Global Energy System based on 100% Renewable Energy – Power, Heat, Transport and Desalination Sectors

Eurasia

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Table of Contents

- Overview
- Current Status
- LUT Energy System Transition Model
- Long-term Energy Demand
- Resources
- Energy Mix
- Storage
- Costs & Investments
- Sectoral Outlook
- Socio-economic benefits
- RE Shares
- Summary
Overview

- Eurasia is structured into 13 regions
  - 7 Federal districts of Russia (North Caucasus district is merged to Southern district), Belarus, Kazakhstan, Uzbekistan and Turkmenistan
  - Caucasus region: Armenia, Azerbaijan and Georgia
  - Pamir region: Kyrgyzstan and Tajikistan
Current Status
Power Sector

Key insights:
- Significant share of fossil fuel power plants in the power generation mix is observed
- Solar PV and wind is growing, but slowly
- Hydropower has the largest share of total RE installed capacity
- Most of the capacity was installed before 1990, an aging power infrastructure
- High share of gas in the generation mix

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Current Status
Heat, Transport and Desalination Sectors

Share of heat generation capacities in 2015

- Historically, a significant share of fossil powered heat generation is present with some shares of bio-based and geothermal heating
- The transport sector is dominated by fossil liquid fuels with around 95% of the share in 2015
- The desalination sector is predominantly based on demand for reverse osmosis and MED desalination plants, with some shares of MSF in 2015

Share of energy sources for transport sector in 2015

Key insights:
- Historically, a significant share of fossil powered heat generation is present with some shares of bio-based and geothermal heating
- The transport sector is dominated by fossil liquid fuels with around 95% of the share in 2015
- The desalination sector is predominantly based on demand for reverse osmosis and MED desalination plants, with some shares of MSF in 2015
LUT Energy System Transition model
Fundamentals: Data Flow

Data preparation
(Technical and financial assumptions)

Model setup and simulation

Power prosumers and individual heat producers simulation

System simulation

Power sector  Heat sector  Transportation sector

Industrial sector:
Industrial fuels  Desalination  CO₂ removal

Results collection and evaluation
(Installed capacities, annual generation, cost of system and components, cost of electricity, CO₂ emissions, etc.)
- The technologies applied for the energy system optimisation include those for electricity generation, heat generation, energy storage and electricity transmission
- The model is applied at full hourly resolution for an entire year
- The LUT model has been applied across all energy sectors
LUT Energy System Transition model

Transport

Electricity

Road

Liquid hydrocarbon (fossil, bio, FT-fuel)

Rail

Methane (fossil, bio, PtCH₄, liquid)

Marine

Hydrogen (PtH₂, liquid)

Aviation

Key insights:
- All forms of transportation categorised into Road, Rail, Marine and Aviation
- Majority of demand to be covered by electricity directly and indirectly by liquid hydrocarbon (including biofuels), methane and hydrogen
- The LUT model applied to the desalination sector
- The desalination demand is from reverse osmosis and MED
Long-term Energy Demand

Key insights:

- A regional cumulative average annual growth rate of about 1.6% in final energy demand drives the transition. This is aggregated by final energy demand growth for power and heat, desalinated water demand and transportation demand linked to powertrain assumptions. This leads to a comprehensive electrification, which massively increases overall energy efficiency, to an even higher growth rate in provided energy services.
- This results in an average annual growth rate of about 0.3% in total primary energy demand (TPED).
- The population is expected to grow slightly from 233 to 239 million people, while the average per capita PED decreases from around 33 MWh/person in 2015 to 25 MWh/person by 2035 and increases up to 35 MWh/person by 2050.
- TPED decreases from around 7600 TWh in 2015 to around 6000 TWh by 2035 and increases up to 8200 TWh by 2050 in this study (which assumes high electrification).
- In comparison, current practices (low electrification) would result in a TPED of nearly 14,000 TWh by 2050.
- The massive gain in energy efficiency is primarily due to a high level of electrification of more than 88% in 2050, saving nearly 5800 TWh compared to the continuation of current practices (low electrification).
Energy Resources (Solar, Wind)

Solar PV generation profile
Regional aggregated PV feed-in profile computed using the weighed average rule

Wind generation profile
Regional aggregated wind feed-in profile computed using the weighed average rule

Key insights:
- Wind: Strong seasonal variation with much higher wind generation during winter time
- Solar PV: Very poor solar PV availability during winter time, but summer is better
- Region wide generation profiles do not fully reflect the actual situation due to huge area of the region, many time zones and high concentration of demand in central Russian regions
Full Load Hours

PV (single-axis tracking) full load hours

Key insights for wind:
- Good wind resources are available almost in every region
- Exceptionally good wind at the Arctic Ocean shores and in the steppe zone

Key insights for solar PV:
- Moderate solar resources in the regions with highest power demand – Central Russian regions
- Good solar resources in Central Asian regions

Wind onshore (E101 at 150m) full load hours

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Key insights:

- Electricity generation is comprised of demand form all sectors (power, heat, transport, desalination)
- Wind energy increases to about 69% by 2030 and steadily declines to about 49% till 2050
- Solar PV supply increases to about 42% of electricity generation in 2050, with some shares of hydropower
- Heat pumps play a significant role in the heat sector with a share of more than 61% of heat generation by 2050 coming from heat pumps on district and individual levels, along with electric heating, some shares of non-fossil gas and biomass based heating
- Gas based heating decreases through the transition from about 56% in 2015 to around 9% by 2050
Energy Storage
 Electricity

Key insights:

▪ Electricity demand covered by storage increases through the transition period up to nearly 200 TWh\textsubscript{el} by 2035 and further significantly increases to over 1000 TWh\textsubscript{el} in 2050

▪ The ratio of electricity demand covered by energy storage to electricity generation increases significantly to around 5.8% by 2035 to about 14% by 2050

▪ Batteries emerge as the most relevant electricity storage technology contributing about 94% of the total electricity storage output by 2050 (more details on slide 19)

* heat storage includes gas and thermal storage technologies
Key insights:
- Storage output covers more than 1000 TWh$_{th}$ of total heat demand in 2050 and heat storage technologies play a vital role with minor shares of electricity storage
- The ratio of heat demand covered by energy storage to heat generation increases substantially to about 21% by 2050 with a major share of heat storage technologies
- Thermal energy storage emerges as the most relevant heat storage technology with around 51% by 2050 (more details on slide 19)
- Power-to-Gas contributes around 49% of the heat storage output in 2050
Global Energy System based on 100% RE – Power, Heat, Transport and Desalination Sectors: Eurasia

Key insights:

- The total annual costs are in the range of 300-450 b€ through the transition period and well distributed across the 3 major sectors of Power, Heat and Transport.
- LCOE remains around 43-57 €/MWh and is increasingly dominated by capital costs as fuel costs continue to decline through the transition period, which could mean increased energy diversification in Eurasia by 2050.
- Costs are well spread across a range of technologies with major investments for PV, wind, batteries, heat pumps and synthetic fuel conversion up to 2050, revamping the old power infrastructure.
- The cumulative investment costs are about 4240 b€.

Global Energy System Cost

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Sectoral Outlook
Power & Heat - Demand

Key insights:
- Electricity consumption per capita across Eurasia increases from over 4 MWh/person in 2015 to about 7 MWh/person by 2050.
- Total heat demand increases steadily from around 3500 TWh\textsubscript{th} in 2015 to 5500 TWh\textsubscript{th} by 2050, mainly driven by higher demand for industrial process heat and growing building space heating demand.
- Space heating and Industrial heat contribute the major share of demand, which is mainly low temperature (LT).
Key insights:

- Wind energy and solar PV emerge as the new major energy providers in the power and heat sector by 2050 across Eurasia.
- Solar PV with 1259 GW and wind with 649 GW constitute a majority of the installed capacities in 2050.
- Heat pumps, electric heating and biomass-based heating constitute a majority of the installed heat capacities during the transition, with a significant increase in 2050 due to the elimination of fossil fuels from the system.
Key insights:
- Utility-scale and some prosumer batteries contribute a major share of the electricity storage output with nearly 94% by 2050
- Pumped hydro energy storage and compressed air energy storage contribute through the transition
- Thermal energy storage emerges as the most relevant heat storage technology with about 51% of heat storage output by 2050
- Gas storage contributes around 49% of the heat storage output in 2050 covering predominantly seasonal demand, which was covered by fossil gas before 2050
Sectoral Outlook
Power – Costs and Investments

Key insights:
- LCOE of the power sector decreases substantially from around 83 €/MWh in 2015 to around 58 €/MWh by 2050
- LCOE is predominantly comprised of capex, as fuel costs lose importance through the transition
- Investments are well spread across a range of technologies with major share in wind energy in the initial periods up to 2030, followed by solar PV and batteries up to 2050
Sectoral Outlook
Heat – Costs and Investments

Key insights:
- LCOH of the heat sector increases from around 32 €/MWh in 2015 to around 47 €/MWh by 2050
- LCOH is predominantly comprised of capex as fuel costs diminish through the transition
- Investments are predominantly in heat pumps, along with electric heating and some shares in biomass heating up to 2050
Sectoral Outlook
Transport – Demand

Key insights:
- The final transport passenger demand increases from around 2.1 million p-km to around 6.8 million p-km
- The final transport freight demand also increases from around 5.2 million t-km to around 8.2 million t-km
- Whereas, the final energy demand for overall transport decreases from 1500 TWh/a in 2015 to 1380 TWh/a by 2050, enabled by higher efficiency with increase in shares of electric vehicles
- Marine freight is aligned to the scenario with a drastic decline in fuels transportation during the transition
Sectoral Outlook
Transport – Road Demand

Key insights:

- The final energy demand for road passengers increases initially up to 750 TWh in 2020 and then decreases significantly to just around 310 TWh by 2050.
- The final energy demand for road freight decreases substantially from around 470 TWh in 2015 to around 280 TWh by 2050.
- The significant decrease in final energy demand for overall road transport is primarily driven by the massive electrification.
Sectoral Outlook
Transport – Rail, Marine and Aviation Demand

Key insights:
- The final energy demand for rail transport increased from around 116 TWh in 2015 to around 125 TWh by 2050
- The final energy demand for marine transport increases steadily from around 130 TWh in 2015 to over 150 TWh by 2050
- The final energy demand for aviation transport increases significantly from nearly 140 TWh in 2015 to around 530 TWh by 2050
Sectoral Outlook
Transport – Defossilisation and Electrification

Key insights:
- Fossil fuel consumption in transport is observed to decline through the transition from about 95% in 2015 to zero by 2050
- Liquid fuels produced by renewable electricity contribute around 34% of the final energy demand in 2050
- Hydrogen constitutes more than 23% of final energy demand in 2050
- Electrification of the transport sector creates an electricity demand of over 2000 TWh\textsubscript{el} by 2050
- Massive demand for liquid fuels kicks in from 2040 onwards up to 2050

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Sectoral Outlook
Transport – Power Capacities and Generation

Key insights:
- Solar PV with around 725 GW and wind with around 370 GW constitute the majority of the installed capacities by 2050
- Wind and solar PV generate all of the electricity in 2050 of nearly 2300 TWh
- Most of the capacity addition is 2035 onwards, with a rapid change in the transport sector towards increased electrification and RE-based fuels beyond 2030
Key insights:

- A-CAES and utility-scale batteries form the major share of installed storage capacities, which increases up to 2050, along with some share of PHES through the transition.
- Storage capacities increase beyond 2030 as electricity demand for transport increases.
- Utility-scale batteries contribute the major share of storage output in 2050 with nearly 130 TWh$_{el}$.
- Conservative charging of vehicles is assumed, which excludes smart charging and vehicle-to-grid functionalities. Both would reduce storage demand. Some storage is needed for synthetic fuels production.
Sectoral Outlook
Transport – Fuel Conversion, Storage Capacities and Heat Management

Key insights:

- Installed capacities of fuel conversion technologies increase significantly beyond 2040, with a major share of water electrolysis and some shares of Fischer-Tropsch and hydrogen up to 2050.
- Installed capacity of gas storage comprised of hydrogen and methane increased up to 3.8 TWh and further declines to around 2.7 TWh by 2050, with major share of hydrogen storage.
- Installed CO$_2$ storage and CO$_2$ DAC increase significantly from 2040 onwards, with major share of CO$_2$ DAC.
- Heat for fuel conversion process is managed with excess heat and recovered use of heat.

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Key insights:

- Fischer-Tropsch (FT) and Synthetic Natural Gas (SNG) fuel costs decline through the transition up to 2050.
- FT fuels are in the range of costs of fossil liquid fuels with GHG emissions costs, on a level of about 90 €/MWh.
- Electricity emerges as the most cost effective option with LCOE primary around 20 €/MWh and along with complementary costs of storage and other system components, total LCOE is around 33 €/MWh in 2050.
- Hydrogen (H₂) fuel costs decline to be more cost competitive than fossil fuels, in the range of 57 €/MWh in 2050, while liquid H₂ is in the range of 61 €/MWh.
- CO₂ from DAC is a critical component for synthetic fuels at around 39 €/tCO₂eq in 2050, using waste heat.
**Key insights:**

- The total annual energy costs for transport are in the range of 80-100 b€ through the transition period with an increase from around 90 b€ in 2015 to about 100 b€ in 2030 and further decline to about 80 b€ by 2050.
- Road transport form a major share of the costs in the initial years up to 2030, beyond which the aviation sector dominates the share of costs, as costs in the road sector declines through the transition up to 2050.
- Rail and marine sector costs remain more steady through the transition.
- Annual system costs transit from being heavily dominated by fuel costs in 2015 to a very diverse share of costs across various technologies for electricity, synthetic fuels and sustainable biofuel production by 2050.
- FT units produce naphtha as a by-product, which is included in overall system costs but not in transport cost.
Key insights:

- Investments are predominantly in wind up to 2040, beyond that in solar PV along with significant investments in fuel conversion technologies such as Fischer-Tropsch, water electrolysis and others.
- A significant increase in annual fixed operational costs is observed beyond 2030, with more fuel conversion technologies up to 2050.
- Whereas, the annual variable operational costs decrease beyond 2035 to very low amounts by 2050.
Sectoral Outlook
Transport – Passenger and Freight Costs

Key insights:
- The total annual costs for transport are in the range of 80-100 b€ through the transition period with a decline from around 90 b€ in 2015 to about 80 b€ by 2050
- Final transport passenger costs decline for road transport through the transition, whereas for marine and aviation there is a marginal decrease, with rail being stable
- Similarly, final transport freight costs decline in the case of road and increase slightly for aviation and remains stable for rail and marine
Key insights:

- The steady rise in water demand across Eurasia leads to increased desalination capacities and some water storage by 2050.
- Installed capacities of power generation for the desalination sector increases through the transition to around 870 GW by 2050, which is mainly renewables.
- The LCOW for desalination increases through the transition from 1.3 €/m³ in 2020 to 1.8 €/m³ by 2050.
Key insights:

- GHG emissions can be reduced from around 1800 MtCO$_2$eq in 2015 to zero by 2050 across all energy sectors
- The remaining cumulative GHG emissions comprise around 23 GtCO$_2$eq from 2018 to 2050
- The presented 100% RE scenario for the Eurasian energy sector is compatible with the Paris Agreement
- Deep defossilisation of the power sector is possible by 2030, while the heat and transport sectors are lagging and a massive decline of emissions is possible beyond 2030 up to 2050
Job Prospects – Power Sector

Key insights:
- Total direct energy jobs in Eurasia are set to increase with the initial ramp up of installations from about 556 thousand in 2015 to around 871 thousand by 2025, after a decline in 2030, it is observed to steadily rise to around 925 thousand by 2050.
- With great potential for wind power, bulk of the jobs from 2020 to 2030 are observed to be associated with wind power development creating around 353 thousand jobs in 2025.
- Solar PV emerges as the prime job creator in the region up to 2050 with about 411 thousand jobs.
- Operation and maintenance jobs continue to grow through the transition period and become the major job segment by 2050 with 51% of total jobs, as fuel jobs decline rapidly.
Electricity generation and capacities

Key insights:
- Wind energy capacities are predominantly in the north west regions of Eurasia
- Solar PV is mainly in the south west and central regions of Eurasia
- Overall, PV has a major share of the installed capacities in Eurasia
- Installed capacities are considered across all energy sectors

Regional electricity generation
Storage capacities and throughput

Electricity

Key insights:
- Utility-scale and prosumer batteries along with compressed air energy storage contribute a major share of the electricity storage capacities, with some shares of pumped hydro energy storage in 2050 across Eurasia.

Key insights:
- Storage capacities are considered across all energy sectors.
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Storage capacities and throughput

Heat

Regional heat storage capacities

Key insights:
- Gas storage contributes the most for heat storage capacities in 2050 covering predominantly seasonal demand, covered by fossil gas before 2050
- Some shares of thermal energy storage on district and individual levels are installed across Eurasia

Key insights:
- Gas storage heat output provides most of the heat storage demand across Eurasia
- Thermal energy storage on district and individual levels contributes substantially in many of the regions

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Major RE Supply Shares in 2050

Key insights:
- PV-Wind energy dominates the total electricity generation-supply shares with some hydro in 2050
- Electricity generation shares across Eurasia for all energy sectors are
  - Solar PV at about 47.8%
  - Wind energy at about 47.4%
  - Hydropower at about 3.6%
Major RE Capacities in 2050

Key insights:
- Solar PV dominates the total electricity generation capacity, with wind and some hydro across Eurasia in 2050
- Installed capacities in 2050 across Eurasia for all energy sectors are
  - Solar PV: 2603 GW
  - Wind energy: 1165 GW
  - Hydropower: 79 GW
Storage Supply Shares in 2050

Key insights:
- Battery storage mainly plays a role in providing diurnal storage with around 15% of the total supply.
- SNG via PtG plays a role in providing seasonal storage with just 0.4% of the total supply for the power sector. The other sectors are not considered here, however sector coupling of the power and heat sectors, indirectly leads to a lower SNG demand in the power sector due to more flexibility.
- Prosumers play a significant role and hence a large portion of batteries can be observed in 2050, also with low costs of solar PV and batteries.
- Storage supply shares are considered for just the power and heat sectors.

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Losses (Curtailment, Storage, Grids) in 2050

Key insights:
- The total losses in a 100% RE-based electricity system in 2050 are just around 38% of the total generation.
- Curtailment has a share of 3.9%, storage contributes 21.4% and grid losses amount to 12.7%.
- RE-based electricity system is significantly more efficient in comparison to the current system based predominantly on fossil fuels and nuclear.
- Losses are considered for just the power and heat sectors.

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Total Cost and Share of Primary Generation

Key insights:
- Total LCOE by 2050 is around 57.6 €/MWh (including generation, storage, curtailment and some grid costs), the range for 75% of regional power demand is 44.2 – 60.7 €/MWh
- A 58% ratio of the primary generation cost to the total LCOE can be observed, in a range of 50% - 80% for 75% of regional power demand
- Cost of storage contributes substantially to the total energy system LCOE, with the ratios ranging from 30 – 50% across Eurasia for 75% of regional power demand
- Costs considered are just for the power and heat sectors
Summary – Power & Heat

- Electricity consumption per capita increases from over 4 MWh/person in 2015 to about 7 MWh/person by 2050, while total heat demand increases steadily from around 3500 TWh\(_{th}\) in 2015 to 5500 TWh\(_{th}\) by 2050.

- Solar PV with 1259 GW and wind with 649 GW constitute a majority of the installed power capacities by 2050, while heat pumps, electric heating and biomass based heating constitute a majority of the installed capacities for heat generation by 2050.

- Utility-scale and prosumer batteries contribute a major share of the electricity storage output, while thermal energy storage emerges as the most relevant heat storage technology in the transition.

- LCOE of the power sector decreases substantially from around 83 €/MWh in 2015 to around 58 €/MWh by 2050, while LCOH of the heat sector increases marginally from around 32 €/MWh in 2015 to around 47 €/MWh by 2050.

- Deep defossilisation of the power and heat sectors is possible from around 1420 MtCO\(_{2eq}\) in 2015 to around 370 MtCO\(_{2eq}\) in 2030 and further to zero by 2050.
Summary – Transport

- The modes of transportation are: Road, Rail, Marine and Aviation
- The main forms of energy supply are direct and indirect electricity, the latter with liquid hydrocarbons, methane, hydrogen and some biofuels
- The final energy demand for transport decreases from 1500 TWh/a in 2015 to 1380 TWh/a by 2050 mainly driven by the massive electrification of road transport
- Electricity demand for sustainable transport increases substantially up to 2000 TWh\textsubscript{el} by 2050 with high levels of direct and indirect electrification in transport
- Fuel utilisation reduces drastically through the transition as fossil fuels are completely replaced by electricity and synthetic fuels
- The final energy costs for transport remain around 80-100 b€ through the transition period, with massive reduction for road, while an increase for marine and aviation
- GHG emissions can be reduced from about 380 MtCO\textsubscript{2eq} in 2015 to zero across the transport sector by 2050
Summary – Desalination

- The water desalination demand is mainly covered by reverse osmosis.
- The steady rise in water demand and water stress leads to increased desalination capacities and some water storage by 2050.
- Installed capacity of power generation for the desalination sector increases through the transition period to around 870 GW by 2050.
- Utility-scale solar PV and onshore wind comprise around 94% of the installed capacity by 2050.
- Installed storage capacities are dominated by gas storage, while storage output is mainly from utility-scale batteries.
- The LCOE for desalination increases through the transition from 1.3 €/m³ in 2015 to 1.8 €/m³ by 2050.
- GHG emissions can be reduced from about 0.9 MtCO₂eq in 2015 to zero across the desalination sector by 2050.
Summary – Energy Transition

- Eurasia can reach 100% RE and zero GHG emissions by 2050, as wind and solar PV emerge as the new source of electricity providers.
- The LCOE obtained for a fully sustainable energy system for Eurasia remains stable at around 43-57 €/MWh by 2050.
- The annual energy costs are in the range of 300-450 b€ through the transition, with cumulative investment costs of about 4,240 b€ up to 2050.
- Wind and solar PV emerge as major electricity providers with around 91% of the total electricity supply by 2050.
- Heat pumps play a significant role in the heat sector with a share of about 61% of heat generation by 2050 coming from heat pumps on district and individual levels.
- Batteries emerge as the key storage technology with 94% of total storage output.
- GHG emissions can be reduced from about 1800 MtCO$_{2eq}$ in 2015 to zero by 2050, with remaining cumulative GHG emissions of around 23 GtCO$_{2eq}$.
- Around 925 thousand direct energy jobs are created annually in 2050 across the power sector in Eurasia.
- A 100% RE system across Eurasia is more efficient and cost competitive than a fossil based option, which is compatible with the Paris Agreement.
## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>BECCS</td>
<td>Bioenergy Carbon Capture and Storage</td>
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<tr>
<td>BEV</td>
<td>Battery Electric Vehicle</td>
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<tr>
<td>CAES</td>
<td>Compressed Air Energy Storage</td>
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<td>CAPEX</td>
<td>Capital Expenditures</td>
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<tr>
<td>CCS</td>
<td>Carbon Capture and Storage</td>
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<td>CC GT</td>
<td>Combined Cycle Gas Turbine</td>
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<tr>
<td>CHP</td>
<td>Combined Heat and Power</td>
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<td>CSP</td>
<td>Concentrated Solar Thermal Power</td>
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<tr>
<td>DAC</td>
<td>CO₂ Direct Air Capture</td>
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<td>DACCS</td>
<td>Direct Air Carbon Capture and Storage</td>
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<tr>
<td>DH</td>
<td>District Heating</td>
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<td>DME</td>
<td>Dimethyl Ether</td>
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<td>FCEV</td>
<td>Fuel Cell Electric Vehicle</td>
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<td>FLH</td>
<td>Full Load Hours</td>
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<tr>
<td>FT</td>
<td>Fischer-Tropsch</td>
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<td>GHG</td>
<td>Greenhouse Gases</td>
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<td>GT</td>
<td>Gas Turbine</td>
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<td>GW</td>
<td>Gigawatt</td>
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<td>HDV</td>
<td>Heavy Duty Vehicle</td>
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<tr>
<td>HHB</td>
<td>Hot Heat Burner</td>
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<td>HT</td>
<td>High Temperature</td>
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<tr>
<td>HVAC</td>
<td>Heating, Ventilation, and Air Conditioning</td>
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<tr>
<td>HVDC</td>
<td>High Voltage Direct Current</td>
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<td>ICE</td>
<td>Internal Combustion Engine</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<td>IH</td>
<td>Individual Heating</td>
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<td>LCOC</td>
<td>Levelised Cost of Curtailment</td>
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<td>LCOE</td>
<td>Levelised Cost of Electricity</td>
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<td>LCOH</td>
<td>Levelised Cost of Heat</td>
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<td>Levelised Cost of Transmission</td>
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<td>LCOW</td>
<td>Levelised Cost of Water</td>
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<td>LDV</td>
<td>Light Duty Vehicle</td>
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<td>LNG</td>
<td>Liquefied Natural Gas</td>
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<td>LT</td>
<td>Low Temperature</td>
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<td>MDV</td>
<td>Medium Duty Vehicle</td>
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<td>MED</td>
<td>Multiple-Effect Distillation</td>
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<td>MSF</td>
<td>Multi-Stage Flash</td>
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<td>MT</td>
<td>Medium Temperature</td>
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<td>MW</td>
<td>Megawatt</td>
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<td>OCGT</td>
<td>Open Cycle Gas Turbine</td>
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<td>OPEX</td>
<td>Operational Expenditures</td>
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## Acronyms 2

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>PHEV</td>
<td>Plug-in Hybrid Electric Vehicle</td>
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<tr>
<td>PHES</td>
<td>Pumped Hydro Energy Storage</td>
</tr>
<tr>
<td>PP</td>
<td>power plant</td>
</tr>
<tr>
<td>PtG</td>
<td>Power-to-Gas</td>
</tr>
<tr>
<td>PtH</td>
<td>Power-to-Heat</td>
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<tr>
<td>PtL</td>
<td>Power-to-Liquids</td>
</tr>
<tr>
<td>PtX</td>
<td>Power-to-X</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaics</td>
</tr>
<tr>
<td>RE</td>
<td>Renewable Energy</td>
</tr>
<tr>
<td>R/O</td>
<td>(Seawater) Reverse Osmosis</td>
</tr>
<tr>
<td>SNG</td>
<td>Synthetic Natural Gas</td>
</tr>
<tr>
<td>ST</td>
<td>Steam Turbine</td>
</tr>
<tr>
<td>TES</td>
<td>Thermal Energy Storage</td>
</tr>
<tr>
<td>TPED</td>
<td>Total Primary Energy Demand</td>
</tr>
<tr>
<td>TW</td>
<td>Terawatt</td>
</tr>
<tr>
<td>TTW</td>
<td>Tank to Wheel</td>
</tr>
</tbody>
</table>
Further Findings

Results for an overview on global aspects and all other major regions are available:

- Global results [link]
- Europe [link]
- Eurasia [link]
- MENA [link]
- Sub-Saharan Africa [link]
- SAARC [link]
- Northeast Asia [link]
- Southeast Asia/Pacific [link]
- North America [link]
- South America [link]
- Supplementary Data [link]
- Report [link]
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Further information and all publications at:
www.energywatchgroup.org
www.researchgate.net/profile/Christian_Breyer