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2nd Almaty
Energy Forum

CARBON NEUTRALITY SCENARIOS FOR CENTRAL ASIA (CAS)

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2nd Almaty Energy Forum

Building resilient energy systems in Central Asia

Almaty, 14 – 16 November 2022



Salient background information

Central Asia (CAS) - one of eight# interconnected regions in UNECE's Carbon Neutrality Project

Findings must always be understood in the global context

Scenarios seek to attain cost-minimal carbon neutrality by 2050 under different sets of technology and policy options

Modelling necessarily entails numerous assumptions## about the future – key sources of uncertainty

and 15 world regions

e.g., scenarios assume a future world free of geopolitical conflicts

- **Reference scenario (REF)**
SSP 2* serves as point of departure, i.e., without dedicated sustainable energy or climate policies (essentially the REF scenario of the Pathways Project)
- **Carbon Neutrality (CN)**
Normative scenario mandating carbon neutrality of UNECE's aggregate energy system by 2050 (and beyond until 2100)
- **Special technology deep dives**
 - Hydrogen – production options and markets (H₂)
 - Carbon capture, utilization, and storage (CCUS), including direct air capture (DAC)
 - Nuclear energy – realizing its potential, new application and markets (NUC)
- **Carbon Neutrality Innovation (CNi)**
All three deep dive technology cases combined: synergies, trade-offs and benefits

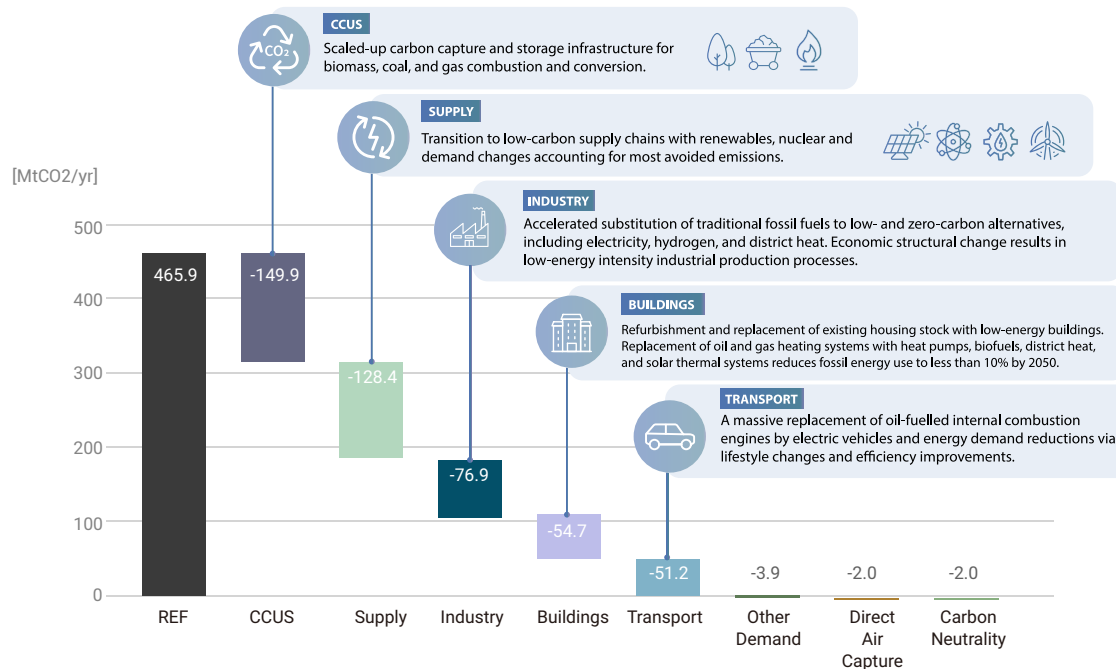
* Shared Socio-economic Pathways # (SSP 2)



Carbon neutrality requires comprehensive energy system transformation involving all economic sectors and society at large

How different sectors may contribute to Carbon Neutrality?

Technology interplay – supply side and demand side plus lifestyle changes



CO₂ mitigation in 2050 - Central Asia
from Reference (REF) to Carbon Neutrality Innovation (CNI)



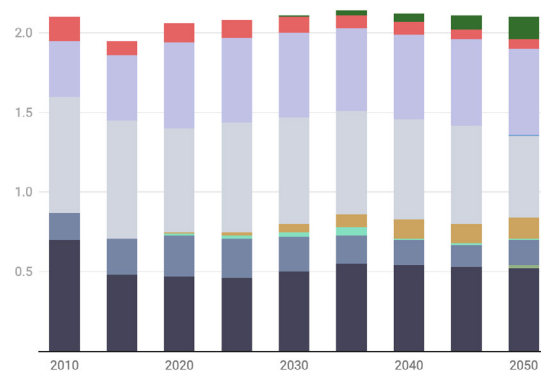
Industry

Final energy mix [EJ]

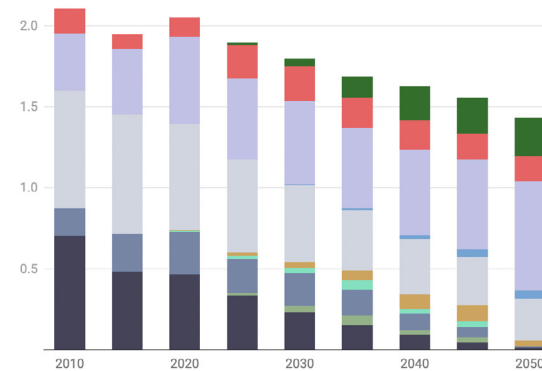
Decarbonization accomplished via

- Energy intensity reductions throughout the industrial production process, structural change and efficiency improvements
- Electrification
- Cogeneration
- Hydrogen
- CCUS

■ Coal
 ■ Biomass
 ■ Oil-liquids
 ■ Bio-liquids
 ■ Coal-liquids
 ■ Gas-liquids
 ■ Gas
 ■ Hydrogen
 ■ Electricity
 ■ Heat
 ■ Other



Final Energy - Industry [EJ]
Reference (REF)



Final Energy - Industry [EJ]
Carbon Neutrality Innovation (CNI)

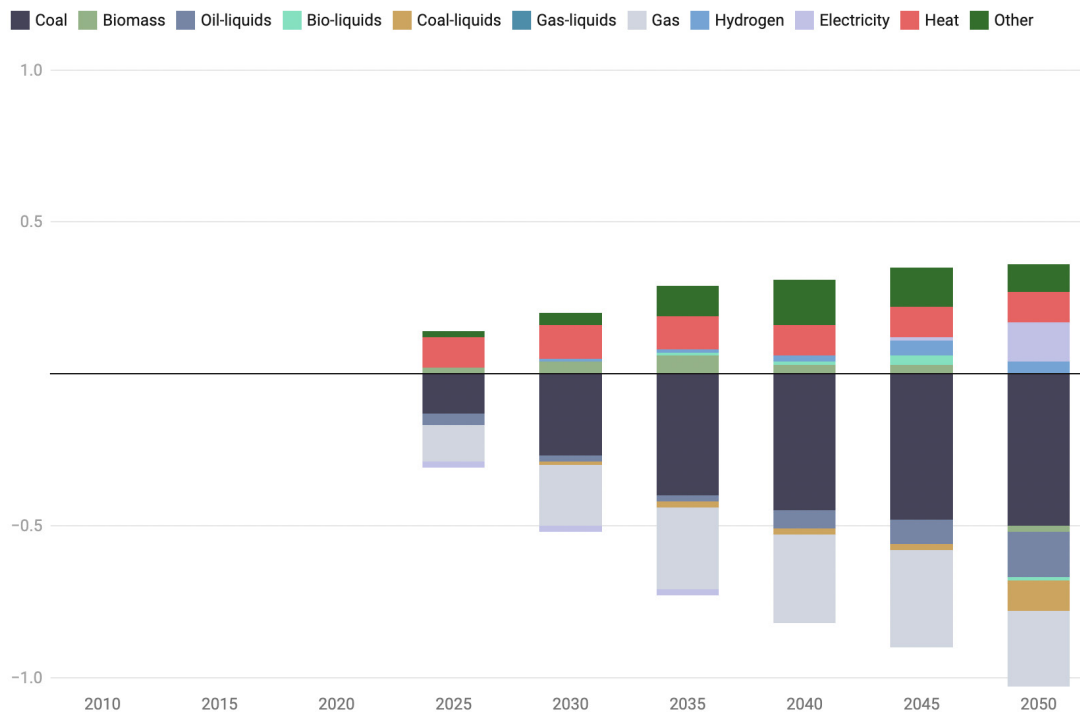


Industry

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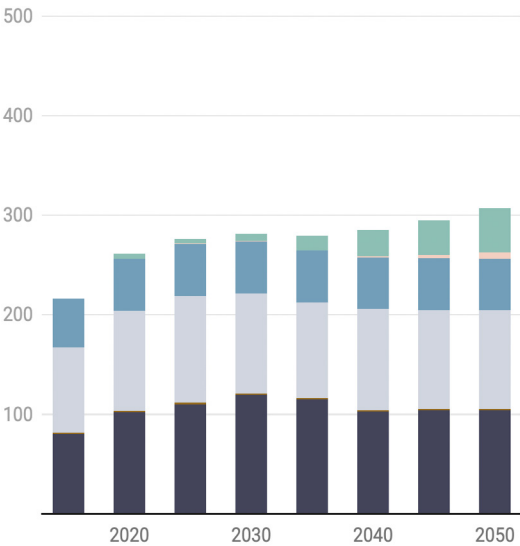
Transformation of Industry
Carbon Neutrality Innovation (CNI) vs Reference (REF) in [EJ]



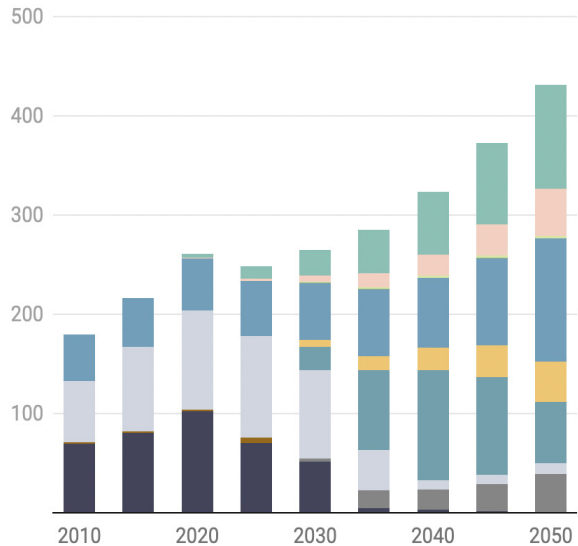
Electricity generation [TWh], Central Asia (CAS)

Coal
 Coal CCS
 Oil
 Oil CCS
 Gas
 Gas CCS
 Nuclear
 Hydro
 Biomass
 Biomass CCS
 Geothermal
 PV

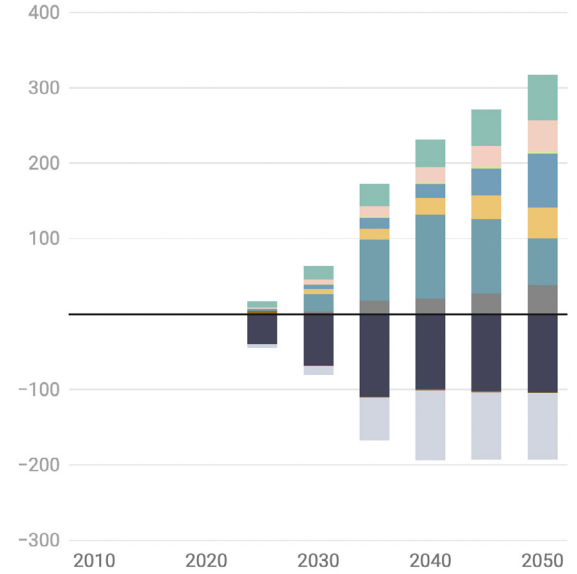
 CSP
 Wind Onshore
 Wind Offshore
 Other



**Electricity generating mix [TWh]
Reference (REF)**



**Electricity generating mix [TWh]
Carbon Neutrality Innovation (CNI)**

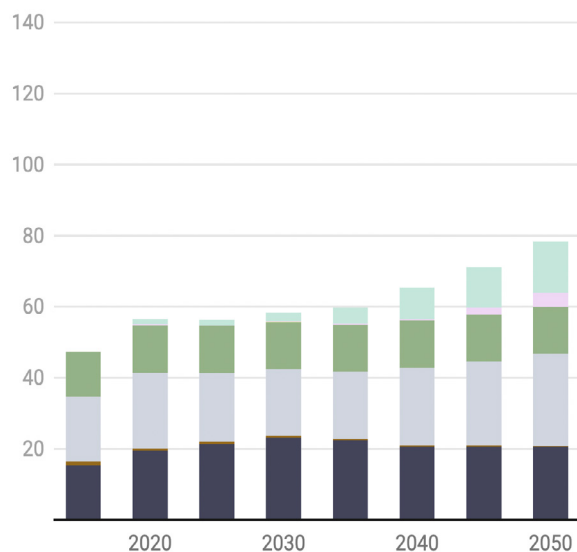


**Transition in Electricity generating mix [TWh]
Reference (REF) vs. Carbon Neutrality (CNI)**

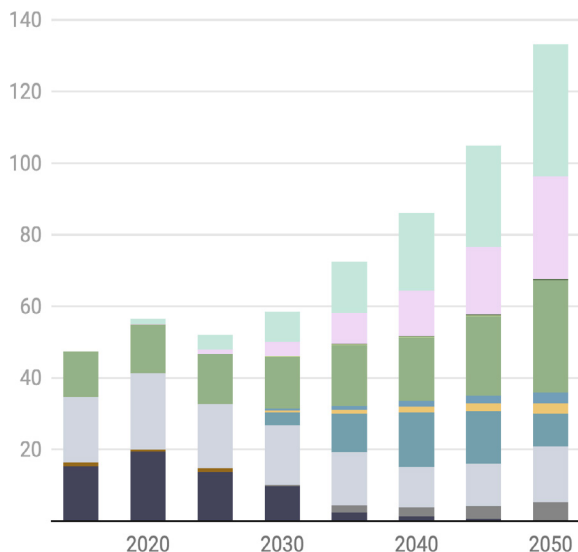
Electricity generating capacities [GWe], Central Asia (CAS)

Coal
 Coal CCS
 Oil
 Oil CCS
 Gas
 Gas CCS
 Nuclear L
 Nuclear S
 Hydro
 Biomass
 Biomass CCS

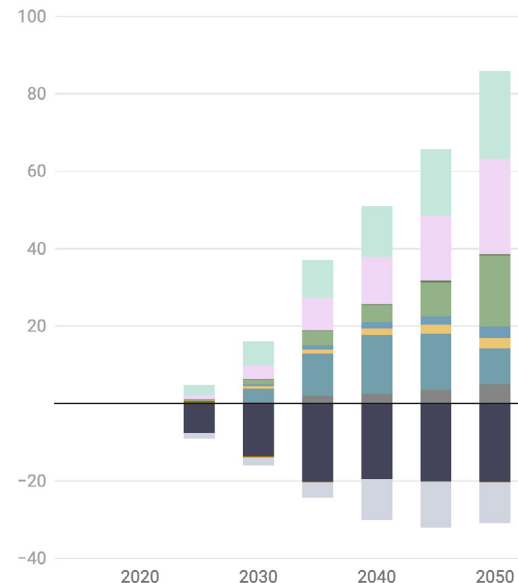
Geothermal
 PV
 CSP
 Wind Onshore
 Wind Offshore



**Electricity generation capacity [GWe]
Reference (REF)**



**Electricity generation capacity [GWe]
Carbon Neutrality Innovation (CNI)**



**Transition in Electricity generation capacity [GWe]
Reference (REF) vs. Carbon Neutrality (CNI)**

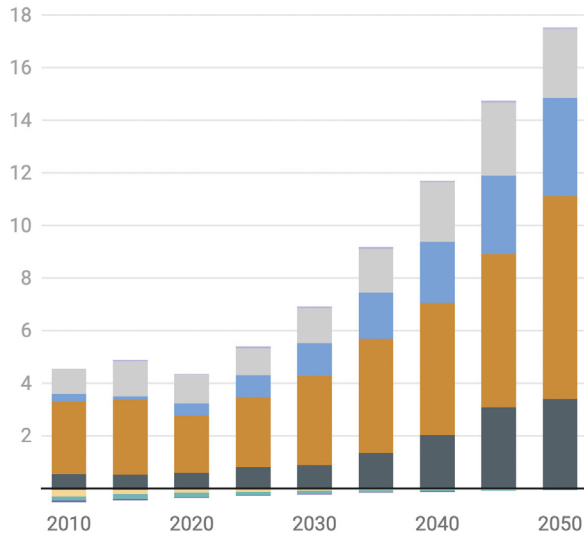


Attaining carbon neutrality is projected to result in steep decline of fossil fuel exports

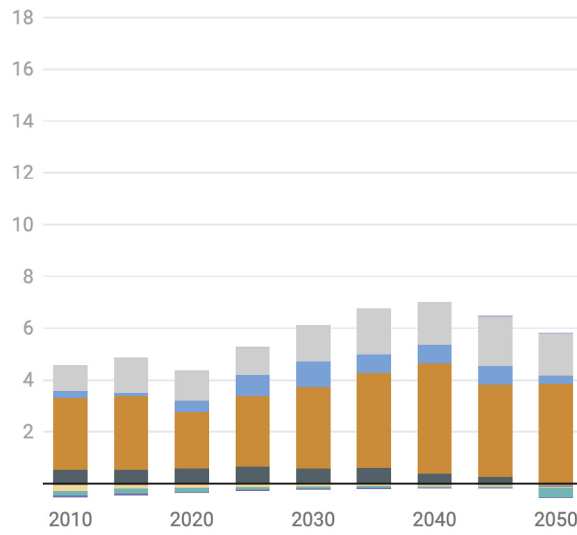
Central Asia (CAS) – External energy trade [EJ]

■ Coal X ■ Coal M ■ Oil X ■ Oil M ■ Liquids X ■ Liquids M ■ Gas X ■ Gas M ■ Electricity X ■ Electricity M ■ Hydrogen X ■ Hydrogen M

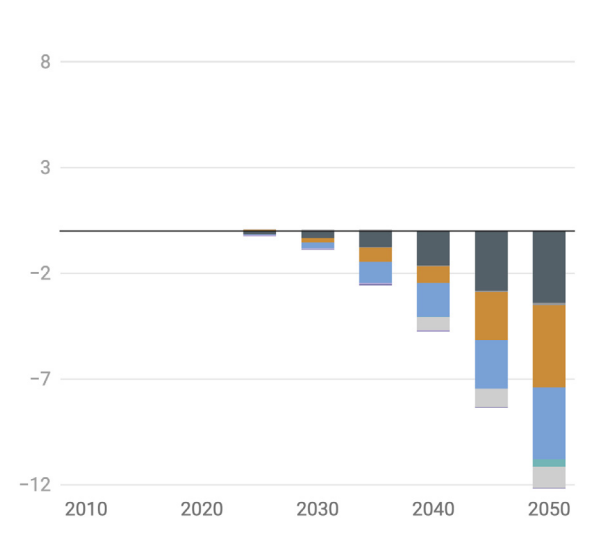
X = Exports M = Imports



**Energy trade [EJ]
Reference (REF)**



**Energy trade [EJ]
Carbon Neutrality Innovation (CNI)**



**Transition in Energy trade [EJ]
Reference (REF) vs. Carbon Neutrality (CNI)**



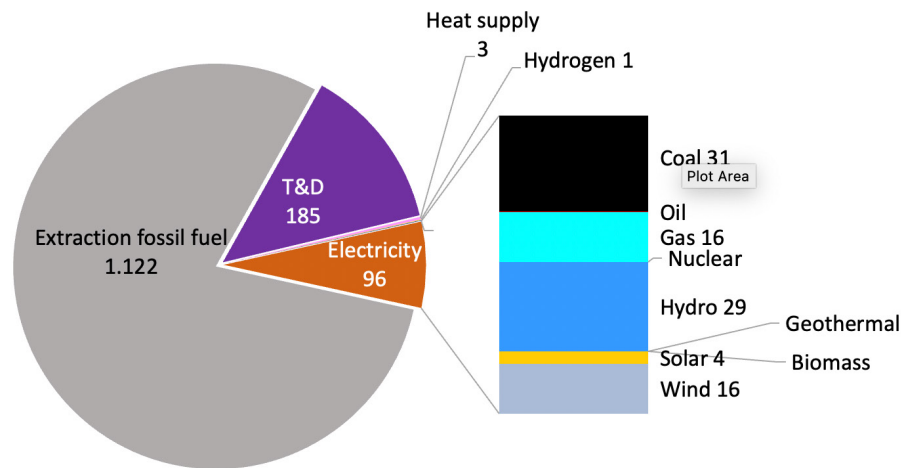
Energy system transformation and technology interplay incur costs (and benefits)

Key elements of the transformation include

- Divestment in fossil fuel infrastructure
- Investment in measures reducing energy intensities and improving efficiency
- Stepped up investment in all low-carbon technologies, fuels and measures
- Percentage increase in cumulative capital outlays is modest compared to the UNECE aggregate
- But there are substantial decline in energy export revenues

Cumulative energy system investment requirements 2020 – 2050 [Billion USD₂₀₂₀]

Reference (REF:): 1,407 Billion USD
Carbon Neutrality (CNI): 1,526 Billion USD



Fossil fuel infrastructure includes mining/extraction, transport and processing
T&D = Transmission, distribution and storage

All investments stated in Billion USD₂₀₂₀



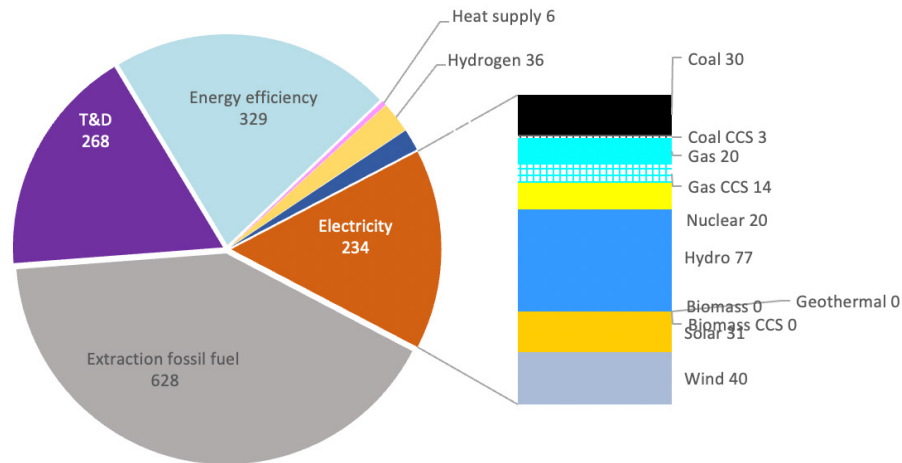
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Concluding remarks

- Not on track
- Carbon neutrality is techno-economically feasible (based on numerous assumptions)
- Supply is primarily a technology/engineering challenge (key domain of technology interplay) subject of socio-political debate which path is the “right” one
- Demand side management, life-style changes and associated infrastructure transformation are integral parts of technology interplay
- A carbon neutral energy system entails:
 - I. accelerated phase-out of conventional fossil fuel use
 - II. electrification of all sectors through renewables and nuclear power
 - III. widespread innovation of low and lowest-carbon technologies (e.g., CCUS, DAC, hydrogen and nuclear energy) and measures lowering energy demand
- Technology exclusion reduces flexibility and increases costs
- Regional cooperation fosters innovation, technology learning and dissemination
- Expand institutional capacity for analysis and comparative assessments (with stakeholder involvement) for informed policy and decision making
- No one size fits all
- Always be aware of trade-offs
- No further procrastination – the time to act is now

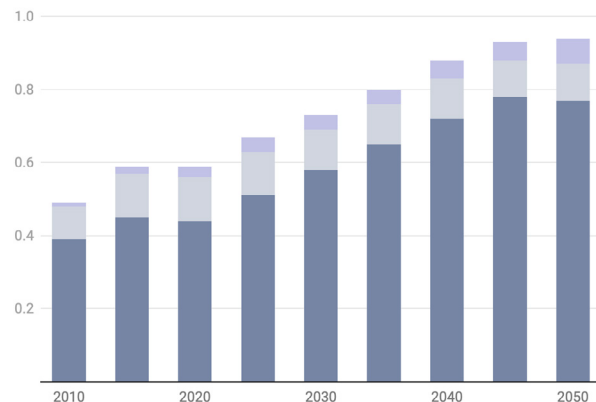


Transportation Final energy mix [EJ]

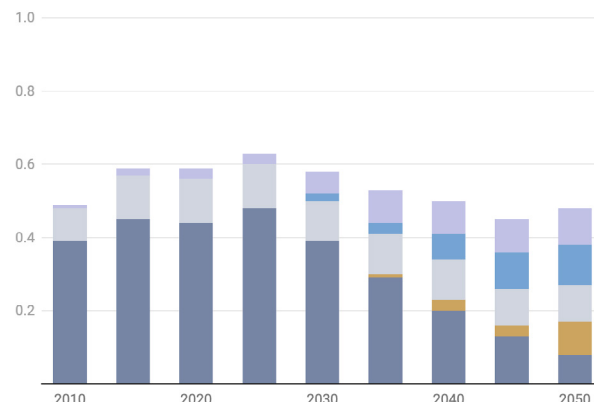
Decarbonization via

- Fuel and technology switching
- Lifestyle changes and modal shifts
- BEVs and fuel cells

Oil-liquids Bio-liquids Coal-liquids Gas-liquids Gas Hydrogen Elec Other



Final Energy - Transportation [EJ]
Reference (REF)



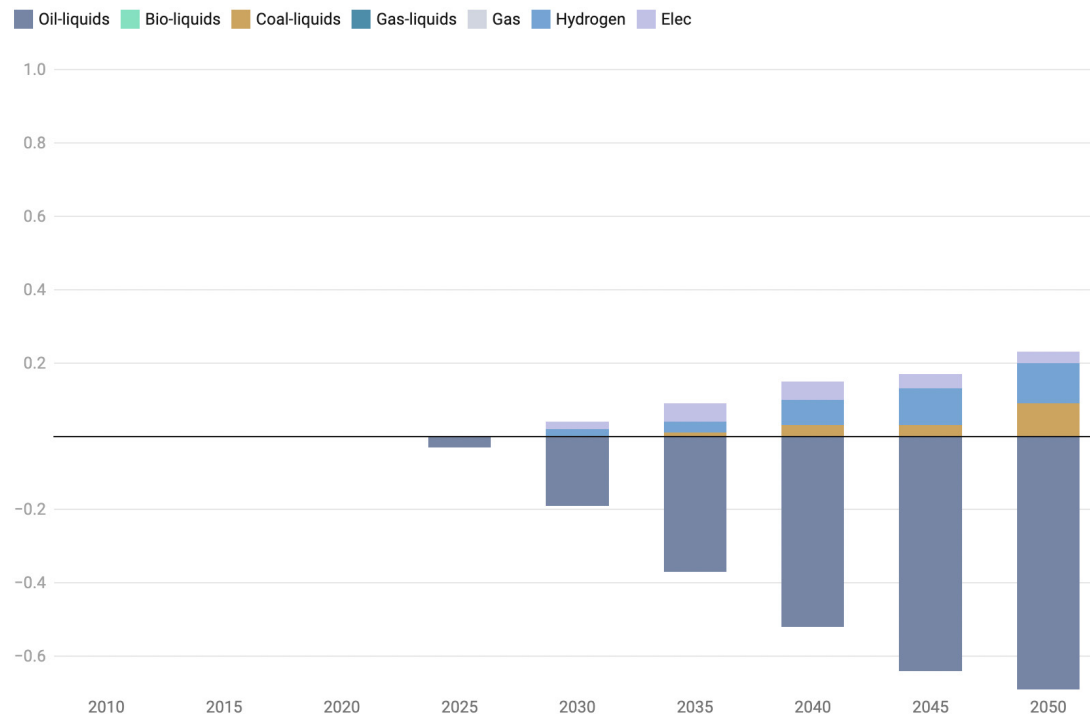
Final Energy - Transportation [EJ]
Carbon Neutrality Innovation (CNi)



Transportation Final energy mix [EJ]

Decarbonization via

- Fuel and technology switching
- Lifestyle changes and modal shifts
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Transition in Transport
Carbon Neutrality Innovation (CNI) vs Reference (REF) in [EJ]

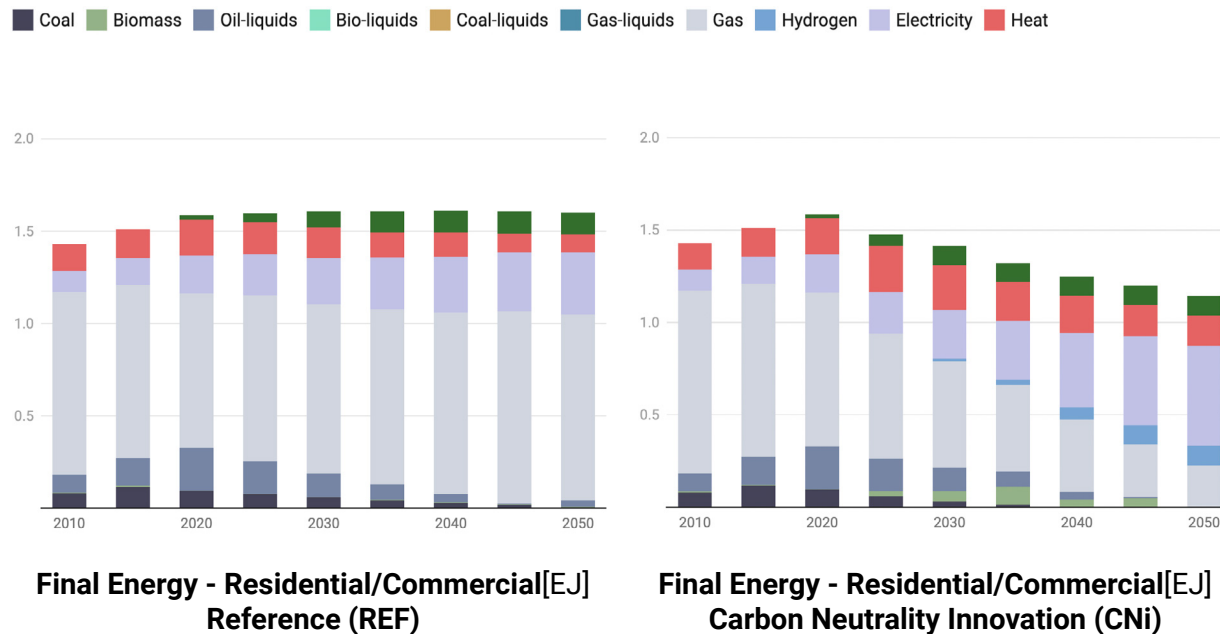


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Residential/Commercial Final energy mix [EJ]

Decarbonization via

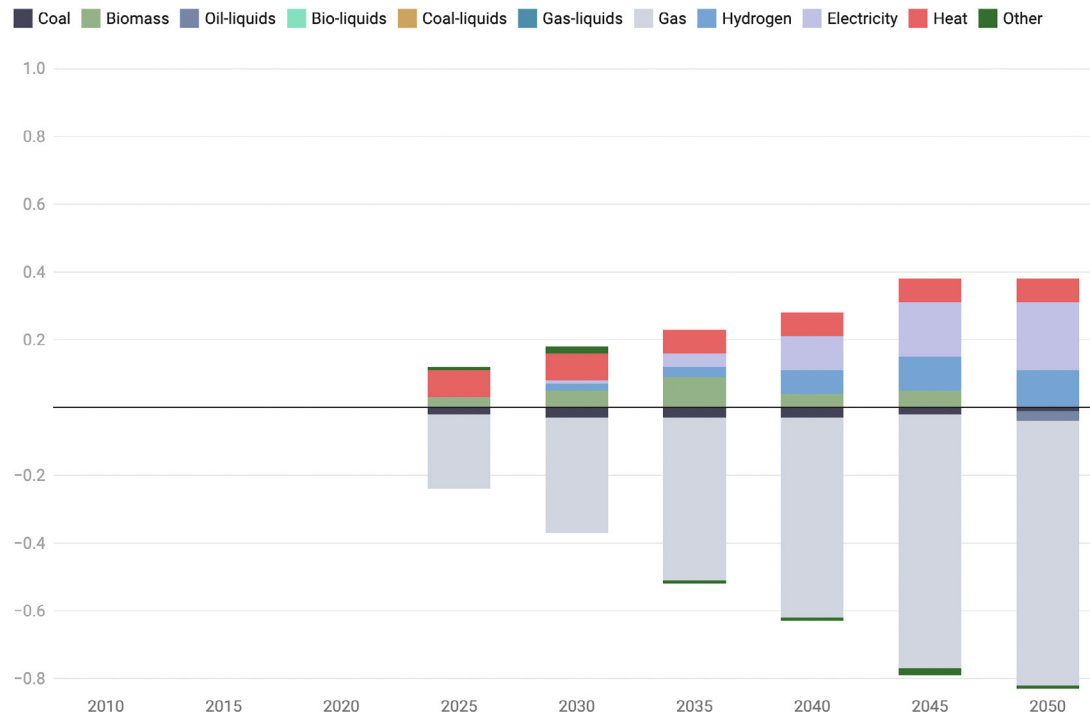
- Efficiency improvements & replacement of the building stock and lifestyle changes
- Electrification incl heat pumps
- Hydrogen incl fuel cells & cogeneration
- Biomass (transition fuel?)



Residential/Commercial Final energy mix [EJ]

Decarbonization via

- Efficiency improvements & replacement of the building stock and lifestyle changes
- Electrification incl heat pumps
- Hydrogen incl fuel cells & cogeneration
- Biomass (transition fuel?)

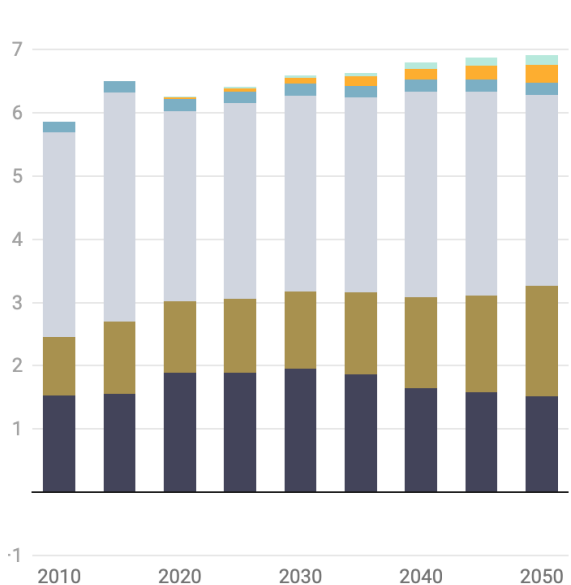


Transition in Residential/Commercial
Carbon Neutrality Innovation (CNI) vs Reference (REF) in [EJ]

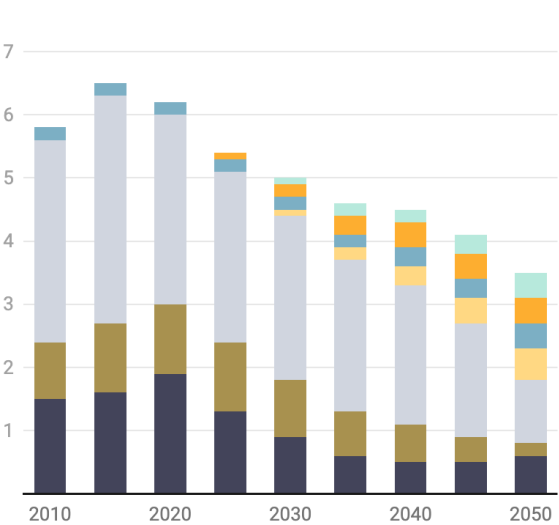


Central Asia (CAS) – Total Primary Energy Supply – TPES [EJ]

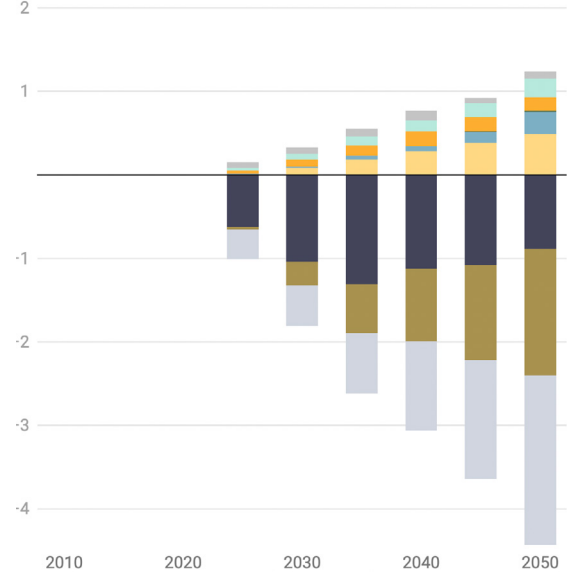
Coal
 Oil
 Gas
 Nuclear
 Hydro
 Geothermal
 Solar
 Wind
 Biomass
 Net SE imports



Energy trade [EJ]
Reference (REF)



Energy trade [EJ]
Carbon Neutrality Innovation (CNI)



Transition in Energy trade [EJ]
Reference (REF) vs. Carbon Neutrality (CNI)

