Lecture – 3

Energy Systems Transition

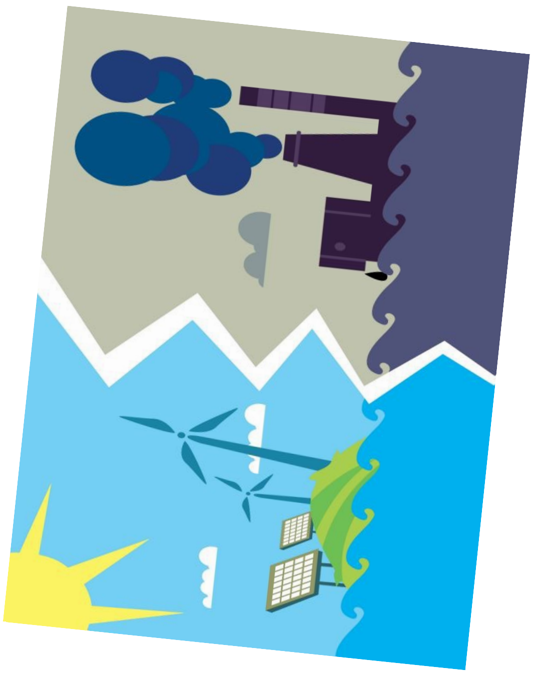
Widodo W. Purwanto
Magister Teknik Sistem Energi
Departemen Teknik Kimia

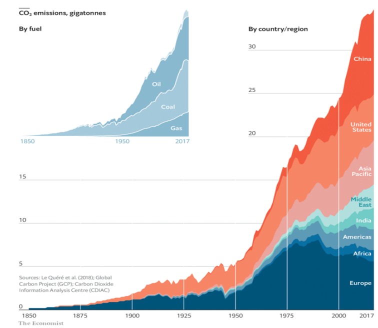
Outline

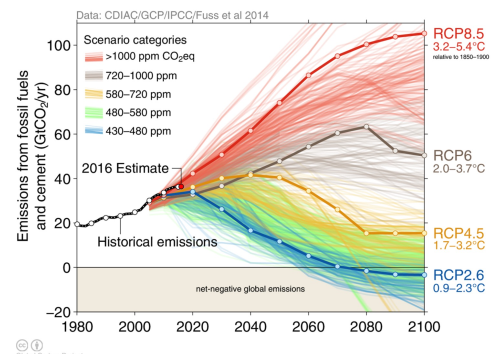
- Key drivers of energy transition
- Energy transition consequences
- Barriers of energy transition
- Pathways of decarbonization
  - Opportunities for supply sector
  - Opportunities for demand sectors
- Enabling just transition
- Skills for energy transition

Key Drivers of Energy Transition

Energy and climate change – *two ways relationship*

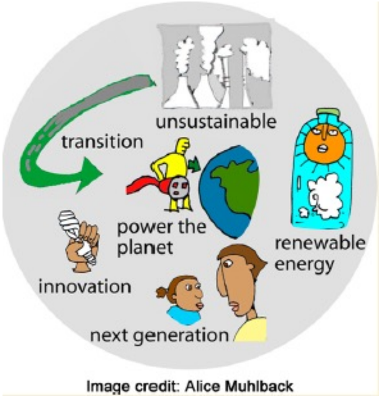


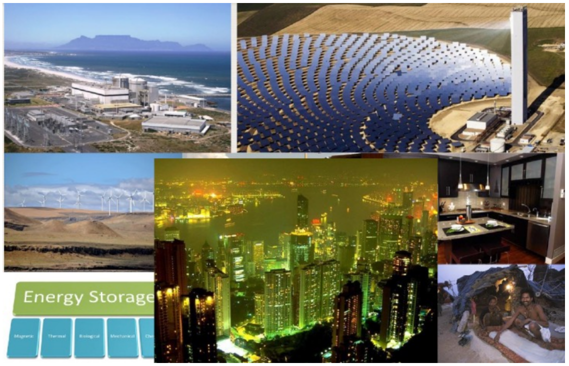


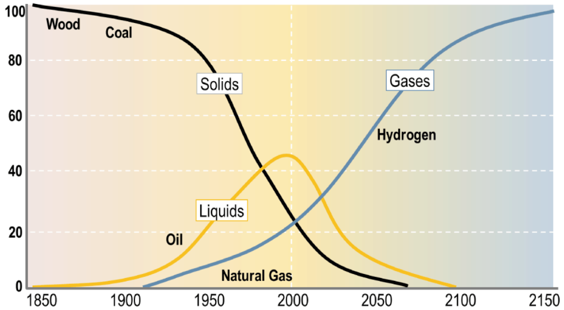


Energy transition

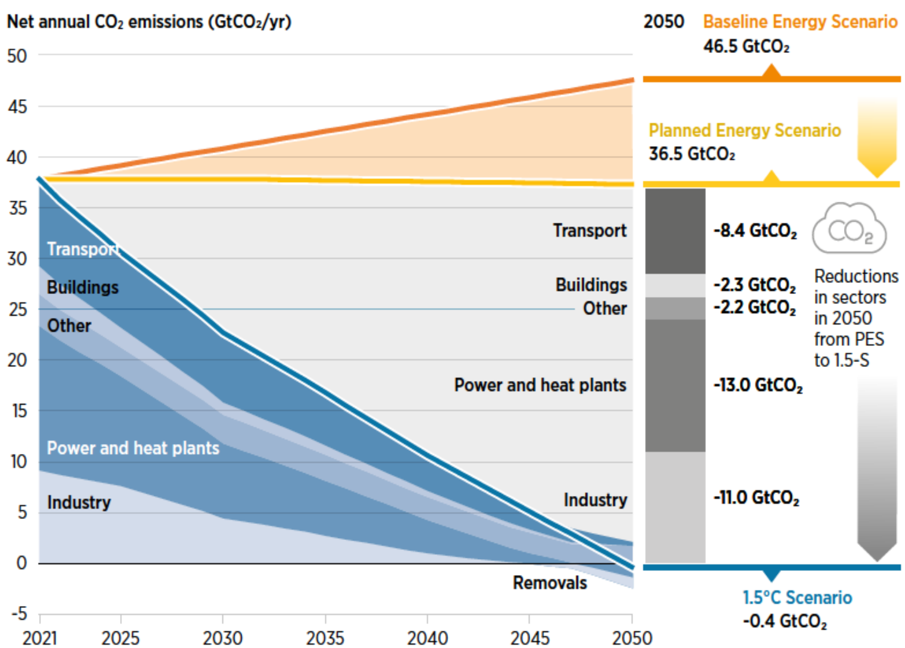
Energy transition – *parthway towards transformation of energy systems from fossil-based to net-zero carbon*

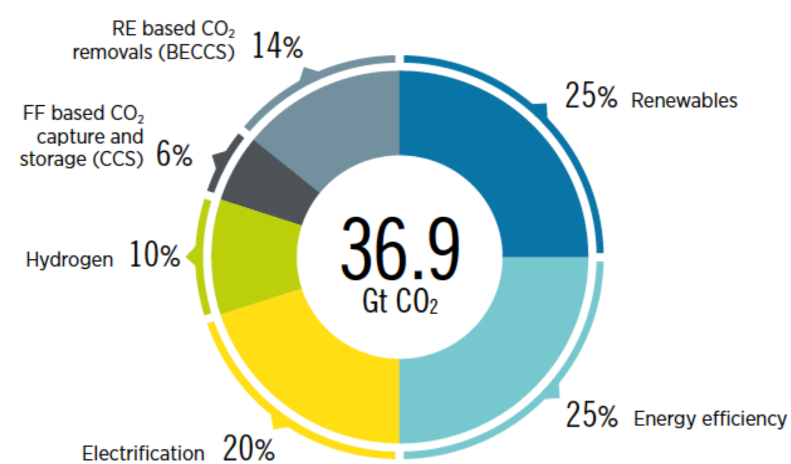






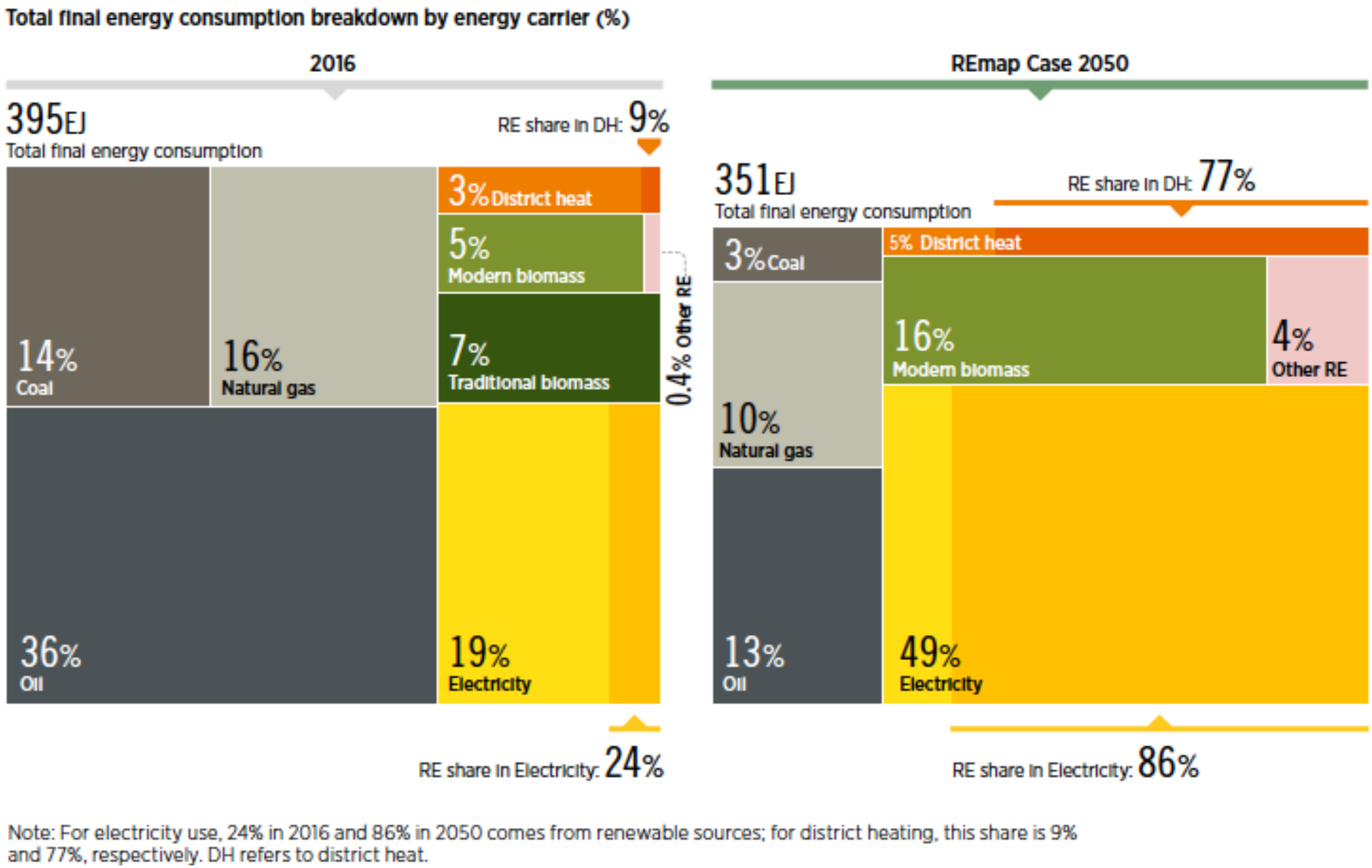
NZE for 1.5°C and abatement strategies





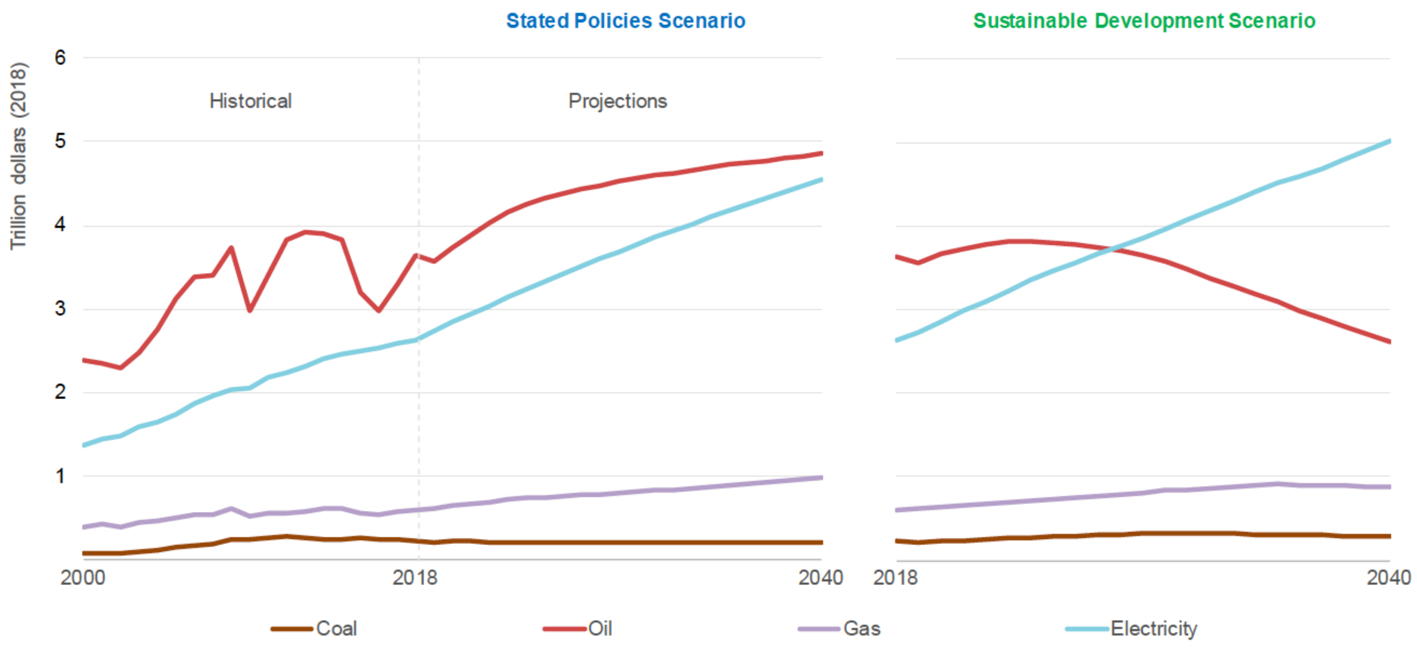
Source: IRENA, 2021, 2022

Electricity becomes the main energy source by 2050



Source: IRENA, 2019

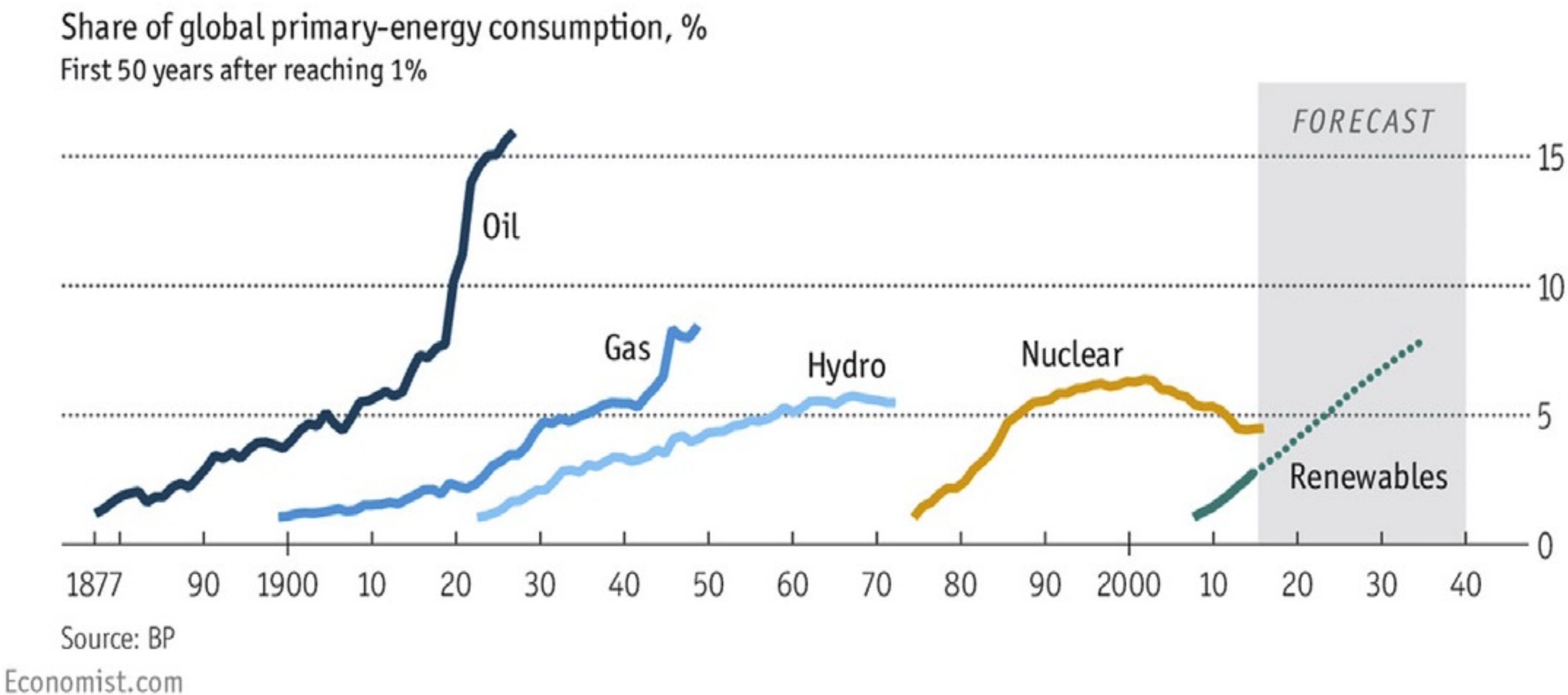
Electricity overtakes oil to become the largest element in consumer energy spending



Note: Includes taxes.
Source: Based on IEA (2018), *World Energy Outlook 2018*, www.iea.org/weo2018.

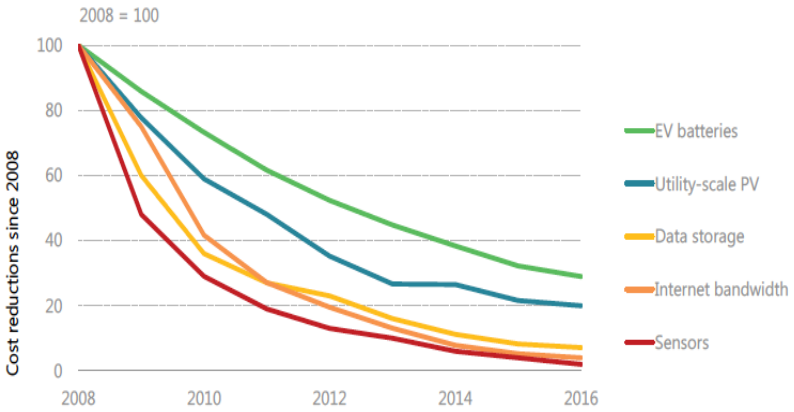
Source: IEA, 2020

Ready for the take off?



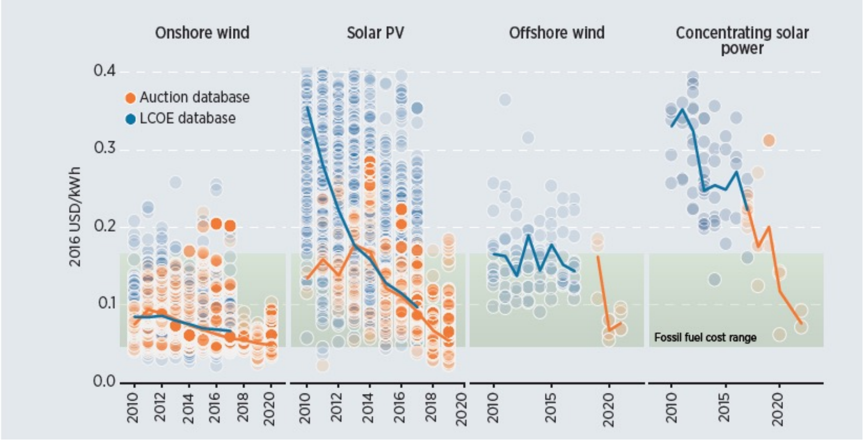
Source: Pickl, 2019

Cost reductions in RE power and digital sector



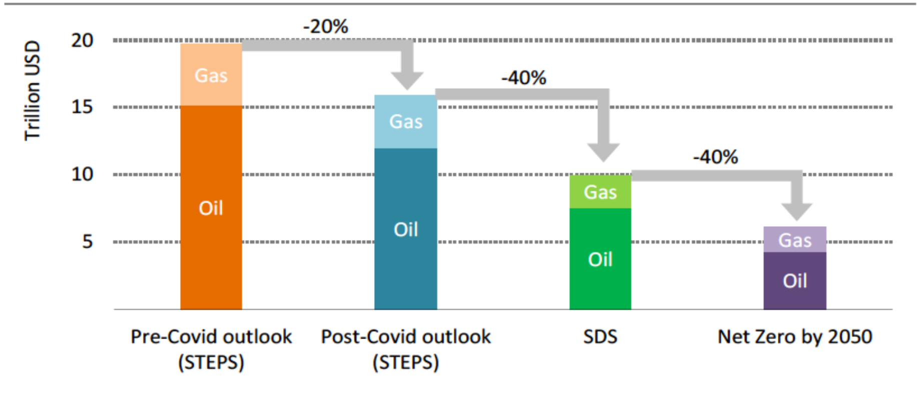
Note: EV = electric vehicle.

Source: Based on BNEF (2017), *Utilities, Smart Thermostats ans the Connected Home Opportunity*; Holdowsky etal. (2015), *Inside the Internet of Things*; IEA (2017), *Renewables*; *Tracking Clean Energy Progress*; *World Energy Investment*, Navigant Research (2017), *Market Data: Demand response*. Global Capacity, Sites, Spending and Revenue Forecasts.

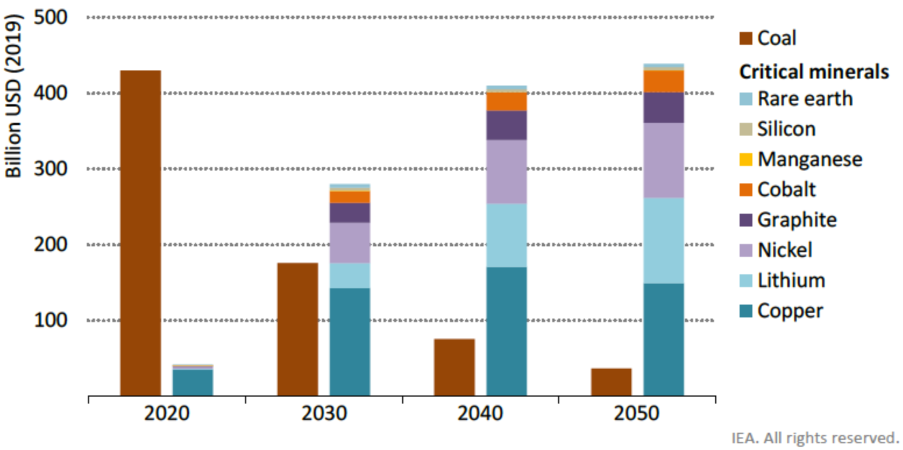


Source: IEA, 2019, IRENA, 2018

Present value of future oil & gas, coal and critical minerals production to 2050



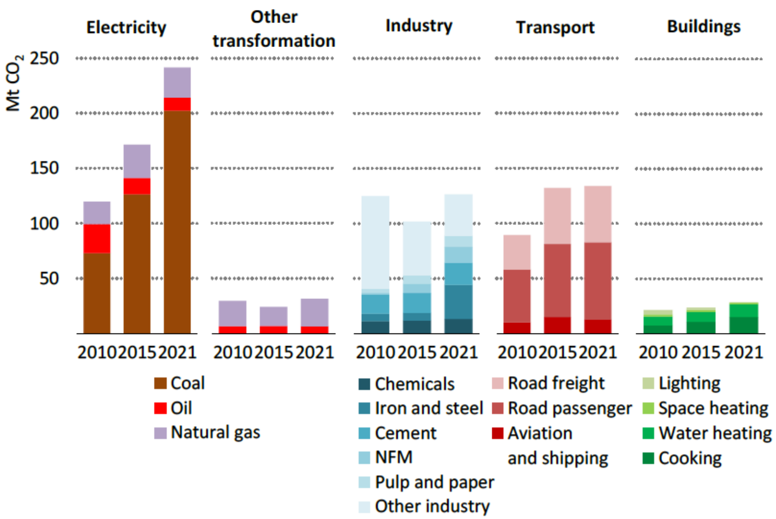
The pandemic and the prospect of an acceleration in clean energy transitions cut expectations of future income from hydrocarbons.

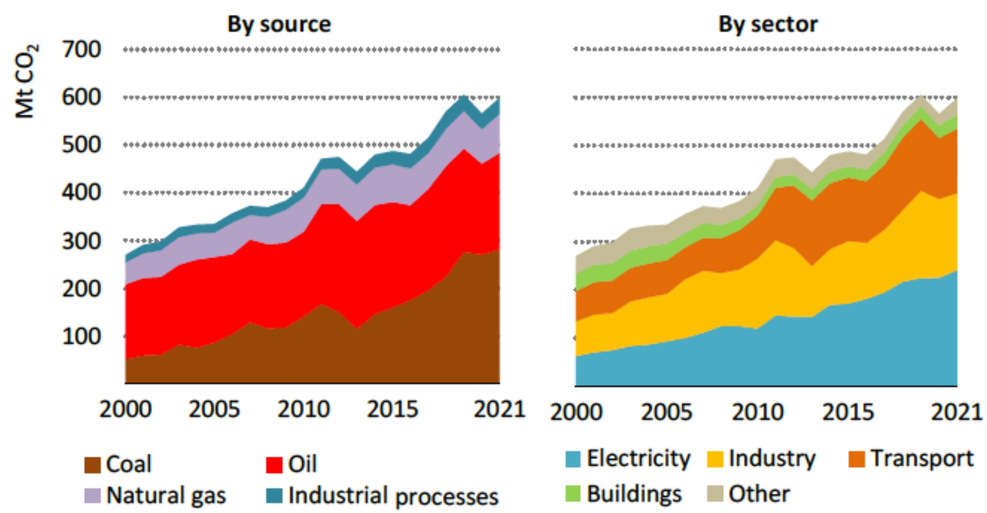


The market for critical minerals approaches that of coal today in the 2040s

Source: IEA, 2021

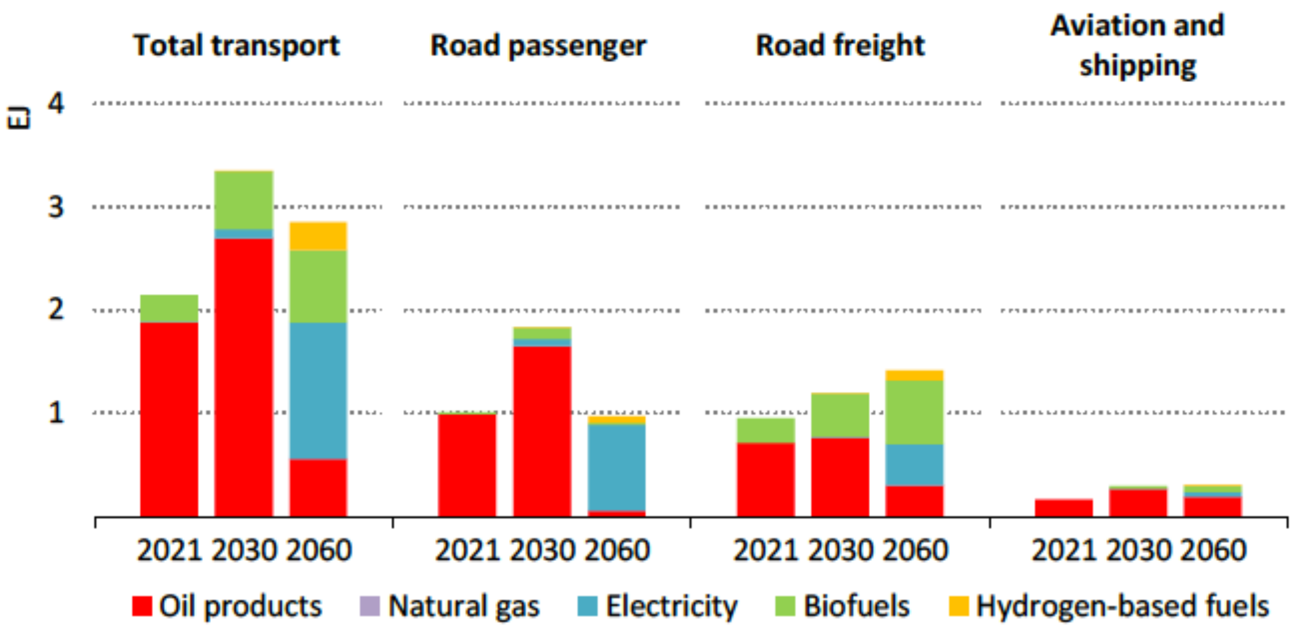
CO_2 emissions from fuel combustion by sector and sub-sector in Indonesia, 2010 – 2021





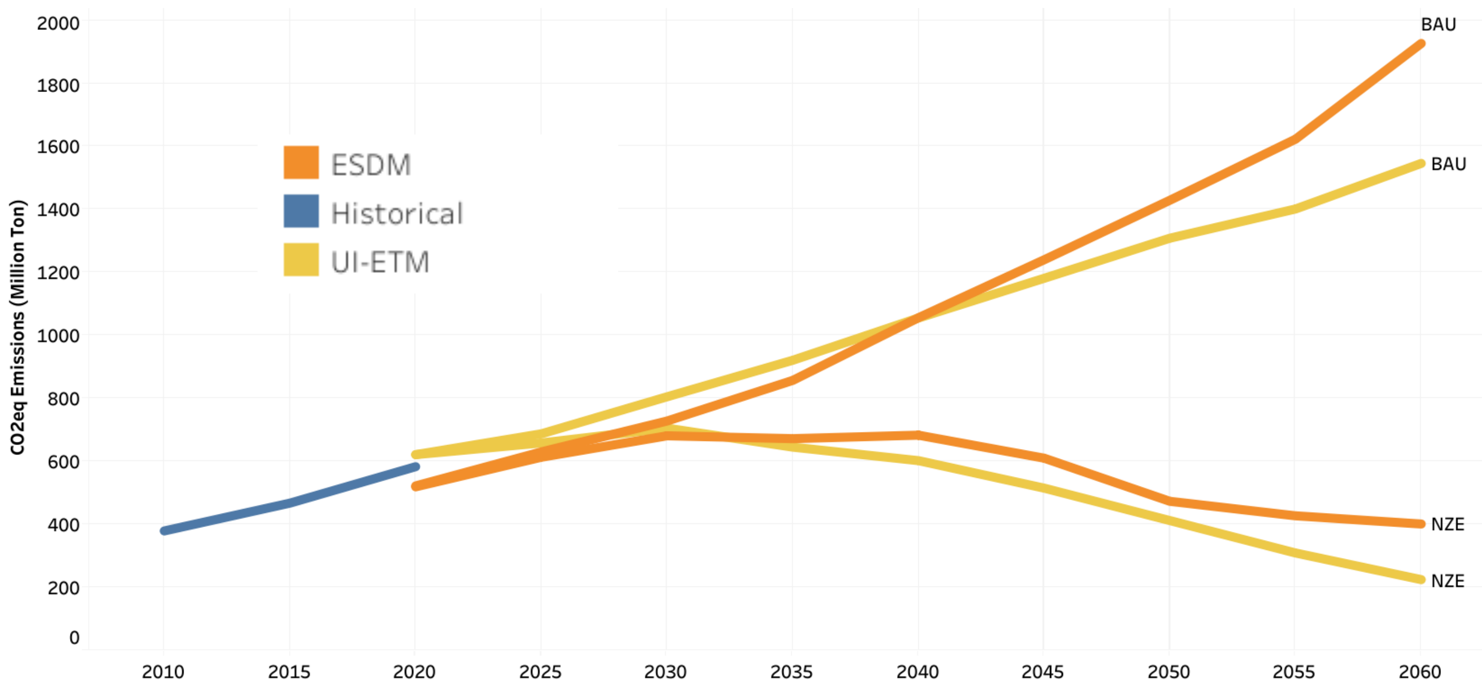
Source: IEA, 2022

Energy consumption in transport by fuel and by mode in Indonesia, 2030 and 2060



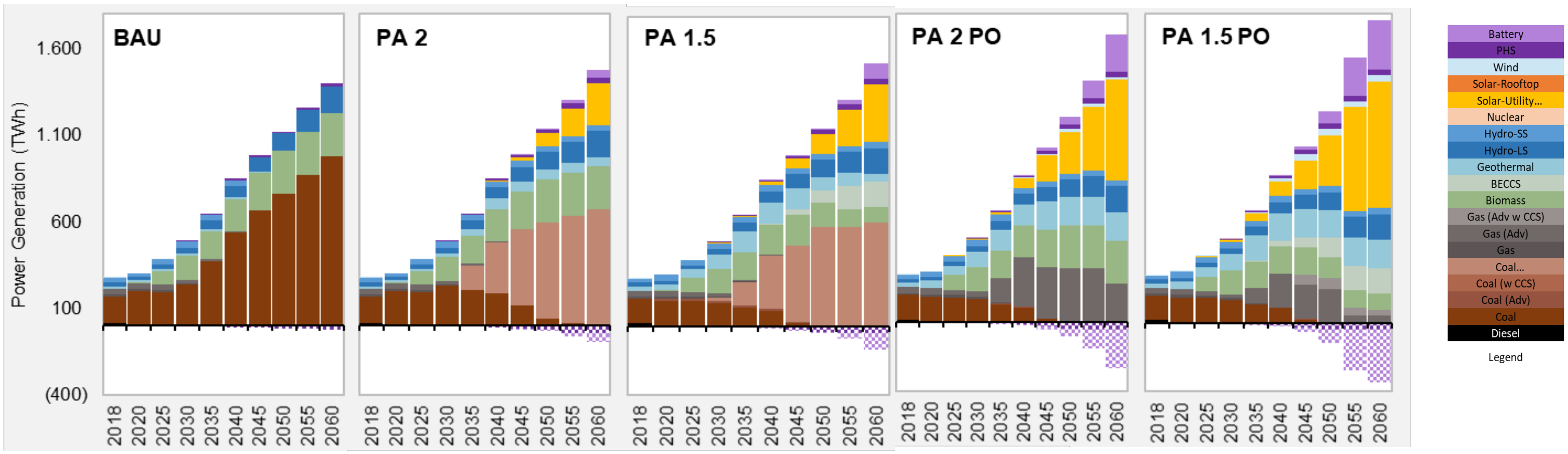
Source: IEA, 2022

CO_2 emissions reduction NZE 2060 Indonesia– *Energy + Industry*



Source: UI-ETM

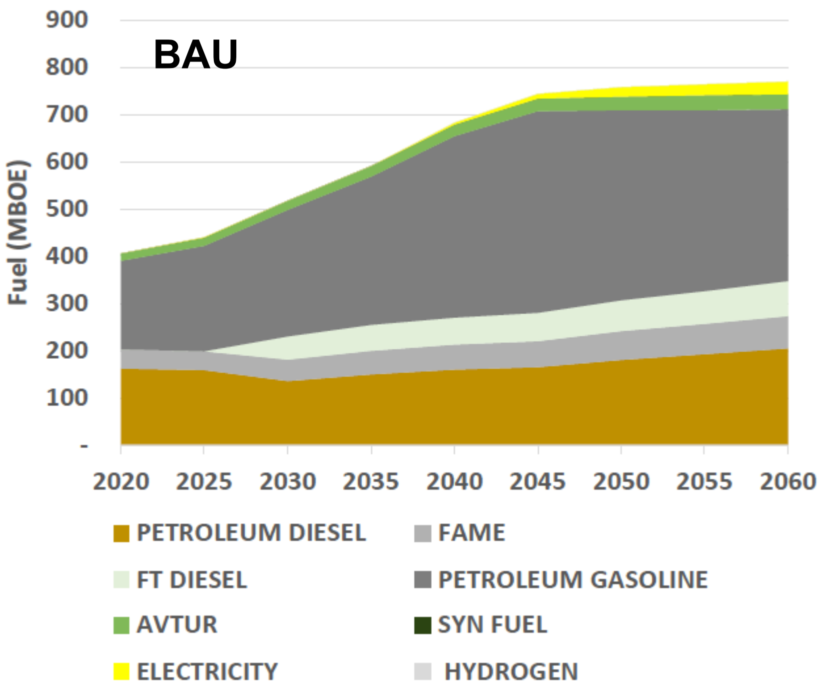
Pathway NZE for power sector

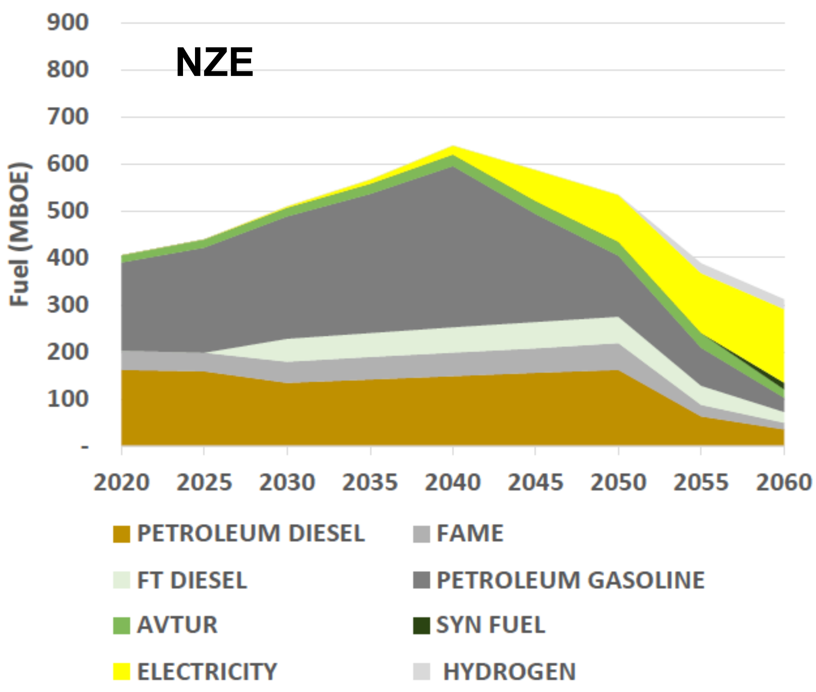


- ✓ Natural gas as a bridge for renewable energy era.
- ✓ R&D for CCS & BECCS becomes important as a net-negative technology and deployment is needed by 2040.
- ✓ Solar PV utility scale will cover unused agricultural land, lake, and abandoned mining field starting from 2055.
- ✓ Significant contribution of battery and pump hydro storage to balance the intermittency of solar PV.

Source:UI-ETM

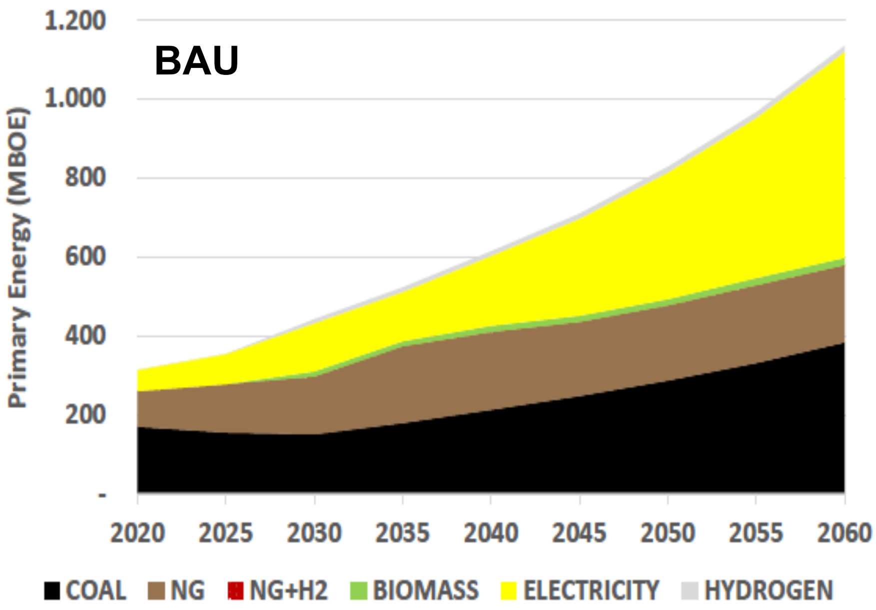
Pathway NZE for transport sector

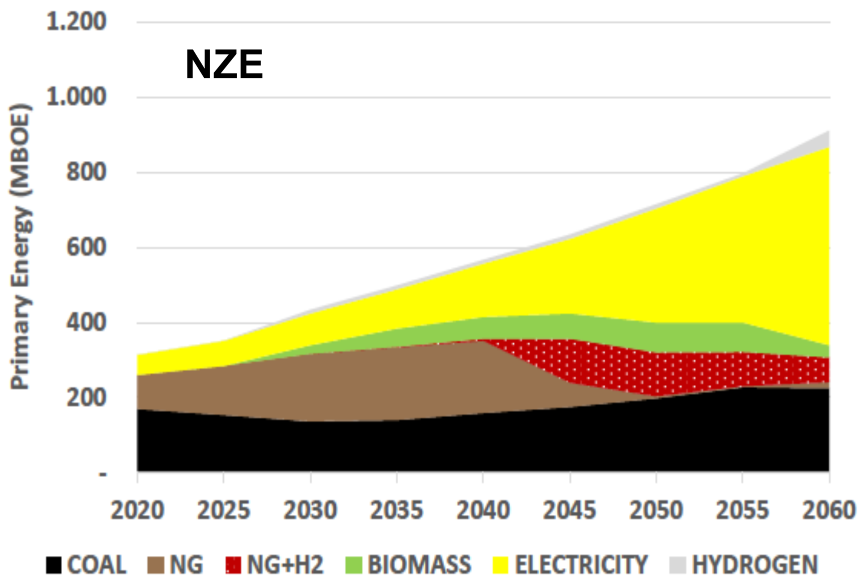




Source: UI-ETM

Pathway NZE for industrial sector





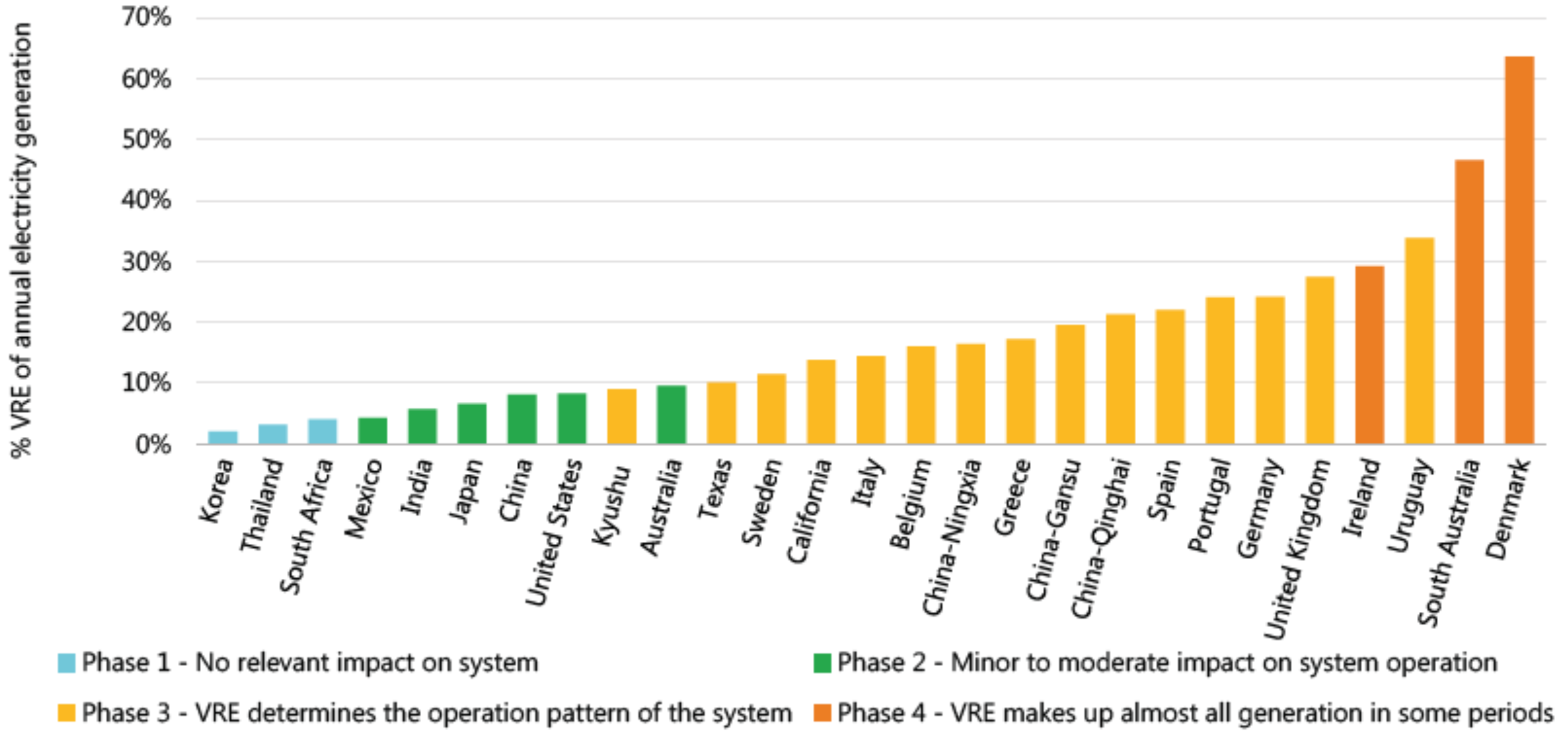
Source: UI-ETM

Energy Transition Consequences

Consequences of energy transition

- Future clean energy requires changes to physical system, consumer behaviour, and market rules,
- Moving from an energy systems of scarcity (fossil fuel) to one of potential abundance for almost every country (RE),
- The country that have benefitted from fossil fuel production, it could geo-political changes and potentially disrupt (stranded asset),
- The greatest challenges for fossil fuel-producing countries to adopt a new and diversified economic model.

VRE is increasingly influencing power system operations

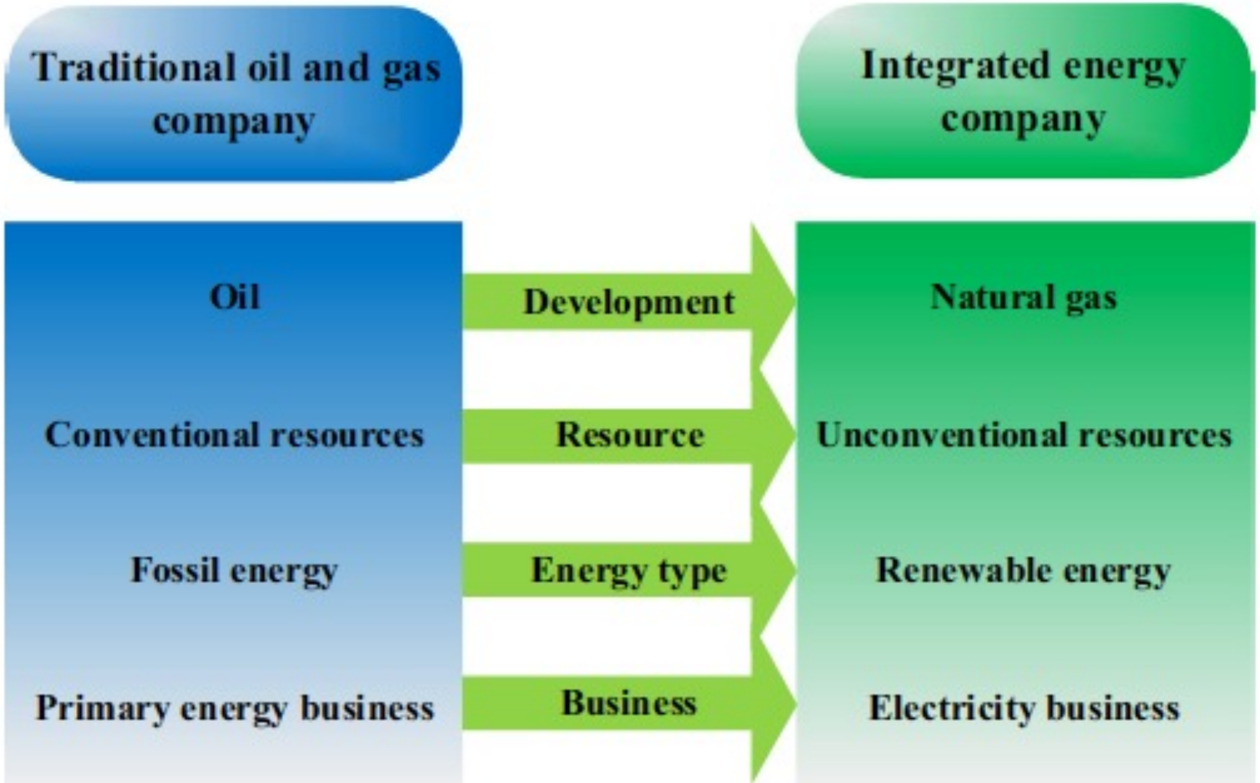


Note: China = the People's Republic of China.

Source: IEA (forthcoming), *Renewables 2019: Analysis and Forecasts to 2024*.

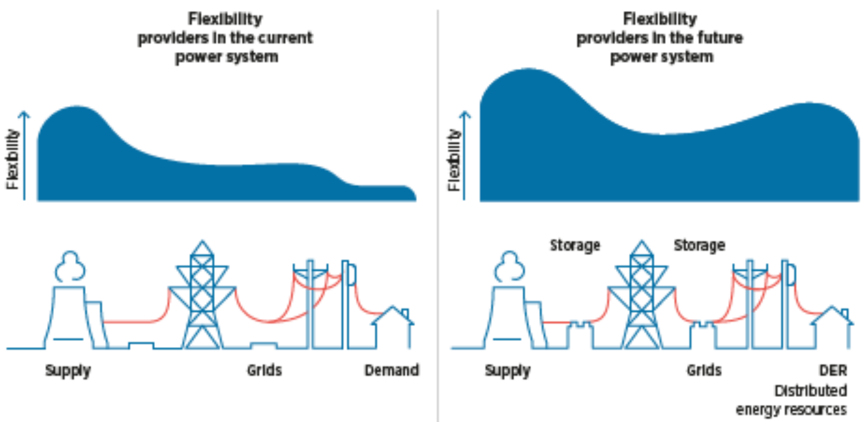
Source: IEA, 2019

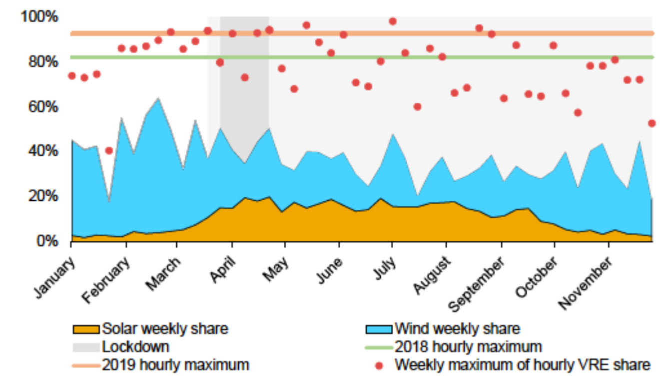
The transition of traditional oil and gas companies to integrated energy companies

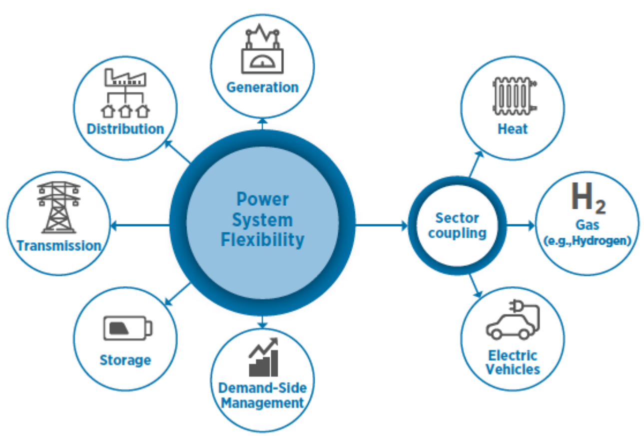


Source: Lu et al. , 2019

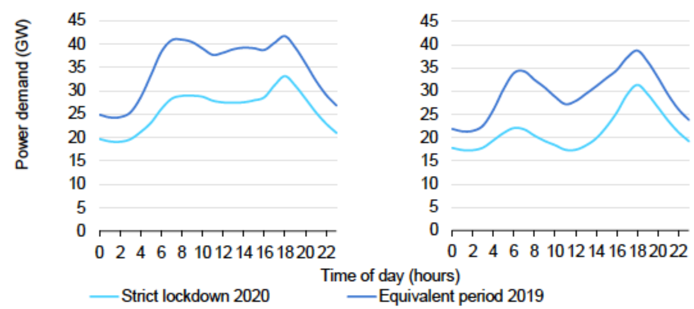
Flexibility in current and future power systems







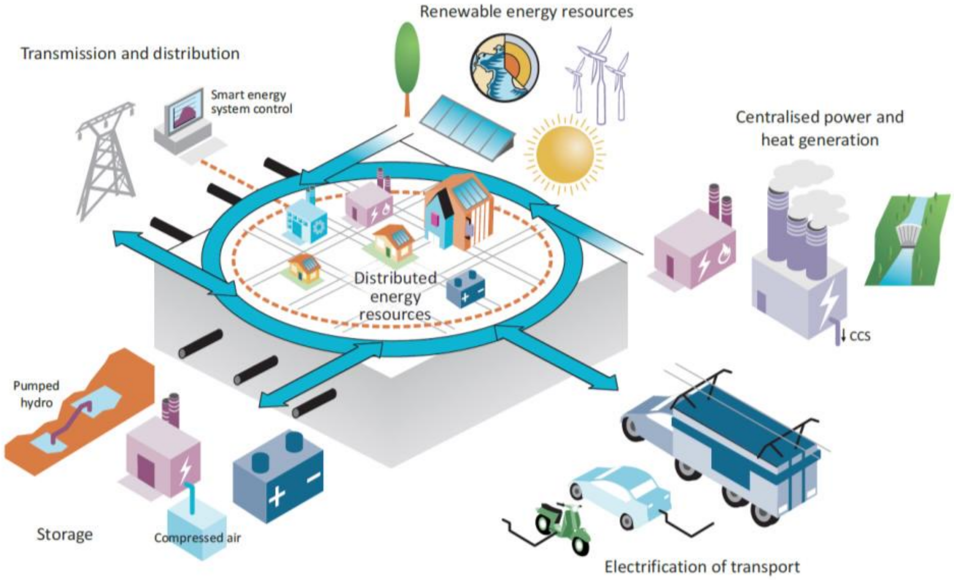
Changing average weekday load (left) and net load (right) patterns in Italy during lockdown relative to the same period in 2019

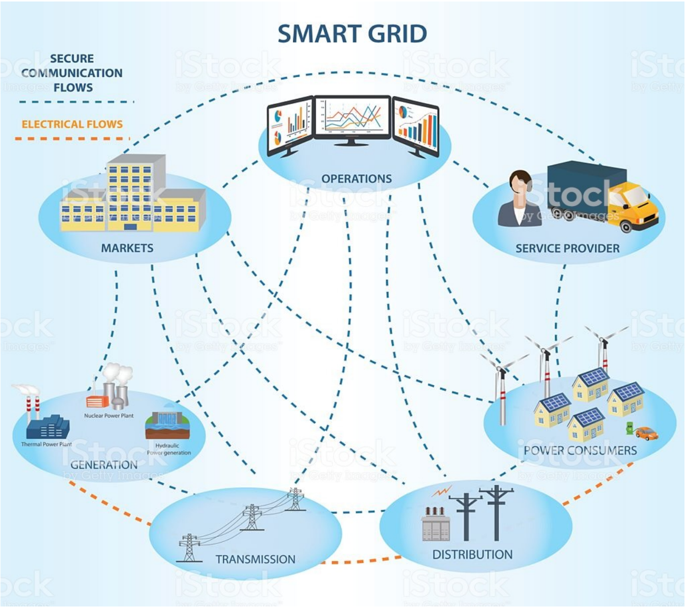


Source: IEA, 2020

Source: IRENA, 2019

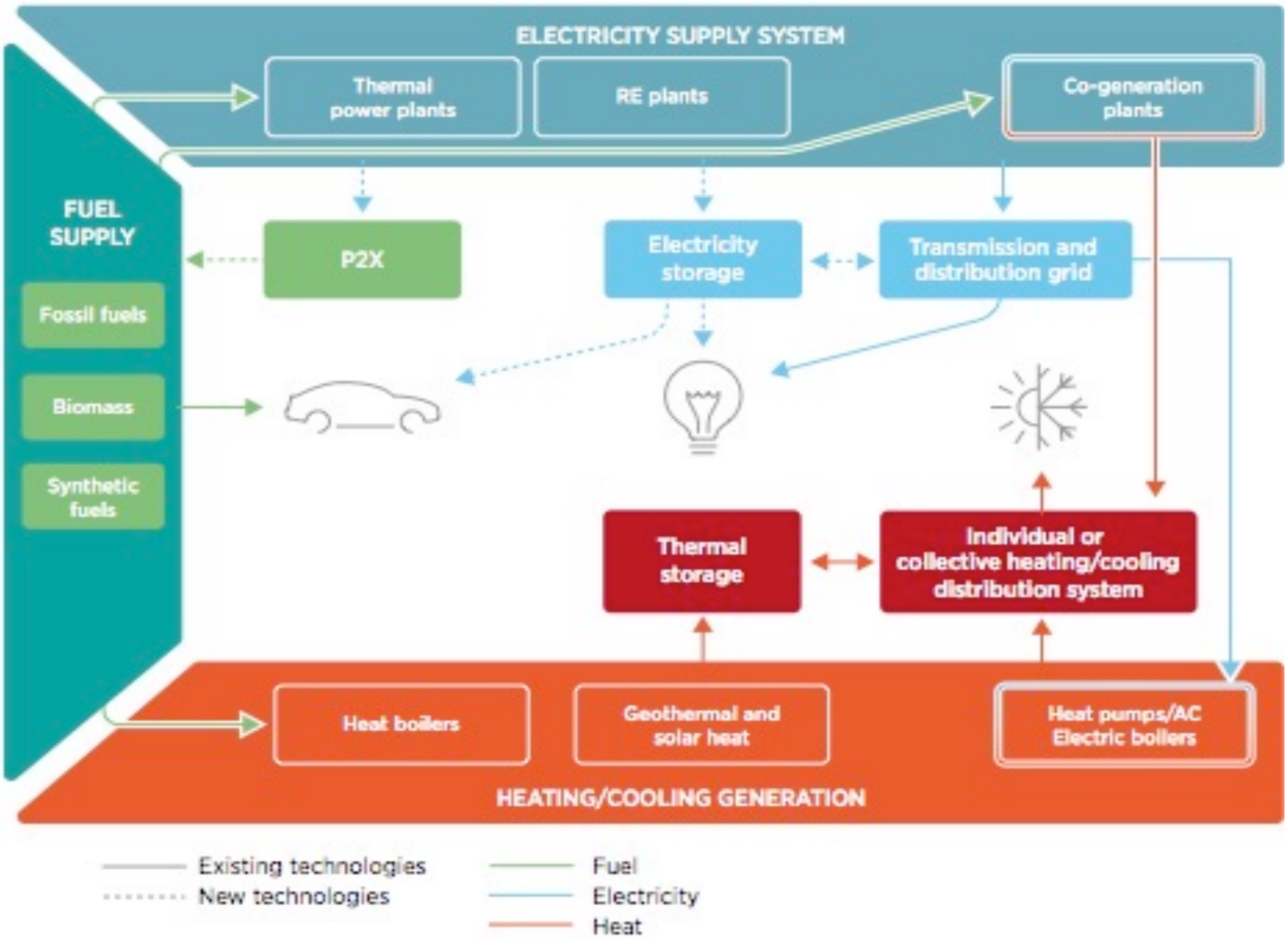
An interconnected and integrated electricity system of the future





Source: IEA, 2014

Sector coupling



P2X = Power-to-X.

Barriers of Energy Transition

Main barriers

- The power industry structure is single buyer with IPPs is closely related to political interests and remains tied on heavy regulated price,
- The actors involved, including governments, businesses, workers and communities have a tendency to protect the status quo and keep fossil-intensive industries alive,
- Policy makers and power companies tend to encourage coal use as cheap energy source of state electricity. The expansion of coal power plants accounts for over 7% of the global coal power expansion,
- Capital spending of state-owned enterprises are low because they are subject to price control.
- Regulatory environment is the key barrier for renewables deployment.

State of electricity regulation in ASEAN member countries

Country	Regulator	Regulator independence	Market structure
Brunei Darussalam	Dept. of Electrical Service	Under the Ministry of Energy	Single buyer
Cambodia	Electricity Authority of Cambodia	Independent	Single buyer
Indonesia	Dept. of Energy and Mineral Resources	Under the Ministry of Energy and Mineral Resources	Single buyer
Lao PDR	Dept. of Electricity	Under the Ministry of Energy and Mines	Single buyer
Malaysia	Energy Commission	Independent	Single buyer
Myanmar	Ministries of Electric Power	Under the Ministries of Electrical Power	Single buyer
Philippines	Energy Regulatory Commission	Independent	Price pool
Singapore	Energy Market Authority	Under the Ministry of Trade and Industry	Price pool
Thailand	Energy Regulatory Commission	Independent	Single buyer
Viet Nam	Electricity Regulatory Authority	Under the Ministry of Industry	Cost-based pool

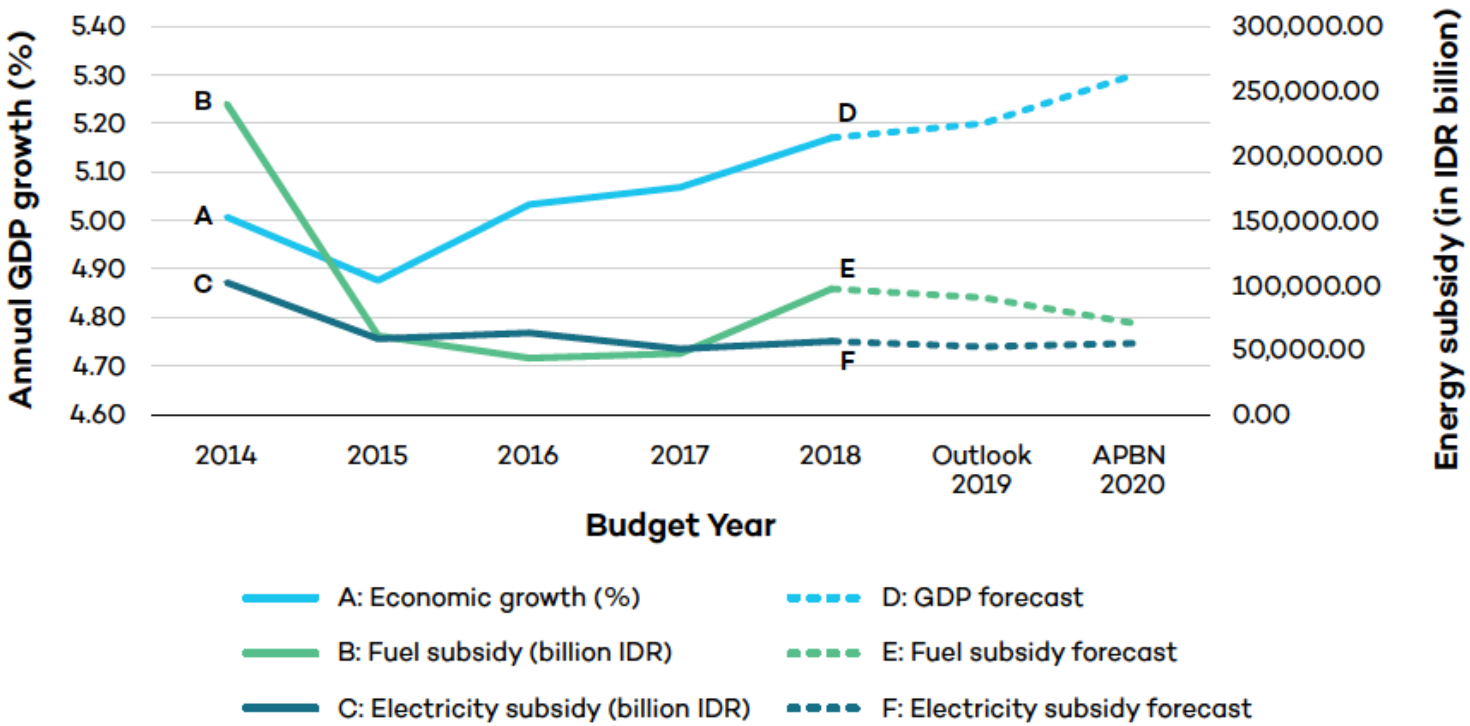
Source: Syaiful, I. (2015), "ASEAN power market integration", presented at ACE-HAPUA-IEA-World Bank Workshop, 13 March 2015.

Pool price = beda harga per daerah sesuai dgn value chain

Source: IEA

Indonesia's economic growth and energy subsidy

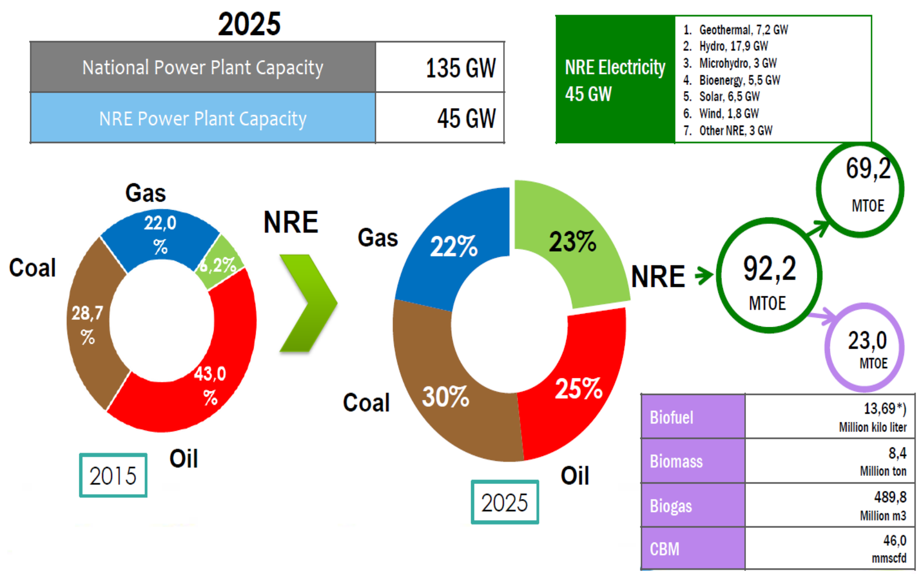
Barrier = fuel cell dikasih subsidi, RE ngga

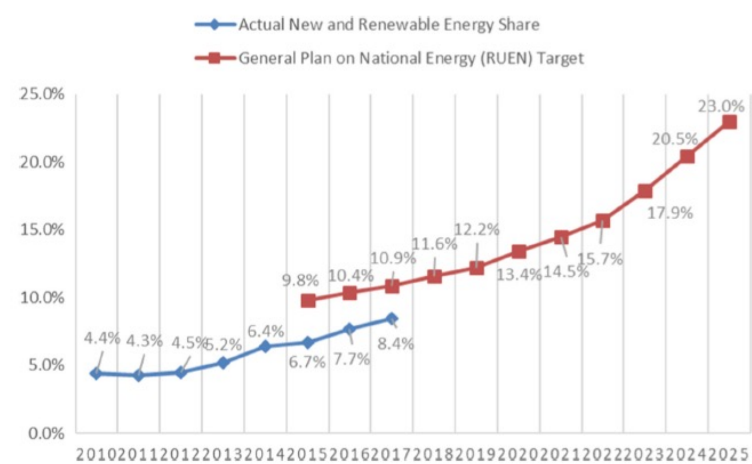


Source: Government of Indonesia, 2018; Kementerian Keuangan Republik Indonesia, 2020.

Source: IISD

Current achievement of RE share is far from the target

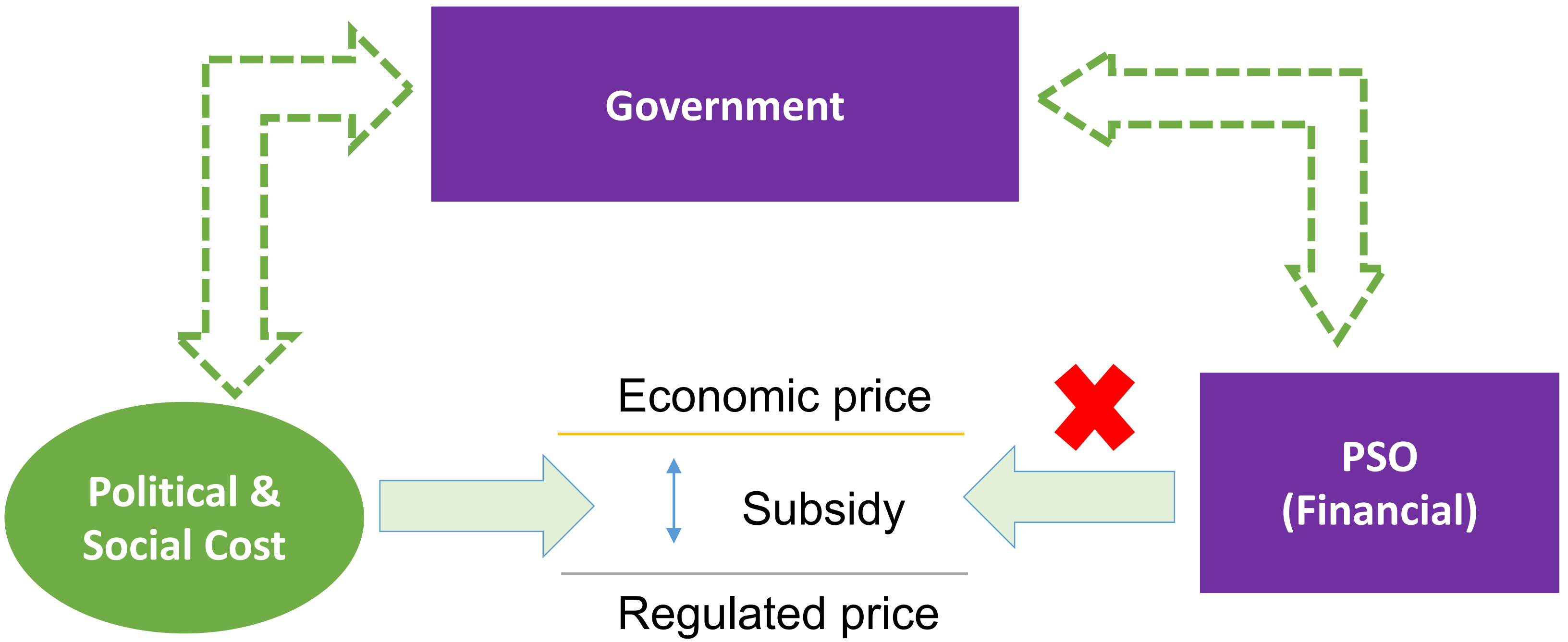




Source: MEMR

Source: Maulidia et.al, 2019

Political and social cost by Gov.



Pathways of Decarbonization

Decarbonization Pathways

Supply

Power Plant

1. Renewable energy
2. CCS Power plant
3. Distributed power generation

Refinery

1. Power to Gas
2. Biorefinery implementation
3. Synthetic fuel refinery

Demand

Building

Cooling

1. Energy Efficiency
2. CHP

Cooking

1. Electric stove
2. Natural gas stove

Lighting

1. LED

Other Appliance

1. Energy Efficiency

Industry

Cement

1. Co-firing biomass
2. CCS
3. Lower clinker ratio
4. Co-firing biomass and CCS

Steel

1. Scrap material
2. DRI-EAF Technology

Chemical

1. Electricity based chemical
2. Biomass based chemical

Alumunium

1. Scrap material

Heat

1. Electrification of heat
2. Natural gas mixed with H_2
3. Biomass

Transport

LDV

1. EV
2. biofuel

HDV

1. Biofuel
2. EV
3. Fuel cell vehicle
4. LNG vehicle

Rail

1. Biofuel
2. Electric train

Ship

1. LNG Ship
2. Biofuel

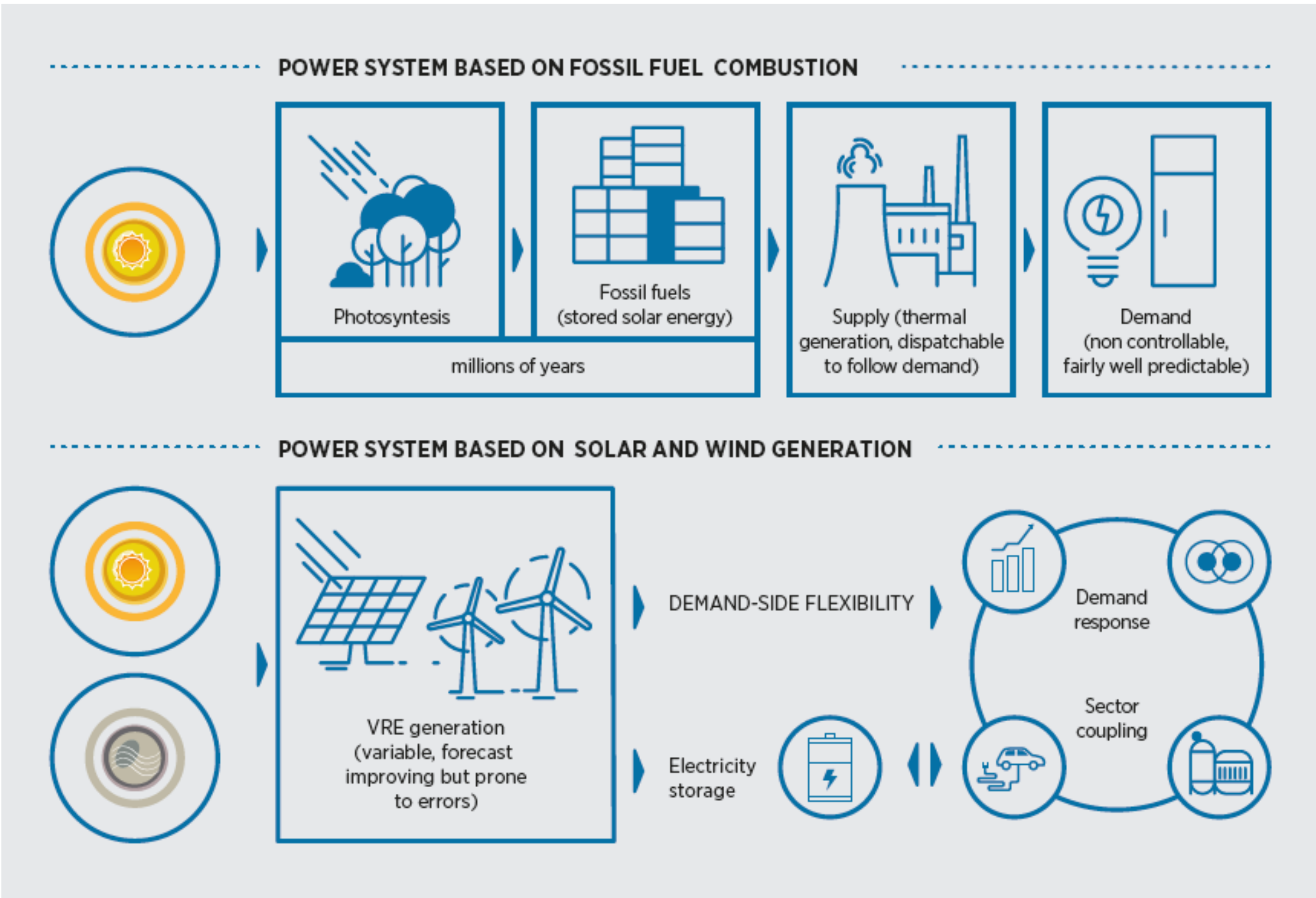
Aviation

1. Synthetic fuel

Renewables
CCUS
Energy efficiency
Electrification
Hydrogen fuels
Low emission fuel

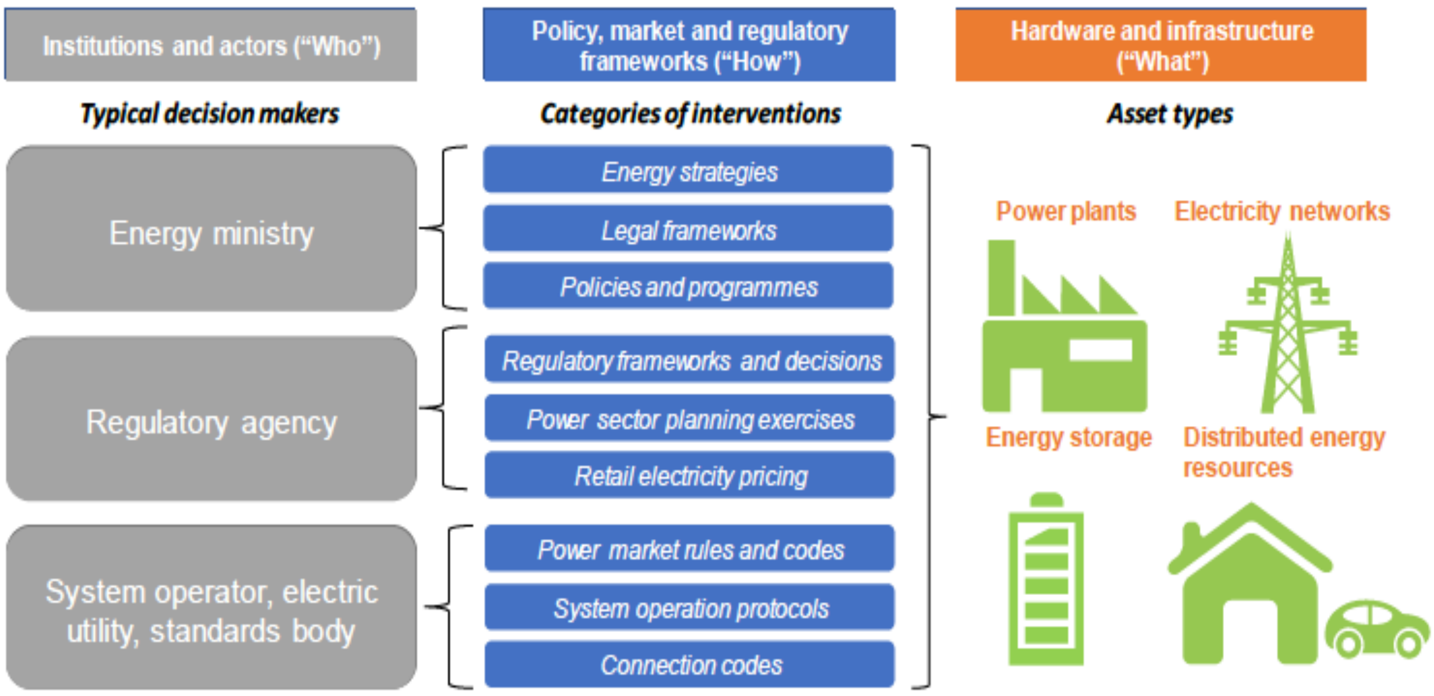
Opportunities for Supply Sectors

Power system structure before and today with the different roles of demand



Source: IRENA, 2019

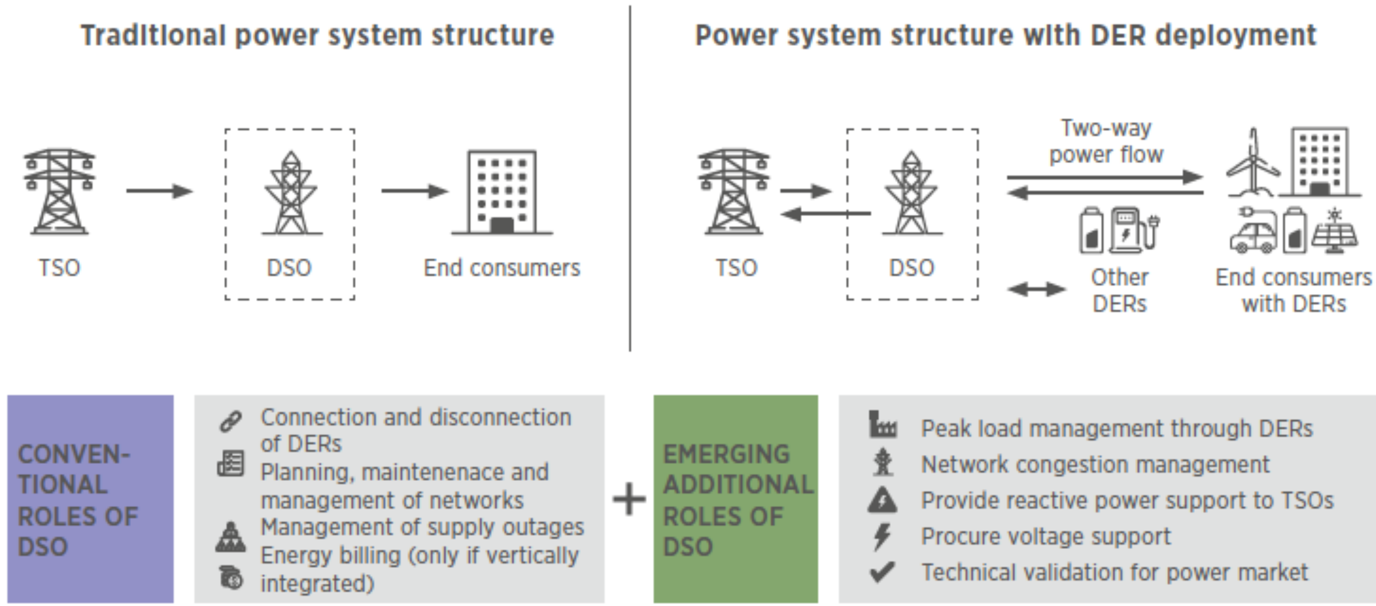
Layers of power system flexibility

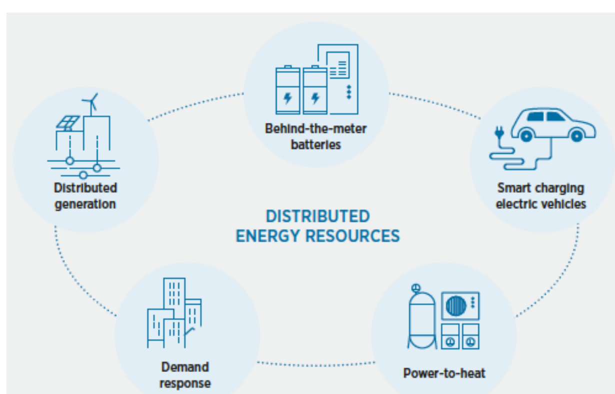


Source: Adapted from (IEA and 21CPP, 2018), *Status of Power System Transformation 2018: Advanced Power Plant Flexibility*.

Source: IEA, 2019

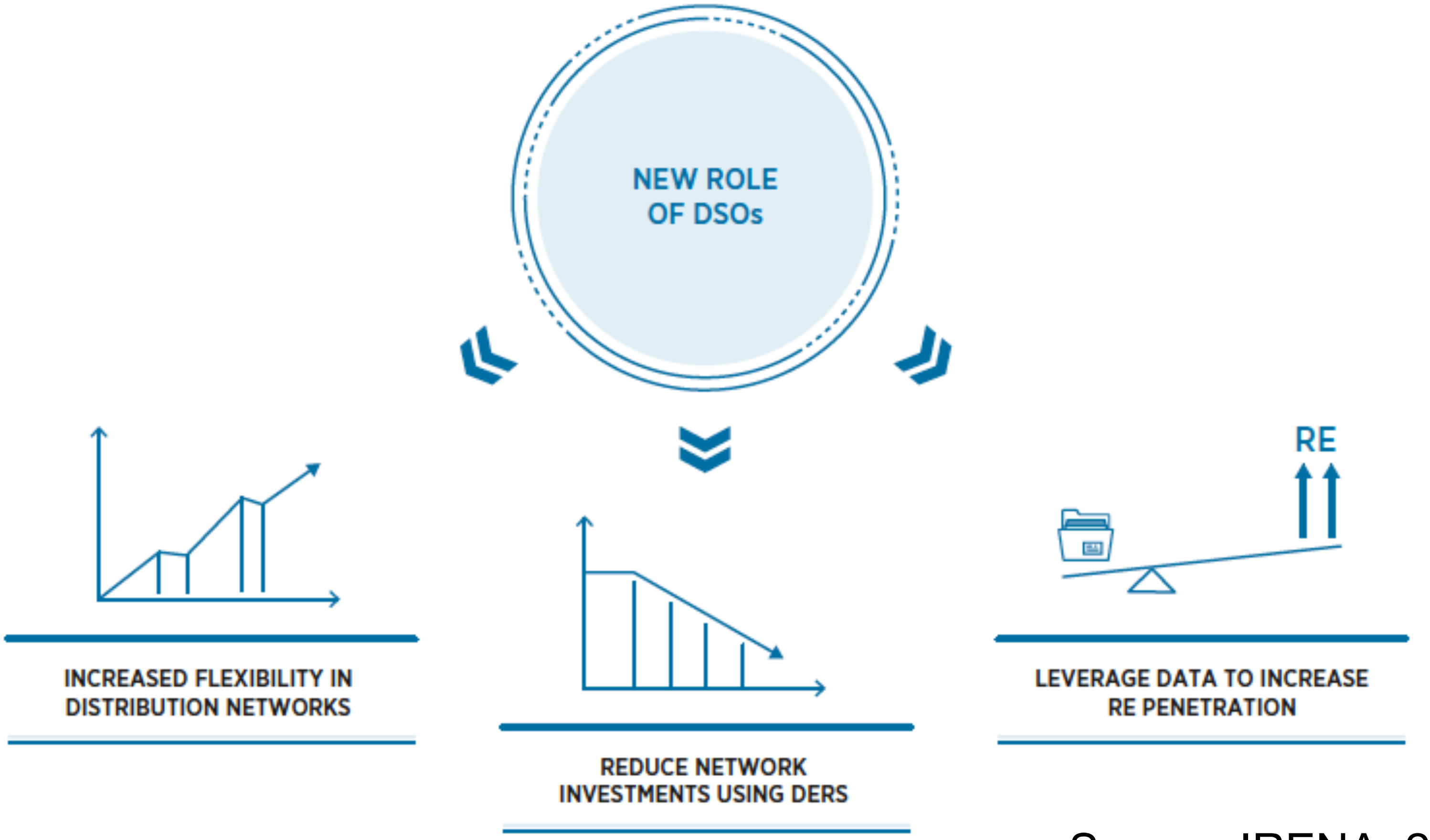
Power system structure with DER deployment





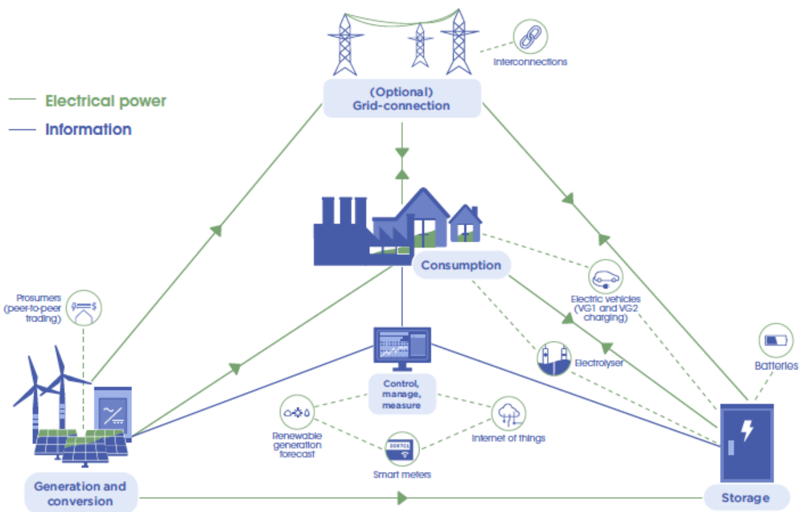
Source: IRENA, 2020

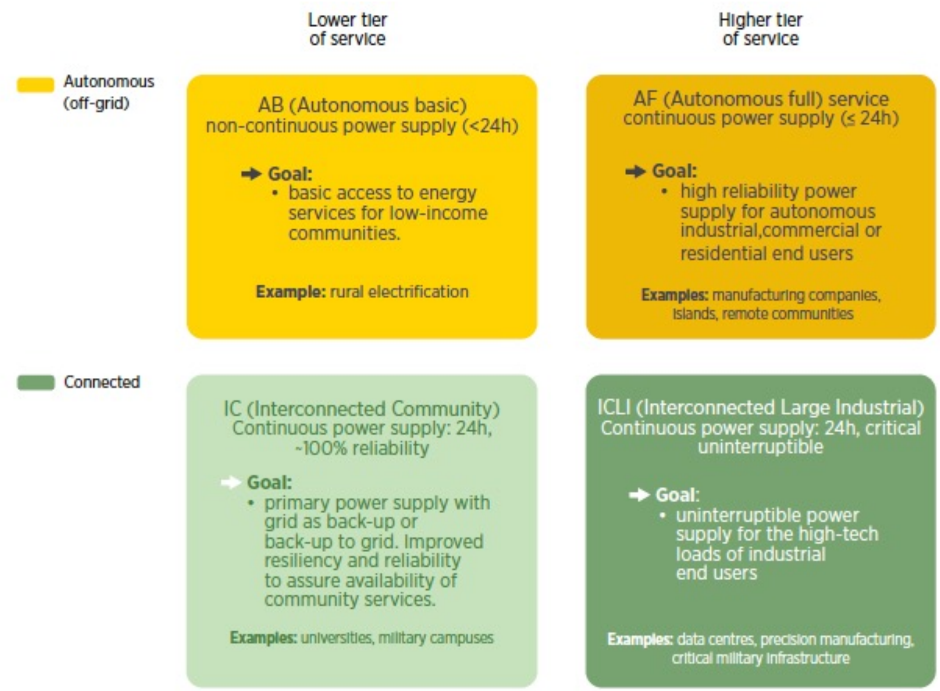
Key advantages of the new role of distribution system operators



Source: IRENA, 2020

Mini-grid functionalities and types

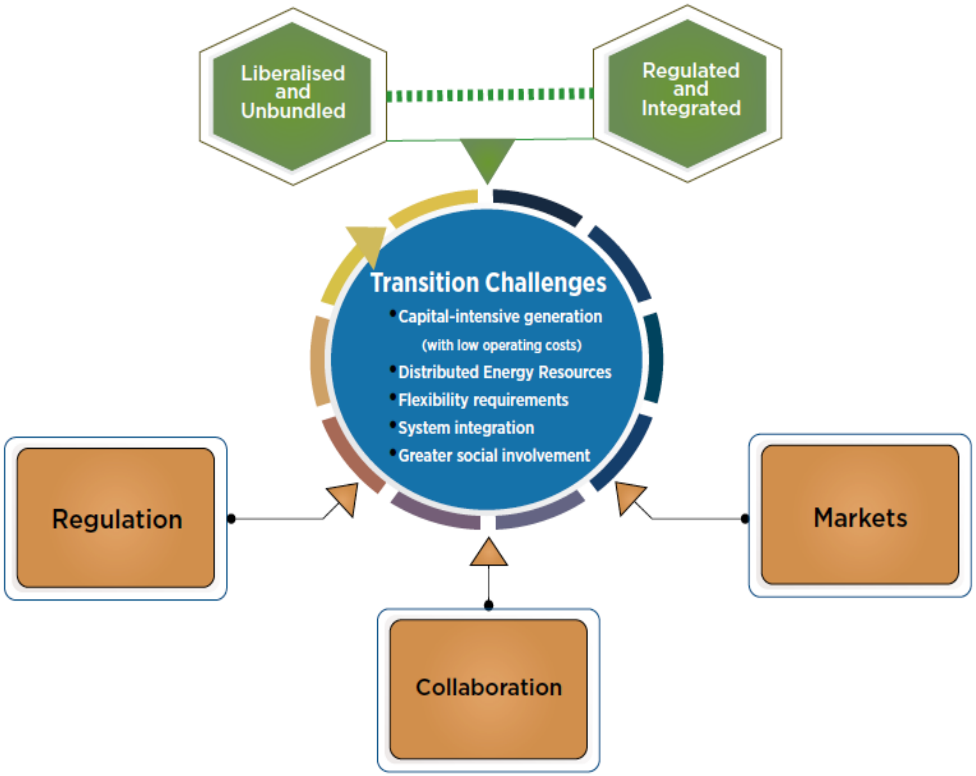




Based on: (IRENA, 2016a).

Source: IRENA, 2020

Transition challenges common to all power system structures

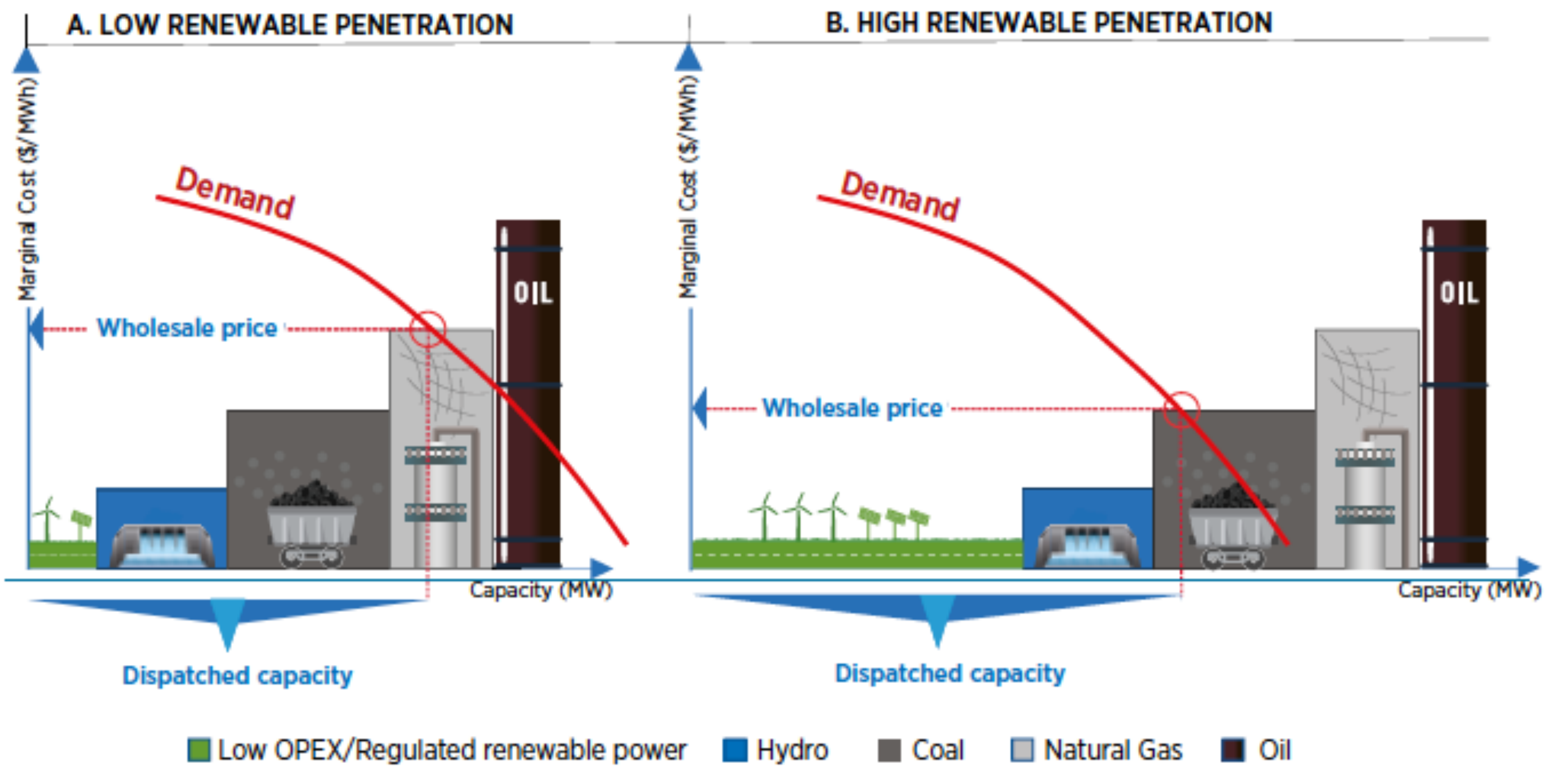


Power system structure

For the purposes of this brief, **"power system structure"** is used as a short form for **"power system organisational structure"**, encompassing both the market mechanisms behind liberalised power systems and the organisational structures of regulated power systems. The term "power market" is equivalent to "power system structure" for a liberalised power system. However, because this brief broadly addresses both the liberalised and non-liberalised contexts, the term "power system structure" is used throughout.

Source: IRENA, 2020

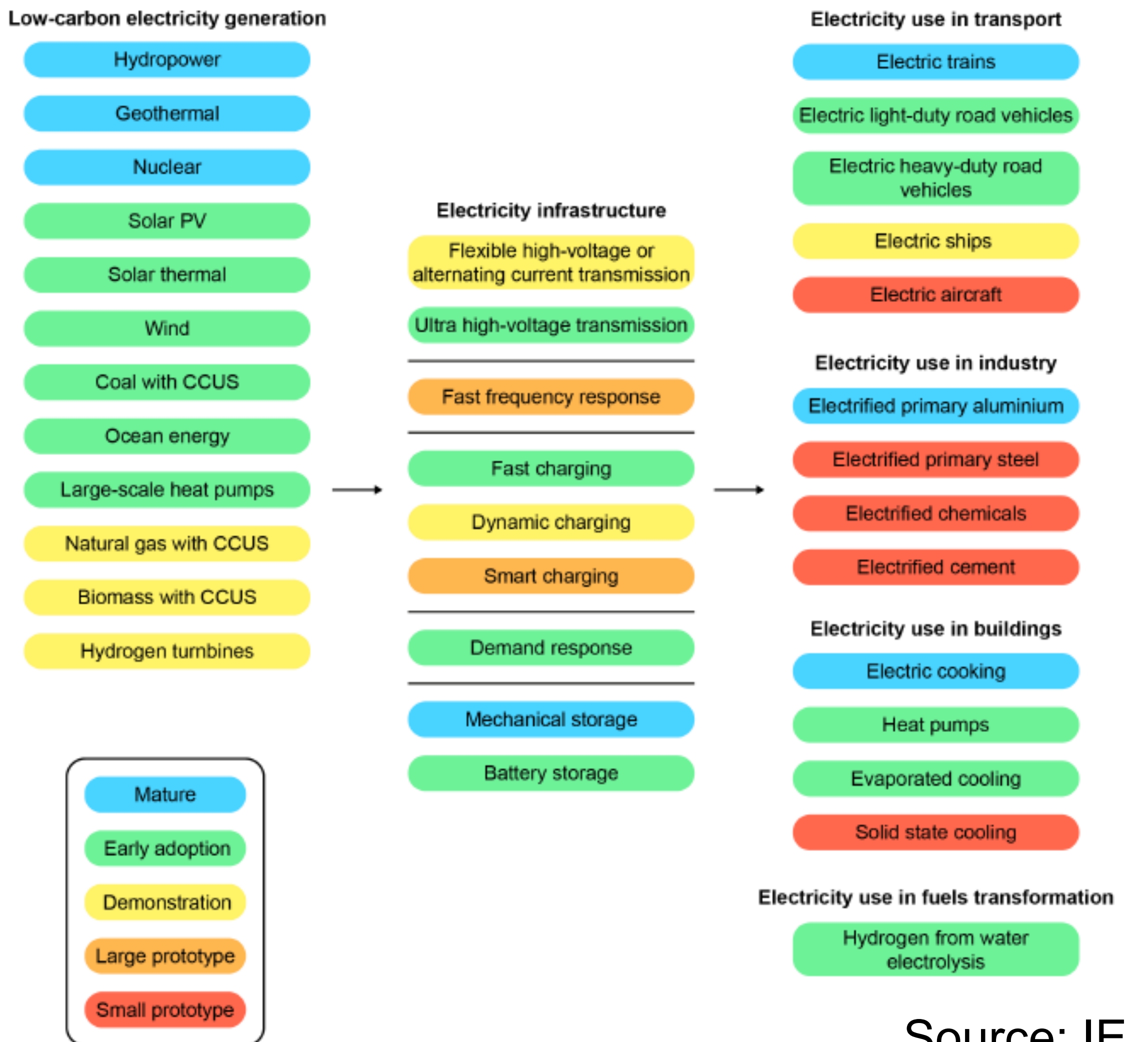
Evolution of wholesale market price and dispatched capacity



Note: Each block represents a generation technology, shown in ascending order of marginal cost (merit order).
MW = megawatt; MWh = megawatt hour; OPEX = operational expenditure.

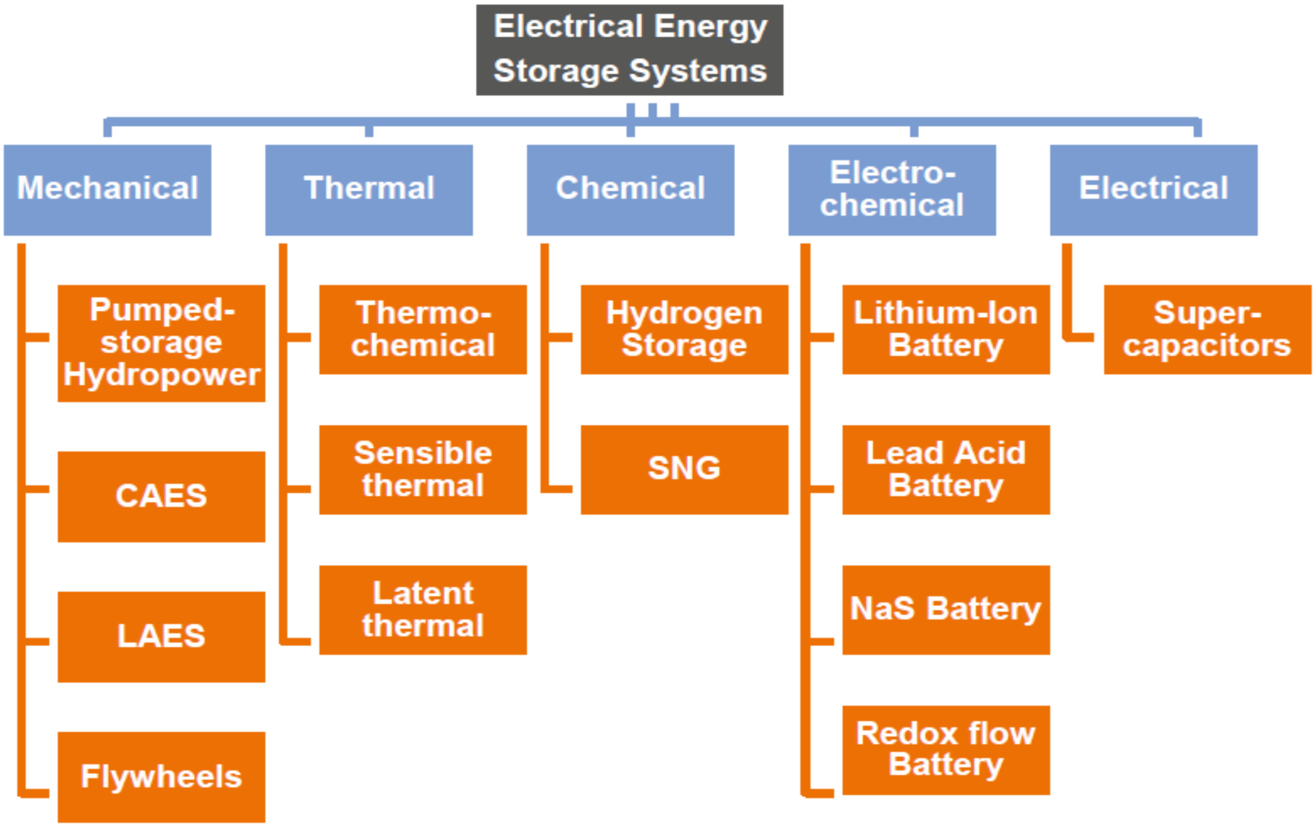
Source: IRENA, 2020

Readiness level of technologies along the low-carbon electricity value chain



Source: IEA, 2020

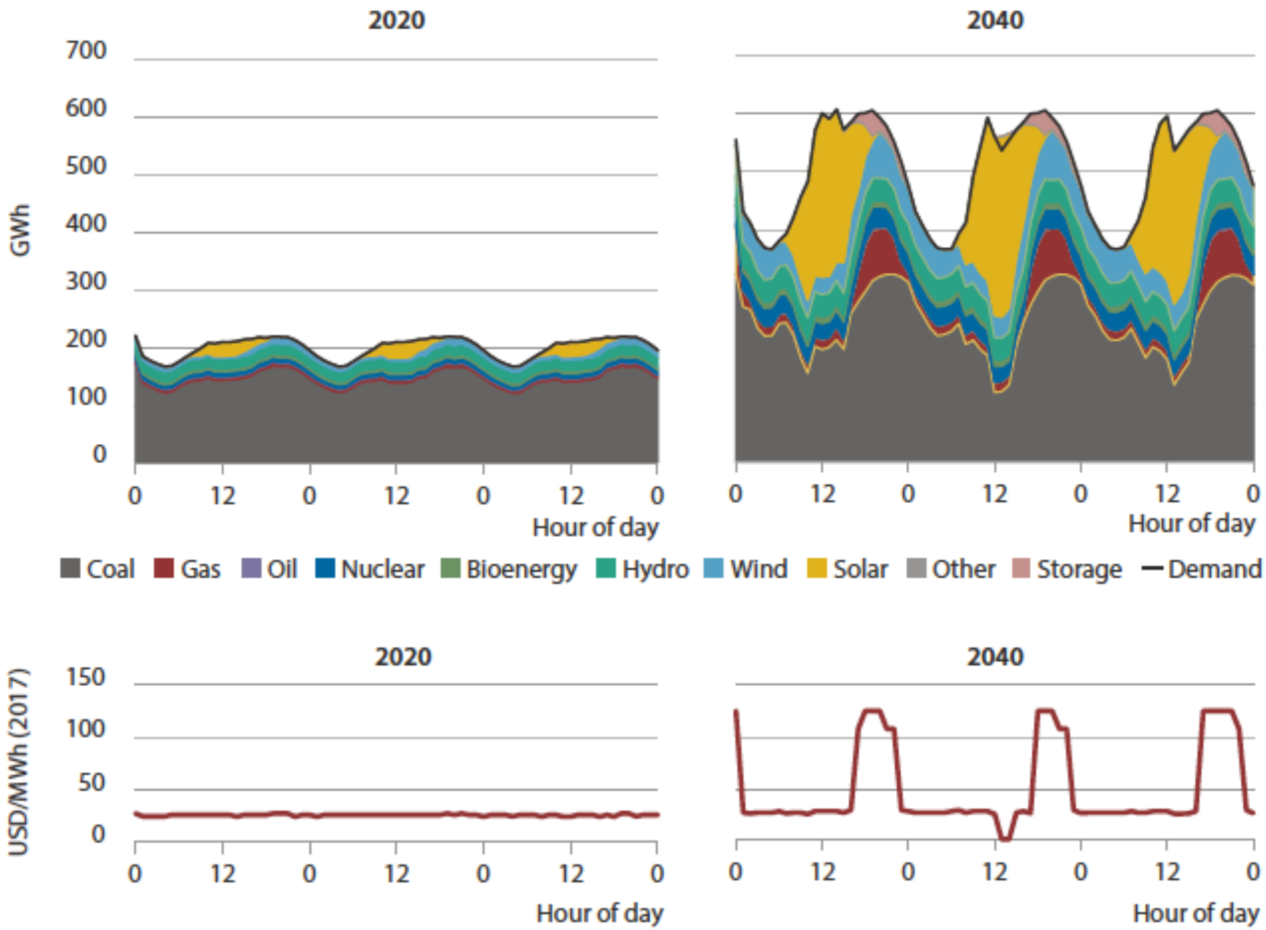
Electricity strorage system



Source: PwC (2015) CAES is Compressed Air Energy Storage; LAES is Liquid Air Energy Storage; SNG is Synthetic Natural Gas

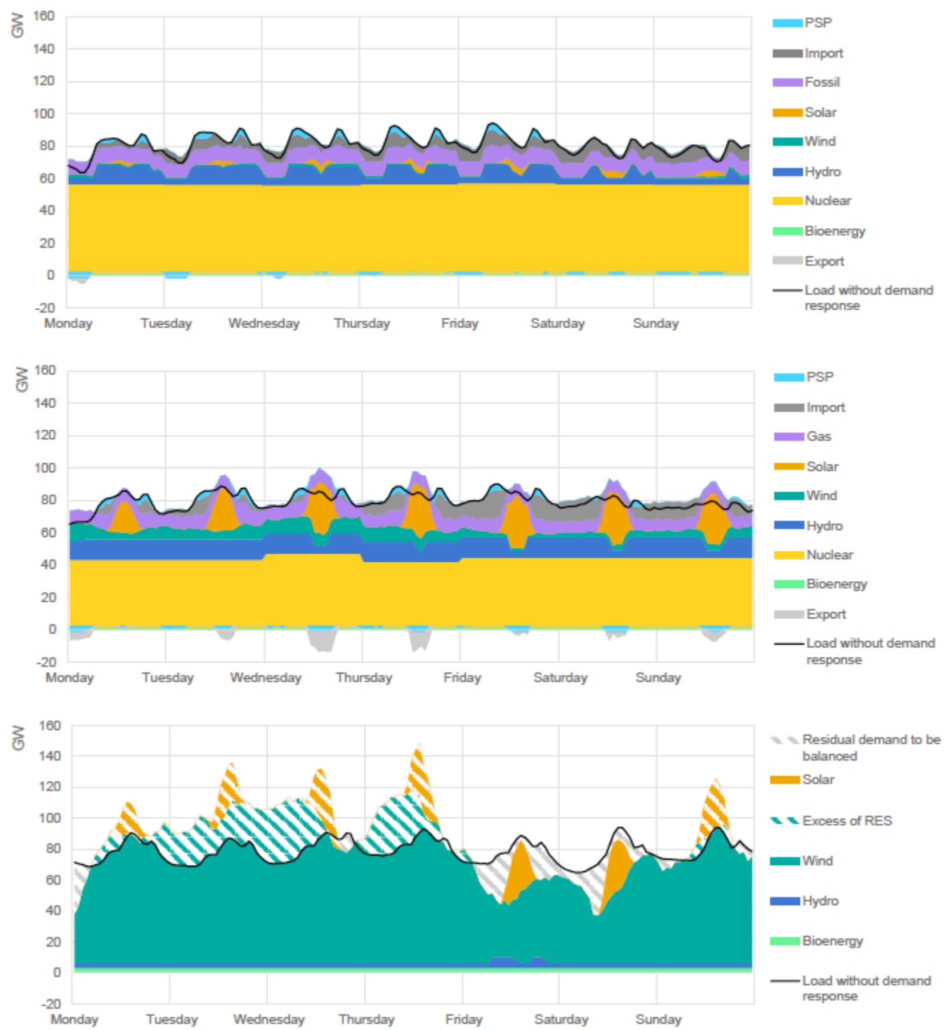
Source: WEC, 2016

Hourly generation mix and wholesale market price of electricity in India, 2020 and 2040



Source: IEA, 2020

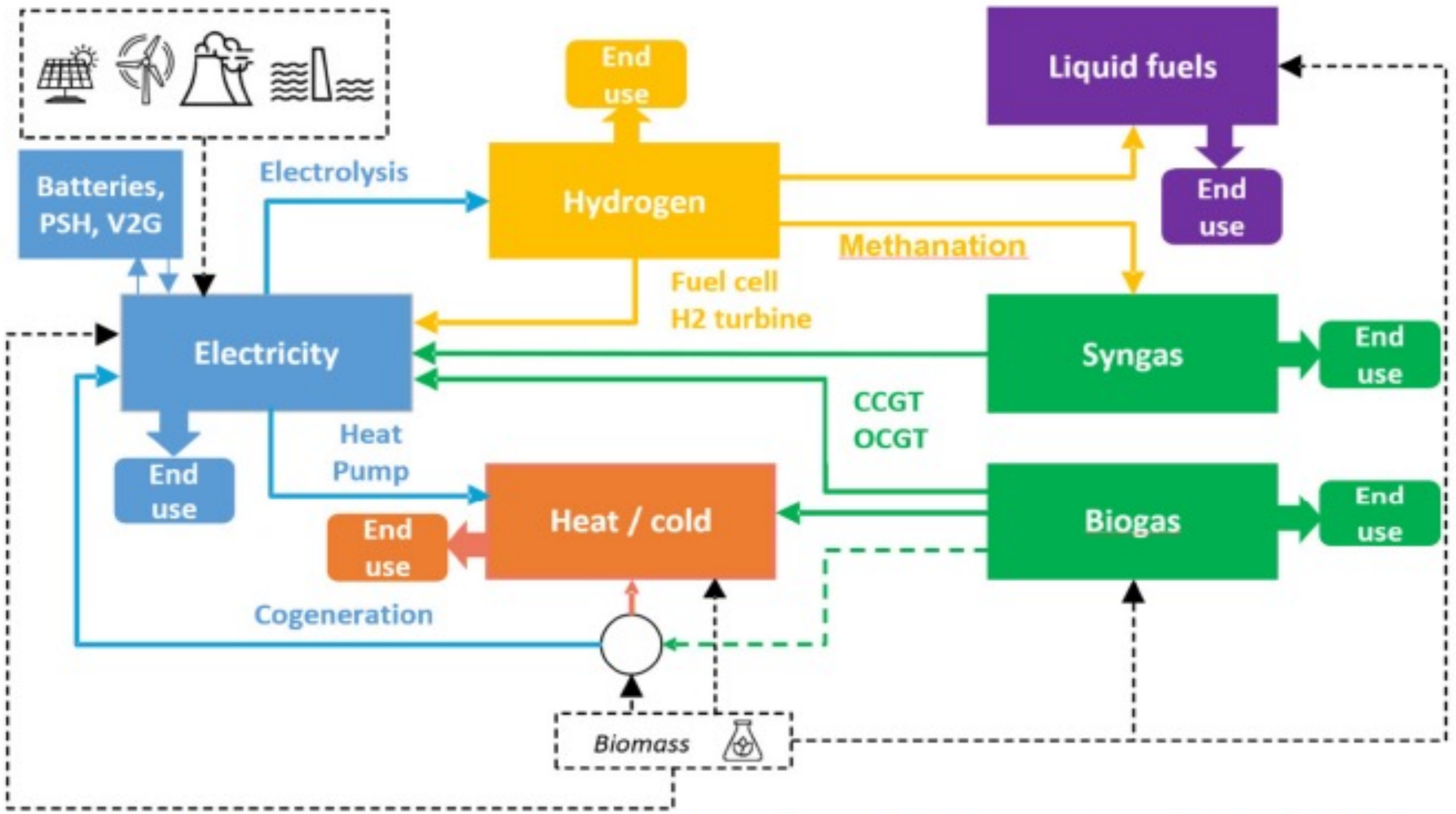
Generation and flexibility mix in the second week of January, today, 2035, and 2050



Note: Change of label from "Fossil" in 2019 to "Gas" in 2035 is due to decommissioning of coal.
Source: own analysis carried out by RTE.

Source: IEA, 2021

Couplings of the power system with other energy carriers

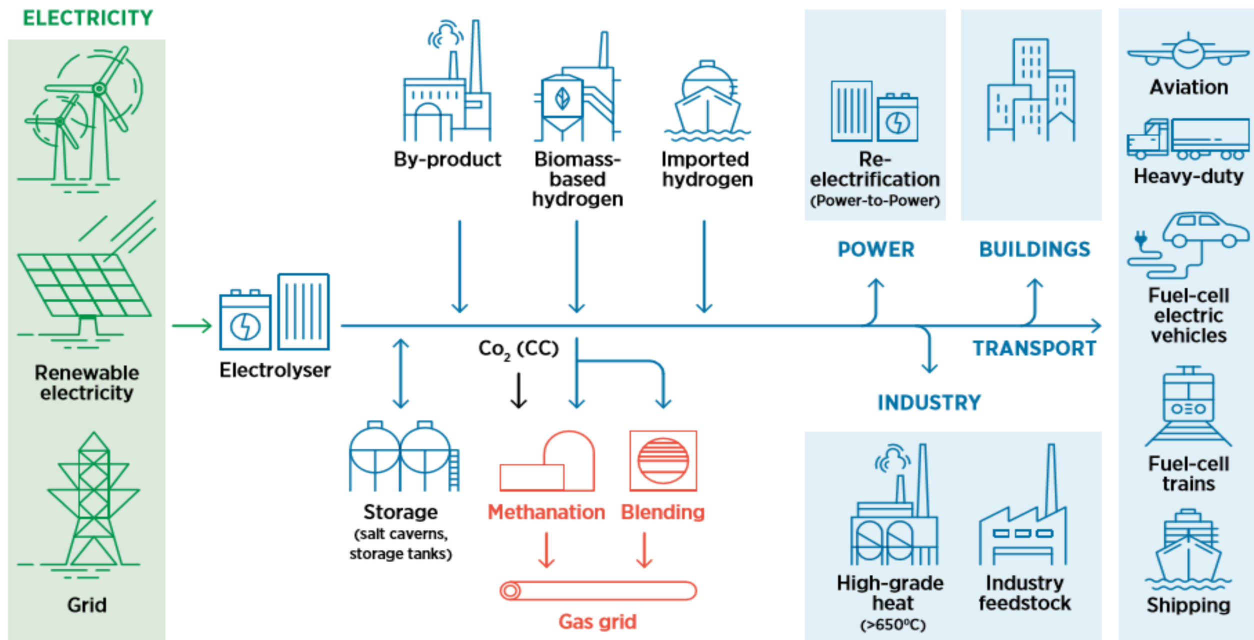


Source: RTE (2019), Groupe de travail « interfaces entre l'électricité et les autres vecteurs ». Document de cadrage, [Work Group "Interfaces between electricity and other vectors", Framework Document].

Source: IEA, 2021

Power-to-X concept

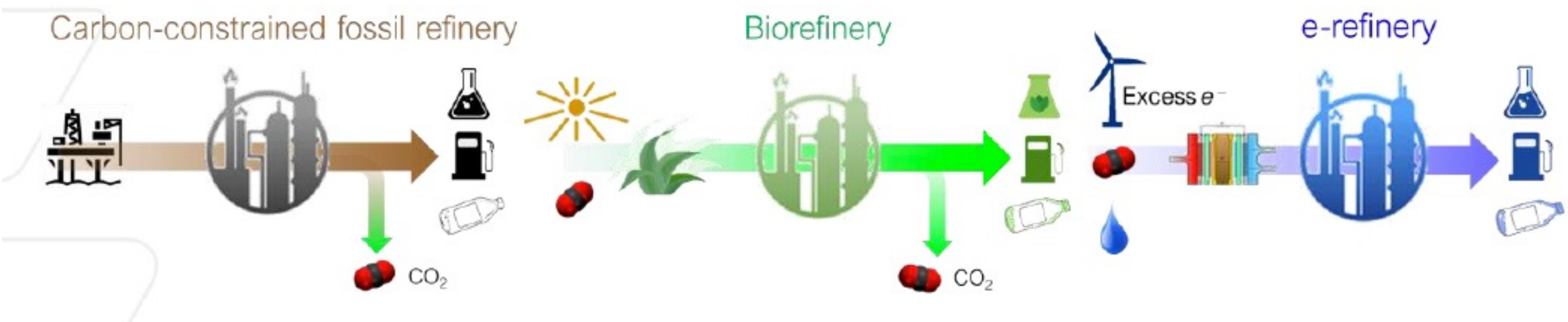
- *Power-to-Gas,* producing gaseous substances such as hydrogen/ methane
- *Power-to-Liquid,* liquid fuels for transport/storage of renewable energy
- *Power-to-Chemicals,* to produce basic chemicals for the chemical industry



Source: IRENA, 2018d.

Source: Centi, 2020

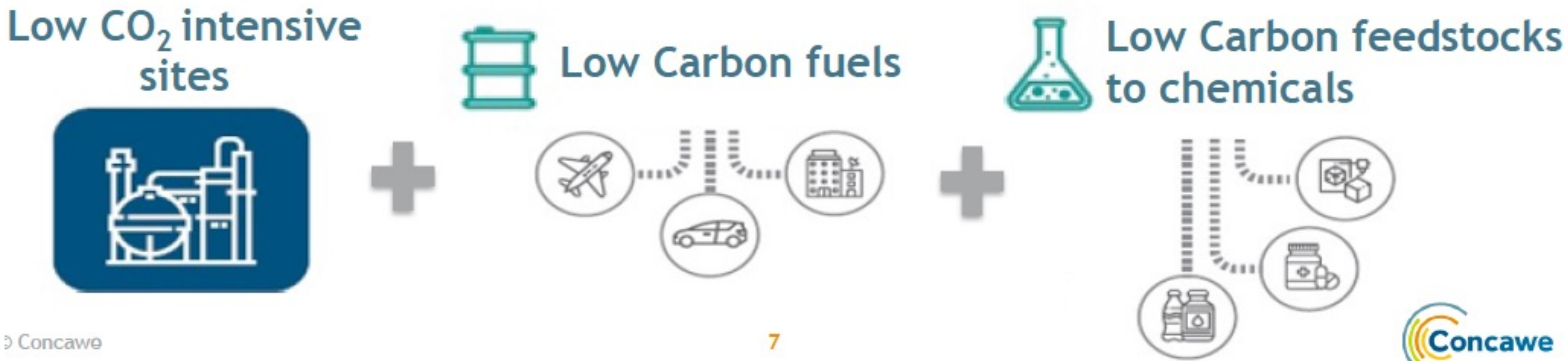
The refinery of today, tomorrow, and the future



Producing more fuels and chemicals with dramatically lower CO_2 emissions → Integration among types

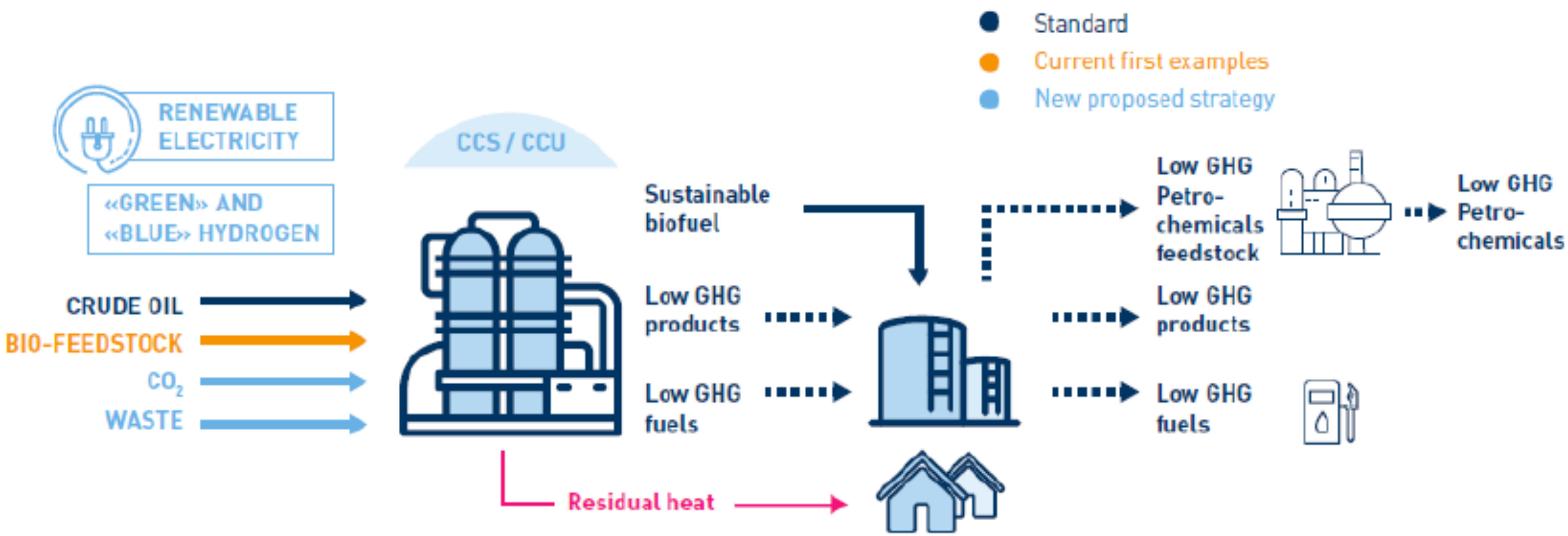
Source: Ryan P. Lively, 2022

Main challenges for future refinery



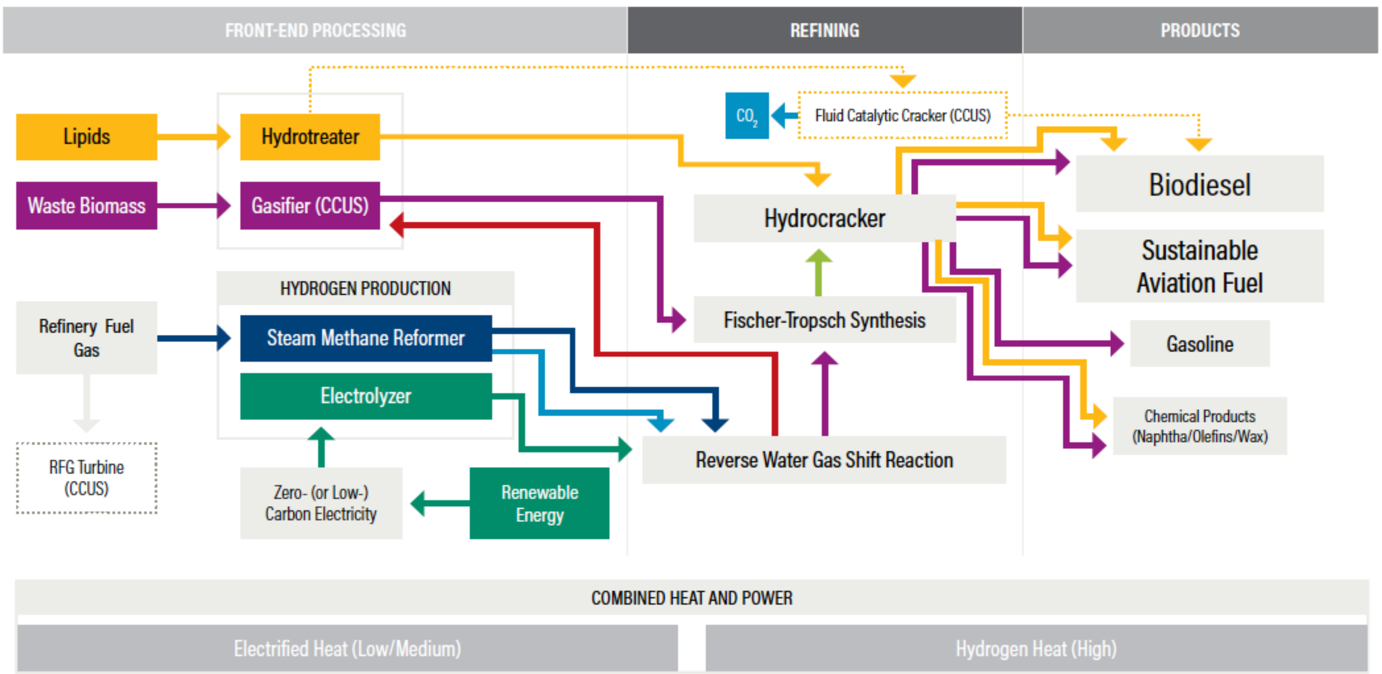
Source: Concawe

Conceptual sustainable refinery as an energy hub within an industrial cluster



Source: Concawe

Conceptual semi-circular refinery



Note: : RFG = refinery fuel gas; CO_2 = carbon dioxide; CCUS = carbon capture, use, and storage; FT = Fischer-Tropsch.

Source: WRI, 2021

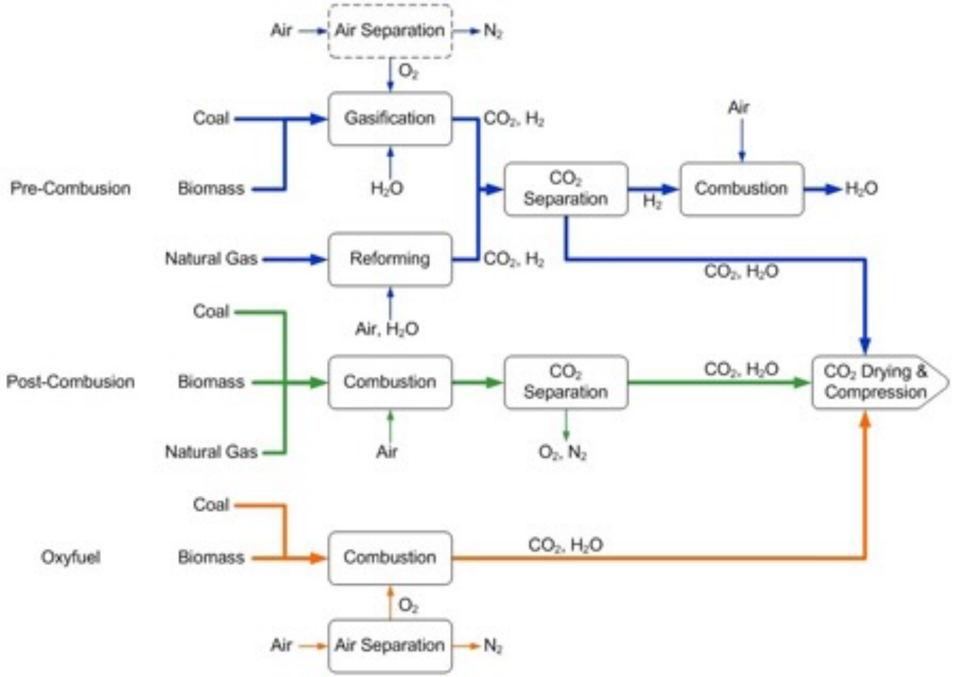
Artistic Impression of the refinery of the future

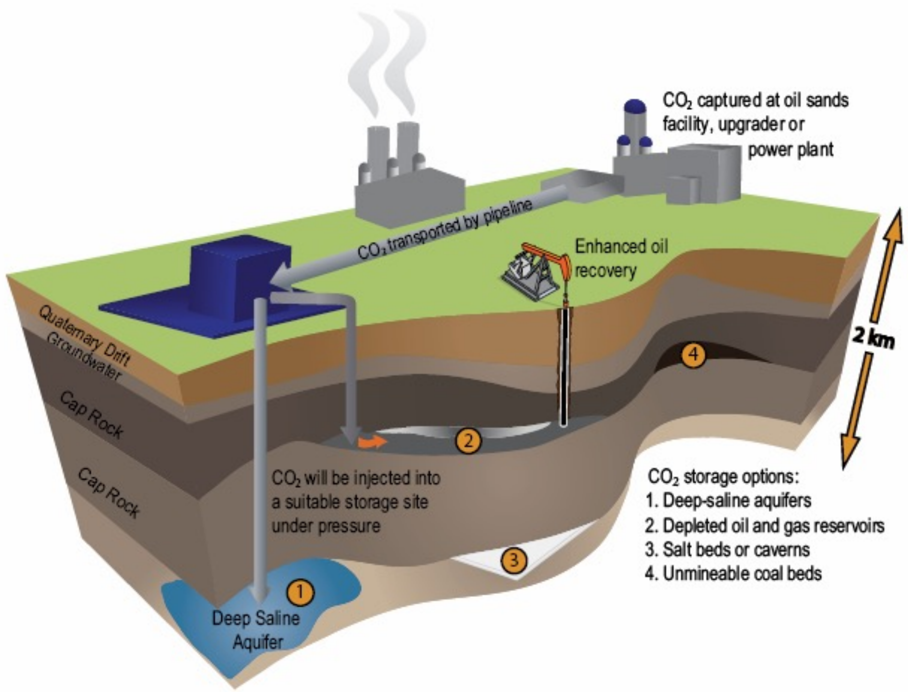
Oil refining (bottom left quadrant) is fully integrated with a petrochemical facility (top left quadrant).

Renewable energy (top right quadrant) integration within the refining process results in nearly a CO2-neutral operation.

Source: Alabdullah et al, 2020

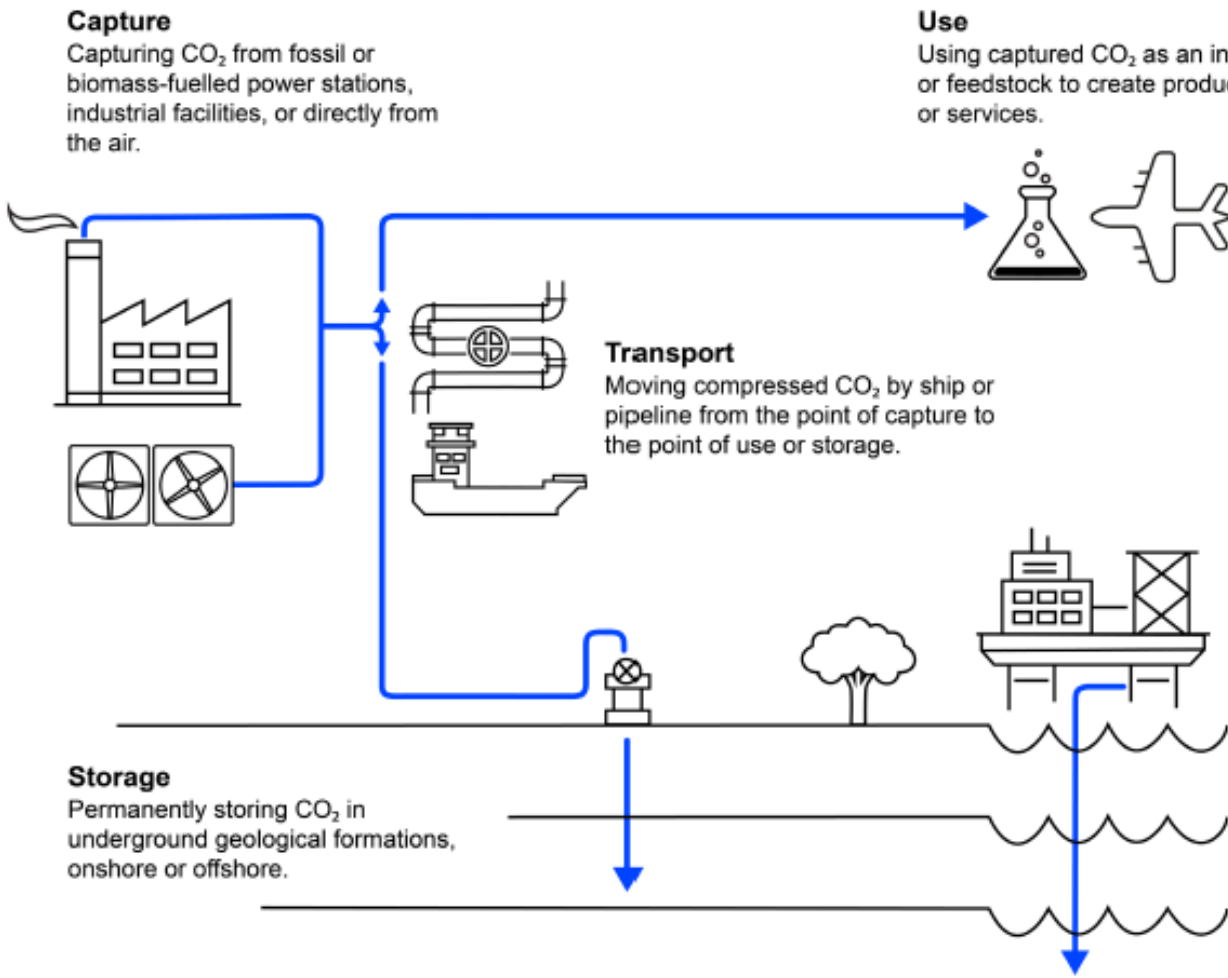
What is CCUS?





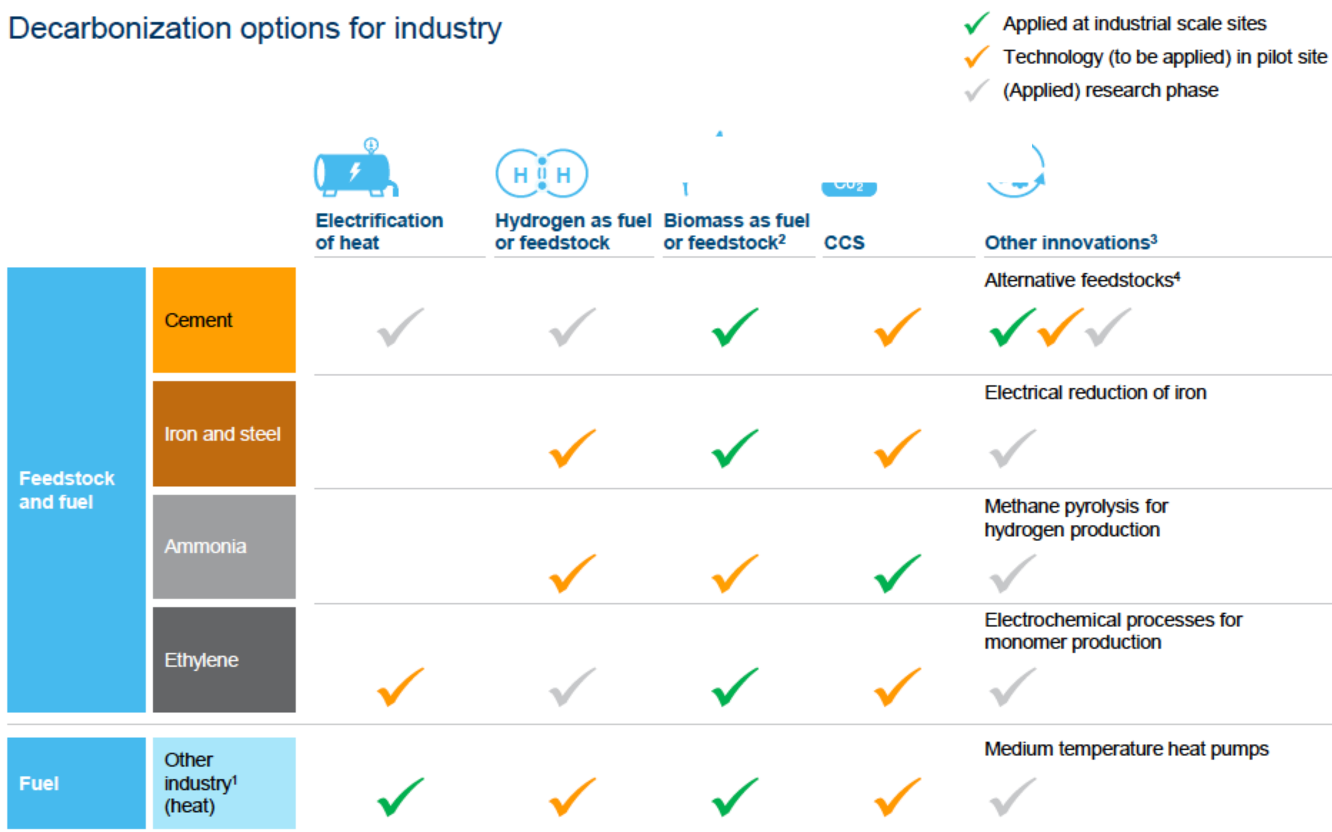
Source: CO2 solution

Schematic of CCUS



Opportunities for Demand Sectors

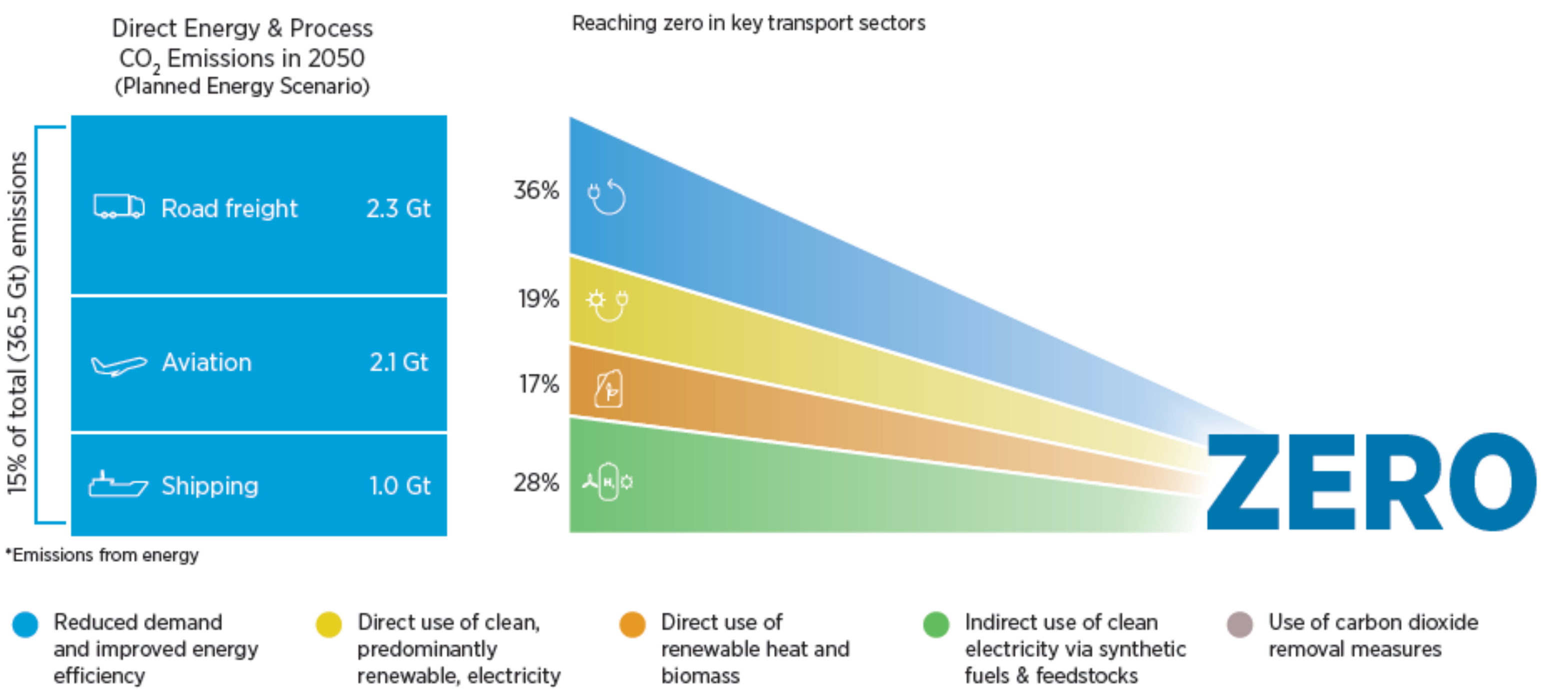
Four decarbonization pathways for Industry



1 Includes heat demand in other sectors, such as manufacturing, construction, food and tobacco, etc.
2 Type of biomass depends on the sector and process: Cement (mostly solid or gaseous biomass), Iron and steel (charcoal or biogas), ammonia (biogas), ethylene (biodiesel, sugar, bioethanol)
3 Not exhaustive
4 Technological maturity depends on the type of alternative feedstock

Source: McKinsey, 2018

Options for reducing emissions from transport sectors

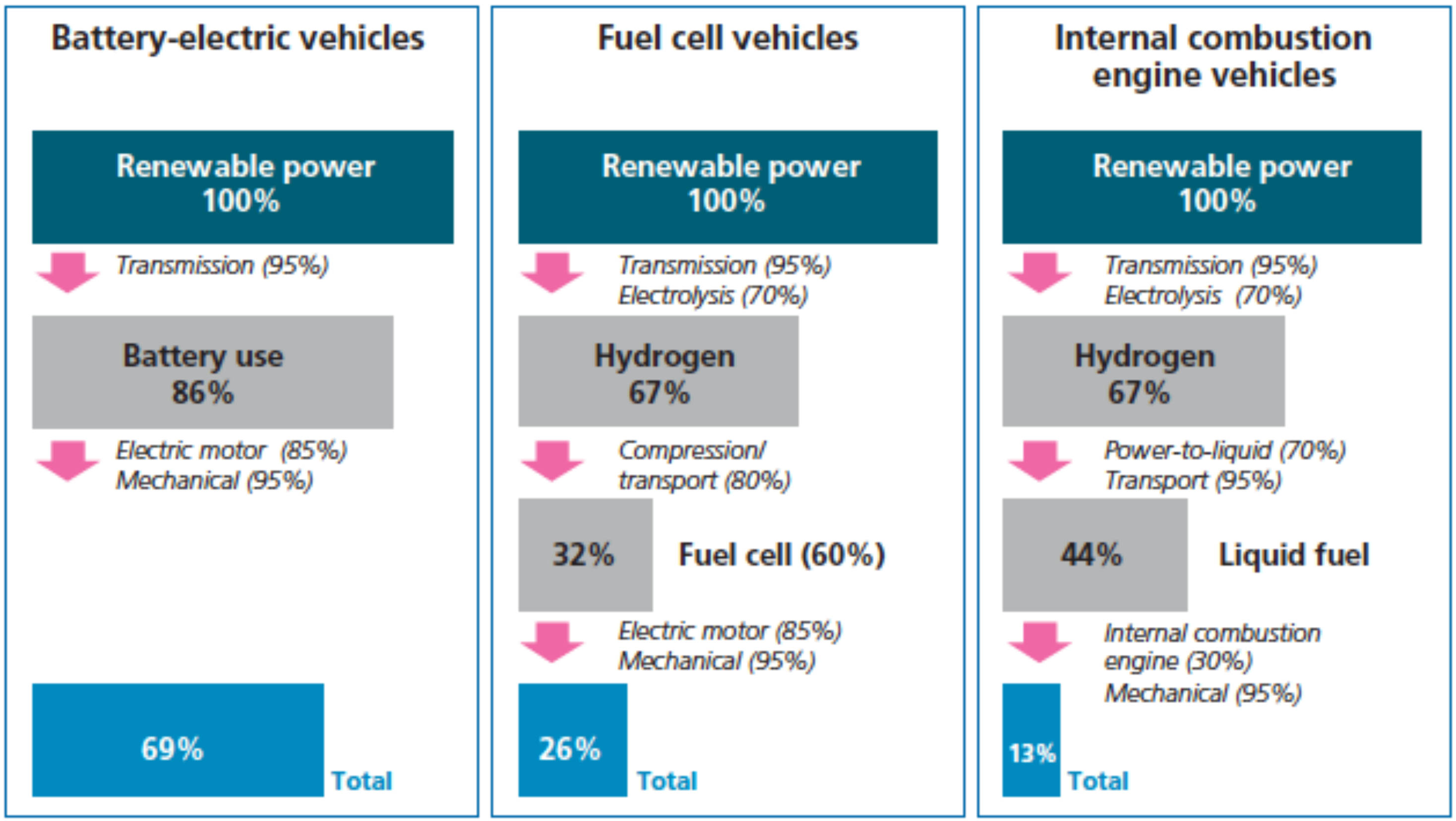


Automakers leaving IC engine market

	2020	2025	2030	2035	2040	2045
SALES BAN	Telsa	BAIC Jaguar	Changan Volvo Ford Fiat Mercedes BMW	General Motor PSA	Honda Subaru Toyota Hyundai	
50 PERCENT TARGET	Nissan					
STOP ON DEVELOPMENT	VW PSA					

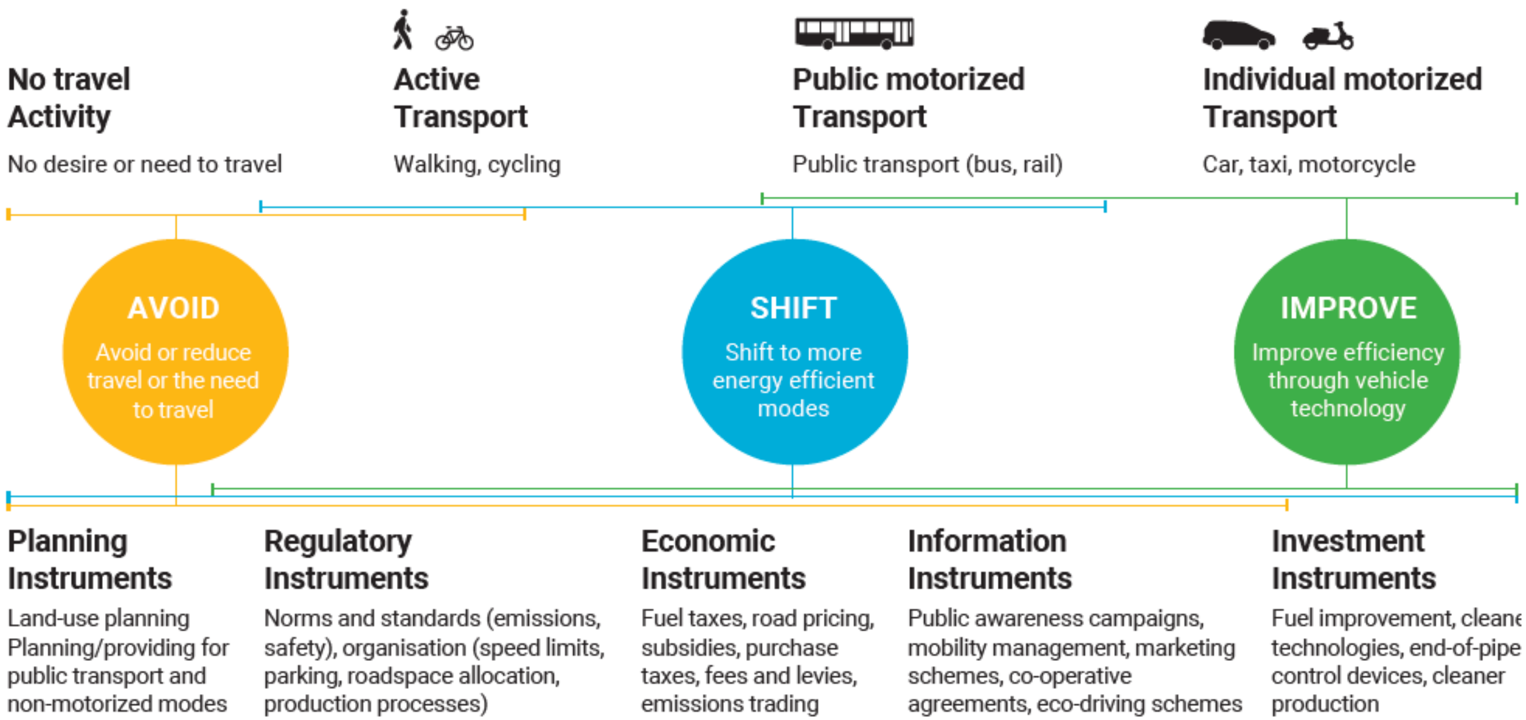
Source: Transformative Urban Mobility Initiative (TUMI).

Conversion efficiency comparison for electricity used in BEVs, FCEVs and synthetic fuel ICEs



Source: EASAC

The avoid-shift-improve approach



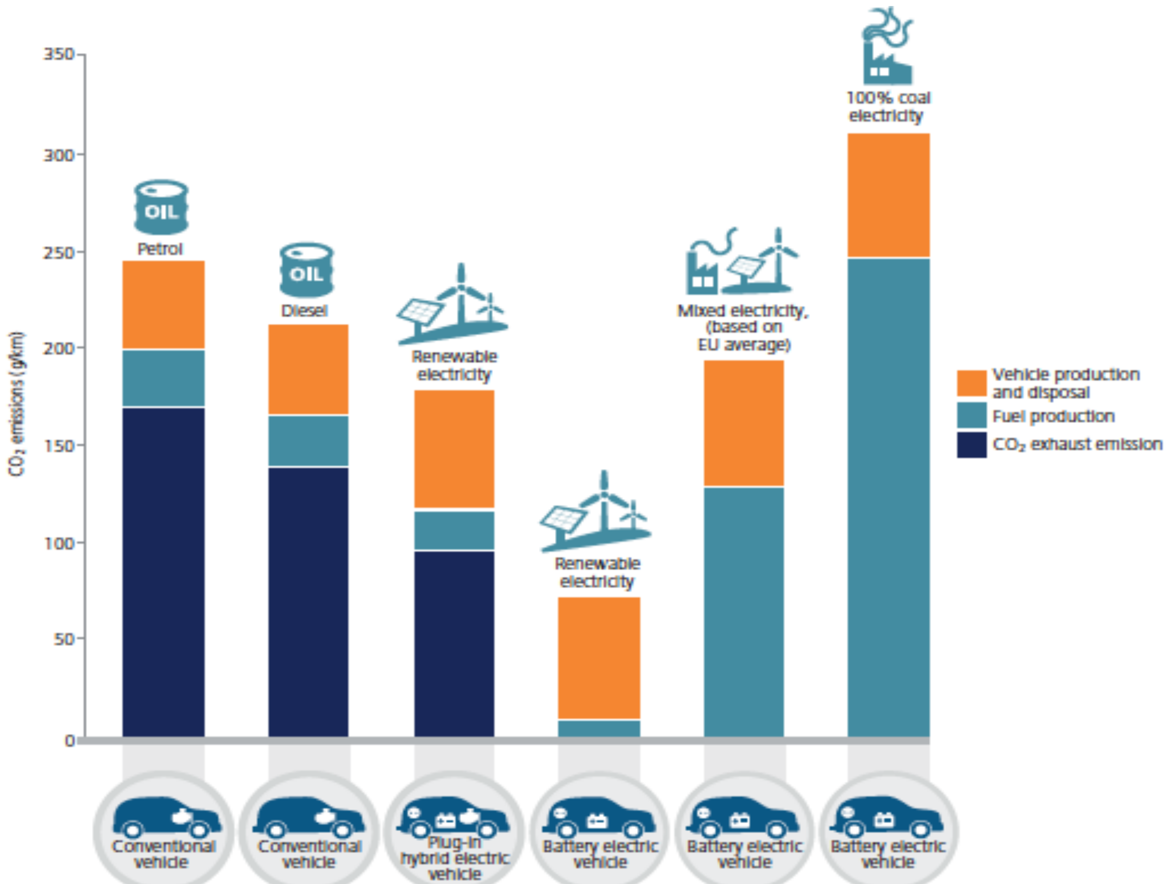
Source: TUMI

Options for short and long-haul transport

	MOST PROBABLE OPTION FOR SHORT HAUL	MOST PROBABLE OPTION FOR LONG HAUL
HEAVY-ROAD TRANSPORT	Battery electric vehicles	Battery electric vehicles (with or without catenary wiring) or Fuel-cell electric vehicles
SHIPPING	Battery electric vehicles or Fuel-cell electric vehicles	Ammonia or Hydrogen (primarily) Biofuels or Synfuels
AVIATION	Battery electric vehicles or Fuel-cell electric vehicles	Biofuels or Synfuels

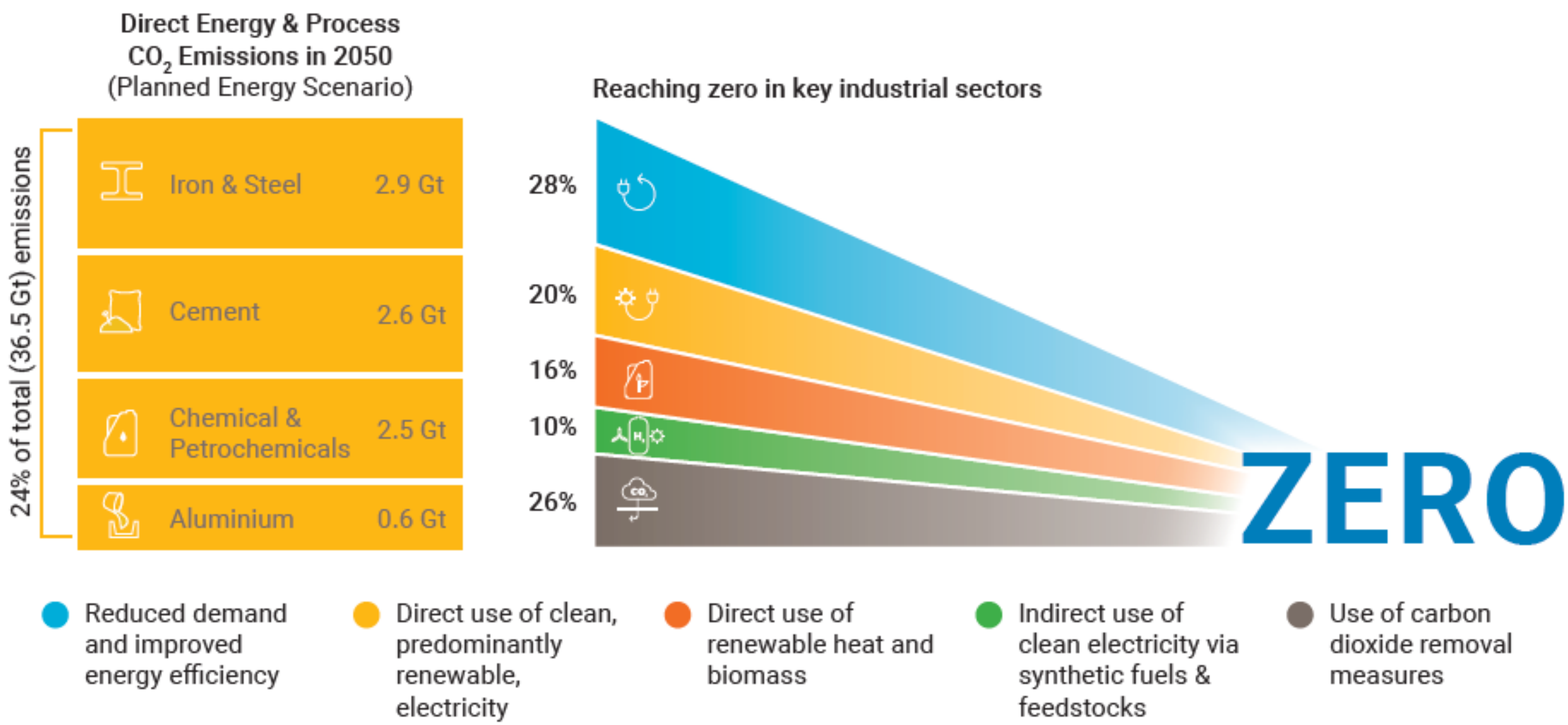
Source: ETC

The range of life cycle CO_2 emissions for different vehicle and fuel types



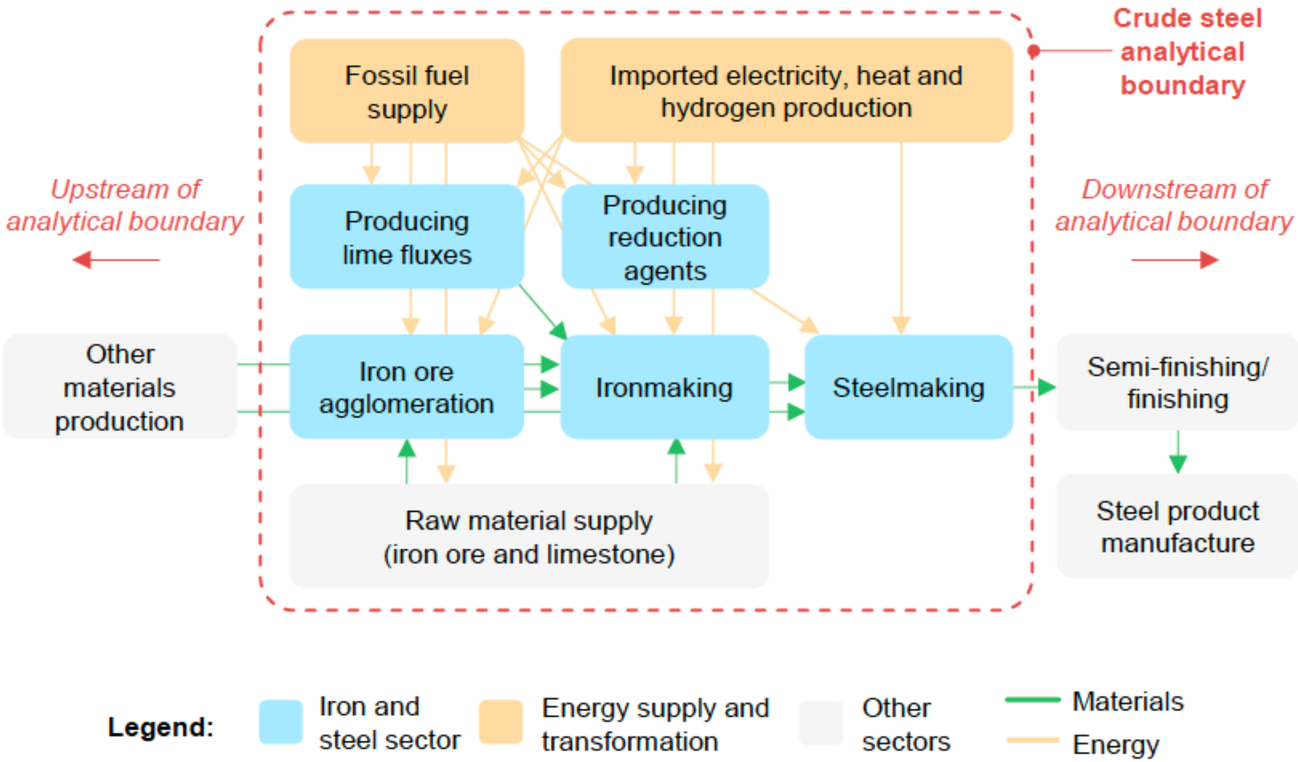
Source: EASAC

Options for reducing emissions from heavy industry



Source: IRENA

Analytical boundary for defining near zero emission steel production



Notes: "Other materials production" refers to the production of material inputs to the iron and steel sector besides iron ore and limestone, including electrodes, alloying elements and refractory linings.

Source: IEA, 2022

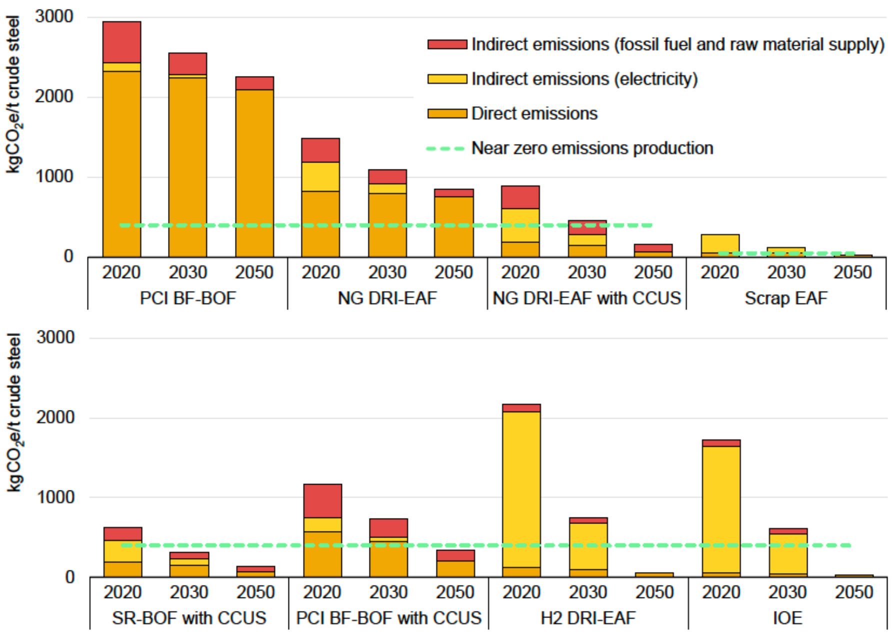
Table 3.1 Thresholds for near zero emission crude steel production with zero scrap use, relative to conventional process technology

<table>
<tr><th rowspan="2">Emissions source</th><th colspan="2">IEA reference values ($kgCO_2e/t$ crude steel)</th><th colspan="2">Near zero emission production thresholds ($kgCO_2e/t$ crude steel)</th></tr>
<tr><th>PCI BF-BOF</th><th>NG DRI-EAF</th><th>Direct</th><th>Direct + indirect</th></tr>
<tr><td>Fossil fuel use in iron ore agglomeration</td><td>235</td><td>40</td><td rowspan="6">400</td><td rowspan="9">400</td></tr>
<tr><td>Producing reduction agents</td><td>110</td><td rowspan="2">700</td></tr>
<tr><td>Fossil fuel use in ironmaking</td><td>590</td></tr>
<tr><td>Fossil fuel use in steelmaking</td><td>0</td><td>25</td></tr>
<tr><td>Lime fluxes and electrodes</td><td>70</td><td>50</td></tr>
<tr><td>Off-gases</td><td>1 320</td><td>0</td></tr>
<tr><td>Imported electricity, heat and hydrogen</td><td>105</td><td>375</td><td>N/A</td></tr>
<tr><td>Fossil fuel supply</td><td>435</td><td>210</td><td>N/A</td></tr>
<tr><td>Raw material supply</td><td>80</td><td>80</td><td>N/A</td></tr>
<tr><td>Total</td><td>2 945</td><td>1 485</td><td>400</td><td>400</td></tr>
</table>

Notes: PCI BF-BOF = blast furnace-basic oxygen furnace with pulverised coal injection; NG DRI-EAF = natural gas-based direct reduced iron-electric arc furnace. All values rounded to the nearest 5 $kgCO_2e/t$. See Box 3.3 for a description of the IEA reference values used in this document.

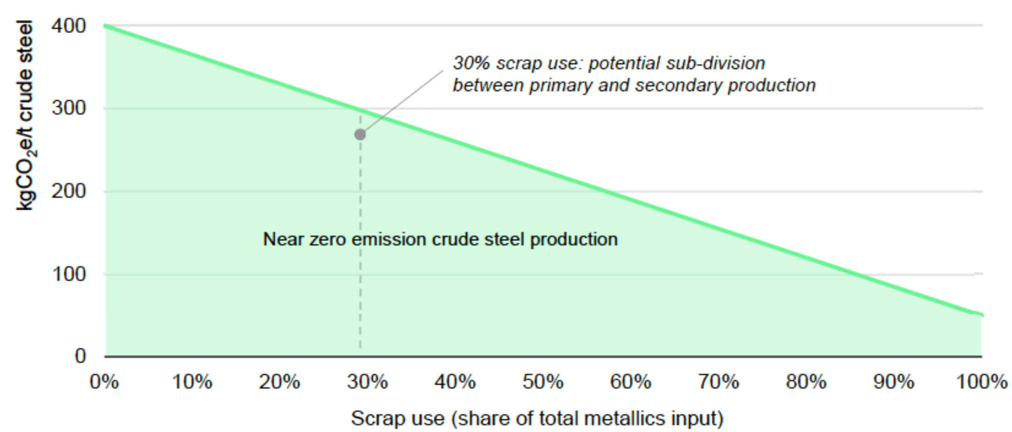
Source: IEA, 2022

Figure 3.3 Global average direct and indirect emissions intensities of crude steel production via key pathways in the Net Zero Emissions by 2050 Scenario



Notes: PCI BF-BOF = blast furnace-basic oxygen furnace with pulverised coal injection; DRI-EAF = natural gas-based direct reduced iron-electric arc furnace; Scrap EAF = scrap-based electric arc furnace; SR-BOF = innovative smelting reduction-basic oxygen furnace; CCUS = carbon capture utilisation and storage; H2 = hydrogen-based; NG = natural gas-based; IOE = iron ore electrolysis. BAT energy intensities used for all process units. All process routes use zero scrap, apart from the Scrap EAF route, which uses 100% scrap. The near zero emission production thresholds are imposed on a direct + indirect emissions basis. See Box 3.3 for a description of the IEA reference values used in this document.

Figure 3.2 Near zero emission crude production threshold as a function of scrap use



Analytical boundary for defining near zero emission cement production

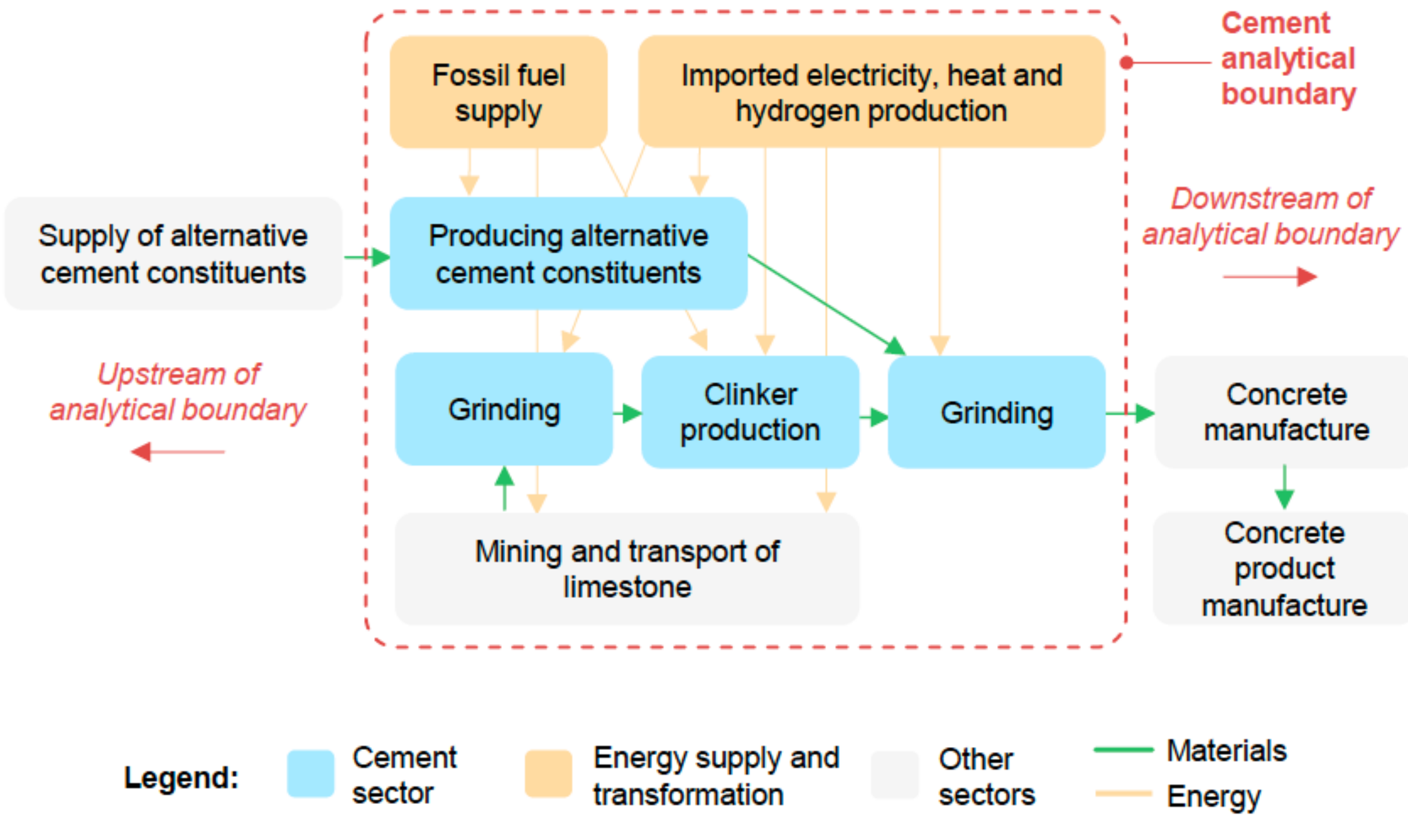
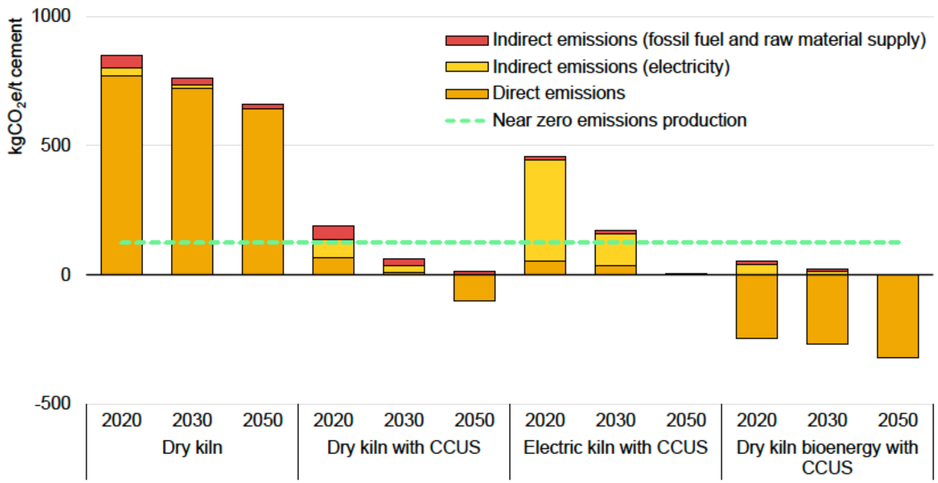
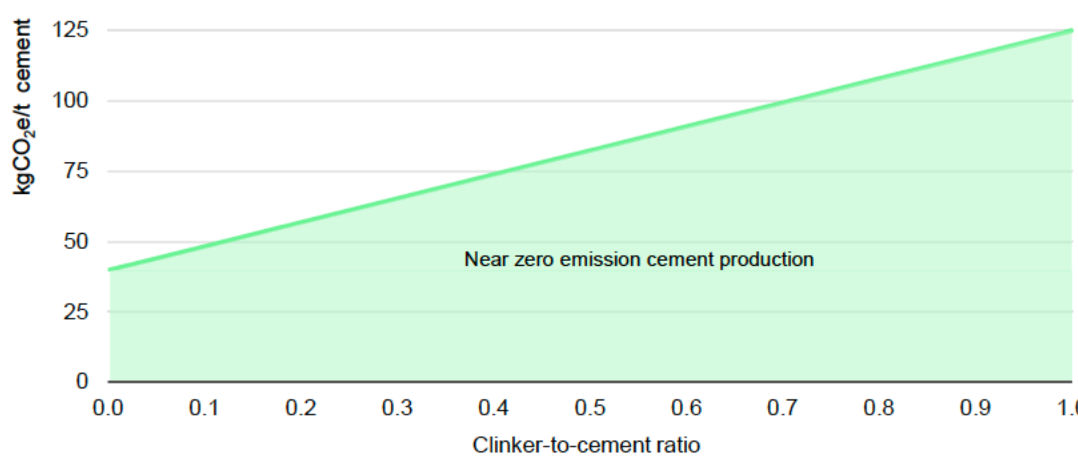


Figure 3.6 Global average direct and indirect emissions intensities of cement production via key pathways in the Net Zero Emissions by 2050 Scenario



Notes: CCUS = carbon capture utilisation and storage; Electric kiln = innovative kiln with electricity providing 100% of the thermal energy inputs; Dry kiln bioenergy = conventional dry kiln fuelled with bioenergy and renewable waste providing 100% of the thermal energy inputs. A clinker-to-cement ratio of 1.0 is used for illustrative purposes for all production pathways, with the near zero emission production threshold imposed on a direct + indirect emissions basis. See Box 3.3 for a description of the IEA reference values used in this document.

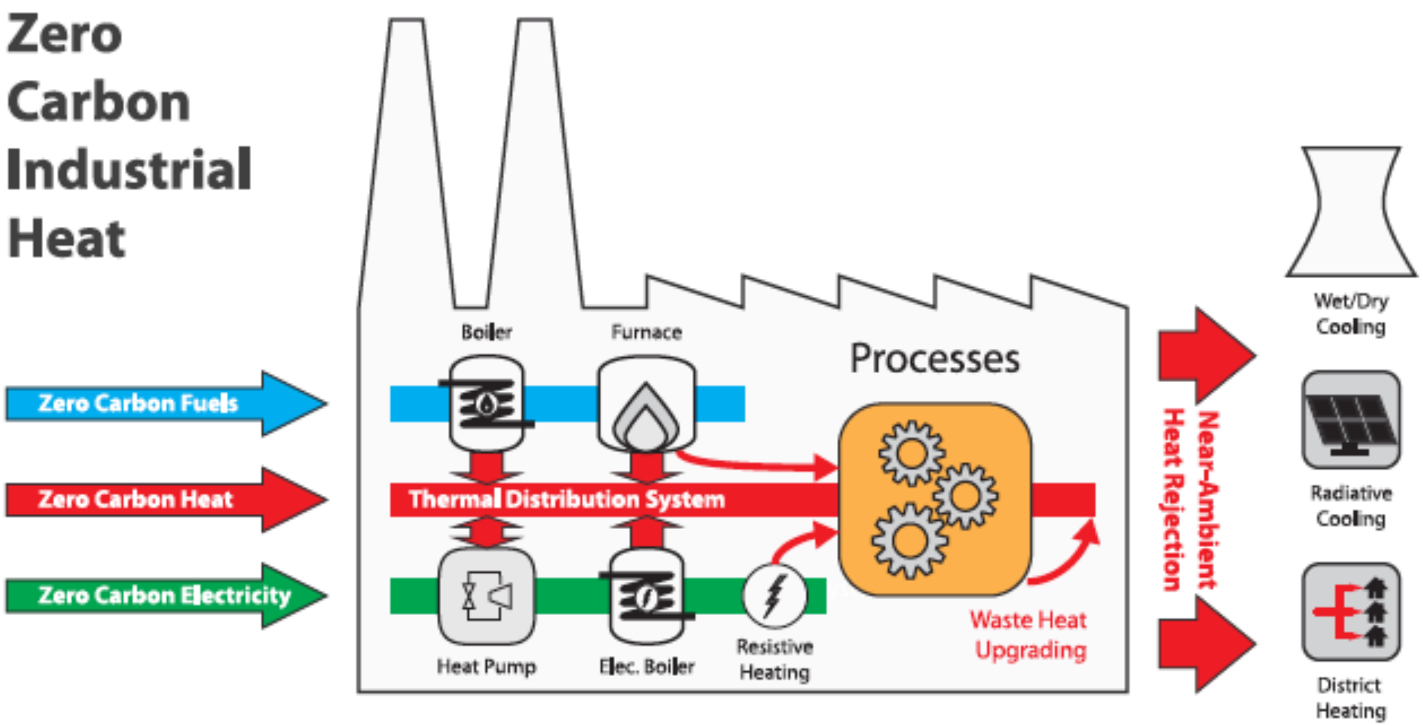
Figure 3.5 Near zero emission cement production threshold as a function of the clinker-to-cement ratio



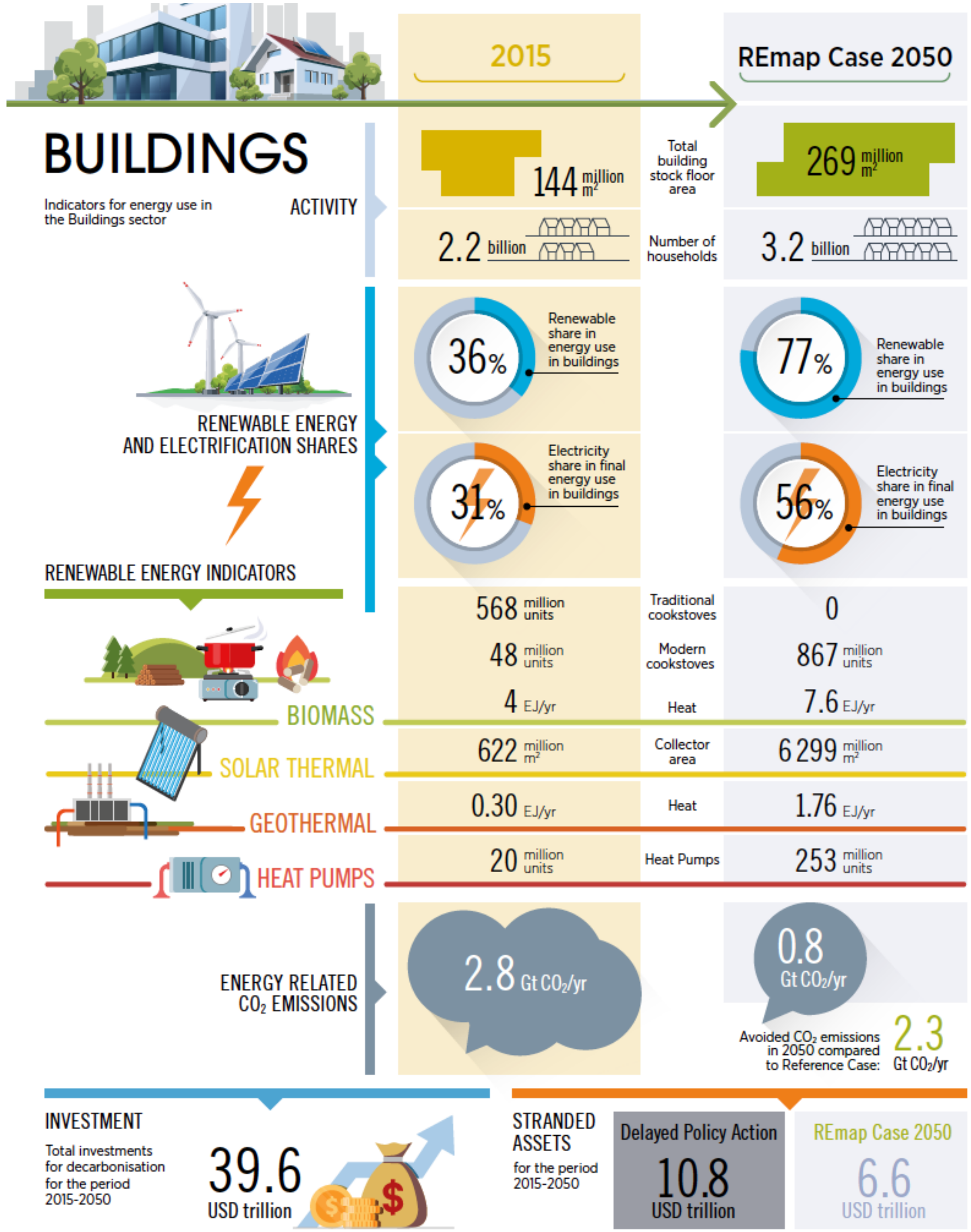
Notes: See the Technical Annex for the formulation of the near zero emission cement production threshold.

Source: IEA, 2022

A schematic of technologies to enable zero-carbon industrial heat

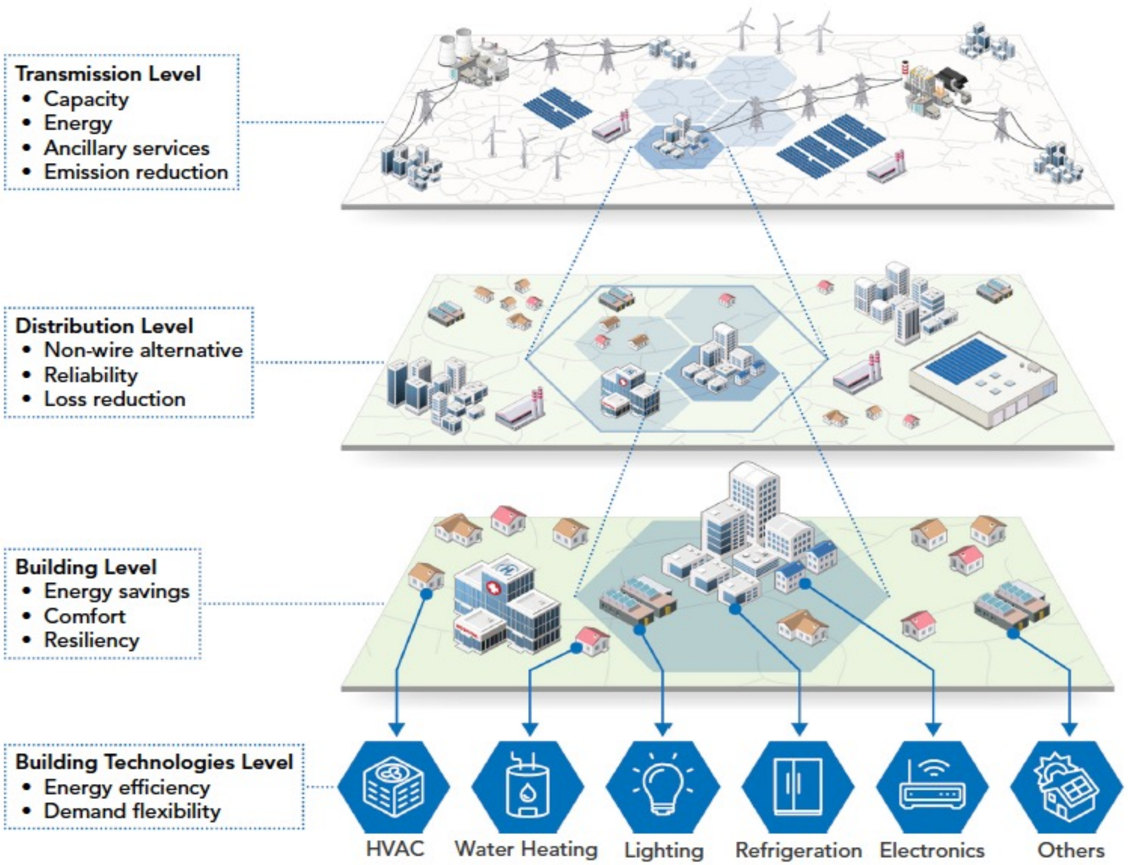


Source: Thiel and Stark, 2021



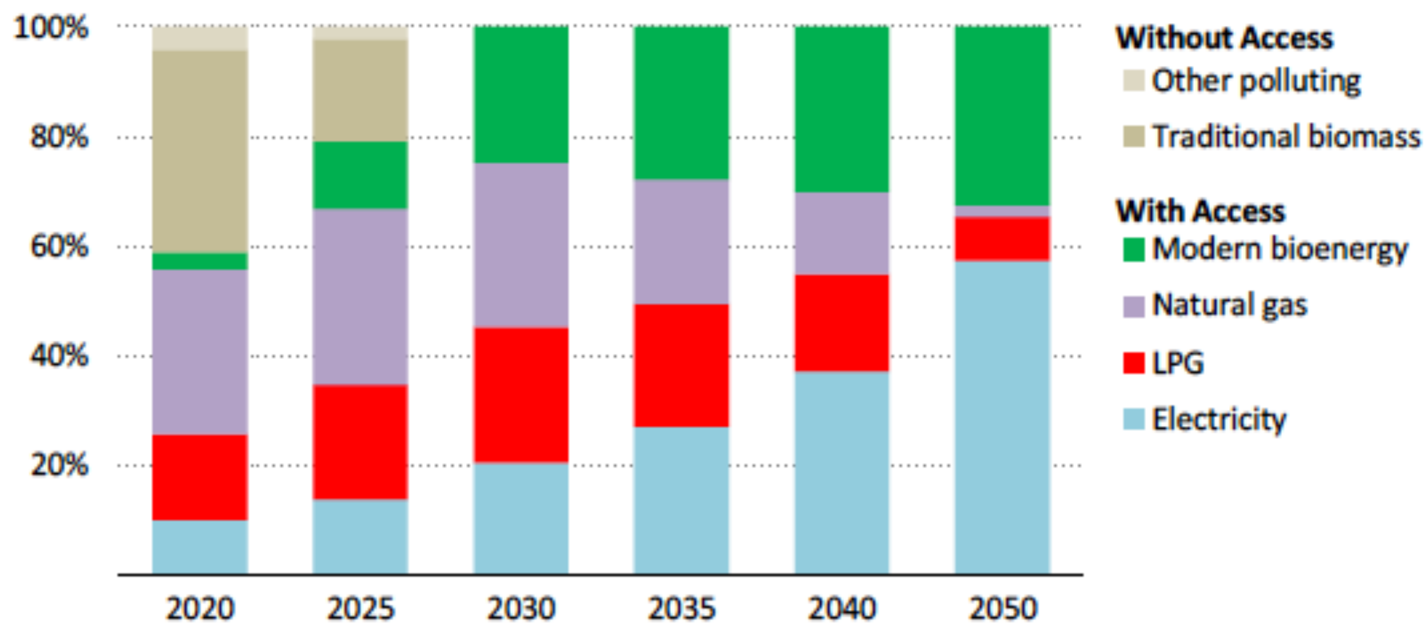
Source: IRENA

Options for building energy efficiency and demand flexibility



Source: Jackson et al, 2021

Primary cooking fuel by share of population in emerging market and developing economies in the NZE



Traditional biomass is entirely replaced with modern energy by 2030, mainly in the form of bioenergy and LPG; by 2050, electricity, bioenergy and bioLPG meet most cooking needs

Source: IEA, 2021

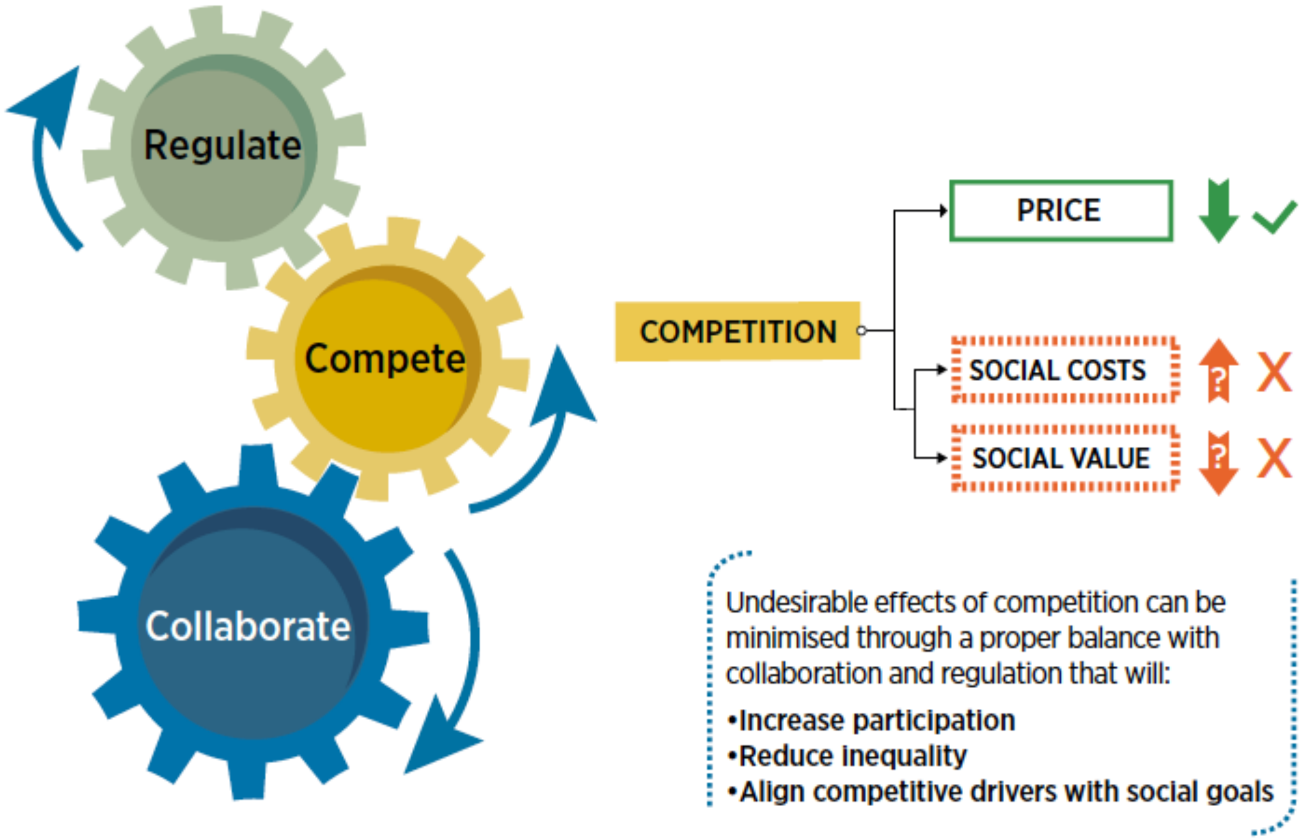
Enabling Just Energy Transition

Just energy transition vision

- Clearly articulate the **Just Transition Vision** – not just in terms of coal exit and use of renewables, but also how job losses will be mitigated.
- Decide which **entity** that will take accountability for the planning and implementation of the Just Transition, working with the various identified stakeholders.
- Ensure **capacity** exists to manage the coal mine and power plant closures and consider a closure agency.
- Determine **funding** needs of the Just Transition and design innovative funding mechanisms to support it.
- Consider **reskilling hubs** to take advantage of the opportunities renewables offer across the energy value chain to mitigate job losses.

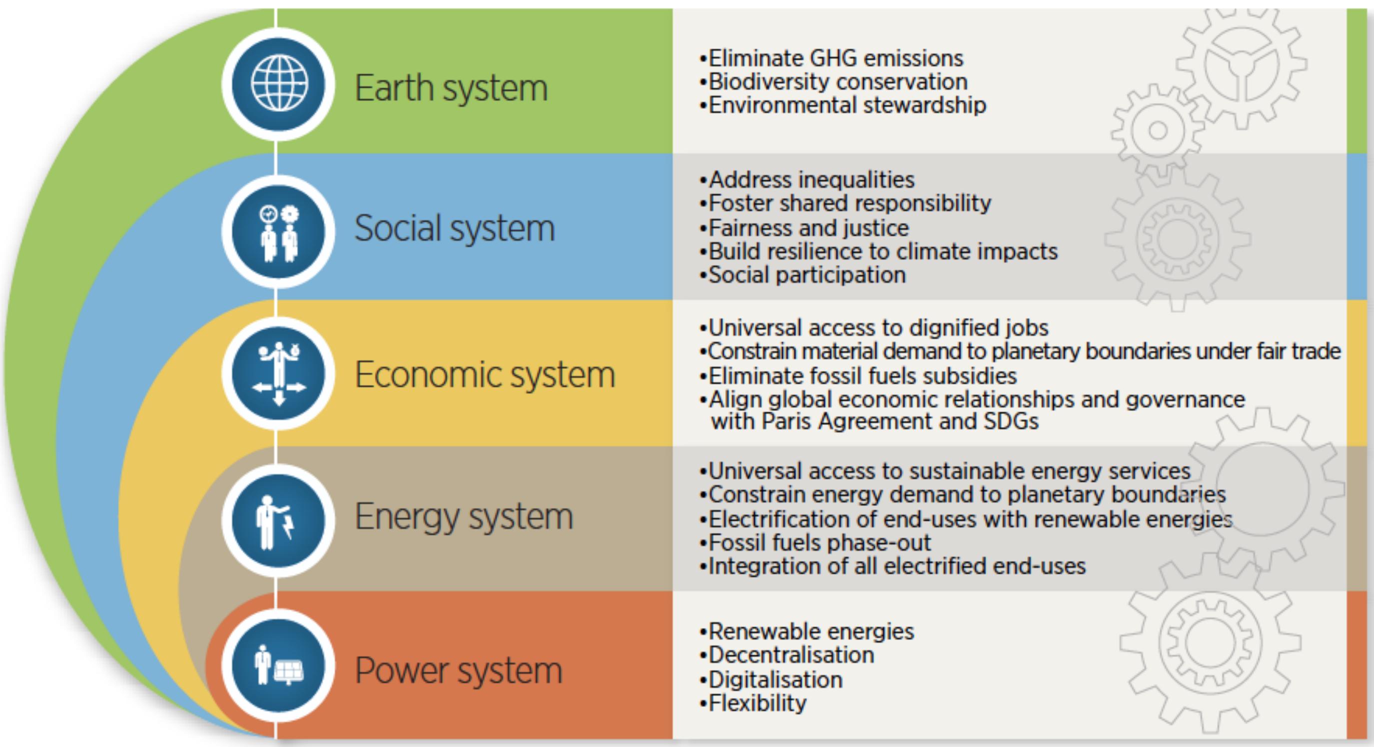
Source: RES4Africa Foundation, A Just Energy Transition in South Africa

The right balance between competition, regulation and collaboration is key for a successful energy transition



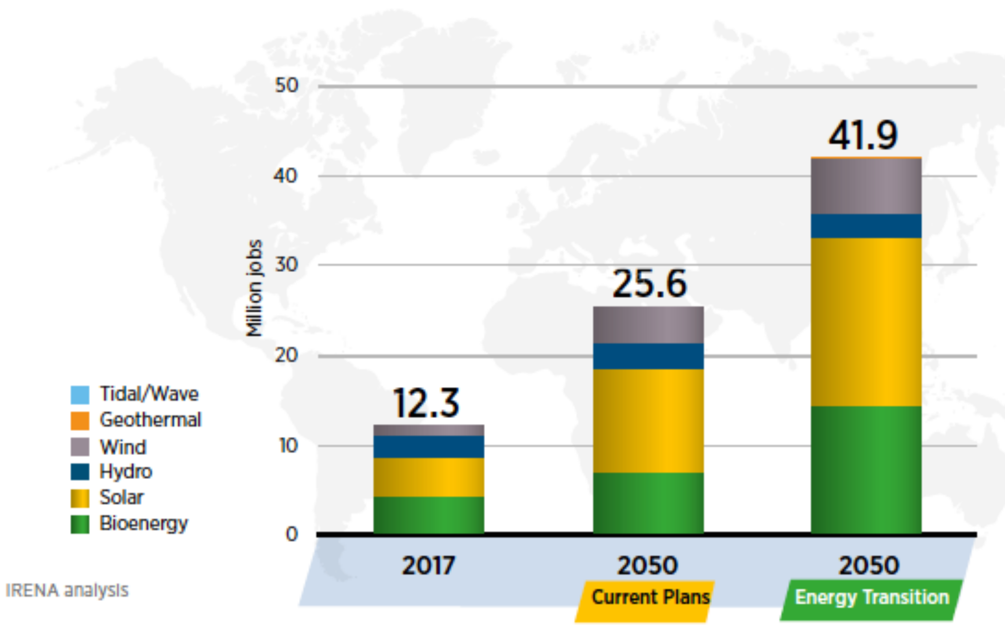
Source: IRENA, 2020

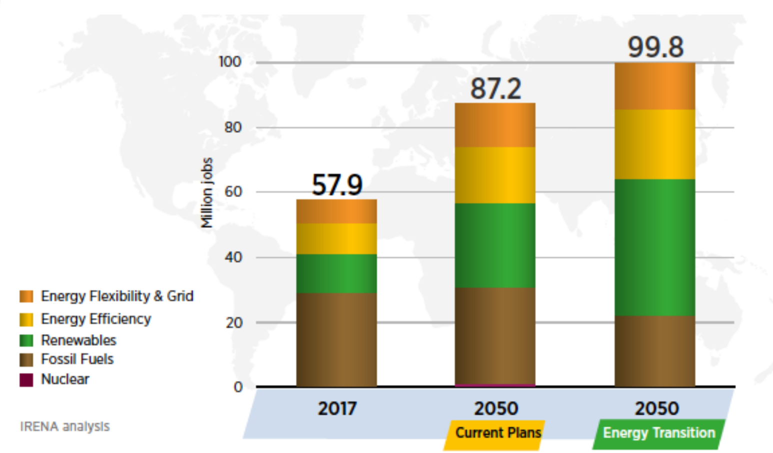
Cross-cutting transformations for a fair and just energy transition



Note: GHG = greenhouse gas; SDGs = Sustainable Development Goals.

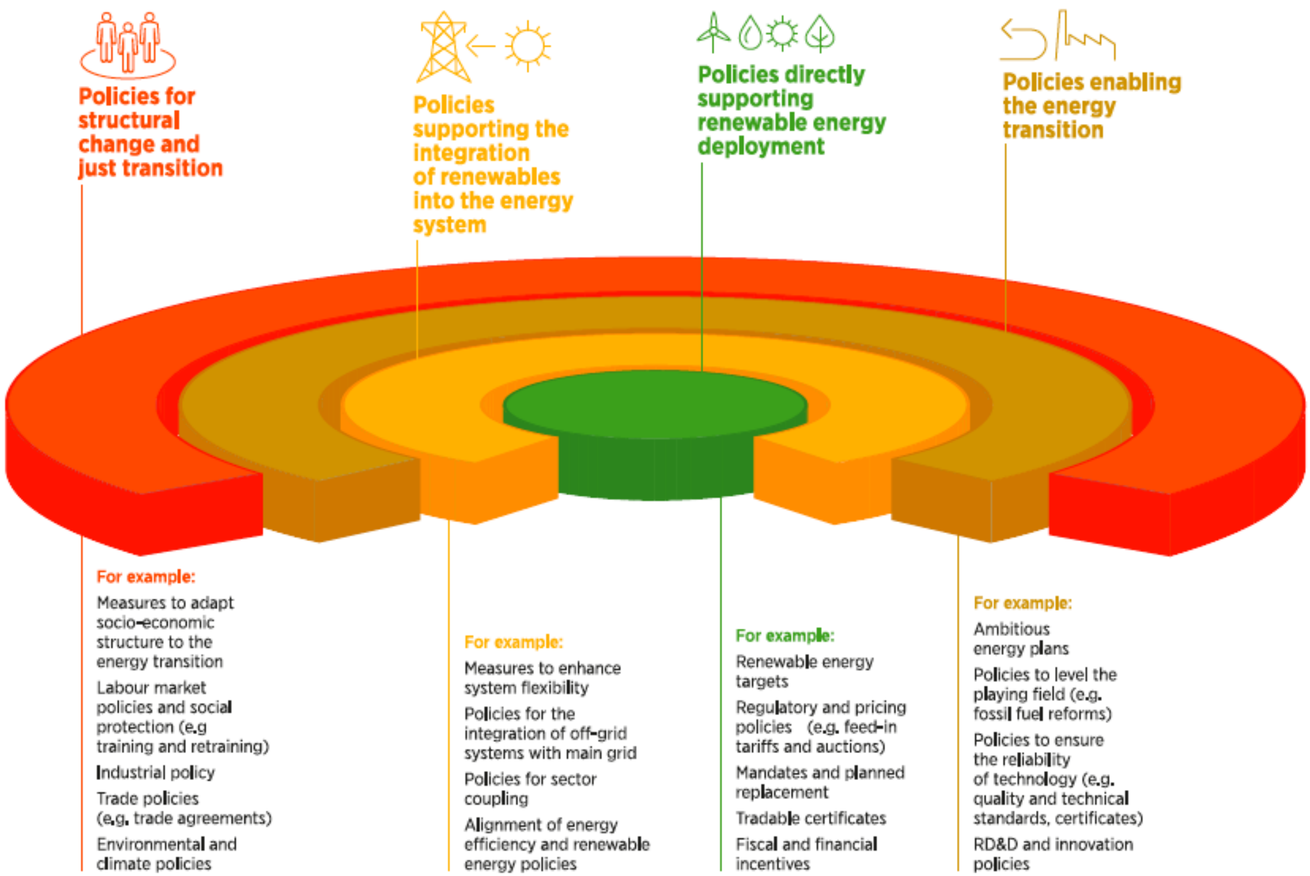
Global jobs in the energy sector (2017 and 2050)





Source: IRENA, 2020

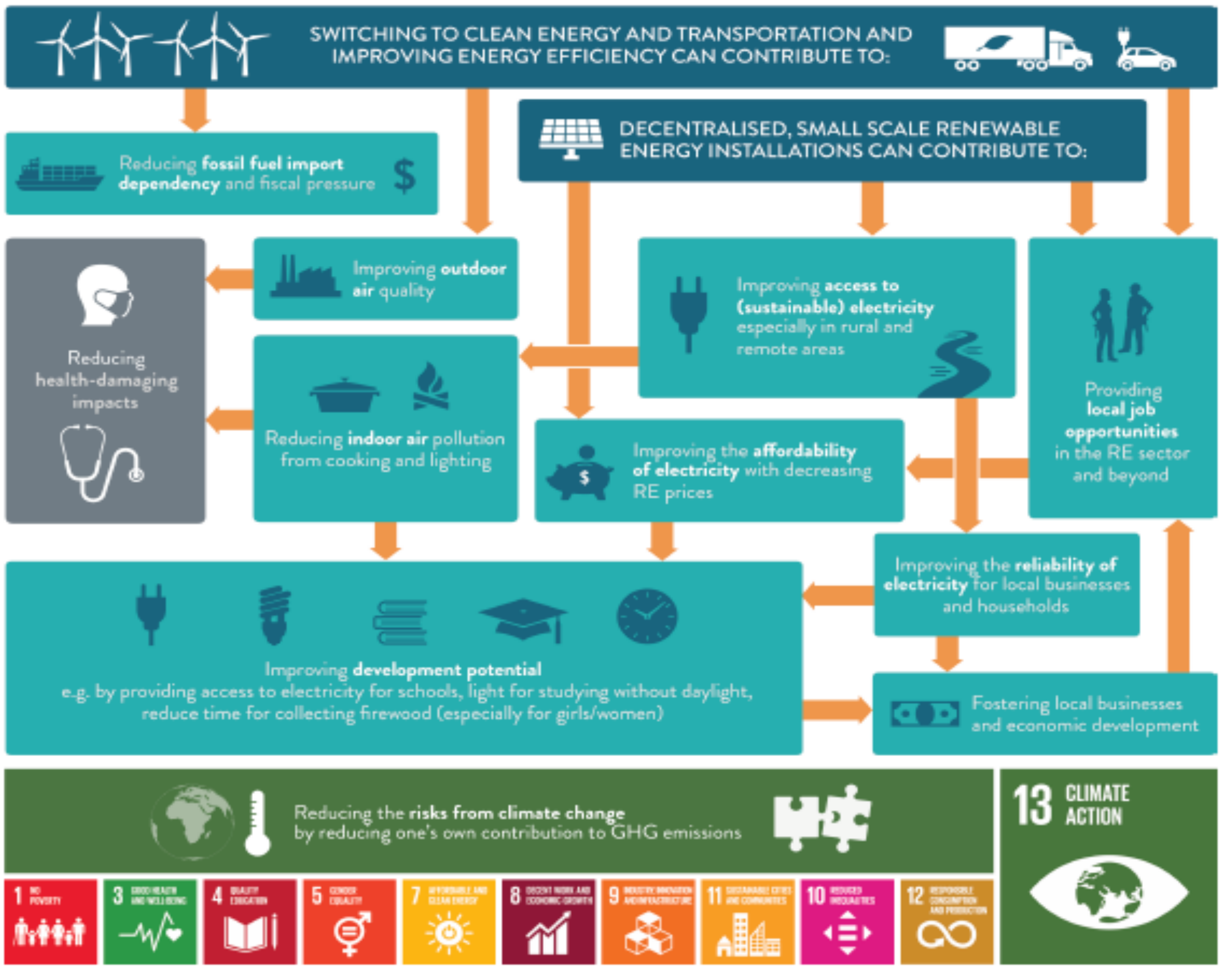
Policy framework for just energy transition



Source: IRENA

Skills for Energy Transition

Co-benefits of energy system transition for sustainable development



Source: Climate analytics

The landscape of innovations for the power-sector transformation

ENABLING TECHNOLOGIES

1 Utility-scale batteries
2 Behind-the-meter batteries

3 Electric-vehicle smart charging
4 Renewable power-to-heat
5 Renewable power-to-hydrogen

6 Internet of things
7 Artificial intelligence and big data
8 Blockchain

9 Renewable mini-grids
10 Supergrids

11 Flexibility in conventional power plants

BUSINESS MODELS

12 Aggregators
13 Peer-to-peer electricity trading
14 Energy-as-a-service

15 Community-ownership models
16 Pay-as-you-go models

MARKET DESIGN

17 Increasing time granularity in electricity markets
18 Increasing space granularity in electricity markets
19 Innovative ancillary services
20 Re-designing capacity markets
21 Regional markets

22 Time-of-use tariffs
23 Market integration of distributed energy resources
24 Net billing schemes

SYSTEM OPERATION

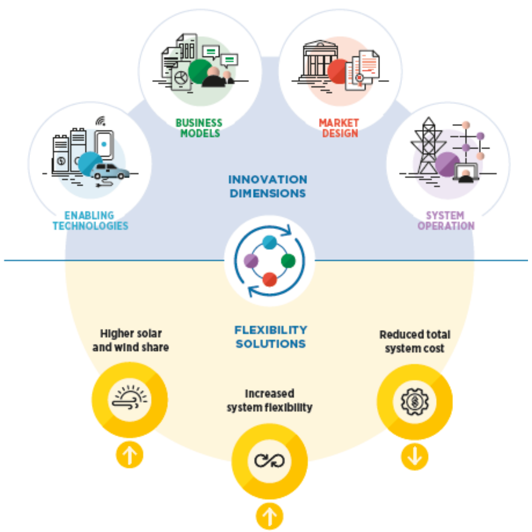
25 Future role of distribution system operators
26 Co-operation between transmission and distribution system operators

27 Advanced forecasting of variable renewable power generation
28 Innovative operation of pumped hydropower storage

29 Virtual power lines
30 Dynamic line rating

Source: IRENA (2019b)

The RE innovation briefs



	OVERVIEW	INNOVATION BRIEFS
Enabling technologies	• Battery storage technologies, able to back up the variability of renewables and provide various services to the grid.	1. Utility-scale batteries 2. Behind-the-meter batteries
	• Technologies that enable electrification of other sectors, opening doors to new markets for renewable generation as well as new ways to store the generation surplus.	3. Electric-vehicle smart charging 4. Renewable power-to-heat 5. Renewable power-to-hydrogen
	• Digital technologies that are introducing new applications in the power sector, changing the boundaries and dynamics of the industry and helping to optimise renewables assets.	6. Internet of things 7. Artificial intelligence and big data 8. Blockchain
	• New and smart grids, both large and small scale, that complement each other and enable new ways to manage VRE generation.	9. Renewable mini-grids 10. Supergrids
	• Refurbishment of existing assets, to adapt to the new conditions and to the needs of the system.	11. Flexibility in conventional power plants
Business models	• Business models that empower consumers, turning them into active participants.	12. Aggregators 13. Peer-to-peer electricity trading 14. Energy-as-a-service
	• Innovative schemes that enable renewable energy supply, in both off-grid and connected areas.	15. Community-ownership models 16. Pay-as-you-go models
Market design	• New regulations in the wholesale markets that encourage flexibility from market participants, better signal firming power supply's value, and properly remunerate their grid support services.	17. Increasing time granularity in electricity markets 18. Increasing space granularity in electricity markets 19. Innovative ancillary services 20. Re-designing capacity markets 21. Regional markets
	• Design and regulatory changes in the retail market that stimulate flexibility on the consumer / prosumer side.	22. Time-of-use tariffs 23. Market integration of distributed energy resources 24. Net billing schemes
System operation	• Distributed generation deployment requires new ways of operating the distribution grid and market facilitation for distributed generation.	25. Future role of distribution system operators 26. Co-operation between transmission and distribution system operators
	• New operation procedures that enhance electricity system flexibility.	27. Advanced forecasting of variable renewable power generation 28. Innovative operation of pumped hydropower storage
	• New ways to operate the grid that reduce VRE curtailment due to grid congestion reducing the need to reinforce the grid.	29. Virtual power lines 30. Dynamic line rating

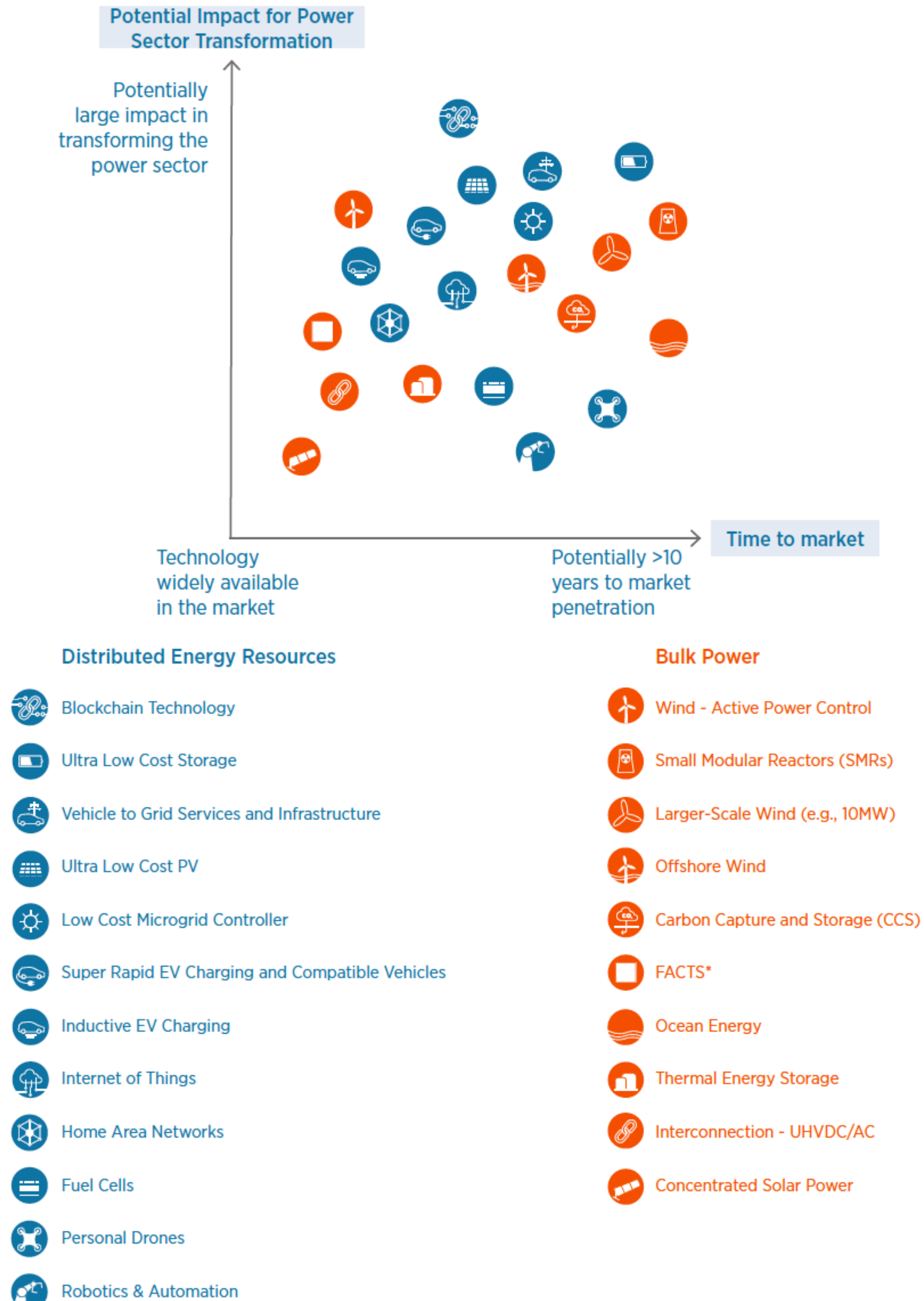
Source: IRENA, 2019

Implications for jobs and employment

A renewable energy future requires different skills than a fossil future:

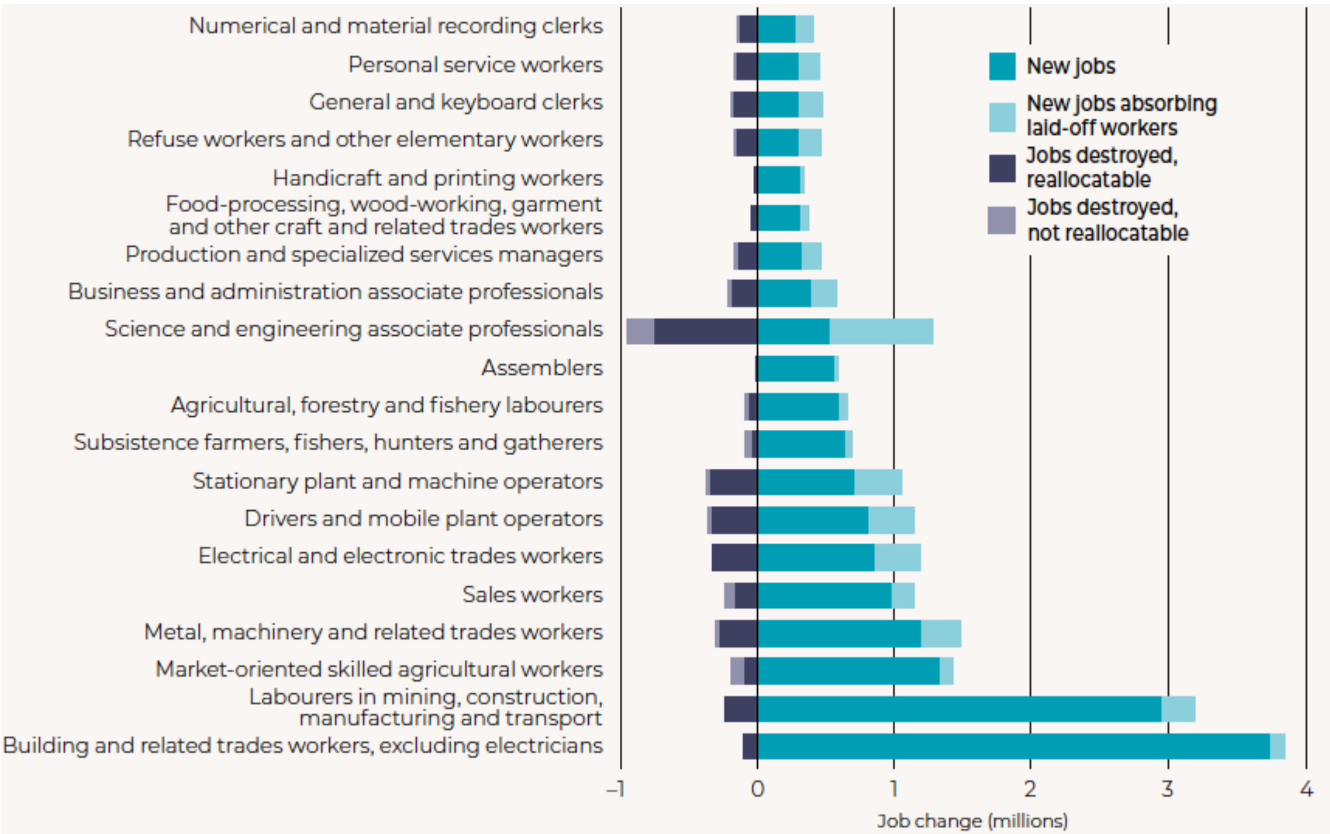
- Less centralized of fossil power than decentralized power
- Production of biofuels and solar panels
- Energy storage
- Installation and maintenance of RE
- ICT skills needed to develop and operate the smart energy and grids
- More interaction with consumers/prosumers

Disruptive technologies for distributed energy resources and bulk power transformation



Source: IRENA, 2020

Occupations most in demand across industries in a global energy sustainability scenario, 2030

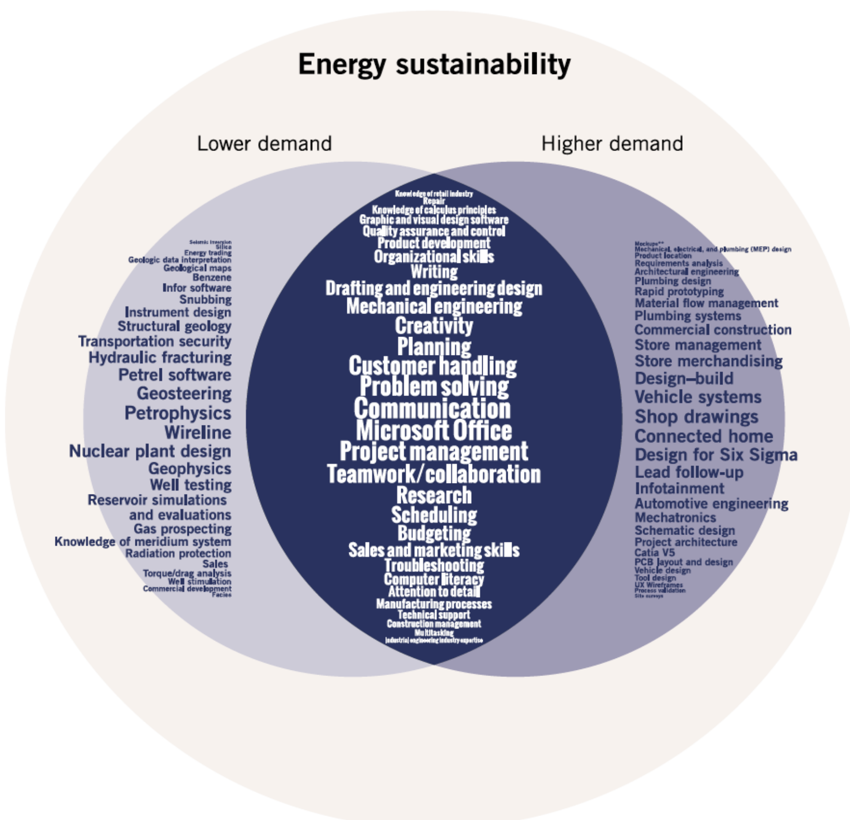


Note: Difference in employment between the sustainable energy scenario (the 2°C scenario) and the business-as-usual scenario (the 6°C scenario) of the International Energy Agency (IEA) by 2030 (ILO, 2018a). Detailed information on the methodology is described in ILO, 2018a, pp. 39, 172–170).

Source: ILO calculations based on EXIOBASE v3 and national labour force surveys.

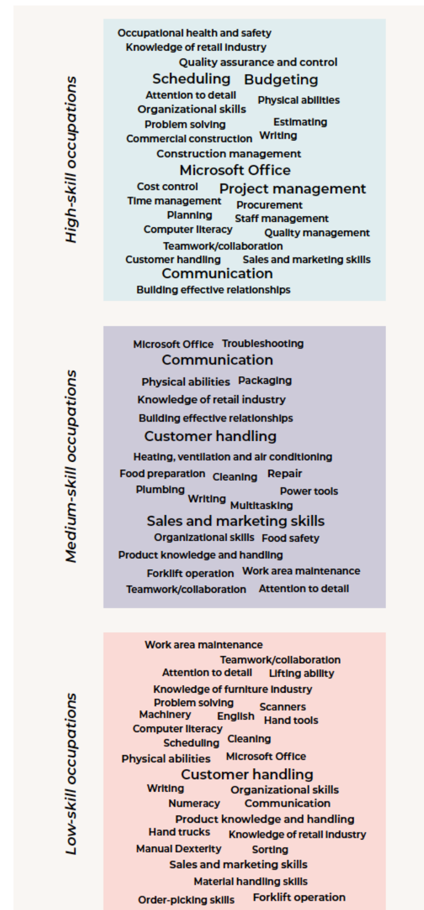
Source: ILO

Overlap of core and technical skills for science and engineering professionals, (energy sustainability scenario)



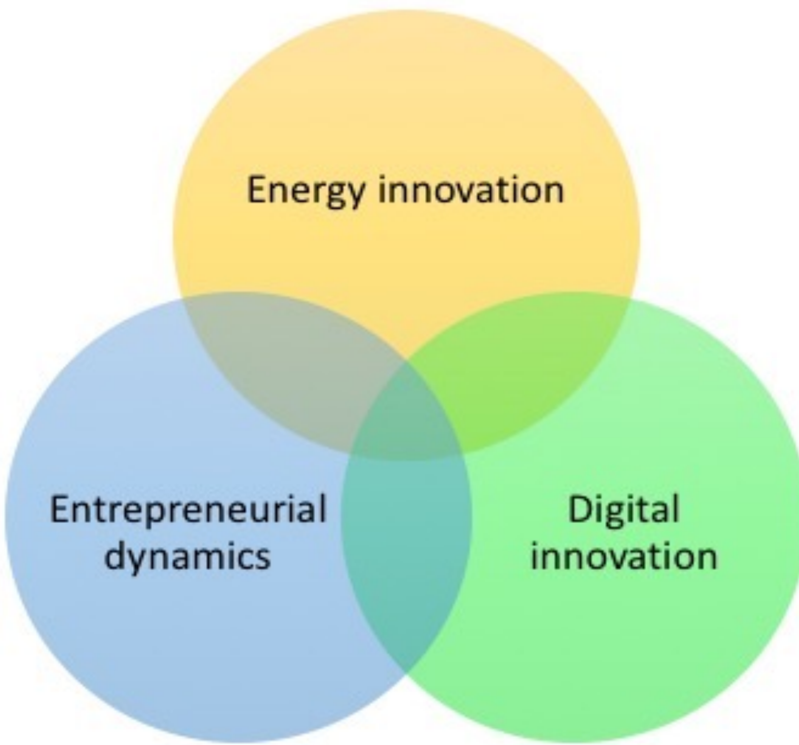
Note: The blue area shows a large overlap of core and technical skills within the same occupation in both declining and growing industries.

Source: Calculations based on real-time data on vacancies, Burning Glass Technologies. US data (2017) are used as a proxy.



Source: ILO

Entrepreneurship, clean energy, and digital innovation confluence



Source: Energy transition hub

Current Actions

JETP, ETM , PERPRES

- The Just Energy Transition Partnership (JETP) dan Energy Transition Mechanism (ETM): US$20 billion (Rp310 triliun) dan US$250–300 million (Rp3,87 triliun).
- Presidential Regulation No. 112 of 2022) - facilitate the deployment of renewable energy sources and localise socioeconomic advantages, the nation has implemented legislative tools in the electrical sector, including feed-in tariffs, auctions, and net metering.

Key Recommendations

- Needs to be better alignment and co-ordination between energy and climate policies, least cost vs least emissions,
- Energy price should reflect not only energy content but energy quality (externalities) and re-direct fossil subsidies to renewable energy,
- Develop more flexible of electricity energy systems and sectoral coupling for increasing RE's role for urban area and low-carbon energy and CCUS
- Capitalize renewable energy supply for small and medium-scale project for increasing modern energy access in remote and rurar area supporting local economy and inclusivity,
- Provide financial support to promote clean energy innovation, entrepreuners/start up/business,
- Create more low carbon/RE jobs and STEM education must prepare.

Thank You

ENERGY TRANSITION