UNECE

ENERGY

Pathways to Sustainable Energy

Phase I – Insights and Recommendations

Phase II - Proposal

Roadmap for the Presentation

ENERGY

1. **Pathways to Sustainable Energy Project Phase I Review**
   - Pathways Project Design and Objectives
   - Key Takeaways
   - Detailed Scenarios and Modelling Results
   - Expert Groups Insights - Role of All Technologies in Attaining Sustainable Energy in the UNECE Region
     - Reducing the Environmental Footprint of the Energy Sector
     - Deep Transformation of the Energy System
     - Sustainable Resource Management
   - Proposed Concept for an Early Warning System for Policy Makers

2. **Policy Recommendations from Phase I**

3. **Phase II & Next Steps**
   - Phase II Proposal
   - Partner Organisations

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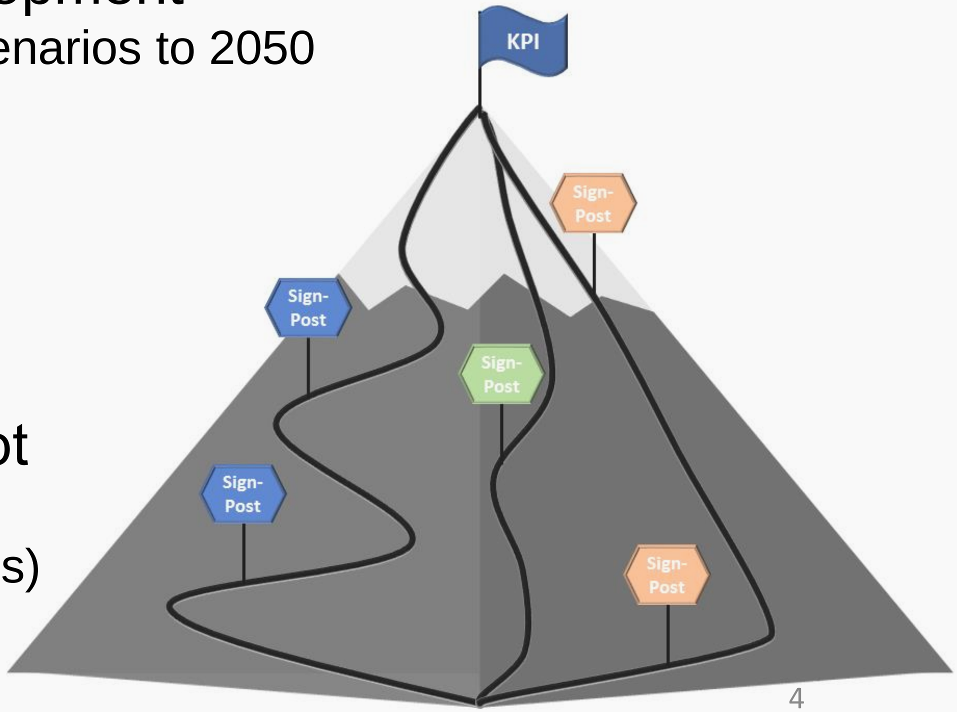
Project Objectives

ENERGY

How can the UNECE Region attain Sustainable Energy (SE)?

- Current Phase: May 2017 – Oct 2019

- Outputs
  - Pathways and Scenario Development
    - Sub-regional modelling of SE scenarios to 2050
    - Policy and technology options
  - Policy dialogue
    - Adaptive policy pathways
    - Policy dialogues
    - Sub-regional workshops
  - “Early-warning system” concept
    - SE Targets
    - Key Performance Indicators (KPIs)
    - Signposts



For more information visit website: **https://www.unece.org/energy/pathwaystose.html**

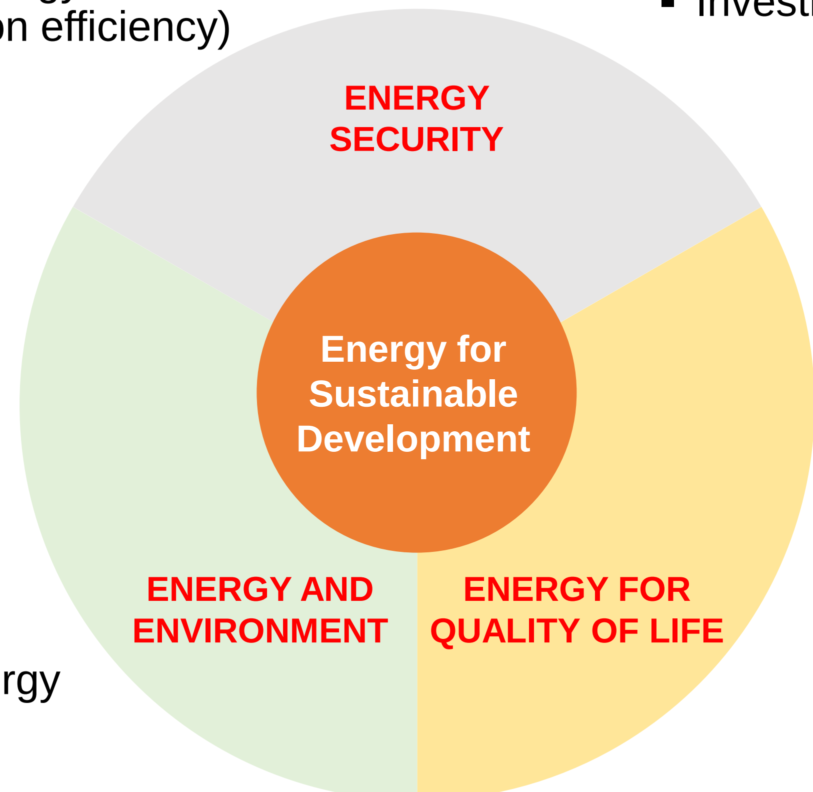
Pathways Project and Sustainable Energy

Three Pillars

ENERGY

"Secure the energy needed for economic development"

- Energy Efficiency (energy intensity of economy, rate of improvement of energy intensity, conversion efficiency)
- Fuel mix
- Net energy trade
- Investment requirements



"Minimize adverse energy system impacts on climate, ecosystems & human health"

- GHG emissions from the energy system
- Energy-related air pollution, water use & water stress

"Provide affordable energy that is available for all at all times"

- Access to energy services
- Energy affordability
- Food security (biomass use)

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Key Message
"It's still possible but don't delay"

ENERGY

Mission (Im)Possible?

- **Technology transition** is imperative to attain sustainable energy and meet 2ºC target.
- It is possible to achieve sustainable energy but **collaboration, forward looking policy measures for investors & immediate action is needed.** This change implies disruption in the energy sector.

Reality Check

- In UNECE region 80% of today's energy fossil fuel based. Even under a scenario that meets the 2ºC target, fossil fuels will still account for at least 56% of the region's energy mix by 2050 – far way from a net-zero world. **Accelerated decarbonization and energy transition is crucial.**

Investment Implications

- To meet 2ºC target, energy **infrastructure spending** in the UNECE increases by **$200 billion p.a**. (versus Business As Usual scenario of USD 785 billion p.a. through to 2050).
- **Delay is expensive.** The cost of transition rises steeply allowing less time for sectoral and societal adaptation.
- In any case, **the cost increase to meet 2ºC target is negligible** compared to social and health costs. The model assumes nothing on the cost implications of climate change but they will be significant - Air pollution ALONE cost USD 1.8 trillion in 2015 in OECD and BRIICS* combined.

****OECD, The Rising Cost of Ambient Air Pollution thus far in the 21st Century: Results from the BRIICS and the OECD Countries, 2017; BRIICS – Brazil, Russia, Indonesia, India, China, South Africa***

Key Message

“In an uncertain world, better to keep all options on the table and develop a few more”

ENERGY

All technologies* will play a role in attaining sustainable energy in ECE region. **->** The work of the Committee on Sustainable Energy and its Subsidiary Bodies promotes sustainable energy in the UNECE region and focuses on:

Reducing the Environmental Footprint of the Energy Sector

- The 2ºC target/ net zero commitments need **reduced carbon emissions and negative carbon technologies** to bridge the gap until innovative low or zero-carbon energy technologies are invented and deployed.

Long-term Planning - Accelerating the Transformation of the Energy System

- Transform the energy system to **provide energy services based on low carbon technologies**.
- **Modernizing and optimizing fossil-based infrastructure**, integrating low carbon infrastructure, and positioning **energy efficiency at the heart** of the future energy system are essential to achieve sustainable development.
- This is a long-term undertaking and must embrace all pillars of sustainable development seeking to **leave nobody behind** and maintaining social cohesion and inclusion.

Furthering sustainable resource management

- Articulate a vision of a **carbon-neutral circular economy** and embed it with significant country engagement and international cooperation.
- Embrace **circular economy principles** that integrate the full spectrum of the 2030 Agenda’s goals and targets

** NOTE: Definition of “All technologies” – It includes controversial energy carriers*

Key Takeaways

“Sub-regional diversity is important in UNECE and collaboration part of any policy debate”

- <u>*Subregional aspects*</u> *->* **Each country will pursue its own pathway based on their economic circumstances and natural endowments.** The UNECE region is comprised of high and low income countries, countries that are energy rich and energy poor as well as countries in economic transition. ***Lessons learned from subregional workshops*:***

I. <u>***Trade offs between Energy Security, Environment and Quality of Life***</u> ->

Energy security: priority for economic development needed to pay for a *just* transition spanning generations.

Energy poverty: priority in some regions (Eastern Europe, South Eastern Europe, Caucasus and Central Asia)

II. <u>***Lack of investments***</u> on subregional level to accelerate energy transition -> **achieving carbon neutrality and 2ºC target is a shared responsibility**. There is need for partnerships, trade and dialogue on subregional level. Across UNECE there is unequal distribution of investment in energy infrastructure. Renewable energy potential remains untapped in the Caucasus, Central Asia, Russian Federation and South East Europe.

** Following subregional workshops were held with focus on Central Asia subregion (June 2018 in Kyrgyzstan); Belarus, Ukraine, Moldova subregion (November 2018 in Ukraine); Eastern Europe, the Caucasus and Central Asia (May 2019 in Switzerland)*

Key Takeaways

“Sub-regional diversity is important in UNECE and collaboration part of any policy debate”

ENERGY

III. ***Need for institutional and structural reform*** ->

Combating corruption by promoting increased transparency and accountability of the energy sector

Improvement of the legal and regulatory framework to promote new business models.

IV. ***Promoting active citizenship*** -> maintenance of civil society initiatives and promotion of awareness rising campaigns.

- ***Phase II*** **-> There is limited willingness to cooperate on sustainable energy. More joint efforts are needed!**

  This project is a good vehicle for informed collaboration on Pathways to Sustainable Energy. Collaboration requires a trusted source of shared up-to-date knowledge, common scenarios, forums for dialogue and shared experience.

- **There is need for subregional and technology deep-drives for greater clarity on data and situation of energy sector.**

** Following subregional workshops were held with focus on Central Asia subregion (June 2018 in Kyrgyzstan); Belarus, Ukraine, Moldova subregion (November 2018 in Ukraine); Eastern Europe, the Caucasus and Central Asia (May 2019 in Switzerland)*

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Detailed Scenarios and modelling results

1. Methodology
2. Scenario Development
3. UNECE Primary Energy Demand by Scenario
4. Subregional Final Energy Demand by Scenario
5. UNECE Electricity Generation by Scenario
6. Subregional Electricity Generation by Scenario
7. UNECE Investment Requirements
8. Subregional Investment Requirements
9. Energy Affordability
10. Energy Poverty

Methodology

Modelling of Scenarios & Technology Research

- **Two integrated assessment models based on different methodologies**
  - ***GCAM*** **-** ***G***lobal ***C***hange ***A***ssessment ***M***odel
    Equilibrium model clears markets through iterative price adjustments and feedback loops
  - ***MESSAGE*** - ***M***odel for ***E***nergy ***S***upply ***S***ystem ***A***lternatives and their ***G***eneral ***E***nvironmental Impacts
    Optimization model: Supply must meet predetermined demand at minimum system costs (partial equilibrium)

- **Why two different models?**
  - Better delineation of uncertainties inherently associated with
    - Methodological fundamentals
    - Spatial, sectoral and temporal resolution
    - Energy technology and infrastructure resolution
    - Data
    - Assumptions
    - Complexity

- **Technology zoom-in**
  - Technology Research assessing the status and prospects (availability, performance, costs) of current and future energy system technologies

- **Regions Modelled**
  - BMU – Belarus, Moldova and Ukraine; CAS – Central Asia; EEU – Central and Eastern Europe; NAM – North America; RUS – Russian Federation; SCS – South Caucasus; WEU – Western Europe

Modelling Approach

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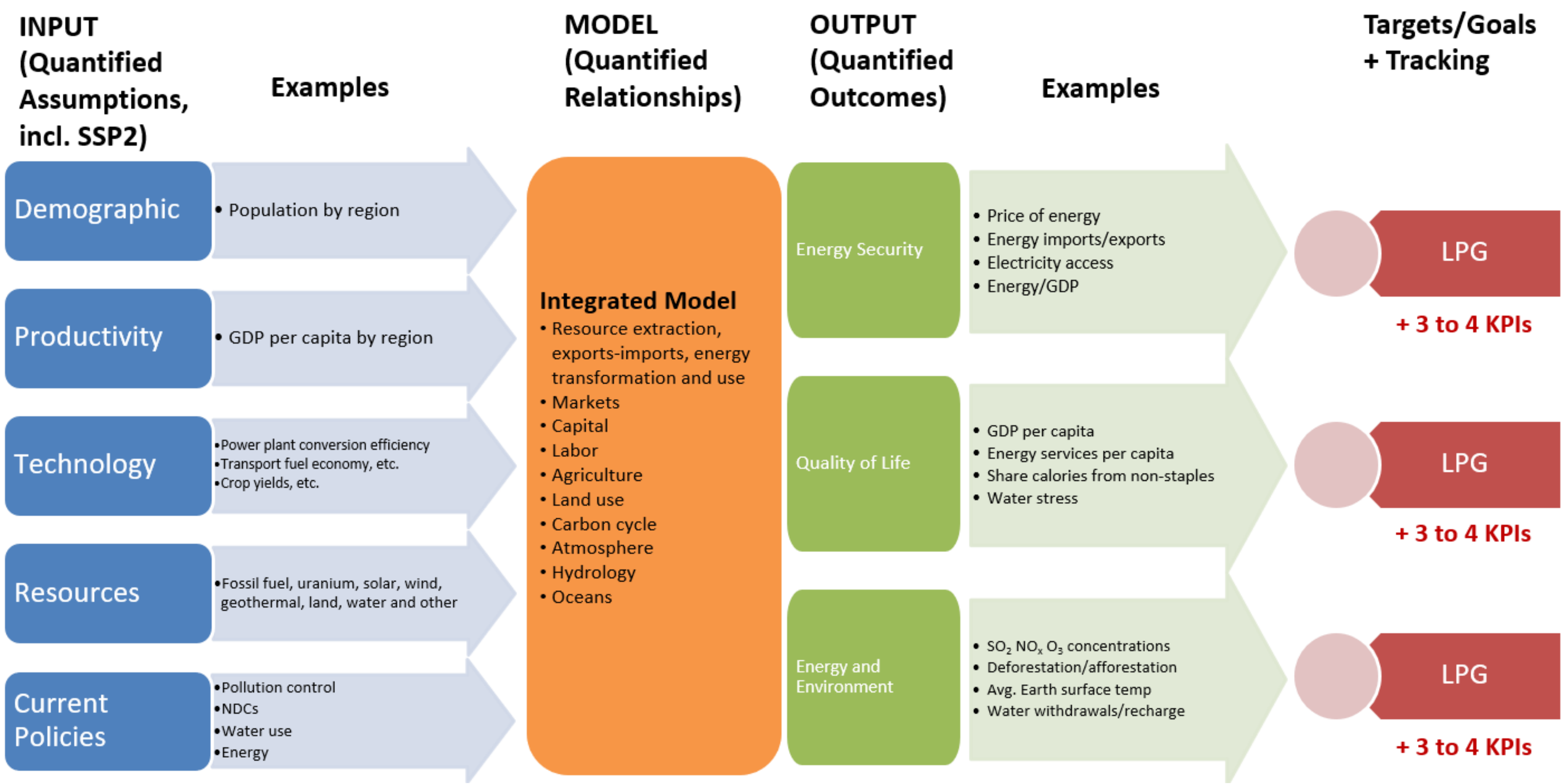

Glossary: SSP2 - Socio-Economic Pathways; KPI – Key Performance Indicators; LPG - Long-Term Performance Goals

Note: Models will be at the disposal of the UNECE's Committee on Sustainable Energy

For more information see: The glossary can be downloaded online: https://www.unece.org/energywelcome/areas-ofwork/pathways-to-sustainable-energy/resources.html

Scenario Development

Three sequential steps

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I. Reference Scenario

Based on Shared-Socio-Economic Pathway 2 (SSP2), a “Middle of the Road” Pathway, as point of departure, i.e., without dedicated sustainable energy or climate policies. A temperature increase of 4.2°C is expected by 2100 with cumulative (2020 – 2100) ECE emissions of 1,250 Gt CO2. Climate change impacts are expected to be very severe and will probably trigger unrecoverable changes in the climate system.

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. A temperature increase of 3.0°C is anticipated by 2100 and the cumulative (2020 – 2100) ECE emissions are 18% lower compared to reference scenario. Climate change impacts are expected to be severe and may trigger unrecoverable changes in the climate system.

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

One key component of Sustainable Energy 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). A temperature increase of 2.1°C is expected by 2100. Emissions are expected to peak by 2020 and negative emissions are mandatory post 2070. Under this scenario, climate change would be limited to, for example, more extreme weather patterns, major damage to coral reefs, major movements in agriculture.

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

From Storylines to Policy Pathways

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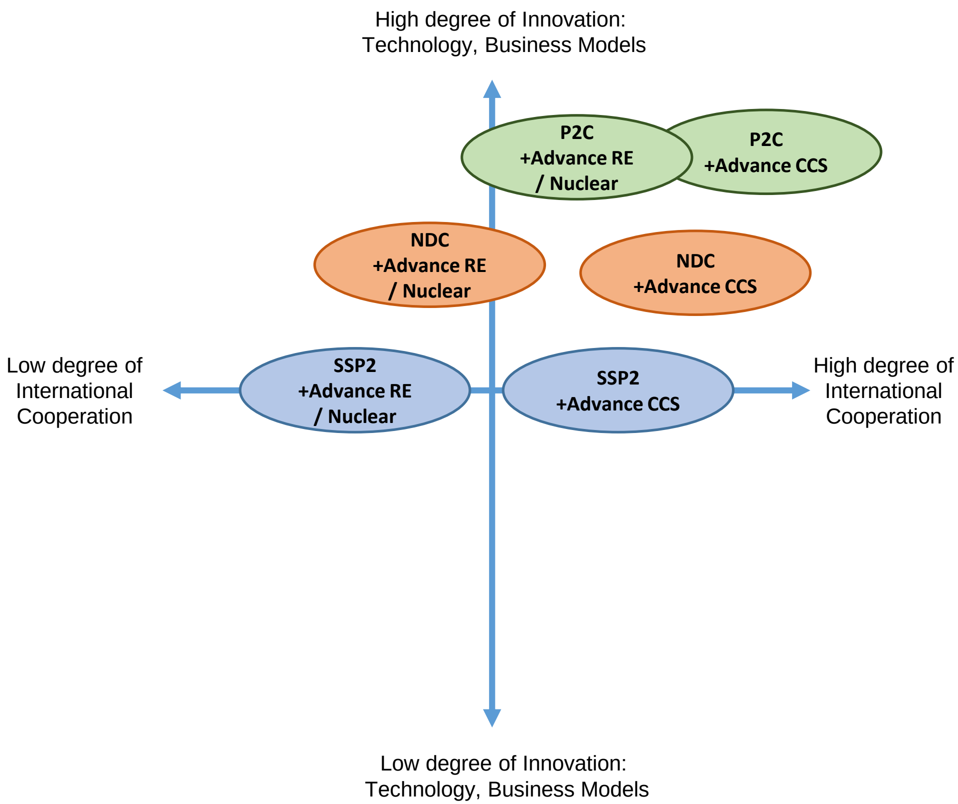
High degree of international cooperation and high degree of innovation are preconditions for attaining Sustainable Energy in the UNECE region. *Provocation*:

-> Is there a willingness to cooperate on SE?

-> If SE is the objective then what needs to be done in the UNECE region in order to be on track?

-> Since 2ºC has been agreed, where is the problem?

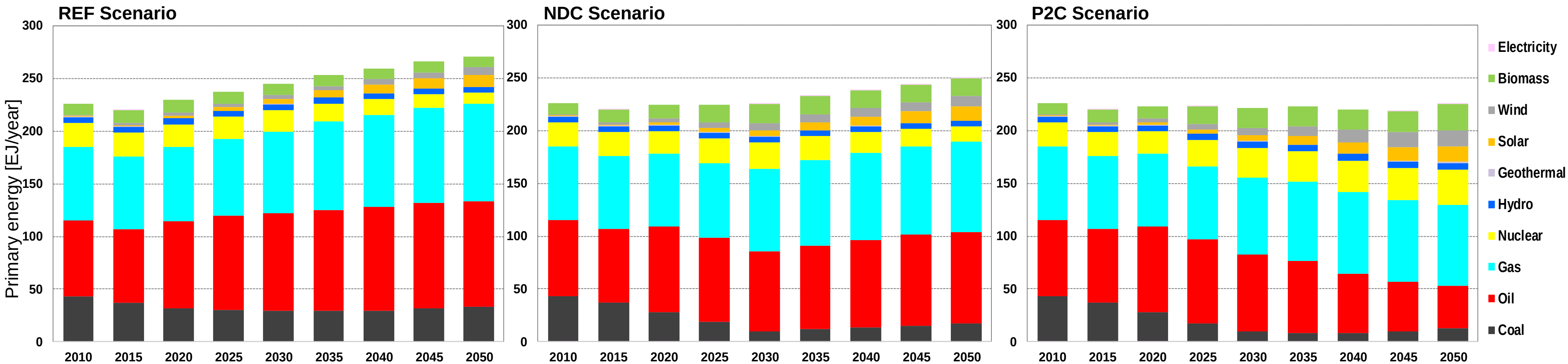


- A range of technology options were tested that allowed to explore technology cost assumption variations for renewable energy (wind, solar PV, CSP, geothermal), CCS, and nuclear. The intention was to demonstrate how variations in technology costs could impact the deployment selected technologies under three policy scenarios.
- The three scenarios and variations within the technology costs can be clustered within the two axes for the scenario space. These two axes were identified during stakeholder workshops and define the most important variables influencing the future of SE.
- The two drivers are "Degree of Innovation" and "International Cooperation". Innovation was interpreted as all types of innovation including technology and business models. International cooperation focuses on how countries cooperate to achieve shared targets, such as the 2030 Agenda and the Paris Climate Agreement.

UNECE primary energy demand by policy scenario

ENERGY

In UNECE, about 80% of today's energy mix is fossil-based. This reinforces the urgency of the Committee's programme of work. No economically rational scenario involving a substantial fall in fossil energy.

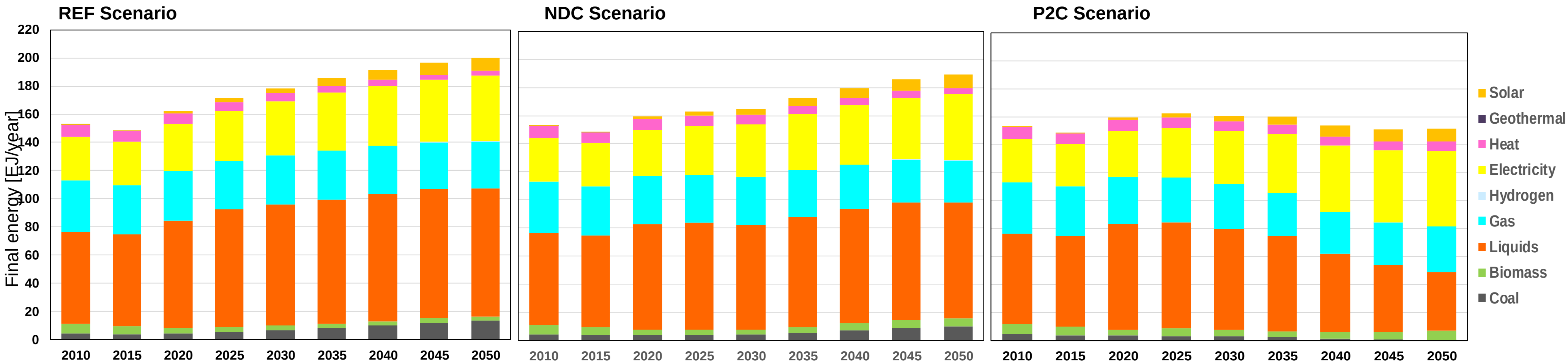


- Energy demand in UNECE decreases in the P2C scenario by 2050, it increases in the REF scenario. In the P2C scenario total energy demand is expected to decrease by 25% compared to the REF scenario (efficiency and intensity improvements in transport and industry sectors, technology and structural changes as well as lifestyle changes).
- In total, the region's 56 countries represented 39% of the world's primary energy consumption (as of 2015) to produce 41% of world GDP. The region produced 40% of the world's primary energy resources and emitted 39% of global CO_2 from fossil fuel combustion.
- Even under a climate change scenario that meets a 2°C target, fossil fuels are expected to account for 56% of the regional energy mix by 2050.

UNECE final energy demand by policy scenario

ENERGY

For the final energy supply technological change is crucial to accelerate energy transition and achieve SE. <u>Overdependence on fossil fuels makes decarbonization crucial.</u>

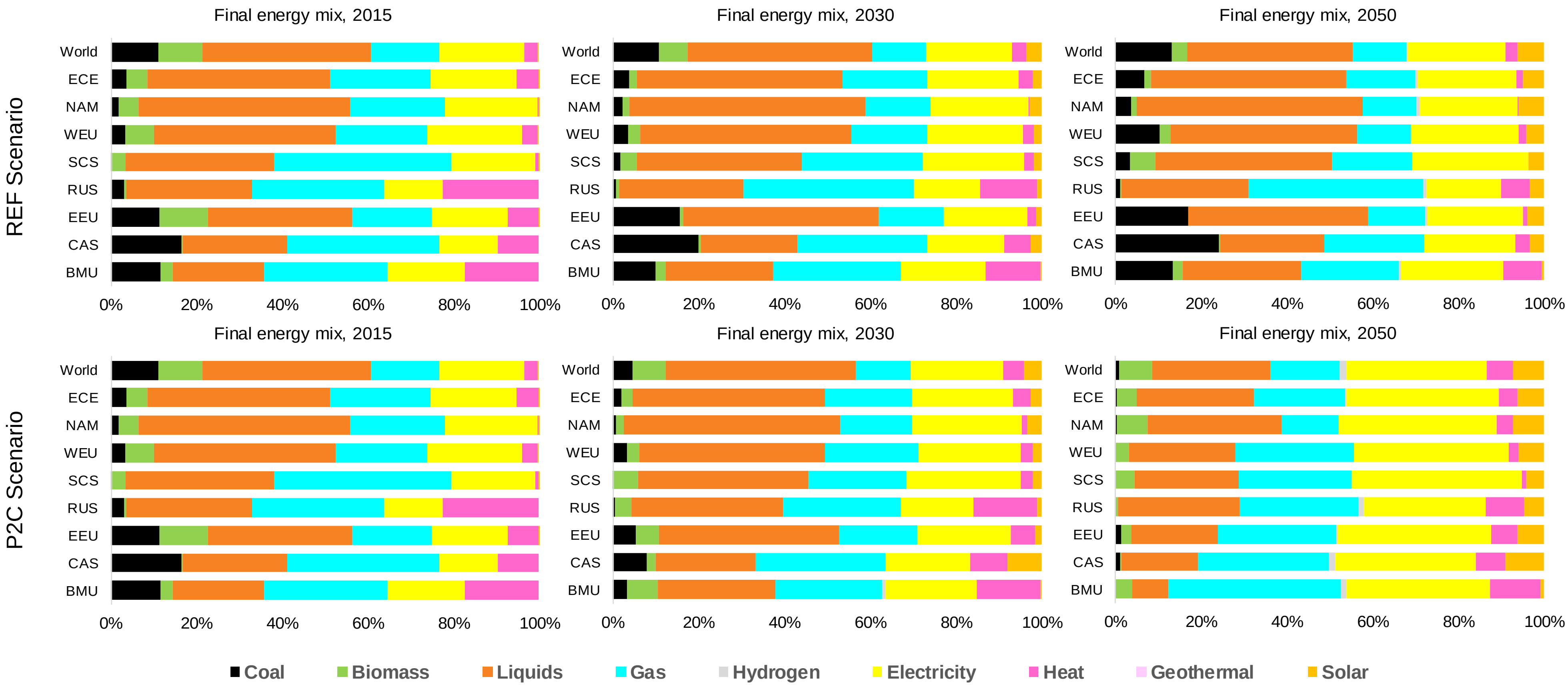


- In REF scenario, the total final energy demand grows after 2020 by 0.7% y-o-y reflecting demographic change. Driven by the transportation sector and non-energy uses, demand for liquids is expected to increase, while gas is anticipated to underperform through to 2050.
- In the NDC scenario, reduced final energy demand is expected to be driven by energy efficiency gains, fuel shifting and infrastructure adaptation. Between 2020 and 2050, final energy demand increased for all fuels (albeit at a lower pace than REF) except from district heat and natural gas. Liquids and electricity (gradually from renewable energy) are anticipated to substitute gas in the final energy mix.
- After initial modest growth, in P2C scenario, final energy faces decades of steady contraction reflecting climate mitigation induced energy system transformation. In comparison to REF scenario, final energy demand is expected to contract by 25%, mainly driven by efficiency and intensity improvements, technology and structural and lifestyle changes.

UNECE subregional final energy demand by policy scenario

ENERGY

The region is comprised of high- and low-income countries, countries that are energy rich and energy poor, and countries that are in economic transition. <u>For some subregions diversification of the energy mix is expected to be faster than for others.</u>



** BMU – Belarus, Moldova and Ukraine; CAS – Central Asia; EEU – Central and Eastern Europe; NAM – North America; RUS – Russian Federation; SCS – South Caucasus; WEU – Western Europe*

UNECE subregional final energy demand by policy scenario

ENERGY

Insights by subregions:

NAM – Share of **solar energy and electricity** in final energy grows by 2050 in REF, this growth is faster in P2C including an increased use of **bioenergy.**

WEU – In REF, the share of liquids grows reflecting the demand for fuels in transportation sector. In P2C, this share declines as **more electrification replaces liquids and fossil fuels.**

SCS – **Gas is being replaced** with liquids in REF and with electricity in P2C.

RUS – The share of district heating declines as **gas-based heating systems penetrate** in REF. In **P2C**, district **heating** is mainly replaced with **electricity**.

EEU – While coal continues to play a role in REF, in P2C **coal is replaced with gas and electricity.**

CAS – In P2C, the **share of solar and electricity increases** as the district heating gradually phases-out. District heating system works with the combined heat and power plants (CHP) that have higher fuel efficiency compared to power-only thermal plants.

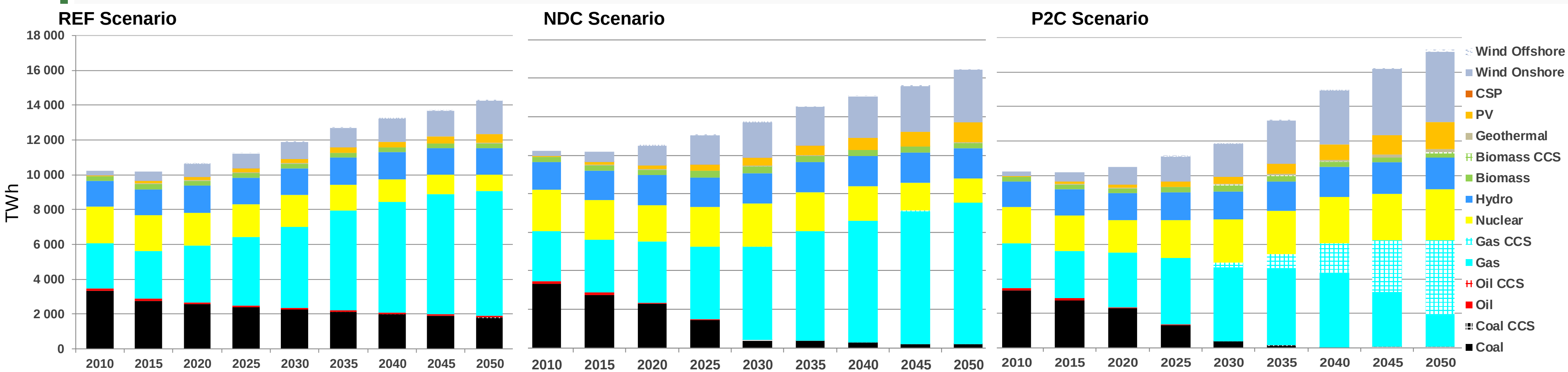
BMU – In P2C, **gas is displacing coal** and accelerating its penetration in the final energy mix.

** BMU – Belarus, Moldova and Ukraine; CAS – Central Asia; EEU – Central and Eastern Europe; NAM – North America; RUS – Russian Federation; SCS – South Caucasus; WEU – Western Europe*

UNECE electricity generation by policy scenario

ENERGY

The traditional energy system is defined by large scale plants that generate single-directional, predominantly fossil-fuel based, power and heat to end-users. The UNECE electricity generation portfolio is anticipated to experience significant structural changes. <u>The future power generation system is expected to incorporate more decentralized and smart systems and requires CCS.</u>

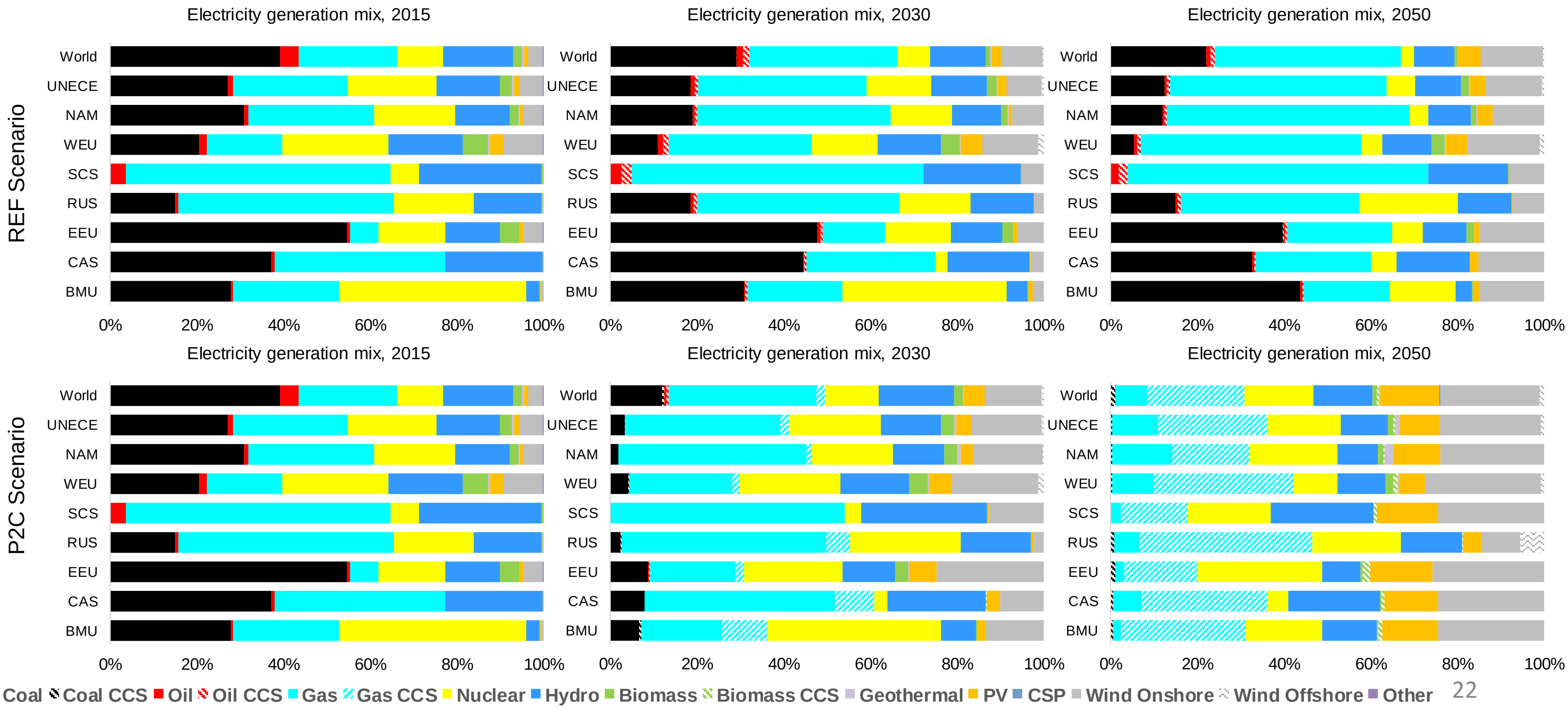


- In the REF scenario, by 2050, hydro and variable renewable energy are expected to follow fast expansion of natural gas. Coal and nuclear energy are anticipated to follow a long-term phase out trajectory post-2040.
- In the NDC scenario, higher electricity output is anticipated towards the end of the forecast period. This will primarily be driven by the uptake of electric mobility. Accelerated phase-out of coal-fired power plants is expected to be replaced by natural gas. Renewable energy is forecast to experience rapid expansion from 2020. Retrofitted coal and gas generation with CCS will slowly be introduced, however, will still remain marginal.
- In the P2C scenario, on the back of widespread electrification of the energy system, 20% higher electricity demand is expected by 2050. This scenario implies a higher degree of diversification with fast up-take of low-carbon emitting technologies. P2C depicts a fundamental realignment of the generation structure with a large share of gas with CCS, fast expansion of offshore wind and solar PV, and a steady expansion of nuclear power. Whilst conventional coal is expected to phase out, some minor coal-fired power generation with CCS is expected to retain the role of coal in the power generation mix.

UNECE subregional electricity generation by policy scenario

ENERGY

In the REF scenario, the electricity generation mix will continue to rely on fossil fuels in all regions. In the P2C scenario, fossils are displaced by natural gas with CCS, nuclear and renewable energy.



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UNECE subregional electricity generation by policy scenario (cont)

ENERGY

Insights by subregions:

NAM – **Gas-based electricity dominates** and reduces the share of coal even in REF. In P2C, the **phase-out of coal is accelerated** and a big share of renewables play role in 2050.

WEU – In REF, **renewable energy** experiences slight **uptake** whilst nuclear energy phases out. In P2C, a **continued relevance of nuclear** energy and **accelerated uptake of renewables** and **gas with CCS.**

SCS – **Gas** continues to remain the **backbone** of the power system in REF, while in P2C **renewables and nuclear** meet more than 75% of the electricity demand.

RUS – **Nuclear and gas continue to grow** steadily in REF. In P2C, **gas with CCS and nuclear energy** play the major role in decarbonization of the power generation system.

EEU – In REF**, coal and nuclear energy experience a decline**, whilst **gas and wind** gradually **gain** traction. In P2C, **zero-carbon technologies** such as solar, wind and nuclear energy gain traction.

CAS – A **rapid phase-out of coal** in P2C compared to REF. **Renewable energy is growing** significantly and gaining market share.

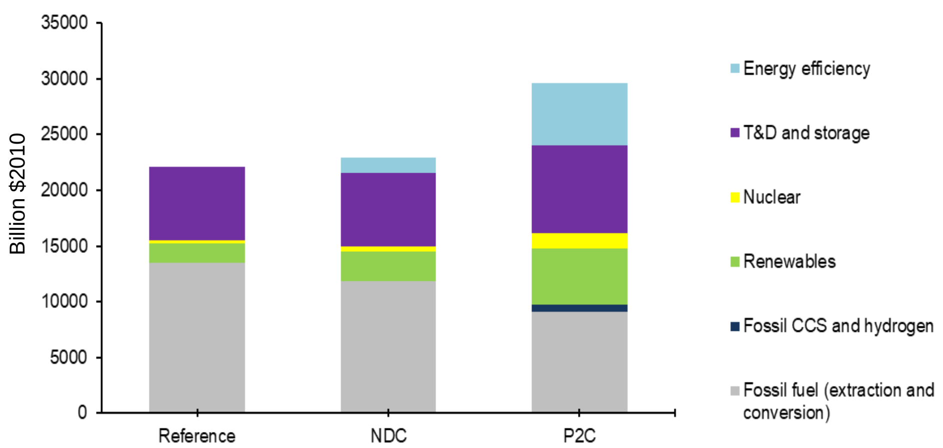
BMU – In P2C, **coal-fired** power plants are **replaced by gas with CCS and renewables.**

** BMU – Belarus, Moldova and Ukraine; CAS – Central Asia; EEU – Central and Eastern Europe; NAM – North America; RUS – Russian Federation; SCS – South Caucasus; WEU – Western Europe*

Investment requirements

Delaying immediate action will increase the overall cost of the energy transition. If 2ºC is the ultimate target than the current economic environment needs to change to allow for a swift energy transition, a gradual change will not meet the set target. A predictable environment with forward looking policies is a precondition for investments in energy innovation and is also essential for both economic growth and environmental protection.

Total Investment Needs by Technology, 2020-2050



- In the REF scenario, in the period from 2020-2050 cumulative investments of USD 23.5 trillion would be required, of which 50% of the total for the extraction of fossil fuels. Electricity generation investments are expected to be dominated by lowest carbon emitting hydro power and wind plants followed by nuclear power and solar.
- In the NDC scenario, during the same period, anticipated investments are slightly higher (by USD 800 billion) than the REF scenario, caused by a different investment portfolio. Energy efficiency and intensity reduction measures are steadily introduced. Investments in wind and solar are expected to dominate power generation.
- In P2C scenario, investments are expected to rise by 24% to USD 29.2 trillion compared to REF scenario. Whilst the upstream fossil fuel investments are anticipated to absorb 28% of investments, investments in energy efficiency will account for 25% of the total. Generation commands almost twice as much capital investment as in REF scenario, of which renewable energy accounts for 60% of generation investment. The difference between the P2C and REF scenario is about USD 6 trillion, or USD 200 billion annually.

Case Study:

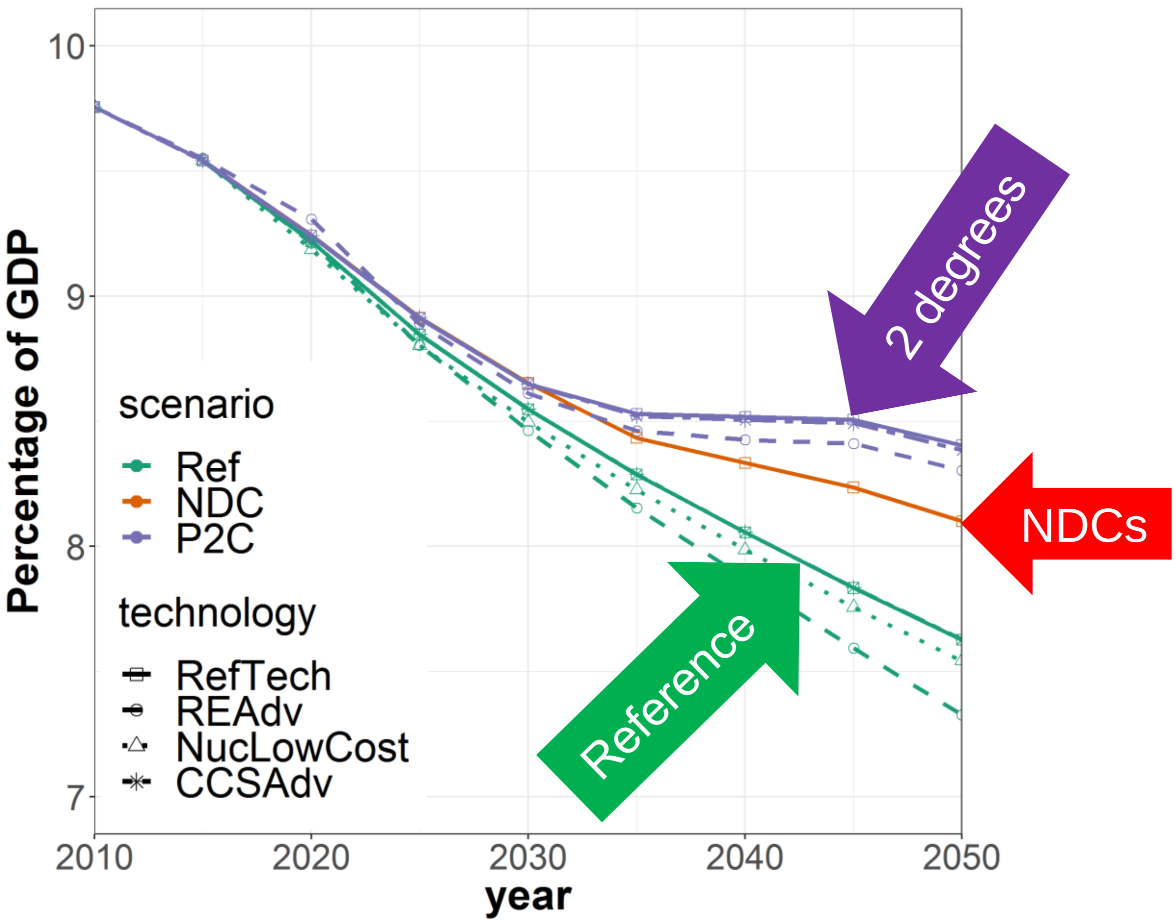
- In 2015, premature deaths caused by air pollution imposed a cost of USD 1.8 trillion on OECD and BRIICS countries. This implies that additional investments required to meet the 2ºC target are negligible compared to health care and social cost of air pollution and again stresses the nexus context of the project.[1]

1 Source: OECD, The Rising Cost of Ambient Air Pollution thus far in the 21st Century: Results from the BRIICS and the OECD Countries, 2017; BRIICS – Brazil, Russia, Indonesia, India, China, South Africa

ENERGY

Energy affordability

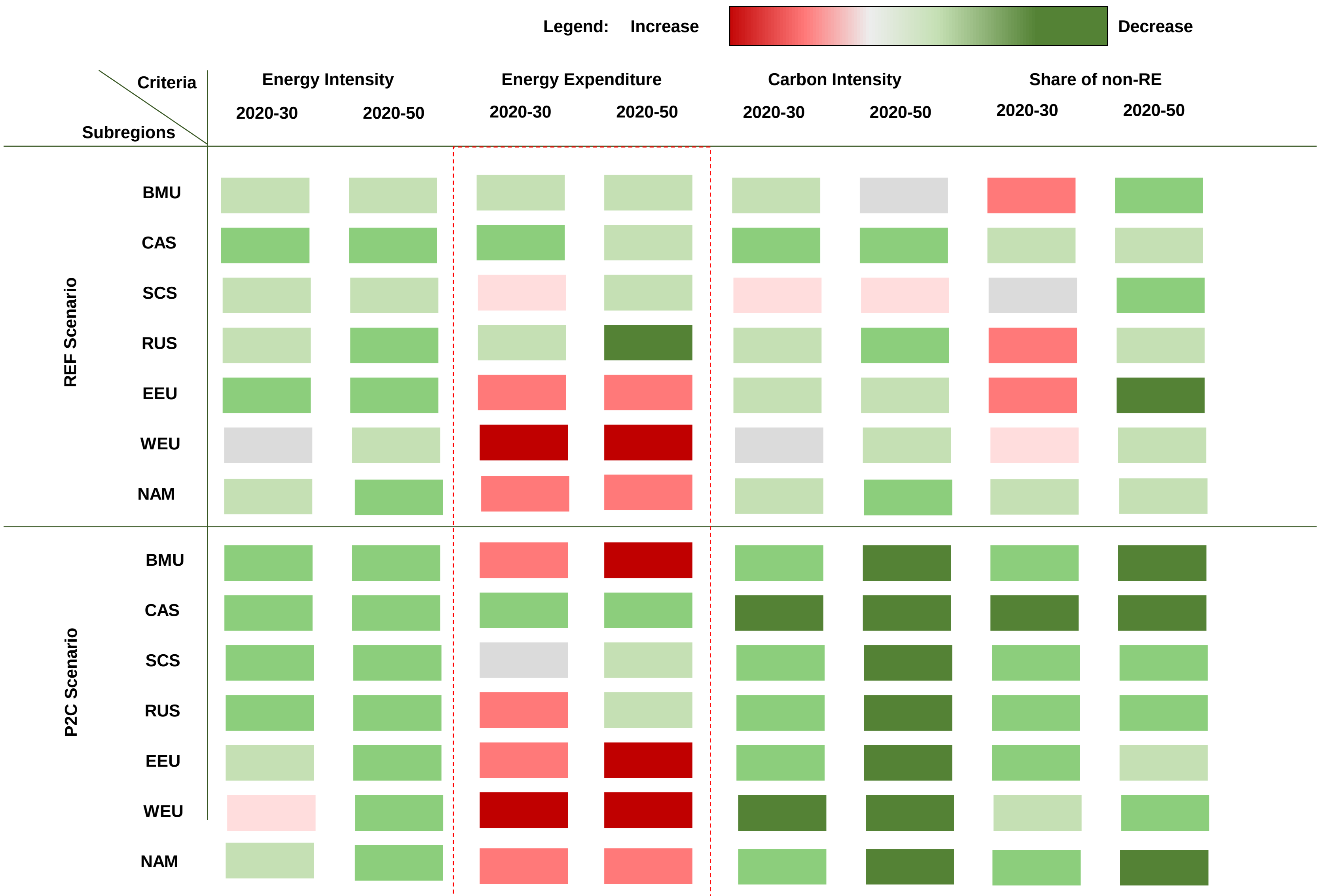
Global energy expenditures as share of GDP (percent)



- Energy expenditure share of GDP **decreases** to 2050.
- Increased **Paris** ambition **increases** energy share of GDP
- **Advanced** technologies help lower costs and **reduce the policy impact.**

Energy poverty in the UNECE still needs to be tackled. Carbon neutrality has consequences for countries. The more urgent this becomes the more expensive and challenging it will be.

ENERGY



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Technologies & Committee on Sustainable Energy Subsidiary Bodies

ENERGY

***All* technologies including energy efficiency will play a role in the modernization of the energy system of the UNECE region and contribute to the implementation of the 2030 Agenda and the Paris Climate Agreement.**

Reducing the Environmental Footprint of the Energy Sector

Group of Experts on Clean Electricity Systems
Group of Experts on Coal Mine Methane
Group of Experts on Gas
Methane Management

Deep Transformation of the Energy System

Group of Experts on Energy Efficiency
Group of Experts on Renewable Energy
Group of Experts on Gas
Group of Experts on Cleaner Electricity Systems

Sustainable Resource Management

Expert Group on Resource Management
Group of Experts on Renewable Energy
Resource Efficiency and Circular Economy

- Expert Groups used the modelling outputs of the Pathways Project to investigate implications on Pathways to sustainable energy and the roles of various technologies based on i) reducing the environmental footprint of the energy sector, ii) deep transformation of the energy system and iii) sustainable resource management.

Detailed Scenarios and modelling results

ENERGY

1. **Expert Groups Insights - Role of All Technologies in Attaining Sustainable Energy in the UNECE Region**

- Reducing the Environmental Footprint of the Energy Sector
  - Role of Coal
  - Role of Gas
  - Role of Nuclear
- Deep Transformation of the Energy System
  - Role of Energy Efficiency
  - Interplay between Natural Gas and Renewable Energy
  - Role of Renewable Energy
- Sustainable Resource Management
  - Food – Water – Energy Nexus
  - Resources and Circular Economy
  - Energy Affordability
  - Energy Poverty

Reducing the Environmental Footprint of the Energy Sector

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Summary

- Ensuring secure, affordable and sustainable energy requires a diverse energy mix, of which coal will remain a part over the project period. Investments in cleaner technologies (e.g. CCUS and HELE) are crucial if cleaner coal is to be maintained in the energy mix in the mid-term.
- Phasing out the coal sector must be managed carefully to mitigate its adverse effects on and minimize negative socio-economic implications for communities, regions and countries that heavily depend on coal. Many coal mines continue to emit methane for decades after closure, a methane management programme must be put in place.
- GHG emissions associated with coal mining need to be reduced. Some coal mines are very gassy and emit significant quantities of methane. Methane has a severe impact on the environment and climate change and must be addressed through recovery, use, and abatement. Annual emissions from one large underground coal mine in the United States can emit 2 million tCO2e per year, or more, a mitigation project at similar size mines rivals CCS projects at power plants.
- Gas demand is expected to be robust in all scenarios. Due to its lower carbon content compared to other fossil-fuels, natural gas contributes to reducing carbon intensity and pollution effects resulting from energy related activities. Combined with CCUS and renewable/ decarbonized gases, it is compatible with deep decarbonization of energy system.
- In spite of the low CO_2 emissions, abundancy and cost-effectiveness of natural gas, methane emissions associated with natural gas need to be managed across the value chain.
- A dialogue on the energy transition is incomplete without considering nuclear power. Nuclear energy will remain an important contributor to a low-carbon energy future in some countries.

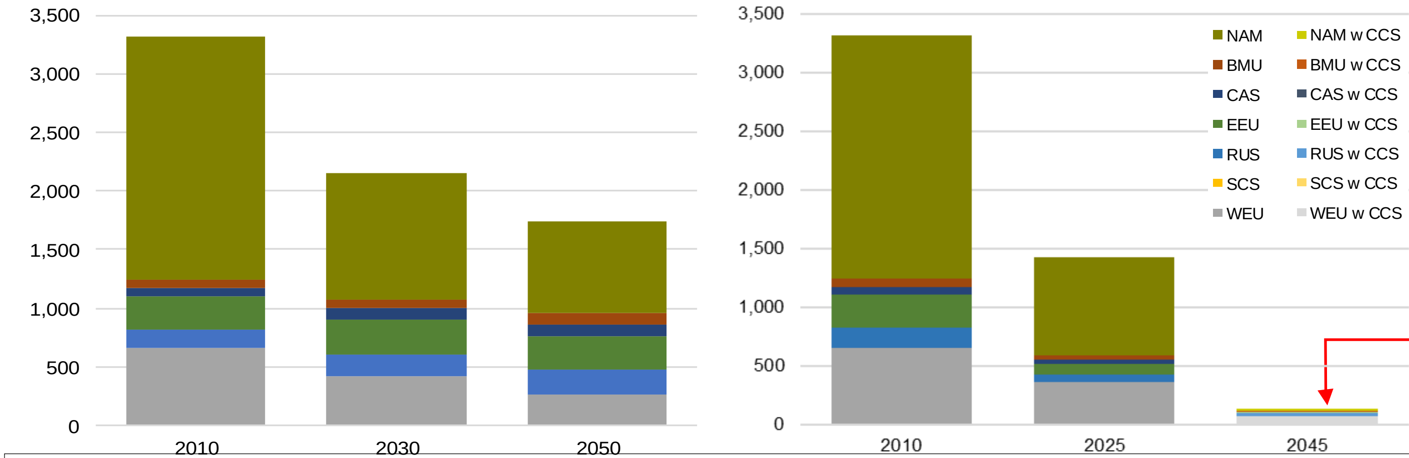
Reducing the Environmental Footprint of the Energy Sector
Coal

ENERGY

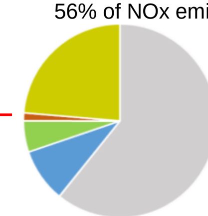
Ensuring secure, affordable and sustainable energy requires a diverse energy mix, of which coal will remain a part. Investments in cleaner technologies (e.g. CCUS and HELE) are crucial if cleaner coal is to be maintained in the energy mix in the mid-term.

Share of Coal in Electricity Generation Mix, TWh

REF Scenario **P2C Scenario**



- CCS is an integrated suite of technologies that can capture up to 90% of the CO2 emissions. Where carbon-storage sites are available, CCS is the lowest-cost decarbonization option at current commodity prices.
- In ECE region, technology is mainly expected to be implemented in Western Europe, North America and Russia..
- Pilot CCS project in Canada[1] reduces 100% of the power station's SOx, 90% of CO2, and 56% of NOx emissions.



- It captures 1mt of CO2 annually, while producing 115 MW of power, which is enough to power approximately 100,000 homes.

- As countries implement their climate change pledges, traditional coal-fired power generation are being shut-down or upgraded. This trend is expected to accelerate in P2C scenario. Deploying HELE coal-fired power plants is a key first step along a pathway to near-zero emissions from coal with CCUS.
- In the P2C scenario, the phase out process in WEU is expected to be more gradual mainly driven by Germany, followed by the UK and Spain. WEU is also expected to account for the largest share of coal with CCS in the power generation mix. Nevertheless, coal is expected to play an increasingly important role in Asia and Africa. UNECE can partner with other UN Economic Commissions and share best practices to help countries in other regions to accelerate energy transition and achieve carbon neutrality.
- Coal-fired power plants have undergone modernization over the past decade experiencing improvements in the operational efficiencies and emission control system performances. Increasing the flexibility of coal power plants' operations could allow a faster deployment of renewable energy sources, thereby reducing the carbon intensity of electricity generation.

[1]*SaskPower Boundary dam coal-fired CCS project, World Coal Association*

** BMU – Belarus, Moldova and Ukraine; CAS – Central Asia; EEU – Central and Eastern Europe; NAM – North America; RUS – Russian Federation; SCS – South Caucasus; WEU – Western Europe*

Reducing the Environmental Footprint of the Energy Sector

Coal

ENERGY

Any <u>reductions in coal's contribution must be managed with appropriate action to mitigate negative socio-economic implications</u> for those communities, regions and countries that depend heavily on coal.

- Social dimension of coal mining communities and the regional infrastructure must be carefully managed through sustained long-term governmental policies.
- In the UNECE region, there are a number of localities, such as Upper Silesia in Poland, Lausitz in Germany or Karaganda in Kazakhstan, which still depend on the coal sector heavily. In such areas, coal mines, power generation plants, metallurgical processing plants, manufacturing and shipping facilities are integrated into dense, interrelated business. Any accelerated coal phase-out thus needs to be supported by proactive processes to facilitate structural transition of the coal sector. It needs to harmonize often conflicting policy realms and will take long-term generation-long planning.

Environmental Concerns

- **Promote a coal phase out, especially in the case of most carbon intensive uses.**
- **Introducing water and air management in existing assets.**

Economic Realities

- **Manage the speed of coal phase-out as local and national economies need to adjust to new circumstances.**
- **Potential for new business opportunities, however, structural change needs to be carefully managed.**
- **The problem of vested interests. The expected resistance of current system beneficiaries and important stakeholders needs to be managed.**

Social Concerns

- **Pivotal in the design of a coal phase-out process. Coal-industry dependent communities face challenges, such as job losses, economic decline, disruptive cultural changes.**
- **A concept of "just transition" can facilitate in structural planning.**
- **Benefits of transition include job creation in low-carbon sectors.**

Case Study[2] – Germany

- Currently ca. 18,500 persons are employed in lignite-fired power plants and mining. An additional 4,000 – 8,000 employees work in coal-fired power plants. Germany is devoted to the retirement of its coal power plants. It is estimated that in REF scenario (w/o additional climate policies) by 2030 number of employees will decrease to approx. 14,500 employees. In accelerated climate mitigation scenarios, reductions could fall to approximately 8,000 employees. By 2038, the regions that are currently still involved in lignite mining will have received funds amounting to €26 billion to ensure they undergo a profound structural change.
- Economic development that will follow energy transition process is expected to create new jobs that will offset employment cuts resulted by coal phase-out. In recent years approx. 100,000 new jobs have been created in renewable energy. Coal phase-out can incentivize needed investments in renewable energy, storage technologies, energy demand management and energy efficiency measures. This forward-looking, innovation based approach will create new opportunities for next generations and allow them to stay in the region and build their lives.

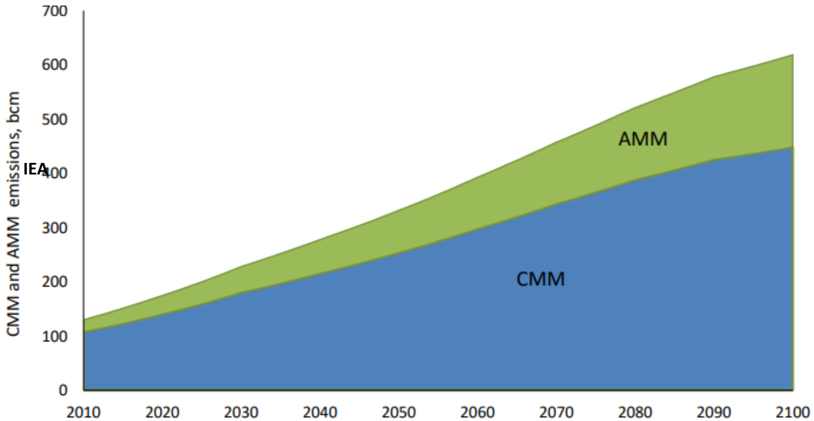
[2]*Phasing out coal in the German energy sector, DIW Berlin, Wuppertal Institute, Eco Logic, 2019*

Reducing the Environmental Footprint of the Energy Sector
Coal

ENERGY

GHG emissions associated with coal mining need to be managed carefully. Some coal mines are very gassy, emitting greater than 750 million tonnes of CO2e annually. Methane has a severe impact on the environment and climate change that must be addressed.

Global Abandoned Mine Methane (AMM) and Coal Mine Methane (CMM) Emissions – Reference scenario, source: PNNL 2018



- The emissions do not cease at the time of mine closure. Methane escapes abandoned mines through natural and mining related fractures and other conduits. As of 2010, the share of abandoned mine methane (AMM) in total CH4 emissions from coal was 17%. This share is expected to increase to 24% by 2050.
- Methane is a potent GHG with a high global warming potential[3] (GWP). Methane emissions should not be forgotten while addressing the problems of air quality. Managing methane emissions throughout the whole coal mining value chain – from quantification of methane resources during coal exploration though capture and use during the mining lifecycle – is essential to converting this pollutant into an asset.
- Capture and use of methane translates directly into better air quality and thus also better quality of life in mining areas and neighboring communities.

Case Study – France

- From 1978 through 2018, three abandoned mines in the Lorraine area of France, the Avion, Divion, and Desiree mines produced 1,538 million cubic meters of methane. Annual gas production in 2018 for the three mine sites was 26 million cubic meters of methane. The owner and operator of these projects, Francaise de l'Energie estimates that over 600,000 tonnes per year of CO2 emissions are avoided annually using the methane as a fuel to supplant coal.

Case Study – China

- There is great potential for AMM recovery and utilization in the emerging markets such as China. Thousands of coal mines have been abandoned in China over the last decade. The trend of coal-mine closures is expected to accelerate over next 5 years in China. It is anticipated that over 4000 artisanal coal mines and over 300 large coal mines will be abandoned in next 3 – 5 years.

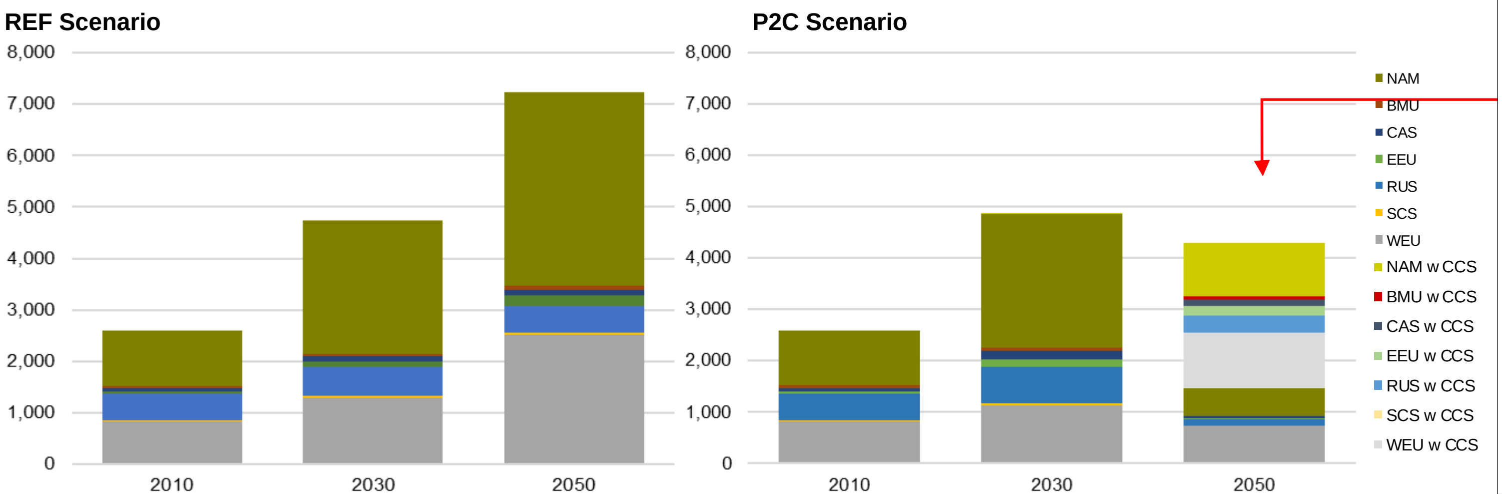
[3]*Global Warming Potential (GWP) is an index, which allows to compare the global warming impact of a greenhouse gas, relative to the most prevalent of the greenhouse gases – CO2. Further it determined the relative contribution of the respective gas to climate change. Based on the 20 year timeframe the GWP of CH4 is 80 times larger to CO2. In the 100-year timeframe the potential of CH4 compared to CO2 falls to 28 times (IGU 2017, GECF 2019).*

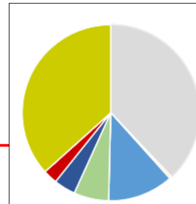
Reducing the Environmental Footprint of the Energy Sector
Natural Gas

ENERGY

Gas demand is expected to be robust in all scenarios. Due to its lower carbon content compared to other fossil-fuels, natural gas contributes to reducing carbon intensity and pollution effects resulting from energy related activities. Only if combined with CCUS and renewable/decarbonized gases, growing gas use can be compatible with deep decarbonization.

Share of Natural Gas in Electricity Generation Mix, TWh





- CCS technology will play important role for natural gas to retain its role in the energy systems under stringent climate mitigation policies.
- However, successful deployment of CCS will require the availability of significant geological storage capacity[4].
- Europe and North America were early movers to conduct the 'bottom-up' approach to the CO_2 storage assessment. In Europe, the North Sea basin was identified as the most prospective area for storage – 3 commercial projects in Sleipner, Snohvit and K12-B.

- As natural gas emits less CO_2 than other fossil fuels, it is the logical choice for a backup in the mid-term to secure electricity supply. Natural gas also enhances air quality in polluted areas. Several success stories include: Beijing, Shanghai, Urumqi, Santiago de Chile, New York, Istanbul, Toronto, Berlin, Dublin, Krakow and Rotterdam.
- Natural gas supply chain is flexible on the back of gas storage, LNG and operational flexibility of gas pipelines. Gas is a very versatile commodity. It can be used in the mobility sector as well as for heating - including precision heat at very high temperatures - for power generation, and in petrochem industry.
- There is considerable scope for gas development in various UNECE sub-regions, notably Southeast Europe, Russia and Central Asia. There are also opportunities in Northern and Western Europe, but the intensity of the debate over climate change in those regions makes it much harder to assess the extent of further penetration of natural gas. If natural gas will play a role in the long-term future energy supply, the entire value chain needs to become carbon neutral. Deployment of negative carbon technologies and CCUS is a precondition.

[4]According to IEA, around 90Gt of storage capacity will be required if CCS technology will contribute up to 12% of CO_2 emissions. In 2050, it accounts to approx. 6GT per year. (source: C. Consoli and N. Wildgust, Current status of global storage resources, 2016)

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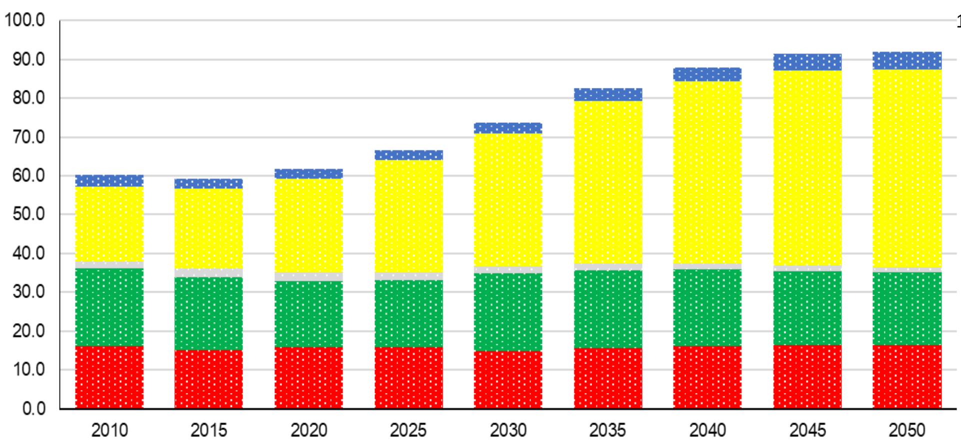
Reducing the Environmental Footprint of the Energy Sector
Natural Gas

ENERGY

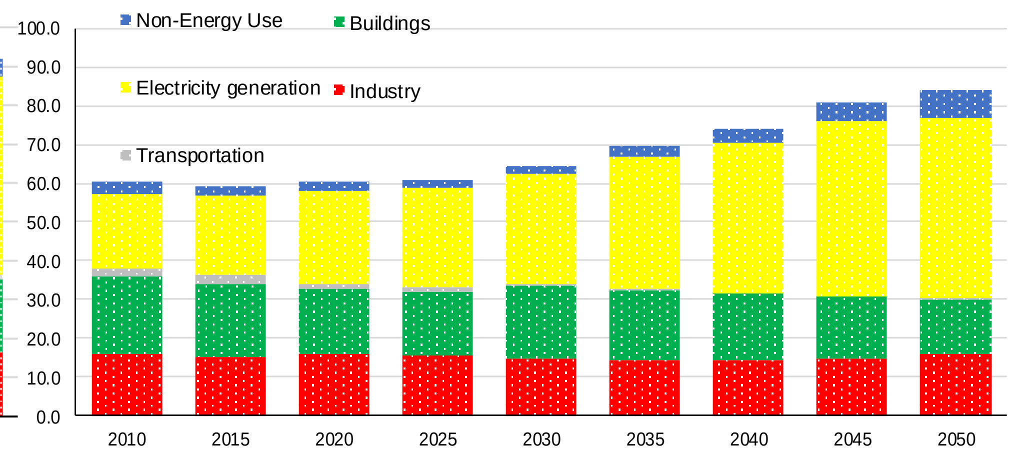
The power generation sector will drive demand for natural gas in both medium and long-term. The plateauing of demand for gas towards the end of the forecast is expected to be driven by increasing competition from renewable energy.

Final Energy Gas Use by Sector per Scenario, EJ/year

REF Scenario



P2C Scenario



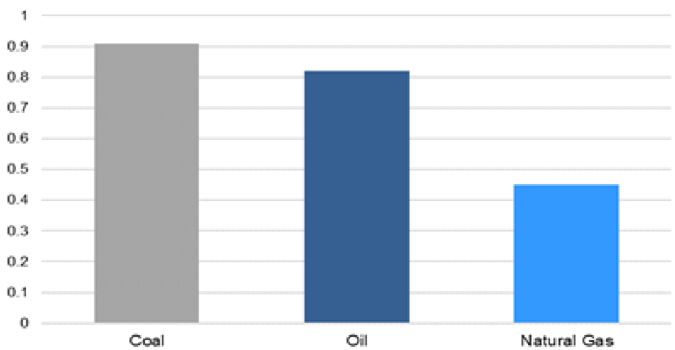
- In both REF and P2C scenarios, the power generation sector is expected to drive the demand for gas in both medium and long-term. In the REF case, in 2030 the demand for gas in power generation is anticipated to be about 30% higher than today, and in 2050 by 53%. The plateauing of demand for gas towards the end of the forecast is expected to be mainly driven by increasing competition from renewable energy. In P2C scenario, increasing penetration of renewable energy into the power generation is exacted to slow down the growth of gas demand.
- Demand for gas in transport sector is expected to remain low due to strong penetration of electric vehicles in transportation sector. In mid-term it will be mainly used as LNG for bunkering in marine sector and long-haul vehicles.

Reducing the Environmental Footprint of the Energy Sector
Natural Gas

ENERGY

In spite of the low CO_2 emissions, abundancy and cost-effectiveness of natural gas, methane emissions associated with natural gas need to be managed across the value chain. Reducing methane emissions provide an opportunity to secure a sustainable energy future, in which natural gas can continue to play a role.

Average CO2 Emission factors of oil, gas and coal-based electricity, source: GECF 2019



- Natural gas contributes to reducing carbon intensity and pollution effects resulting from energy related activities. The lifecycle GHG emissions of gas-fired power generation are 40% lower compared to oil-fired and 50% lower compared to coal-fired. Switching from coal to natural gas in electricity generation can reduce the carbon intensity of fossil energy and improve air quality in many urban areas, in particularly in developing countries, given their rapid rate of urbanization.
- Phasing-out oil and coal power plants and switching to gas would reduce global carbon emissions by ca. 10Gt p.a. allowing a buffer of only 3-5 years until the exploitation of the 2-degrees carbon budget. (SET-Nav 2019)
- Methane is a potent greenhouse gas. Conducting methane emissions mapping exercises in terms of detection, quantification and mitigation of methane emissions along the gas value chain is necessary to better plan emissions management.
- Detection and elimination of methane emissions is a top priority for the natural gas industry.
- There are several collaborative industry initiatives to improve understanding the scale of methane emissions, potential sources, and opportunities for reductions.

Case Study

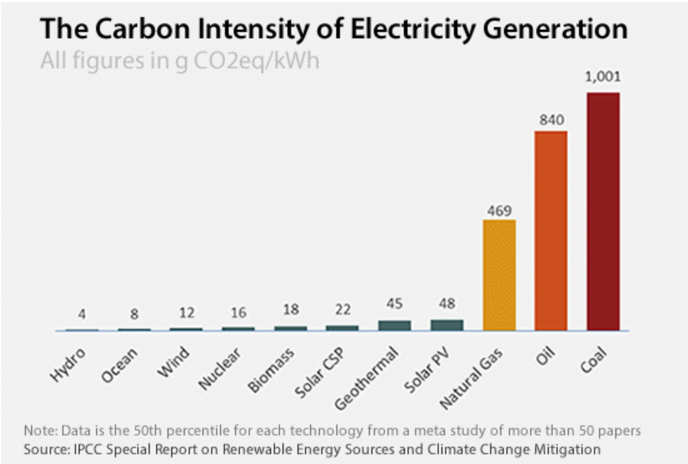
- ***Gas industry initiatives:***
  - Methane Guiding Principles: On 22 November 2017, eight companies signed a set of Guiding Principles on Reducing Methane Emissions across the Natural Gas Value Chain. The Guiding Principles were developed collaboratively by a coalition of industry, international institutions, non-governmental organisations and academics (link). Since then, the initiative has grown to include 32 signatories and supporting orgnisations, all committed to a single goal of delivering reductions in methane emissions in the natural gas sector.
  - GIE and MARCOGAZ published the Report on “Potential ways the gas industry can contribute to the reduction of methane emissions”: While the efforts of the European Union (EU) to reduce the greenhouse gas impact of its energy system is focused on mitigating CO2 emissions, regulation (EU) 2018/1999 on the Governance of the EU requires the European Commission to propose an EU strategic plan for methane. To this end, the Directorate General for Energy of the EC invited GIE and MARCOGAZ to investigate the potential ways that the gas industry can contribute to the reduction of methane emissions and to report their findings. Following to the request, GIE and MARCOGAZ conducted an industry-wide study, with contributions from representatives of the entire gas value chain from exploration and production through to utilisation, including biomethane.
  - UNECE + GMI - Ongoing report “Best Practice Guidance for Methane Management in the Oil and Gas Sector”

Reducing the Environmental Footprint of the Energy Sector

Nuclear energy

ENERGY

Nuclear energy is the world's second largest source of low-carbon power, with about 30% of the total in 2015. It displaces about 2 Gt of CO_2 every year. Reducing costs through economies of scale and deployment of innovative small and medium reactors may improve nuclear power's contribution.



- Many countries have determined that they will not be able to achieve their development objectives without deploying nuclear power. Finland, France, Czech Republic, Russia and Ukraine are expanding their nuclear power base, while Belarus and Turkey are building nuclear power plants for the first time. Poland has no nuclear power plants, however, the country is preparing to build its first nuclear power units in the Pomerania region.
- Advanced nuclear power systems incorporate passive safety features. Reducing costs through economies of scale and deployment of innovative small and medium reactors will have to be accelerated. Over fifty models of such reactors are under design and regulatory approval in different countries. Although attractive as a means to meet carbon neutrality, nuclear power provided by the new plants would be more expensive per kilowatt than several alternatives, including energy efficiency measures, renewable energy sources such as biomass and wind, and new natural gas plants.
- Greater policy and public support are achieved when connectivity is established between nuclear energy and sustainable development in meeting national socio-economic needs, notably jobs and higher value-added manufacturing and services. Also, when national resources and uranium recovery available can further support nuclear energy development and facilitate economic growth.

Case Study - Road to development and carbon neutrality

- To meet energy demand, Finland introduced nuclear energy in 1978. Finland today has four nuclear reactors providing about 30 per cent of its electricity. A fifth reactor is under construction, and another is planned, to take the nuclear contribution to about 60 per cent.
- Finland's four existing reactors (about 2700 MWe net total) are among the world's most efficient, with an average lifetime capacity factor of over 85 per cent and average capacity factor over the last ten years of 95 per cent.
- In June 2019, Finland announced a new energy policy to achieve carbon neutrality by 2035. In addition to the commissioning of two nuclear power reactors, the policy is supportive of operating lifetime extensions for existing reactors.

Deep Transformation of the Energy System

ENERGY

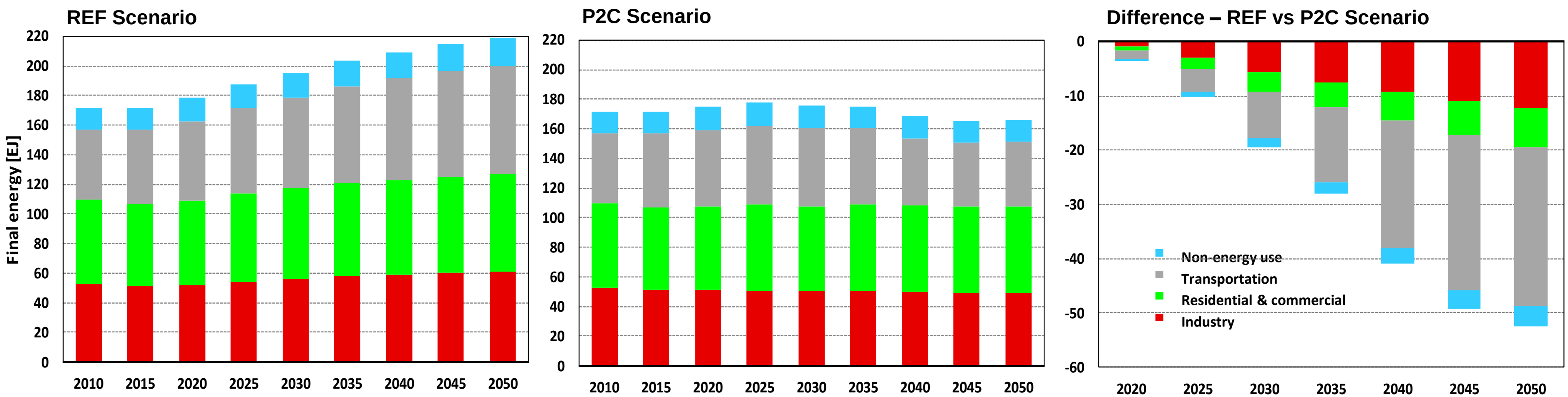
Summary

- The future energy system must be designed with efficiency and productivity as core values. Improving energy efficiency can reduce carbon emissions competitively but cannot lead to deep decarbonization on its own.
- There is potential to enhance the interplay between renewable energy and natural gas in electricity generation in the UNECE region. The flexibility and low capital and operational expenditures make gas a viable source to support introducing intermittent renewable energy into the grid.
- UNECE member States seek to develop flexible systems that would decrease the requirement for natural gas in power generation. There is potential for an increasing interaction between renewable energy and different types of gases. In the long-term renewable and decarbonized gases could displace natural gas.
- The competitiveness of renewable power generation options has been substantially increasing. In 2015, the installed electricity capacity of renewable energy sources in the UNECE region amounted to about 869 GW (388 GW from large hydro power plants), accounting for almost half (49%) of the renewable electricity capacity installed worldwide.
- Renewable energy is playing a key role in the transformation of the energy system. Fostering development and deployment of solutions that increase system flexibility to allow a higher share of renewable energy is pivotal.
- A modernized energy system increasing relies on renewable resources. Digitalization plays a key role in supporting the uptake of renewable energy. The ‘3D energy transition’ to a decarbonized, decentralized and digitalized energy system is underway. Grid operators will need to embrace new business models and increase cooperation with new market entrants and community.

Deep Transformation of the Energy System
Energy Efficiency

ENERGY

<u>The future energy system must be designed with efficiency as its core value.</u> Energy efficiency is a *still* low hanging fruit that can reduce carbon emissions competitively but cannot lead to deep decarbonization on its own.



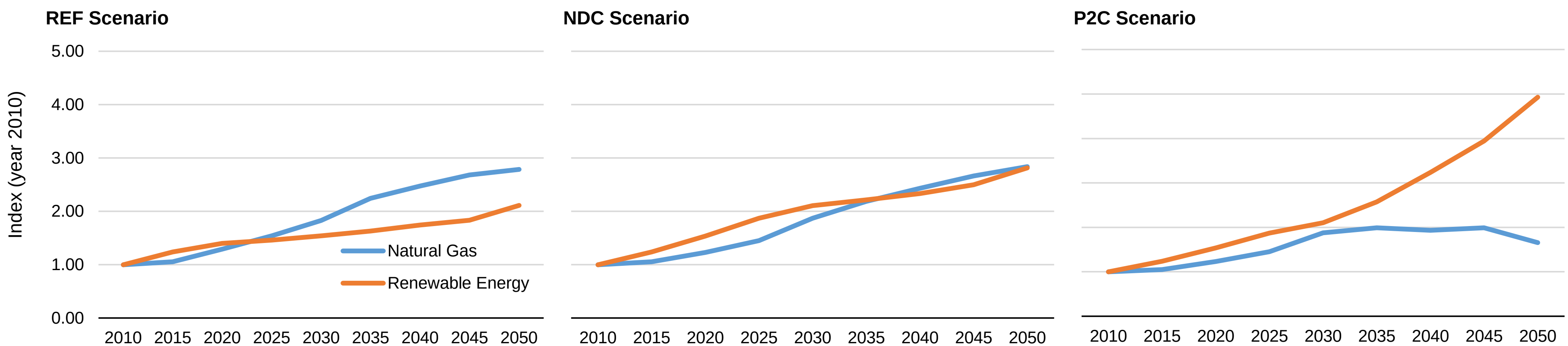
- **Industrial Energy Efficiency**: It brings financial benefits to the companies, not just by the value of the energy saved, but also of increased productivity due to process optimization. The main challenge for improvement of industrial energy efficiency is addressing the issue of highly energy intensive processes in some industrial sectors (e.g. cement, steel, chemicals, etc.). This could be addressed with fostering innovation, and targeted R&D that would drive the industry to better efficiency improvements.
- **Building Energy Efficiency**: Buildings are central to meeting the sustainability challenge. In the developed world, buildings consume over 70% of the electric power generated and 40% of primary energy and are responsible for 40% of CO2 emissions from the energy services they require. The UNECE High Performance Buildings Initiative (HPBI) encourages member States to disseminate and deploy the *Framework Guidelines for Energy Efficiency Standards in Buildings* worldwide. HPBI is aimed at radical reduction of the global carbon footprint of buildings and dramatic improvement in the health and quality of life provided by buildings.
- **Transport Energy Efficiency**: Compulsory fuel economy standards played a pivotal role in boosting the efficiency of road vehicles. Carbon taxes have only a limited impact on the cost of mobility. Change in customer preferences coupled with the speed of innovation and commercialization of new technologies, such as electric vehicles, biofuels and hydrogen, are expected to drive decarbonization of transport. Most of the transport in urban areas is consisted of commuter transportation for short distances. This should be addressed with proper planning of city infrastructure and transport efficiency. Large freight transport remains a challenge due to the volume and complexity of the transportation system

Deep Transformation of the Energy System
Natural Gas and Renewable Energy

ENERGY

<u>There is potential to enhance the interplay between renewable energy and natural gas in electricity generation</u> in the UNECE region. Natural gas capacities can be an enabler in the mid-term to ensure secure and continuous power generation due to renewable energy intermittency.

Growth of Natural Gas vs Renewable Energy in Power Generation, in ECE region by scenarios

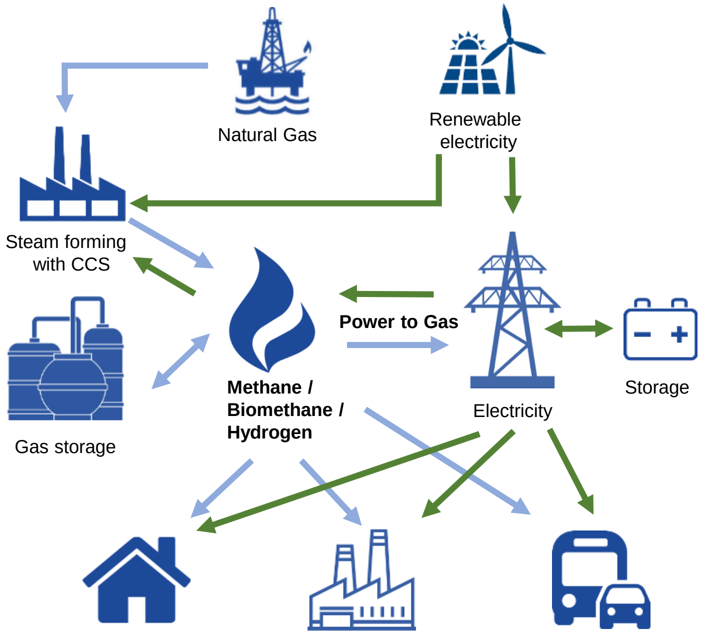


- According to data, based on REF scenario in 2030, natural gas is expected to account for 40% and renewable energy for 26% of the total electricity generation mix. By 2030 in NDC and P2C scenarios, higher penetration of renewable energy is anticipated. Natural gas is expected to marginally increase its share to 41% and renewable energy by additional 10% to 36%, respectively.
- By 2050 in all scenarios greater penetration of renewable energy is anticipated. In the REF scenario, natural gas is expected to account for 51% and renewable energy for 30%. Slight change is expected in NDC scenario – the share or natural gas in the power generation mix is expected to remain at 51% and the renewable energy is expected to increase its share to 39%. In P2C scenario, structural changes occur as countries embrace more stringent climate mitigation policies. The share of natural gas is anticipated to half to 24% whilst the renewable energy is expected to expand to 56%.
- The flexibility and low capital and operational expenditures make gas a viable source to provide the baseload requirements for introducing renewable energy into the grid sustainably.

Deep Transformation of the Energy System
Natural Gas and Renewable Energy

UNECE member States seek to develop flexible systems that would allow decarbonization of the power generation. There is potential for an increasing interaction between renewable energy and different types of gases. In the long-term renewable and decarbonized gases could displace natural gas.

Interplay between Renewable Energy and Gas



- A combination of electrons and molecules, both produced by traditional or renewable sources, and the use of a more integrated and interlinked gas and electricity models will be help to accelerate and deepen energy transition.
- Decarbonization projects such as power-to-gas, energy storage and renewable, decarbonized and low-carbon gases (e.g. green/blue hydrogen and biomethane) will decrease the environmental impact and carbon footprint of the energy sector.
- Renewable/decarbonized gases, such as hydrogen produced through renewable energy and biomethane/biogas could be used for power generation to phase out natural gas as it can be produced in the carbon-neutral manner.
- Power-to-gas technologies use electricity that cannot be used directly or stored in batteries but can be instead stored as gas within the gas system at minimum costs.
- Renewable/decarbonized gas could be used in sectors where electrification is difficult such as aircraft, ships, lorries.
- The existing gas infrastructure can enable the transition to a low emission economy as it can deliver high storage and transmission capacity in an efficient and cost-effective way (gas infrastructure as the backbone of the future energy system).
- This emerging industry is still facing legislative and structural challenges. The value chain for renewable gases is still premature with high energy conversion losses. In addition, public acceptance and perceived safety impose barriers for implementation and further commercialization.

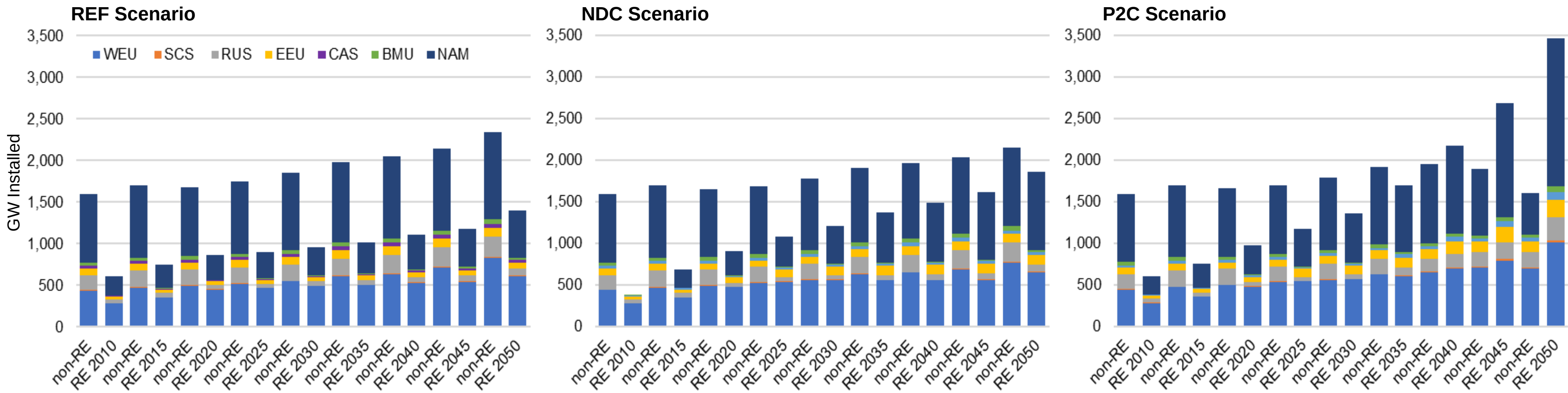
Case Study

- Trinomics study "Impact of the use of the biomethane and of the hydrogen potential on trans-European infrastructure" will be published on September 2019, aims to obtain a better picture on the potential of biomethane and hydrogen to contribute to the decarbonization of the EU energy system, the impacts this will have on gas infrastructure and the extent to which network operators and regulators are prepared to cope with these impacts. This will support the development of policies considering other developments in the European energy system, such as the coupling of the electricity and gas sectors and the electrification of energy demand.
- Other case studies: Uniper Energy Storage (P2G), Transforming North Sea energy supply by gas-wind collaboration (link), GE and eSolar cooperate on solar combined cycle technology (link), First integrated Renewables Combined-Cycle Plant Powered by GE Technology (link)
- Renewable gases: biogas/biomethane, renewable H2 and synthetic gas (based on RES based CO2 + Air capture)
- Decarbonized gases: H2 (90% decarbonized) and synthetic gas (based on RES based CO2 + Air capture)

Deep Transformation of the Energy System
Renewable Energy

<u>The competitiveness of renewable power generation has been substantially increasing.</u> In 2015, the installed electricity capacity of renewable energy sources in the region amounted to about 869 GW (388 GW from large hydro power plants), accounting for almost half (49%) of the renewable electricity capacity installed worldwide.

Non-renewable vs. Renewable Electricity Generating Capacity per Subregion and Scenario



- On the global level, nearly two-thirds of all new power generation capacity added in 2018 was from renewables (mainly solar and wind followed by hydropower and bioenergy), led by emerging and developing economies.
- Increasing installed capacity of renewable energy technologies in many UNECE countries has driven a reduction in capital costs and increased investor confidence in lifecycle costs, improving their economic viability. It must be noted that the role of renewable energy in the energy mix across the region is highly variable. Whilst Europe and North America account for 23% and 16% of the total renewable generation capacity, the Caucasus, Central Asia and Russian Federation collectively account for only 4%.
- Renewable energy potential (power, heat, transport) remains untapped in many UNECE countries, particularly in the Caucasus, Central Asia, the Russian Federation, and South East and Eastern Europe which represent only a fraction (0.2%) of the global investments in renewable energy in 2015 .

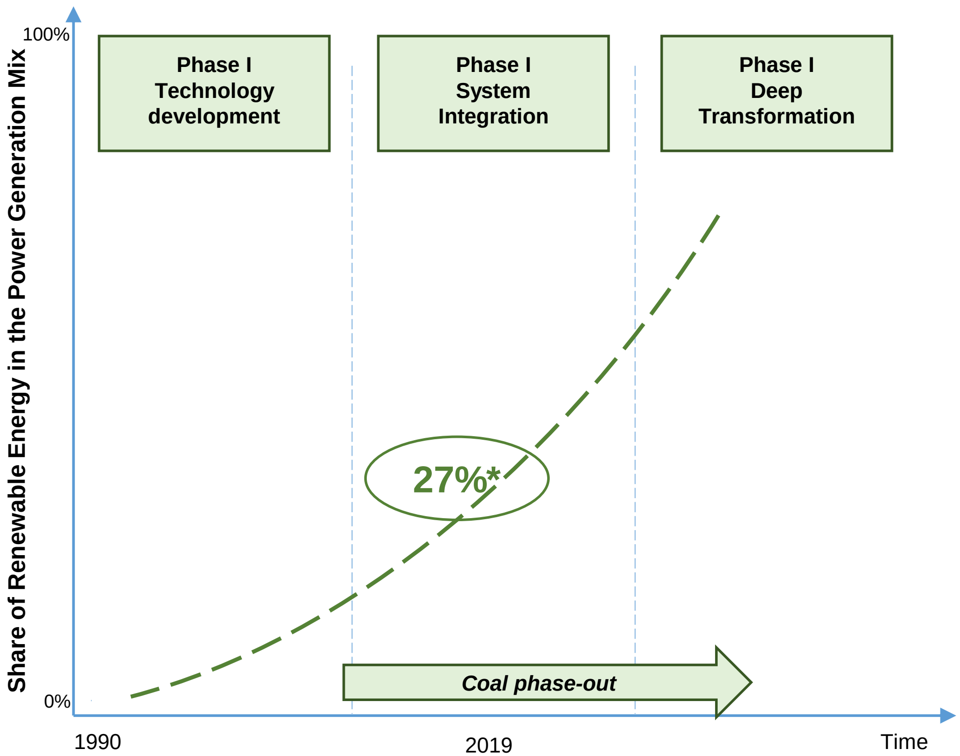
** For subregions abbreviations see slide 5*

Deep Transformation of the Energy System
Renewable Energy

ENERGY

Renewable energy is playing a key role in the transformation of the energy system. Fostering the development and deployment of solutions that increase the system flexibility required to integrate higher shares of renewable energy is pivotal.

Evolution of the Renewable Energy in the Energy System

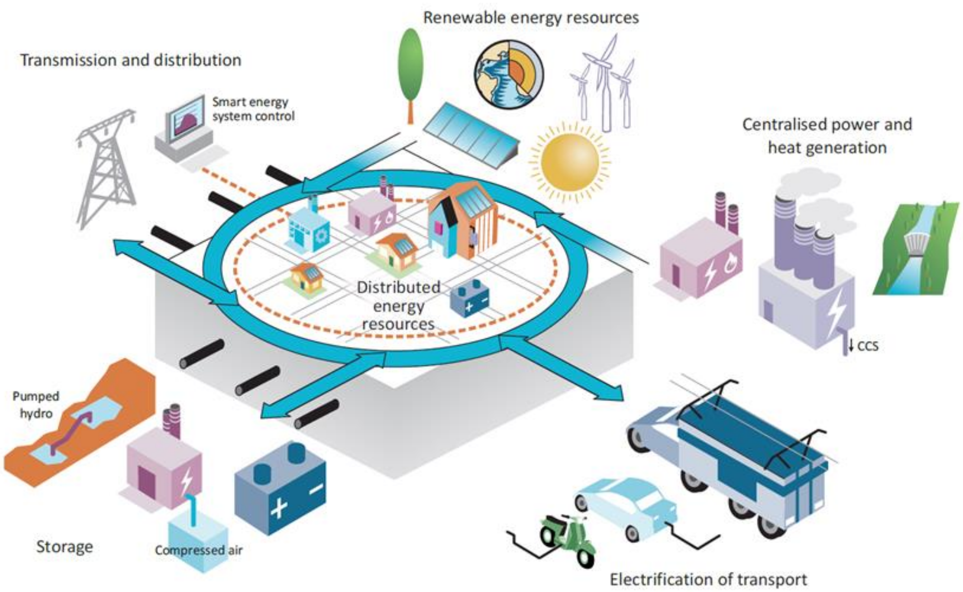


*Share of renewable energy in the total UNECE power generation mix

- The current challenge is to integrate renewable energy technologies into present and future energy systems and different sectors, including electricity generation, heating and cooling, gas and liquid fuel distribution as well as autonomous energy supply systems.
- Integration of fluctuating renewable energy into power and heating grids is one of the biggest challenges towards fostering sustainable energy. Flexible power systems such as hydro power plants and storage systems, can play an important role in grid resilience and stability and are of vital importance to balance the fluctuations of the wind and solar PV.
- Other flexibility options involve demand side management incentivizing customers (private, commercial and industrial) to manage or decrease energy consumption. Heat generation from renewable energy at a large scale (solar, geothermal and biomass) requires the development of heating supply systems, while integration of smaller-scale renewable energy into existing heating systems needs to account for many more factors of the system (temperature, content, water quality, etc.) than the excess electricity generated from non-dispatchable renewable power plants.
- Long term storage will be needed when renewable energy will account for higher share of power generation mix. Power-to-X technologies which can be used for production of hydrogen and subsequent conversion of hydrogen into hydrocarbons such as synthetic methane and methanol, will play important role in deeop decarbonization of the energy system.

A modernized energy system increasing relies on renewable resources. <u>Digitalization plays a key role in supporting the uptake of renewable energy.</u> The ‘3D energy transition’ to a decarbonized, decentralized and digitalized energy system is underway. Grid operators will need to <u>embrace new business models and increase cooperation</u> with new market entrants and community.

Modernised Integrated Energy System, source: IEA 2017



source: IEA 2017

- Innovation and technological developments are steering the direction of the transition. As electricity becomes a vehicle for achieving deep transformation of the energy system, the incumbent energy utility companies that rely on the traditional large centralized generation systems and passive consumers need to modernize to protect their market share.
- New business models will necessarily be developed on lower carbon applications, increasing energy efficiency and more control by customers under the assumptions in this modelling exercise. Platforms of trusted innovative technologies are expected to create the foundation for the further development of such a system.
- Technology integration into the energy system, therefore, is a prerequisite for energy transition and modernization of the energy system. Ongoing innovation and digitalization of the energy system is creating a new generation of consumers.
- Consumers are gradually more interested in installing solar panels and other sources of residential and community scale renewable power generating units are being deployed. Modern customers value to be in control. The so-called prosumers value to produce as well as consume energy. As the cost curve for renewable energy is coming down and more reliable storage solutions (e.g. batteries) are being developed, consumers move to a central position.
- Challenge – cyber security poses a threat to the deep transformation of the energy system. For example, EV charging stations pose an opportunity for hackers to attack the system of the grid and disrupt the service. Currently only few charging stations have protecting software that block intrusion.

Sustainable Resource Management

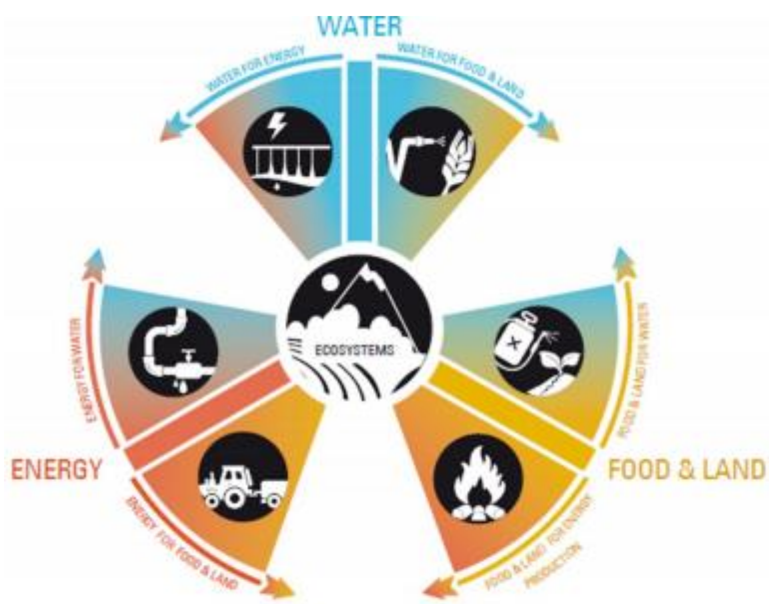
Summary

- The food-water-energy nexus approach aims to enhance security of resources by increasing efficiency, reducing trade-offs, identifying synergies and improving governance across sectors, while protecting the integrity of ecosystems.
- Renewable energy technologies could address some of the trade-offs between water, energy and food production, bringing substantial benefits in all three sectors.
- Low-carbon futures will have implications on countries' resource base and availability, costs and prices of critical raw materials and rare earth minerals. Sourcing these essential materials and minerals will be a challenge and are shifting geopolitical relationships.
- Sustainable resource management practices that embrace circular economy principles and that integrate the full spectrum of the 2030 Agenda should be on the forefront of countries' strategies.

Sustainable Resource Management
Food-water-energy Nexus

The food-water-energy nexus approach aims to enhance security of resources by increasing efficiency, reducing trade-offs, identifying synergies and improving governance across sectors, while protecting the integrity of ecosystems.

Water-Food-Energy-Ecosystems Nexus, source: UNECE 2017



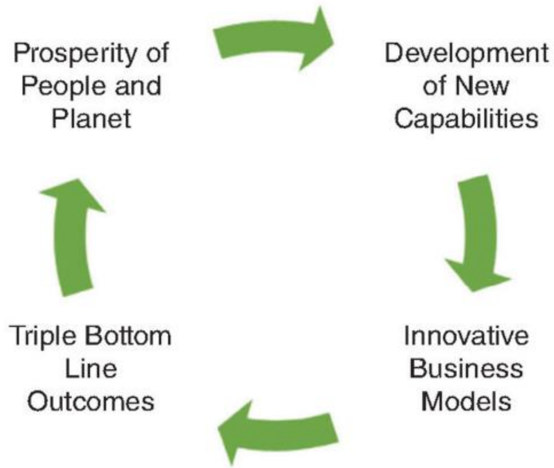
- The objective of the water-energy-food-ecosystem nexus approach is promoting coordination and integrated planning and sustainable management of interlinked resources across sectors in order to accelerate the implementation of the 2030 Agenda and the Paris Climate Agreement.
- Integrated management of natural resources such as energy, raw material and water resources could improve efficiencies, reduce the environmental foot print and eliminate wastes.
- The distributed nature of many renewable energy technologies means that they can offer integrated solutions for expanding sustainable energy while enhancing security of supply across the three sectors. This contributes to addressing the region's strategic energy challenges.

Case Study – Transboundary river basins

- In transboundary river basins in South East Europe, the Caucasus and Central Asia, the riparian countries have active hydropower development, but also have the potential to exploit other renewable sources such as solar, wind and geothermal energy.
- The UNECE promotes transboundary cooperation in both energy sector development and water management. Increasing the share of renewable energy in the region can help to reduce water requirements in the power generation; boost water security by improving accessibility, affordability and safety; and contribute to food security objectives.
- Lack of intersectoral coordination is a major challenge in leveraging all the existing opportunities for renewable energy deployment in the riparian countries. This gap exists on both national and subregional level in energy, land management, and water resources planning.

Sustainable Resource Management
Food-water-energy Nexus

The Food – Water – Energy nexus integrating the security, accessibility and affordability of essential resources underpins the sustainable management of resources with the 2030 Agenda framework. The United Nations Framework Classification of Resources (UNFC) is a tool that breaks "silos" and links policy objectives seamlessly to project implementation.



Case Study – Integration of energy and water resource management

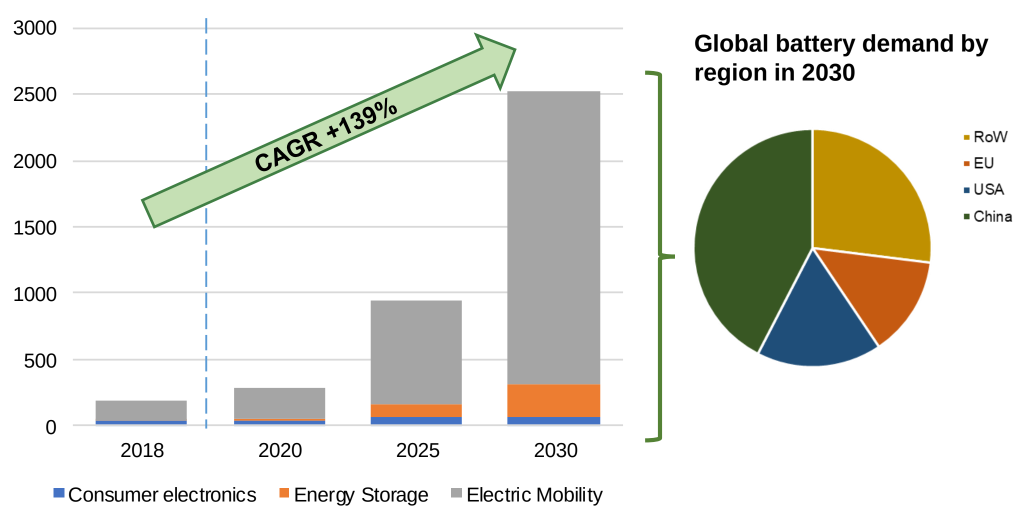
- Energy and water resources are integrally related and strongly interdependent. Facilitating their integrated management and monitoring can therefore offer an important foundation for sustainable development. The United Nations Framework Classification of Resources (UNFC) can support this process by enabling harmonized data and information on energy and water resources.
- The UNECE project "Integrated energy and water resource management in support of sustainable development in South-East Europe and Central Asia" started in 2018, with the participation of Bosnia and Herzegovina, Kazakhstan, Kyrgyzstan and Serbia.
- UNFC has built-in guidance for the management of social and environmental aspects throughout the cycle of natural resource development. Best practices promoted by UNFC delve into approaches that can help to transform challenges into opportunities.

Source: ECE/ENERGY/GE.3/2019/10 United Nations Resource Management System: Concept and design

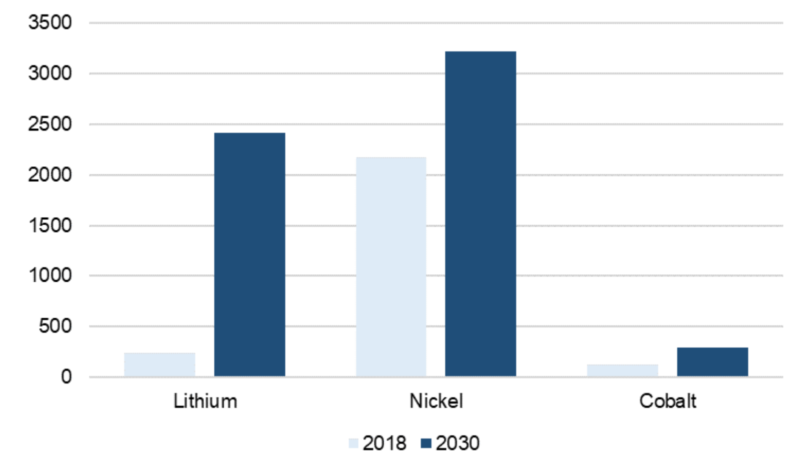
Sustainable Resource Management
Resources and Circular Economy

Low-carbon futures will have implications on countries' resource base and availability, costs and prices of critical raw materials and rare earth minerals. Sourcing these essential materials and minerals will be a challenge and are shifting geopolitical relationships.

Global battery demand by application , GWh



Demand for Metals, 2018 vs 2030, kt



- Massive amounts of critical raw materials will be required (e.g. for batteries and renewable energy technologies, such as lithium, cobalt and nickel) to aliment the energy revolution.
- Limited access, availability and rising costs could be a limiting factor due to induced import dependency bottlenecks with large amounts of materials supplied by a very limited number of countries. Alternative technologies, innovation, acceptable international standards and adoption of circular economy practices can reduce material demand and costs and increase resource security.

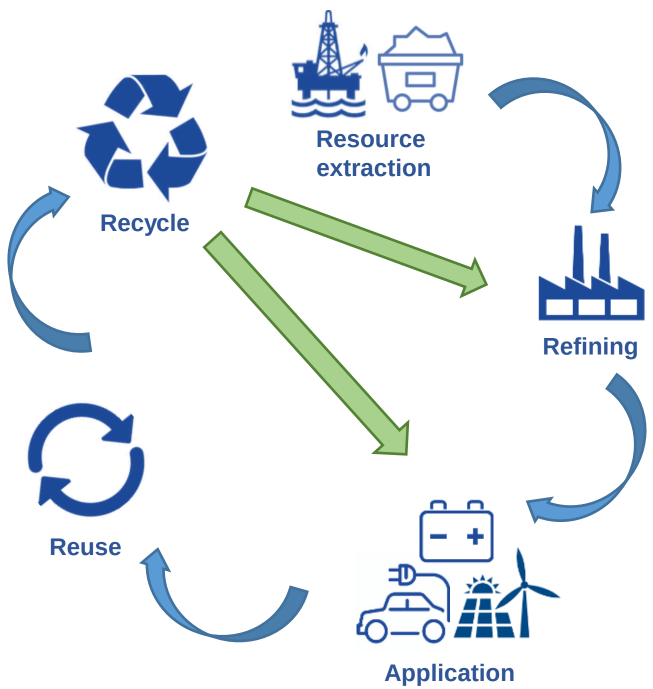
Source: McKinsey and WEF – Global Battery Alliance, 2019

Sustainable Resource Management
Resources and Circular Economy

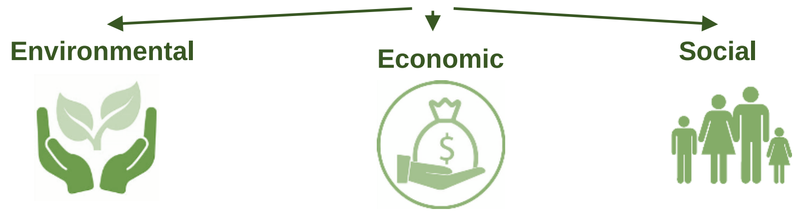
ENERGY

Sustainable resource management practices that embrace circular economy principles and that integrate the full spectrum of the 2030 Agenda should be on the forefront of countries’ strategies.

Renewable Technologies and Batteries value chain



Positive Impact of Circular Economy



- Over 80 elements in the periodic table are required for energy production today. Rate of recycling and reuse varies from 1 to over 80%. Increasing recycling rates will reduce the pressure on demand for primary raw materials, help to reuse valuable materials which would otherwise be wasted, and reduce energy consumption and greenhouse gas emissions from extraction and processing. Over 15 elements of the periodic table have achieved more that 50% recycling rates.
- United Nations Framework Classification for Resources (UNFC) is an existing universal standard that can facilitate policy and strategy formulation, government resources management, industry business process and capital allocation.
- Systems-thinking approach would be required in which the whole life-cycle of resource production and consumption should be considered both from producers and consumers’ side. Apart from price and quality, end-users are becoming more aware about environmental and social issues.
- Knowledge will be crucial for resources management and strengthening the circular economy. There is a need for a comprehensive raw materials management system, such as the United Nations Resource Management System (UNRMS) assessing resources for the circular economy.

Roadmap for the Presentation

ENERGY

1. **Pathways to Sustainable Energy Project Phase I Review**
   - Pathways Project Design and Objectives
   - Key Takeaways
   - Detailed Scenarios and Modelling Results
   - Expert Groups Insights - Role of All Technologies in Attaining Sustainable Energy in the UNECE Region
     - Reducing the Environmental Footprint of the Energy Sector
     - Deep Transformation of the Energy System
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   - **Proposed Concept for an Early Warning System for Policy Makers**

2. **Policy Recommendations from Phase I**

3. **Phase II & Next Steps**
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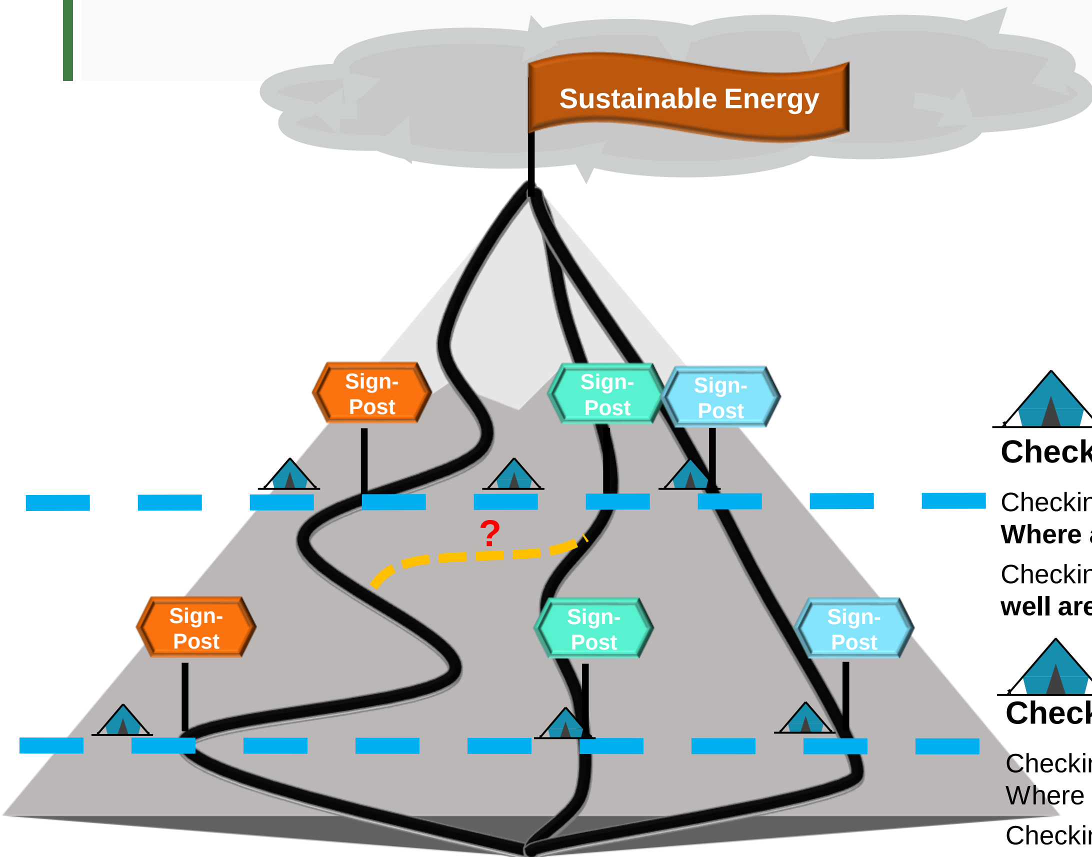
   - Partner Organisations

Conceptualization of an Early-Warning System

ENERGY

The purpose of the early-warning system is to inform countries if achievement of sustainable energy objectives is on track or not.



Checkpoint 2040:

Checking **Sign-Post** in 2040. **Where are we?**

Checking **KPI** in 2040: **How well are we doing** ?

Checkpoint 2030:

Checking Sign-Post in 2030. Where are we?

Checking KPI in 2030: How well are we doing?

- The early-warning system can help identify the national status of moving towards sustainable energy targets in 2050 and to track progress towards the implementation of the 2030 Agenda and the Paris Agreements.
- The early-warning system can also support countries in monitoring achievements of providing clean and affordable energy for all while implementing NDCs, and to allow corrective collective measures if the achievements of sustainable energy objectives are not on track.
- Through the definition of signposts, selected indicators, countries can track if their chosen policy actions prove to be successful, or if course corrections are required.
- The early-warning system shall further help to assess towards which scenario or pathway the world is moving over time. The following graphic visualizes the scenario development, highlighting different pathways that can lead to the same desired result.

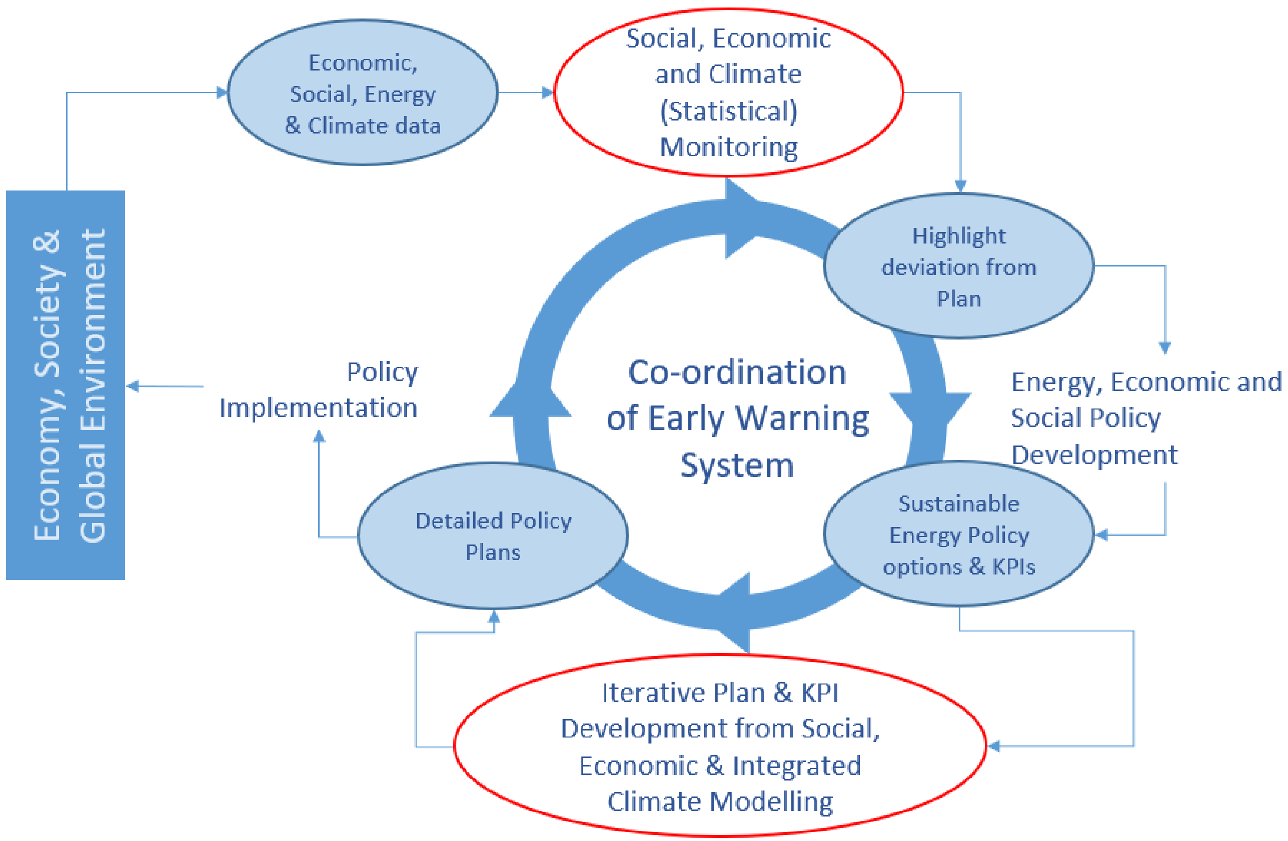
Same starting point - different pathways represent different policy options

Note: for more information document "Early Warning and Planning System"

Elements of an Early Warning System

ENERGY

An early warning system requires an iterative process. Sustainable energy policies affect global economy and environment. Global challenges can be tracked and incorporated in the model making the regional monitoring process more realistic and relevant.



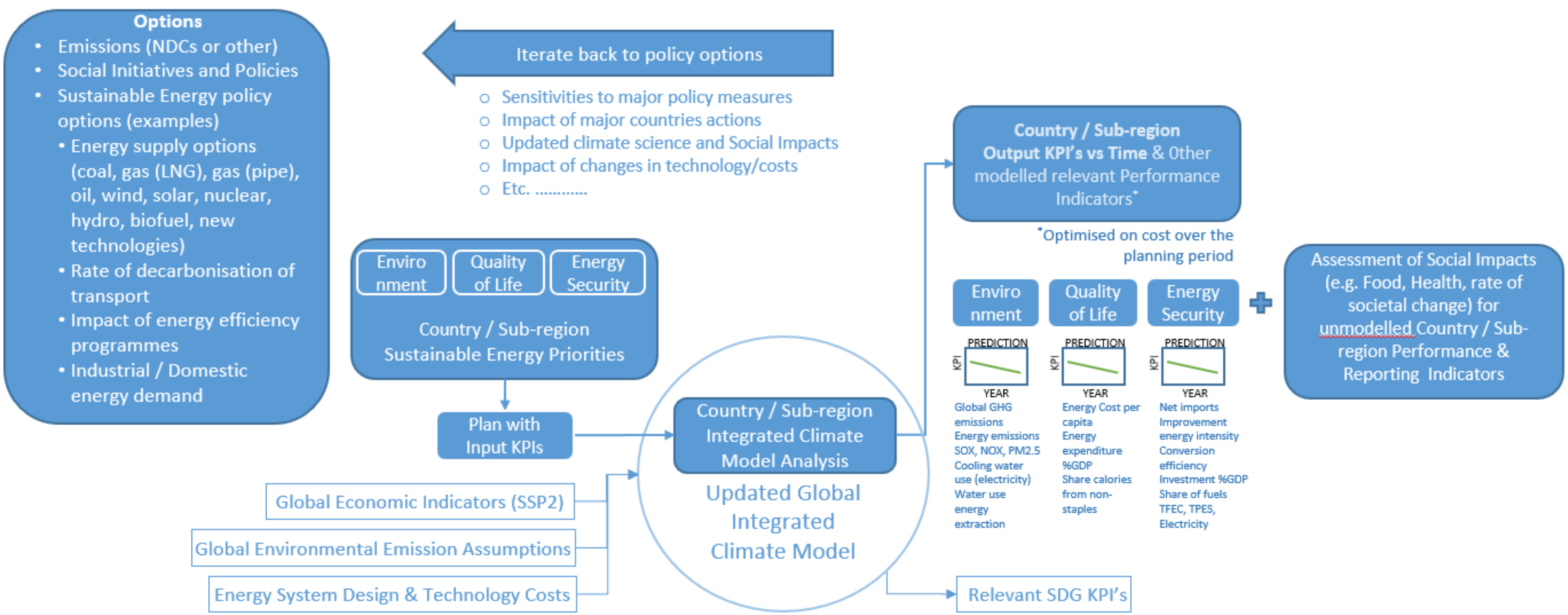
- Any deviations can lead to a revision of the initial targets and the adjustment of sustainable energy aims. The sustainable energy targets and updated input assumptions can then be used to model adaptive pathways towards these targets. Insights from the modelling activity can then be used to aid the policy design with the latest information.
- This process can become iterative. It is estimated that this process would have to be repeated every couple of years to allow enough time for the policy to produce notable results and changes in the global system to be incorporated.
- The overall concept facilitates the use of scenarios to show how and by which methods and indicators unforeseen and undesirable developments can be identified early and reliably.

Note: for more information document "Early Warning and Planning System"

National Level Early Warning System

ENERGY

This Early Warning System uses a two-layered approach. The first, and most important, layer is that of a Member State. The second is that of the UNECE region which is simply a summation of the individual country inputs created in a standardized format by using the same Integrated Energy and Climate Models.



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Countries can choose from various strategic approaches to achieve sustainable energy and meet their international climate commitments.

This project defines sustainable energy through three pillars that embrace sustainable energy goals – i) energy security, energy and quality for life and energy and environment.

The main challenge is to balance trade-offs among competing goals when designing energy policies.

Energy Champions

Countries turn to domestic or global energy champions to finance and manage needed investments while deploying an array of policy measures aligned (e.g, standards or fiscal incentives)

Policy Stretch

Countries consider that intensification of investment in energy efficiency and renewable energy and new entrants in both supply and demand sides accelerate the transformation to a low carbon energy system while meeting the demands of growing economies and populations

Deep Transformation

Countries undertake to transform energy fundamentally. The transformations cover pricing, tariffs, market design, market actors and enabling new categories of demand and supply side players

Note: for more information see “Strategic Options for Countries”

Focus on Energy Champions

- *Implement efficiency standards in appliances, buildings, and industry*
- *Encourage market concentration and global collaboration among industry leaders*
- *Reinforce networks and extend interconnected operations on a wide regional basis*
- *Expand renewable energy capacity in large, central facilities with necessary storage or back-up capacity*
- *Develop a low-carbon transport infrastructure (electric, gas, hydrogen)*
- *Deploy CCS supported by policies similar to those deployed for other low or no carbon technology*
- *Deploy HELE technology to replace the least carbon efficient power technology world-wide*
- *In countries that accept nuclear power, build new plants with existing technology and develop next generation technology*

Focus on Policy

ENERGY

- ***Expand support for low-carbon energy sources, notably renewables, by increasing portfolio obligations and by enabling greater participation of low-carbon distributed generation***
- ***Remove barriers to investment and enhance incentives to accelerate improvements in energy efficiency***
- ***Remove subsidies that distort energy markets, specifically fossil and end-use subsidies***
- ***Institute minimum performance standards for fossil fuel using technology (vehicles, powerplants)***
- ***Encourage accelerated use of ICT to improve demand-side participation in energy markets, to improve efficiencies, and to enable greater penetration of intermittent renewables***
- ***Encourage use of mechanical and chemical storage of electricity***
- ***For countries that accept nuclear power, address capital exposure and improve risk management***
- ***Invest in network infrastructure to support penetration of natural gas and to support increased regional penetration of intermittent renewables***

New Business Ecosystem

ENERGY

- ***Set a real and impactful price on carbon (greater than $120/tonne CO_2). Apply world-wide with revenues generated used to support the transition in developing countries***
- ***Invest in major energy infrastructure improvements in transport, power, and natural gas networks, socializing costs and access***
- ***Remove all energy subsidies other than those designed to commercialize new technology***
- ***Redesign energy markets to provide energy services (quality of life improvements are the business model)***
- ***Deploy ICT to improve system connectivity and efficiencies, improve demand-side participation in energy markets, and enable greater penetration of distributed generation and intermittent renewables***
- ***Conceive balancing markets in the power sector based on energy market boundaries and not political boundaries and enabling full participation by all stakeholders***
- ***Deploy minimum performance standards throughout the energy system (emissions, power station efficiencies, appliance efficiencies, buildings, and so forth)***

Energy Security / UNECE regional interdependence

ENERGY

- Most countries focus on national level actions whereas *a priori* it would appear that **global and regional solutions would be more effective if there were a culture of trust and reliability** in energy transactions.

- For the UNECE region, promoting **mutually beneficial economic-interdependence would accelerate attainment of the 2030 Agenda** through integrative nexus solutions that the notion of sustainable development offers.

- The **regional business models require a foundation of institutionalized investment and transaction frameworks.** Ensuring energy security as part of the ongoing deep transformation creates an imperative to mobilize needed investment in the energy system of the future that is rational and pragmatic socially, environmentally, and economically.

- **Concepts of energy security have evolved** over time from security of supply seen by consuming/importing countries to broader views of energy security that embrace supply, demand, and transit. With increasing penetration of digital technology throughout the energy system and with intensification of climatic events, **the energy system is exposed to new risks of either human (e.g., hacking or terrorist attacks) or natural origins (events like forest fires, hurricanes, or flooding from rising oceans).** These additional security risks create an added imperative to address the challenge of resilience in terms of both planning and recovery.

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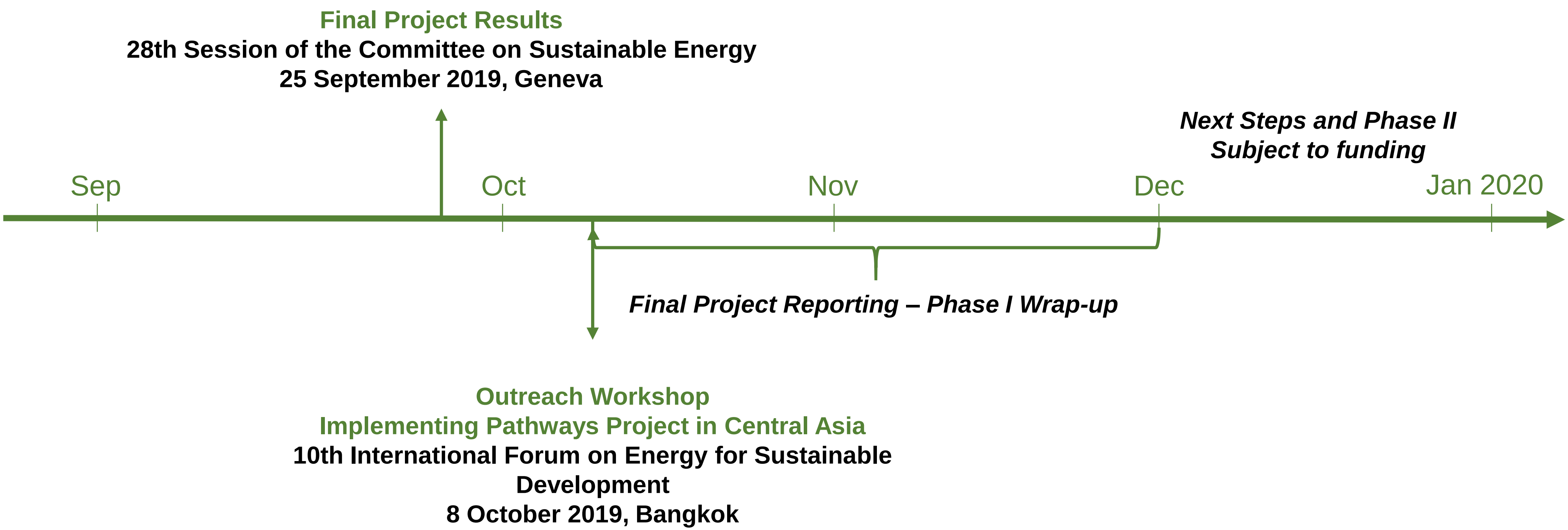
ENERGY

Project Results Outreach - Timeline



Phase II

1. Technological change is essential – *technology deep dives*

- There is considerable technological change and innovation in the pipeline, which needs further scrutiny to refine data, assumptions, types of models and linkages, interpretations and trade offs:
  - Deep dives on Natural Gas, Coal, Nuclear Power, Hydrogen
  - Others as requested and funded to complete the technology suite:
  - E.g. deep dives on Renewable Energy, Energy Efficiency, Power-to-X, Storage
  - Impacts of investing in clean fossil structures on the system
  - Impacts of methane management on the system
  - Nexus synergies
  - Cost and affordability across the region

2. Insights for regional approaches are necessary - *subregional deep dives*

- Phase I is not sufficient to understand the situation on a subregional level. Further analysis at the subregional level can improve understanding about conditions of infrastructure, governance, quality of life and role of different technologies.
- Proposed subregional deep-dives:
  - Caucasus
  - Central Asia
  - Belarus, Moldova and Ukraine
  - South East Europe

Phase II (cont.)

3. Exploring alternative nexus approaches and business models:

- Energy transition: risk and uncertainties, aka critical raw materials, access, scale up, implementation
- Water and Energy nexus
- Food and Energy nexus
- Health and Energy nexus
- Assessment of alternative business models: traditional, large-scale utilities; distributed generation; energy service companies; green energy etc.
- Use of Life Cycle Assessment to evaluate the global environmental impact of new approaches

4. Early Warning System and Global Tracking Framework Report

- Preparation of the status report on progress of the UNECE region in meeting commitments under the 2030 Agenda and the Paris Climate Agreement

5. Testing Strategic Options

- Testing strategic options by using project's modes; and the outcomes of the technology and regional assessments

6. High-Level Political Dialogue on the Project Outcomes:

- If desired, UNECE can work with member States and experts on high level political messages. The intent of the high-level political dialogue will be to enhance the respective awareness of countries’ choices with the expectation that the dialogue will lead to tightened commitments and accelerated action on energy for sustainable development.

7. Dissemination of the Project Results

- Engagement with countries and stakeholders to disseminate the project results and to discuss the results and implications of the project findings at national and local level.
- Build member State engagement and collaborations
- Integration of outputs into expert groups and partner organisations

Partners Activities

Energy Transition Tools

ENavi - Energiewende navigation system

Global Climate Forum

Theatre on Sustainable Mobility

Transition Toolkit

UNECE

ENERGY

Thank you!

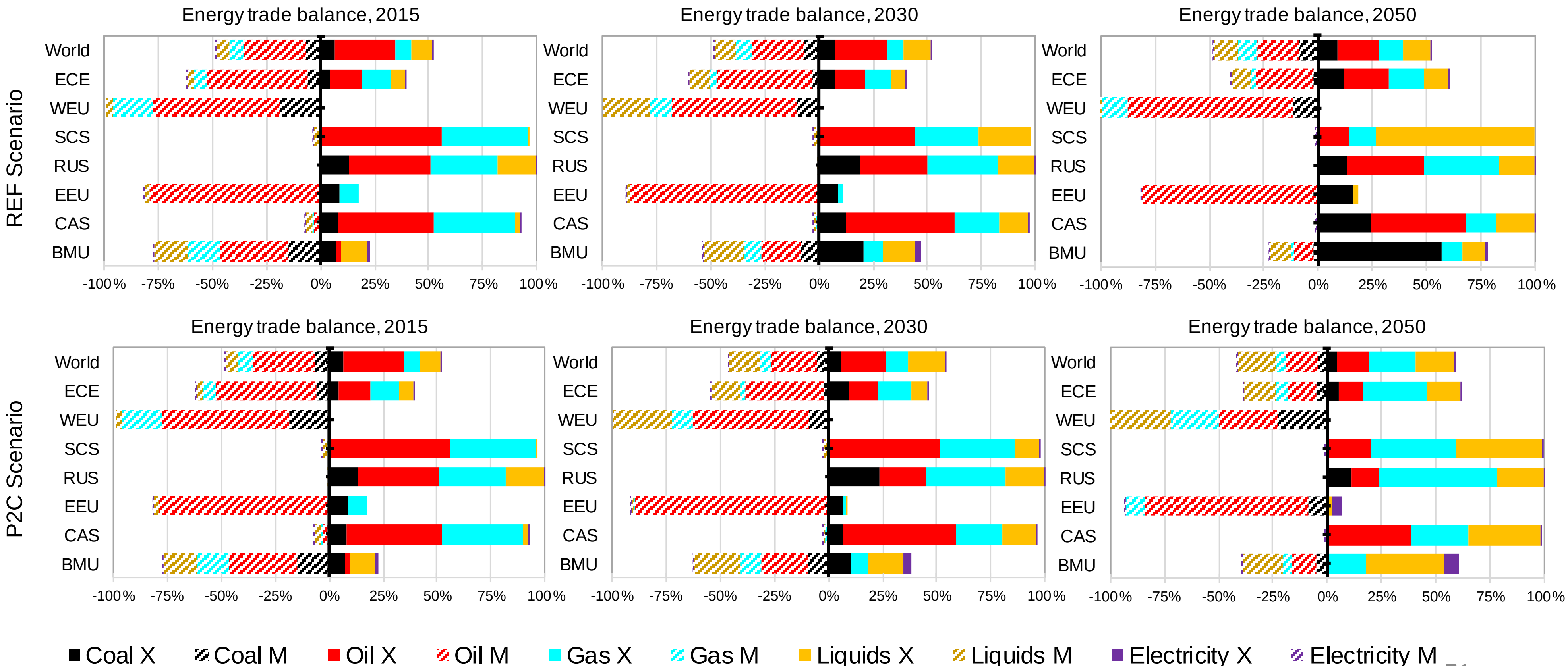
Sustainable Energy Division
UNECE
Date 25 I 09 I 2019, Geneva

More Insights

Energy Security / ECE trade balances by scenarios

ENERGY

Energy security is achieved by ensuring that energy supply, transformation, transport and demand make significant contributions to countries' social, economic, and environmental development. Countries that consider that energy supply can be assured through energy independence are prepared to pay a premium for it. Other countries consider that energy security can be achieved through diversification of technology choices, suppliers, transit routes, and consumers.

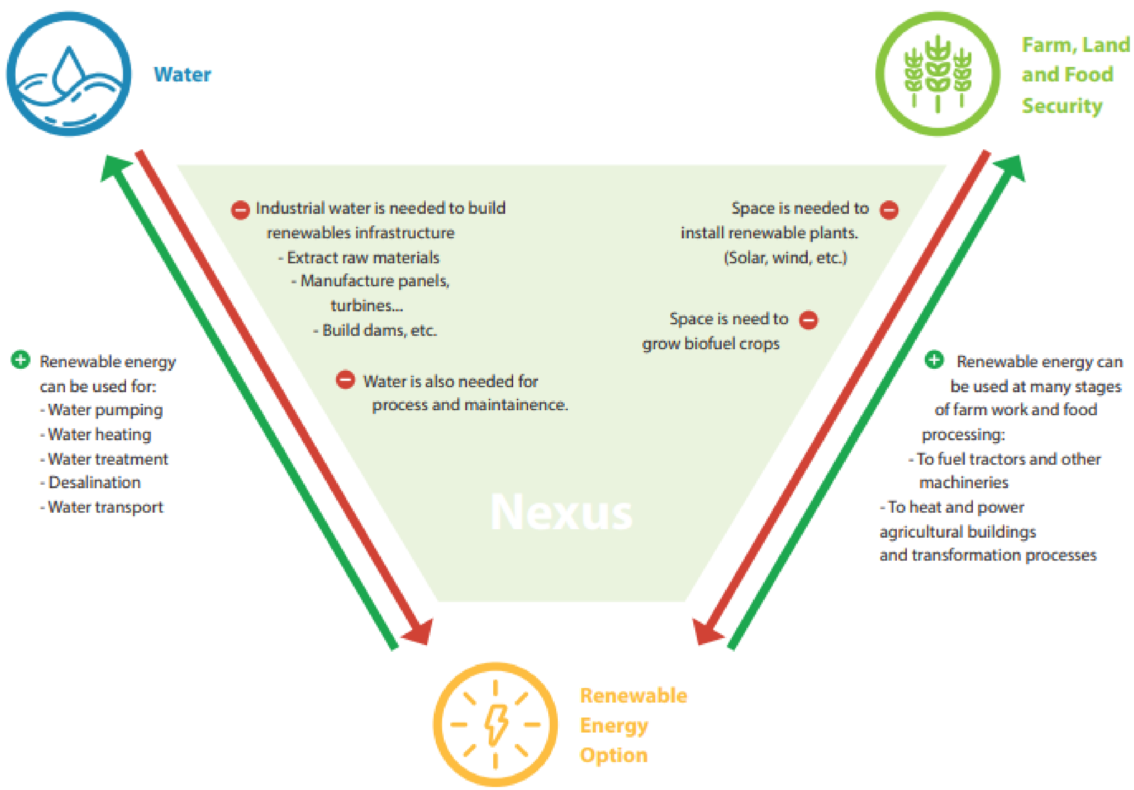


Sustainable Resource Management
Food-water-energy Nexus

ENERGY

Renewable energy technologies could address some of the trade-offs between water, energy and food production, bringing substantial benefits in all three sectors.

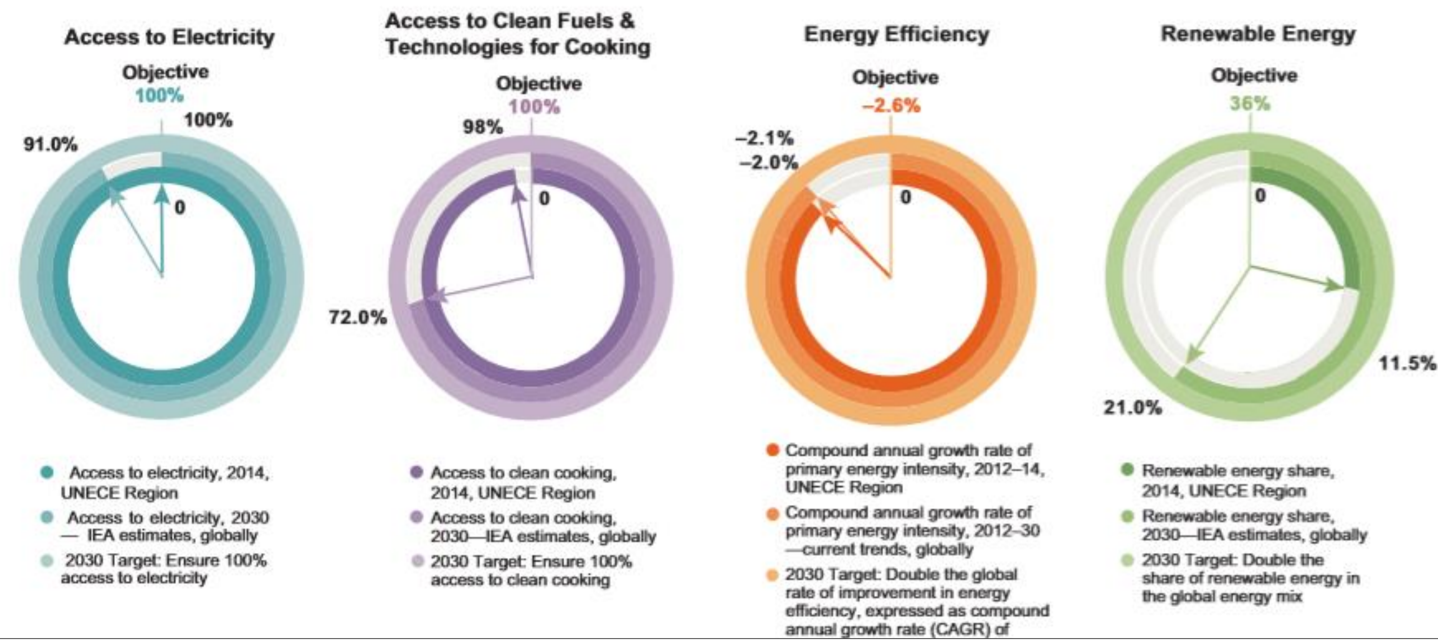
Water, land, renewable energy trade-offs in developing renewable energy sources, source: UNECE 2017



Source: Deployment of Renewable Energy: The Water-Energy-Food-Ecosystem Nexus Approach to Support the Sustainable Development Goals, UNECE 2017

Attainment of the objectives of SDG 7 is falling short in the UNECE region

ENERGY



- Energy underpins the development of economies and most of the goals and targets of the 2030 Agenda on Sustainable Development (2030 Agenda). The energy sector plays a critical role in finding solutions for both sustainable development and climate change mitigation. Since the universal agreement on the seventeen Sustainable Development Goals (SDGs) including the goal on sustainable energy SDG 7 in 2015, countries have commenced with the implementation of the 2030 Agenda.
- However, at this stage, there is a gap between the agreed energy and climate targets and the strategies and systems that are being put in place today to achieve them. UNECE region is not on track. The region has specific climate, economic, environmental and political circumstances which are reflected in inefficient use of energy, power cuts, increasing energy costs, and unsustainable and unaffordable heating in winter.
- Accelerated and more ambitious strategies and policies will be needed to fill the persistent gaps to achieve the 2030 Agenda, and in particular, energy will need to play an increasing role across various SDGs. If gaps are not addressed urgently, more drastic and expensive action will be required to avoid extreme and, potentially, unrecoverable adaptation measures.

Source: Global Tracking Framework: UNECE Progress in Sustainable Energy, UNECE 2017