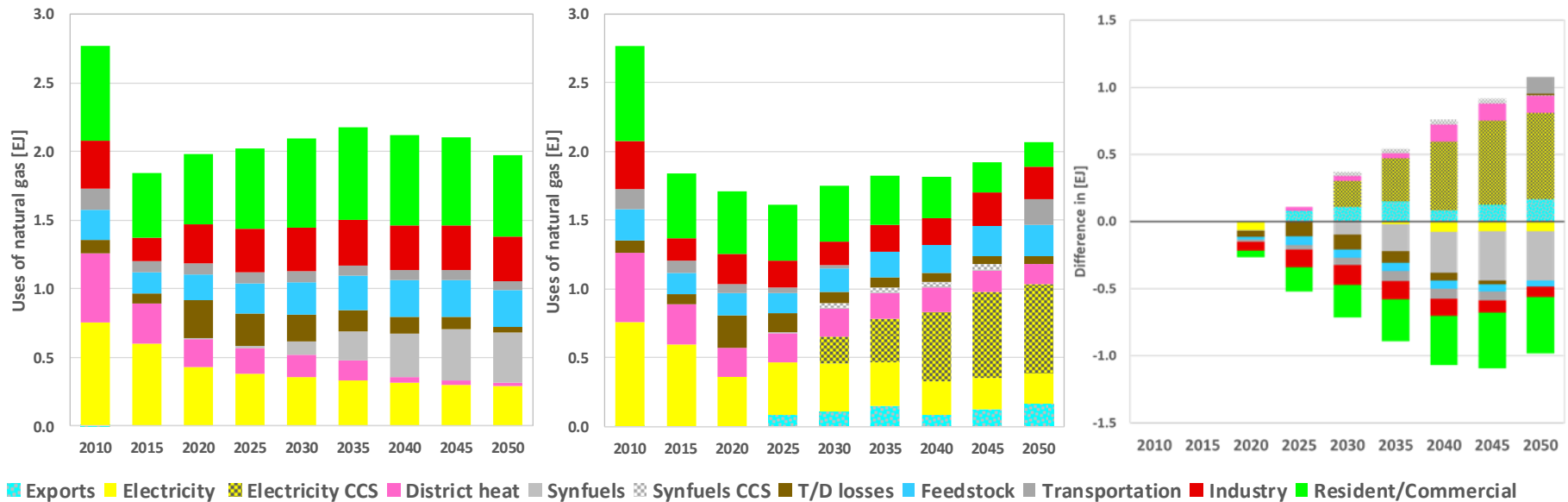


Uses of natural gas in the BMU Region

Reference

P2C

Difference P2C minus REF



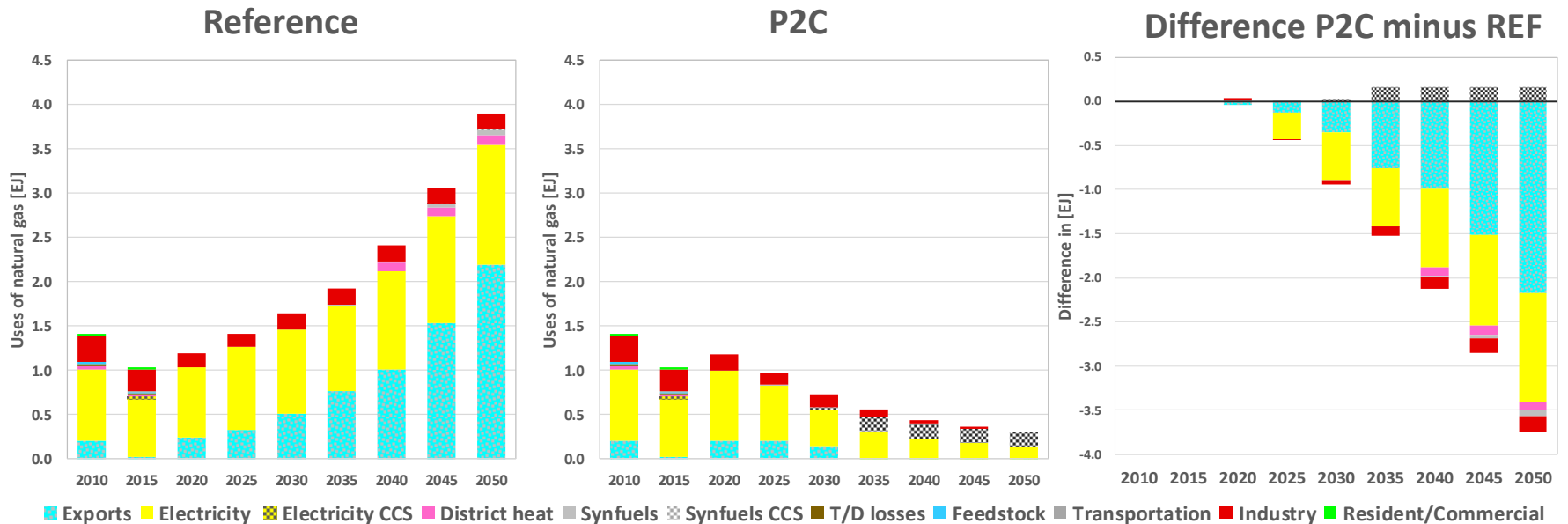
Modeling Results: Fuel markets

Coal markets: BMU

ENERGY



Uses of coal in the BMU Region



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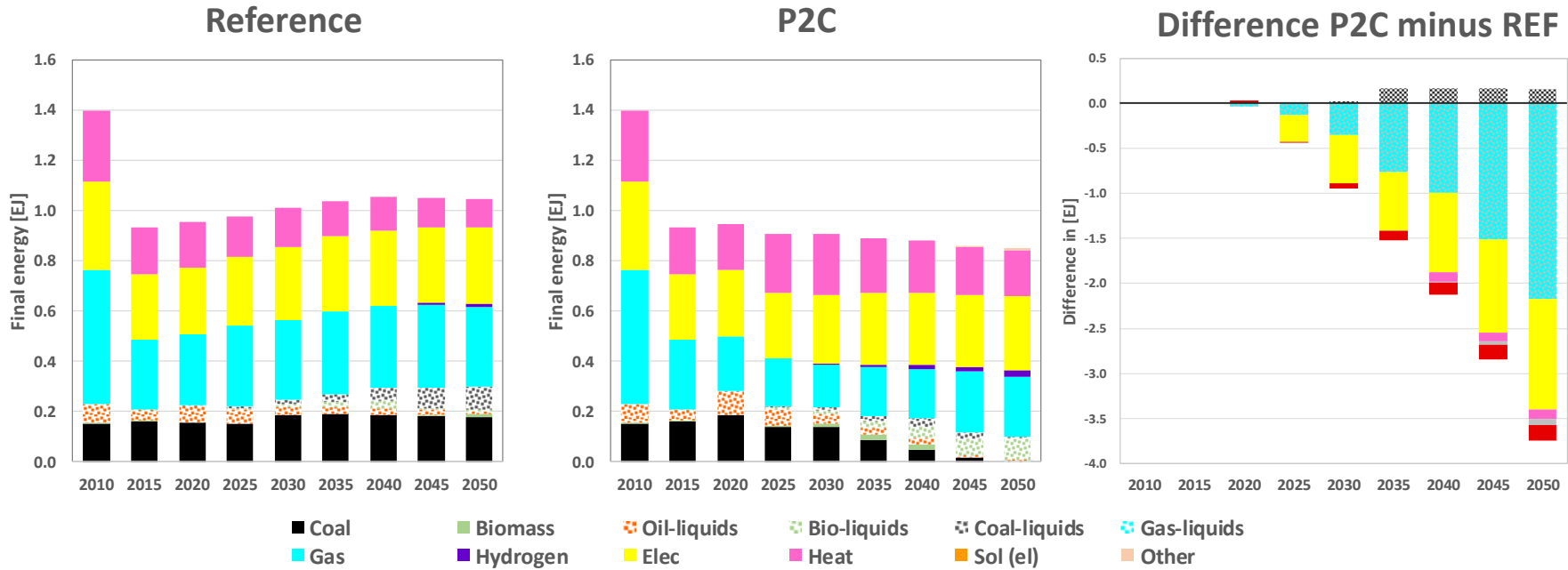
Modeling Results: Sectors

Final energy use: BMU

ENERGY



Industry: BMU Region



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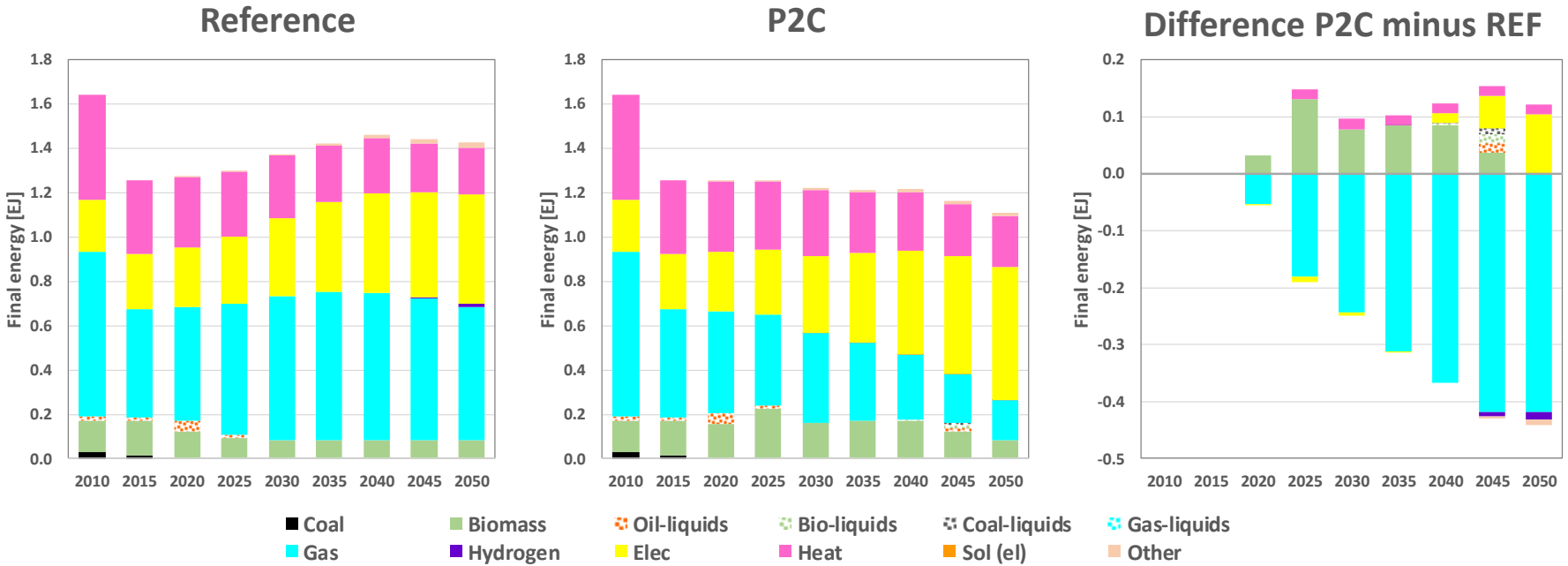
Modeling Results: Sectors

Final energy use: BMU

ENERGY



Residential/Commercial sector: BMU Region



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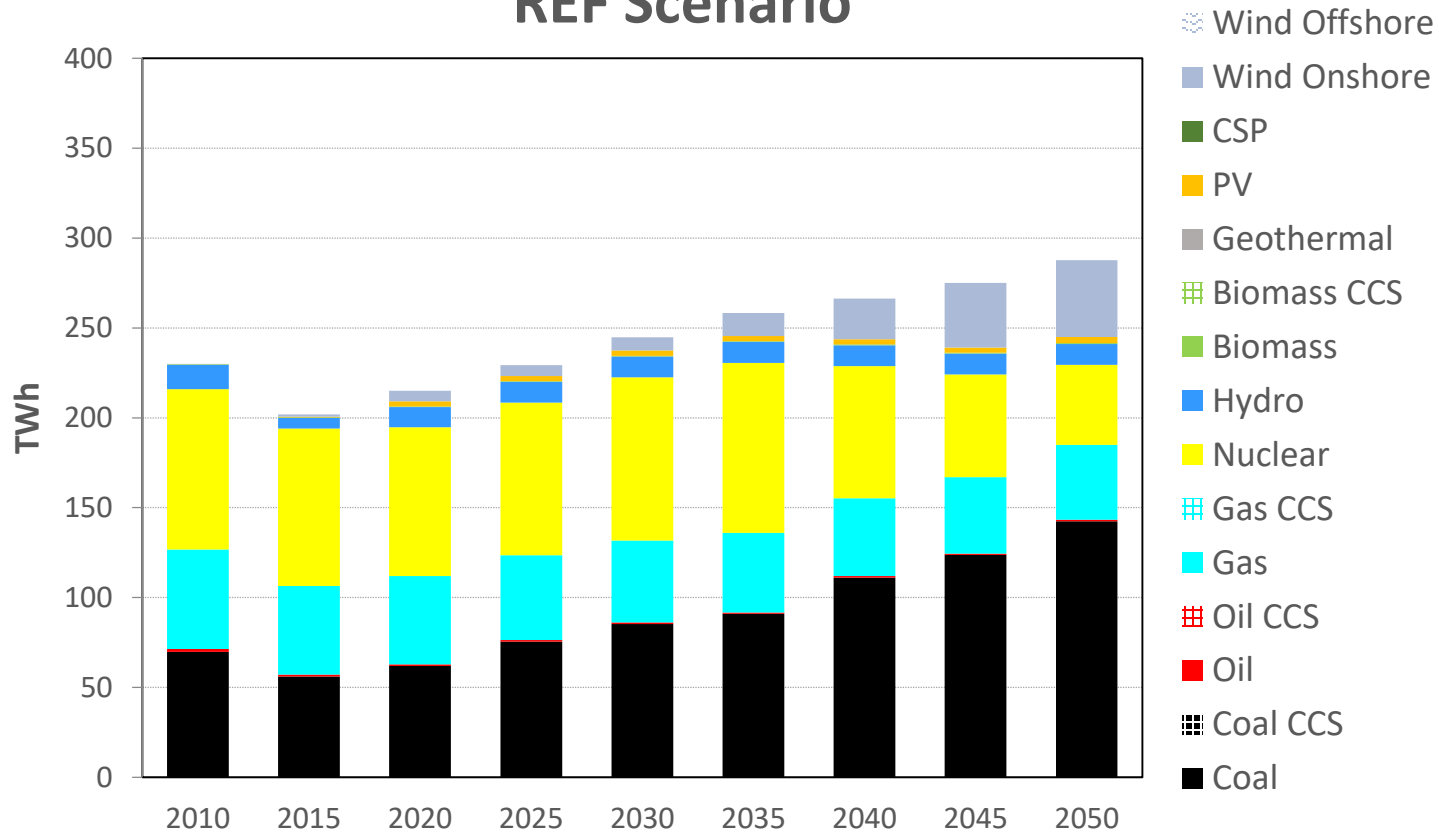
Modeling Results: BMU

Electricity Generation

ENERGY



Electricity generation by technology and fuel - BMU REF Scenario



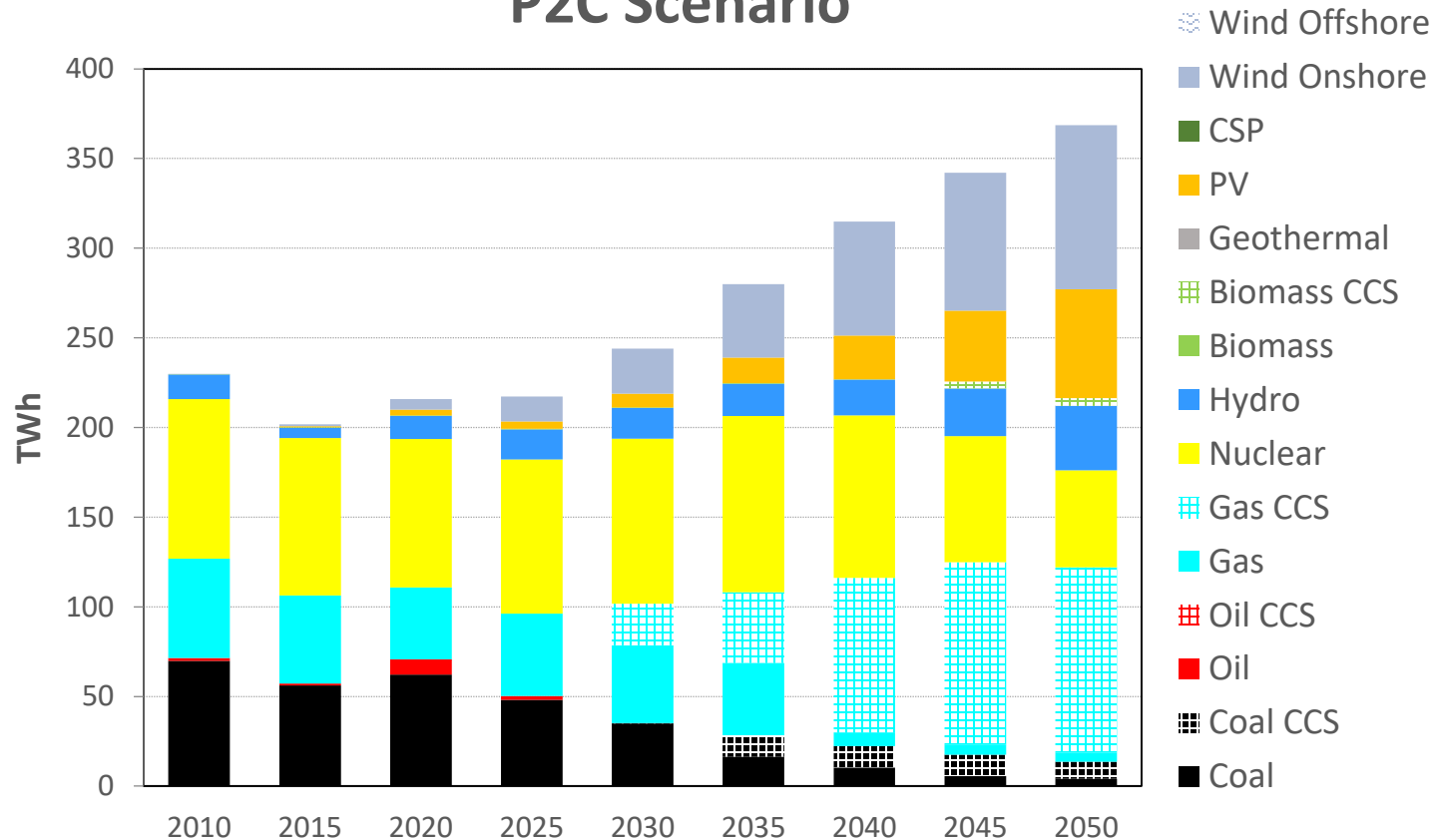
Modeling Results: BMU

Electricity Generation

ENERGY



Electricity generation by technology and fuel - BMU P2C Scenario



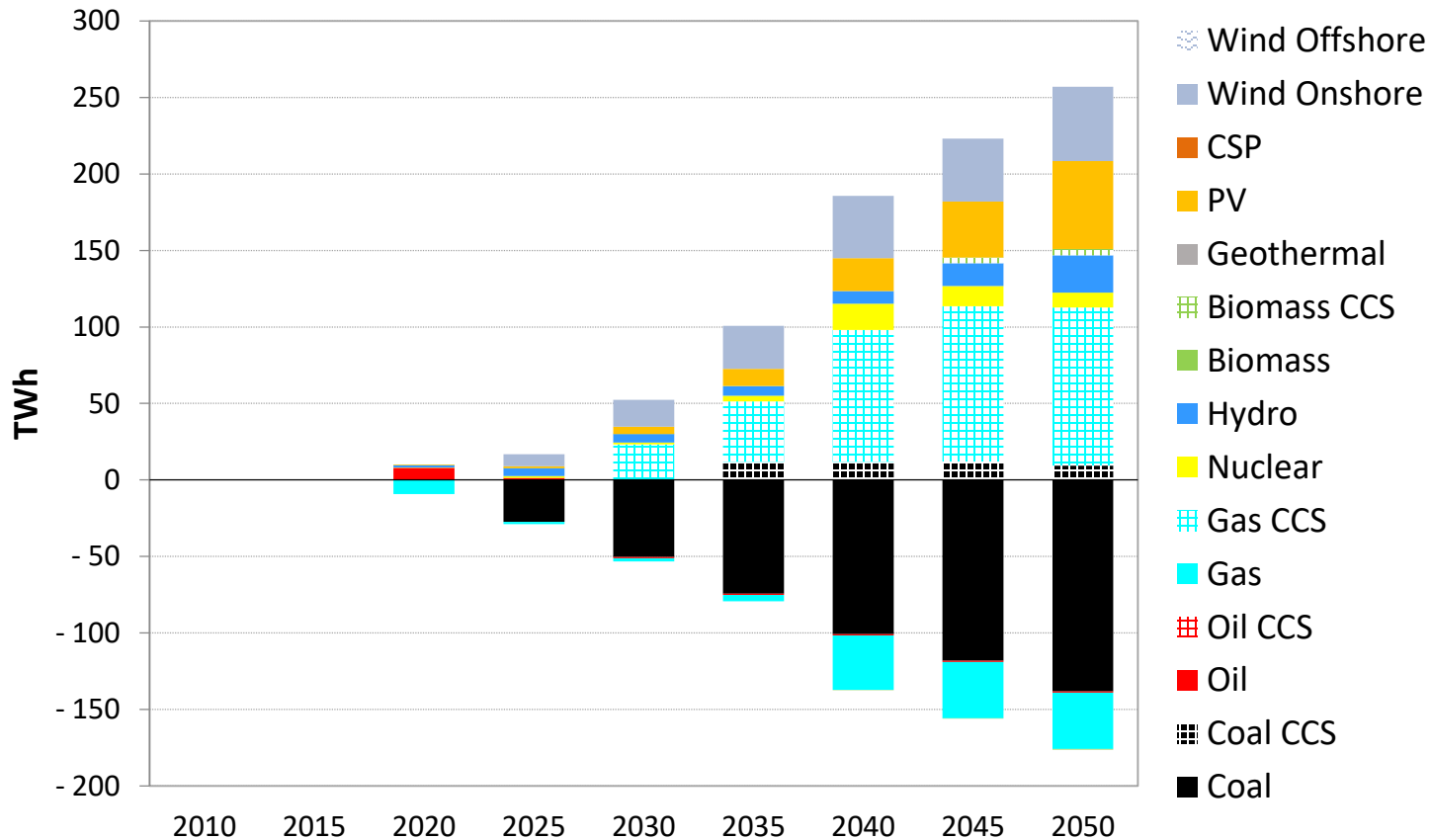
Modeling Results: BMU

Electricity Generation

ENERGY



Difference in electricity generation – BMU: P2C versus REF Scenario



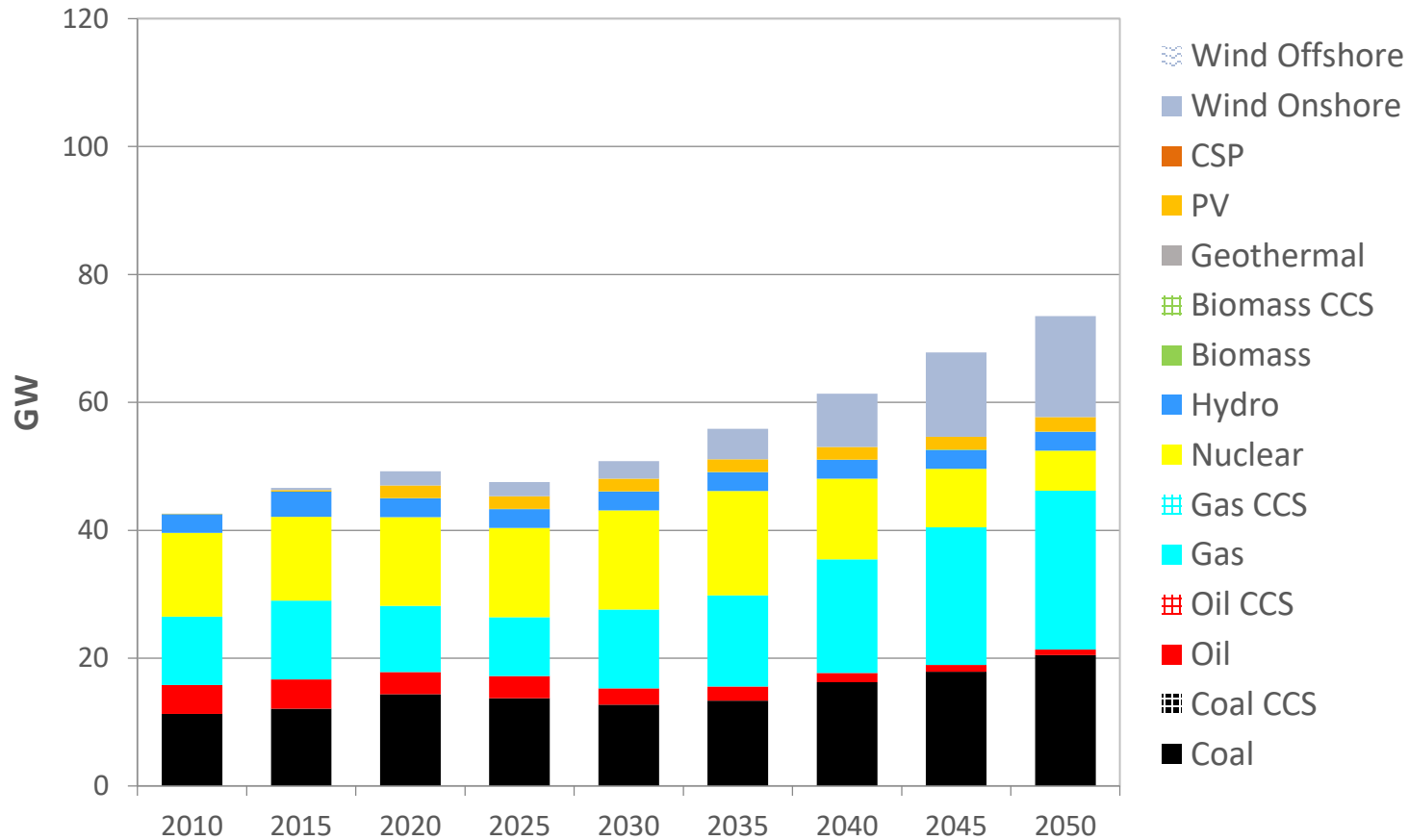
Modeling Results: BMU

Electricity Generation

ENERGY



Generating capacities by technology - BMU REF Scenario



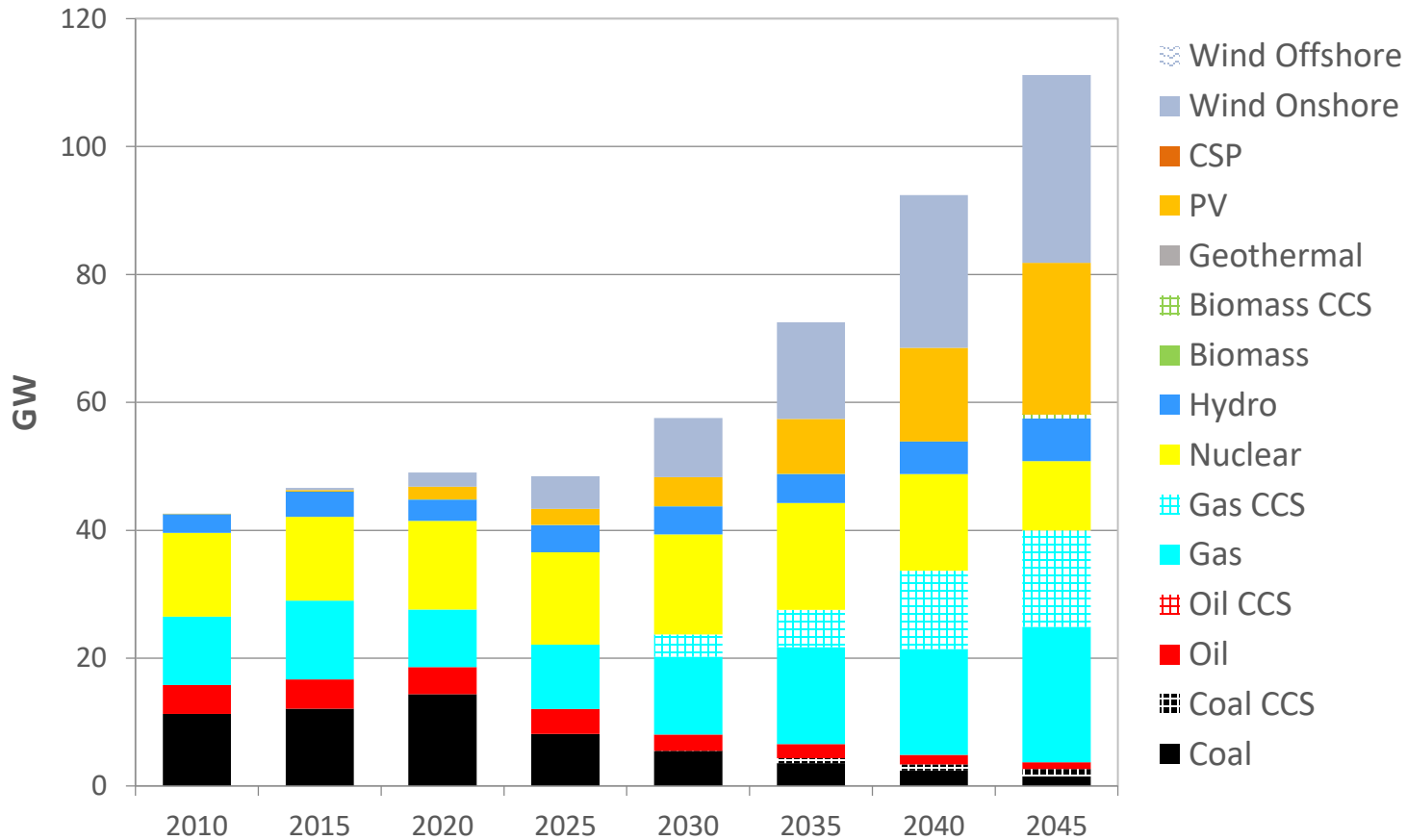
Modeling Results: BMU

Electricity Generation

ENERGY



Generating capacities by technology - BMU P2C Scenario



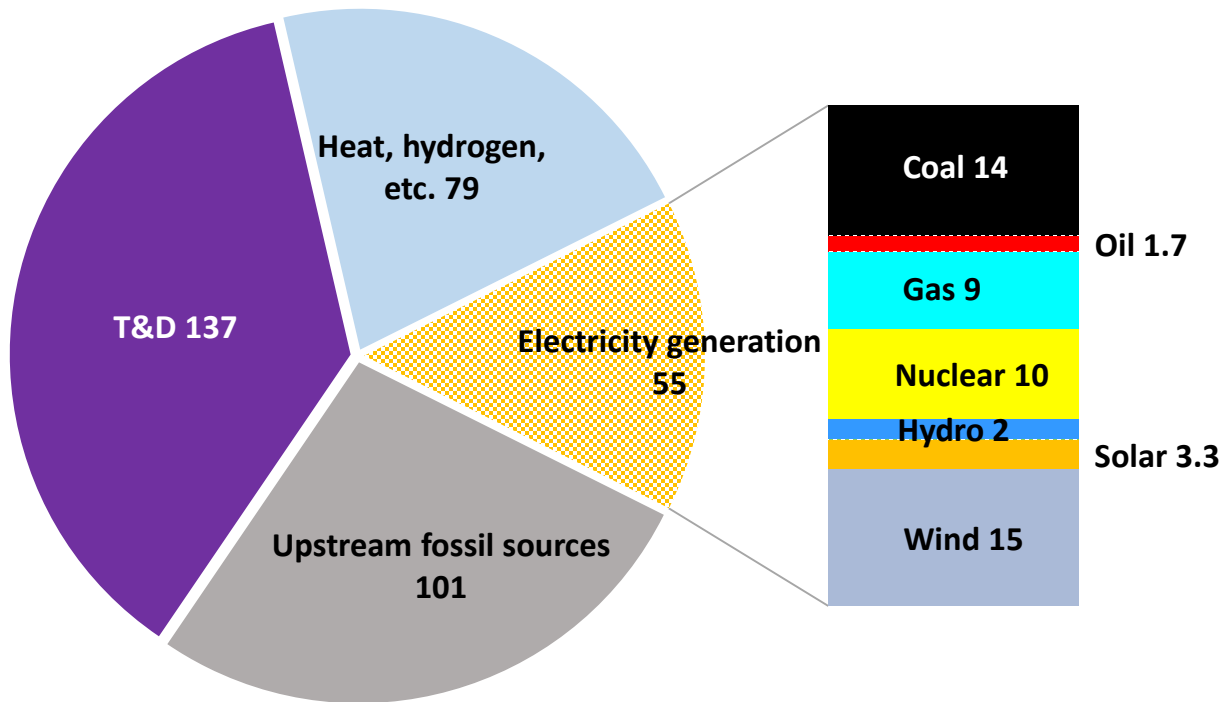
Modeling Results: Indicators

Investment needs: BMU

ENERGY



Cumulative investments 2020-2050: *372 billion US\$*
REF – BMU Region



- Upstream fossil sources
- T&D
- Heat, hydrogen, etc.
- Energy efficiency
- Coal
- Coal CCS
- Oil
- Oil CCS
- Gas
- Gas CCS
- Nuclear
- Hydro
- Biomass
- Biomass CCS
- Geothermal
- Solar
- Wind

- T&D: transmission and distribution of electricity and district heat
- Investments in US\$ at 2010 prices and exchange rates

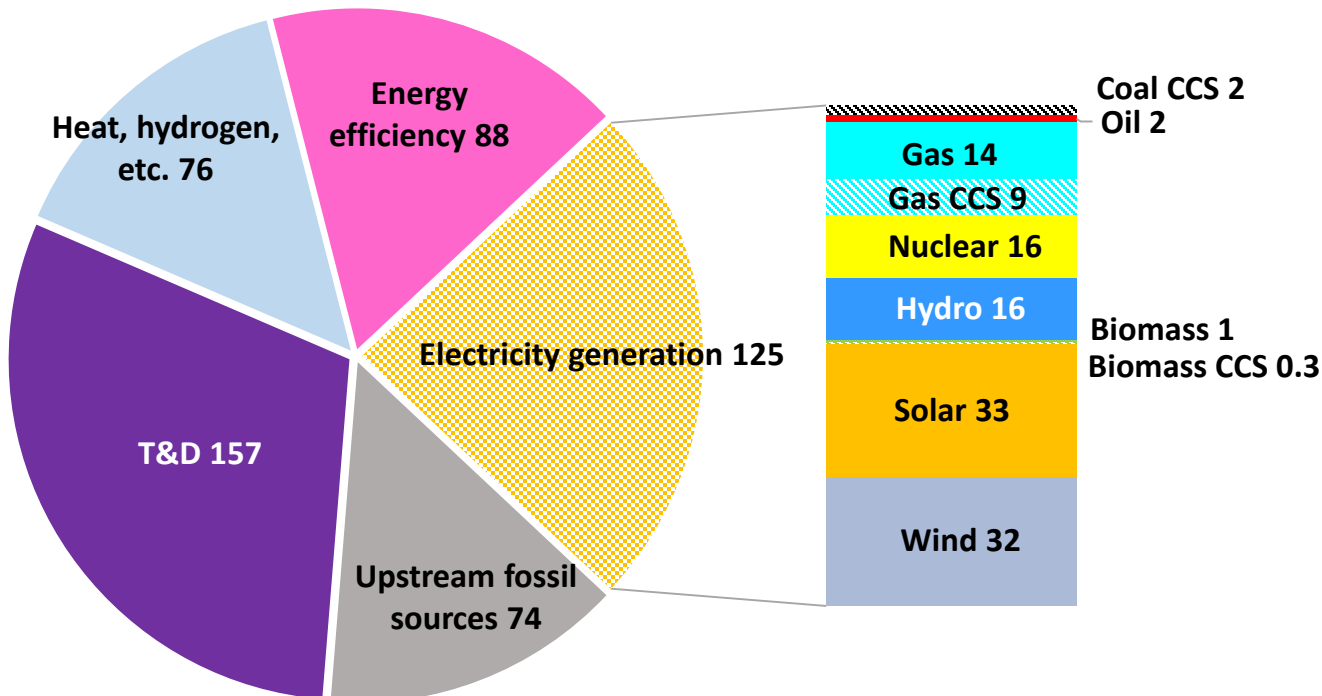
Modeling Results: Indicators

Investment needs: BMU

ENERGY



Cumulative investments 2020-2050: *520 billion US\$*
P2C – BMU Region



- Upstream fossil sources
- T&D
- Heat, hydrogen, etc.
- Energy efficiency
- Coal
- Coal CCS
- Oil
- Oil CCS
- Gas
- Gas CCS
- Nuclear
- Hydro
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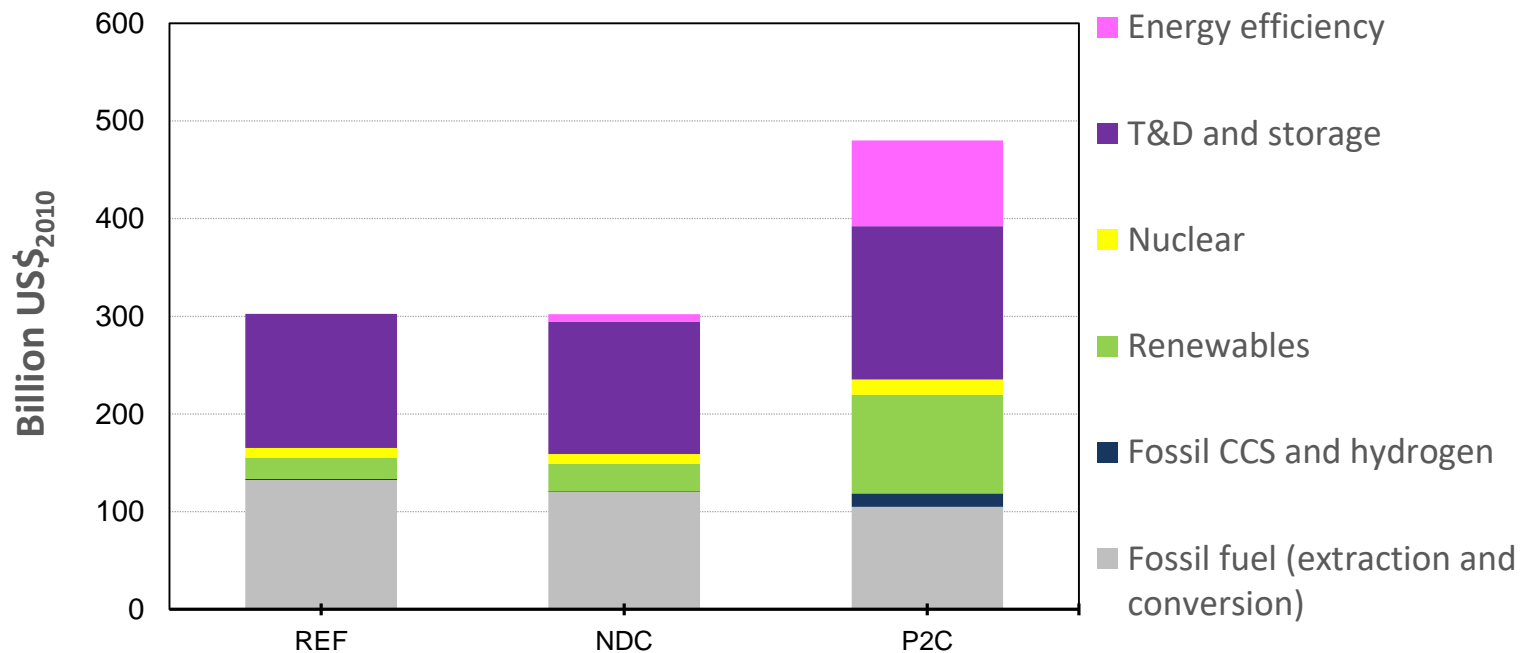
Modeling Results: Indicators

Investment needs: BMU

ENERGY



Comparing investment requirements - BMU REF, NDC and P2C scenarios



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- CCS: carbon capture and storage
- H₂: hydrogen
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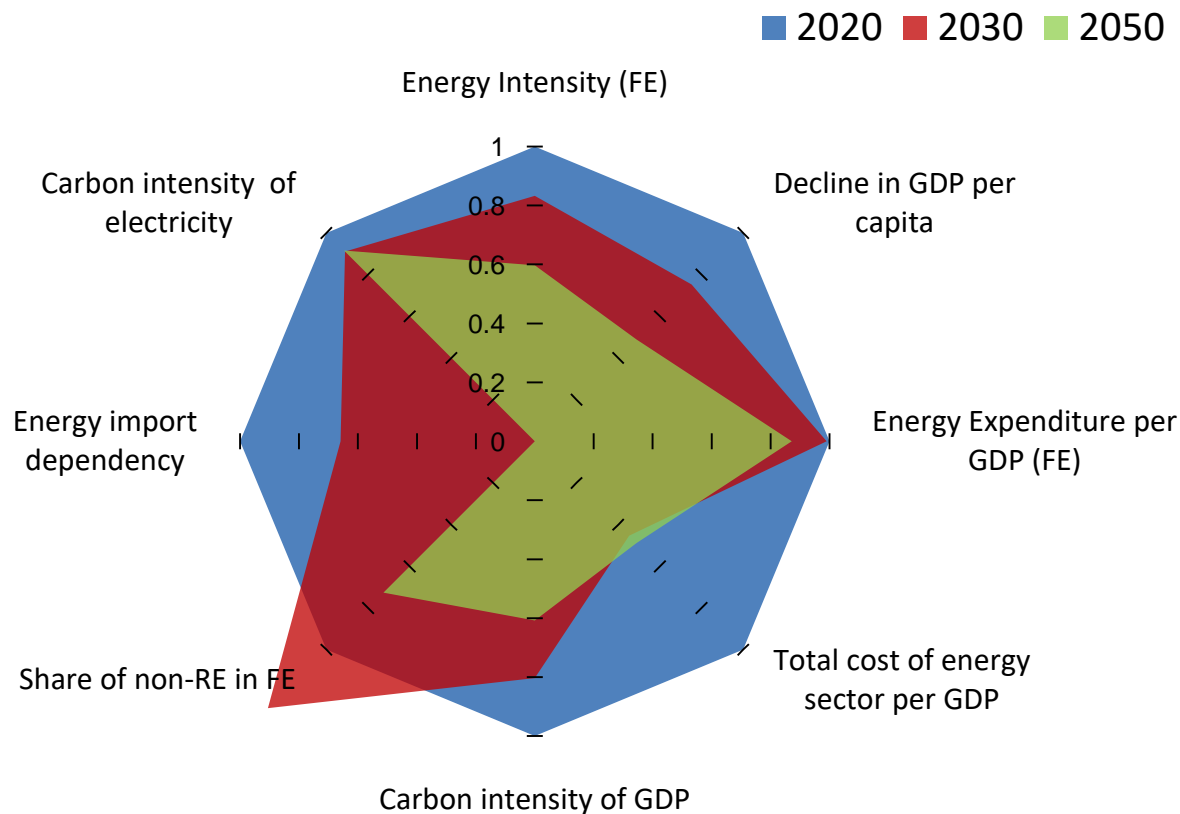
Modeling Results: Indicators

Tradeoffs and synergies: BMU

ENERGY



Indicators: Energy security, environment, quality of life BMU - REF Scenario



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Modeling Results: Indicators

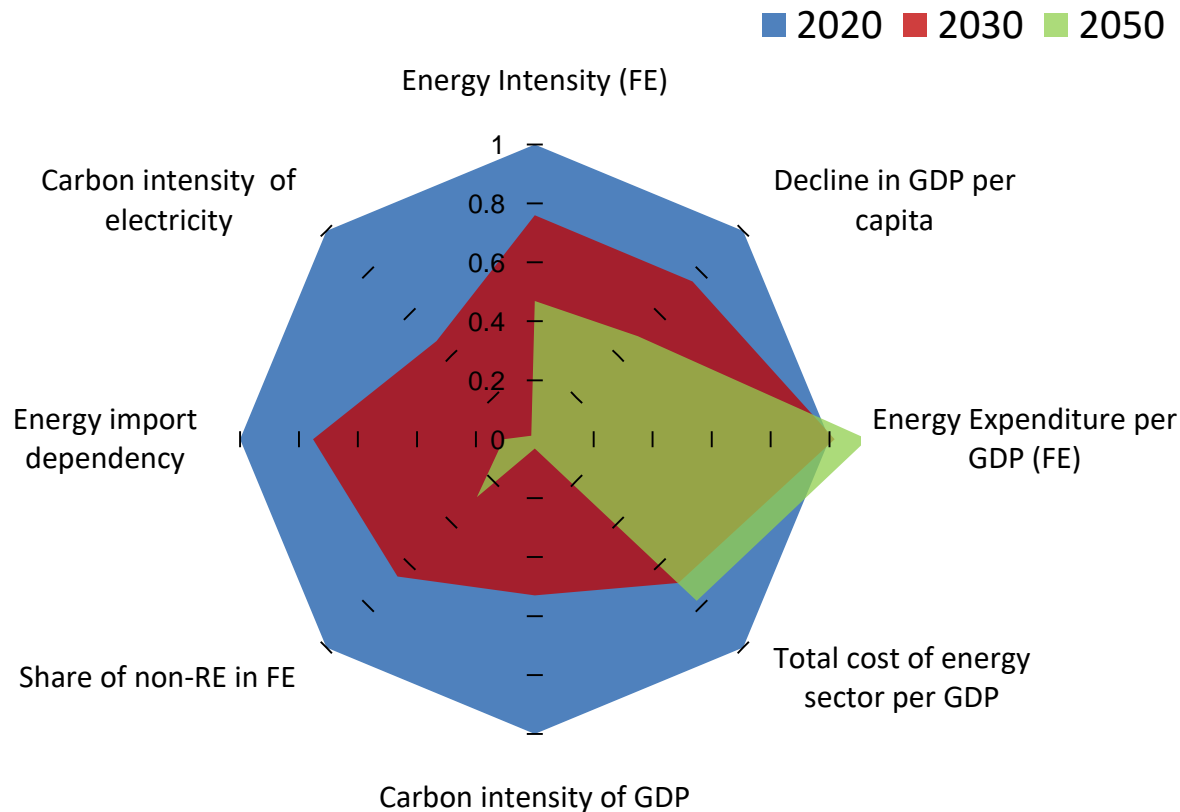
Tradeoffs and synergies: BMU

ENERGY



Indicators: Energy security, environment, quality of life BMU - REF Scenario

Comparing different indicators relative to 2020 REF scenario, BMU



- Indicators are scaled relative to 2020 (2020=1); an *improvement in any indicator will result in values lower than 1*
- If the shape of polygon becomes smaller compared to 2020, it shows improvements in the indicators