UNECE

ENERGY

Pathways to Sustainable Energy

Draft Key Messages and Policy Recommendations for consultation with member States

16 May 2019, Geneva

Roadmap for Discussion

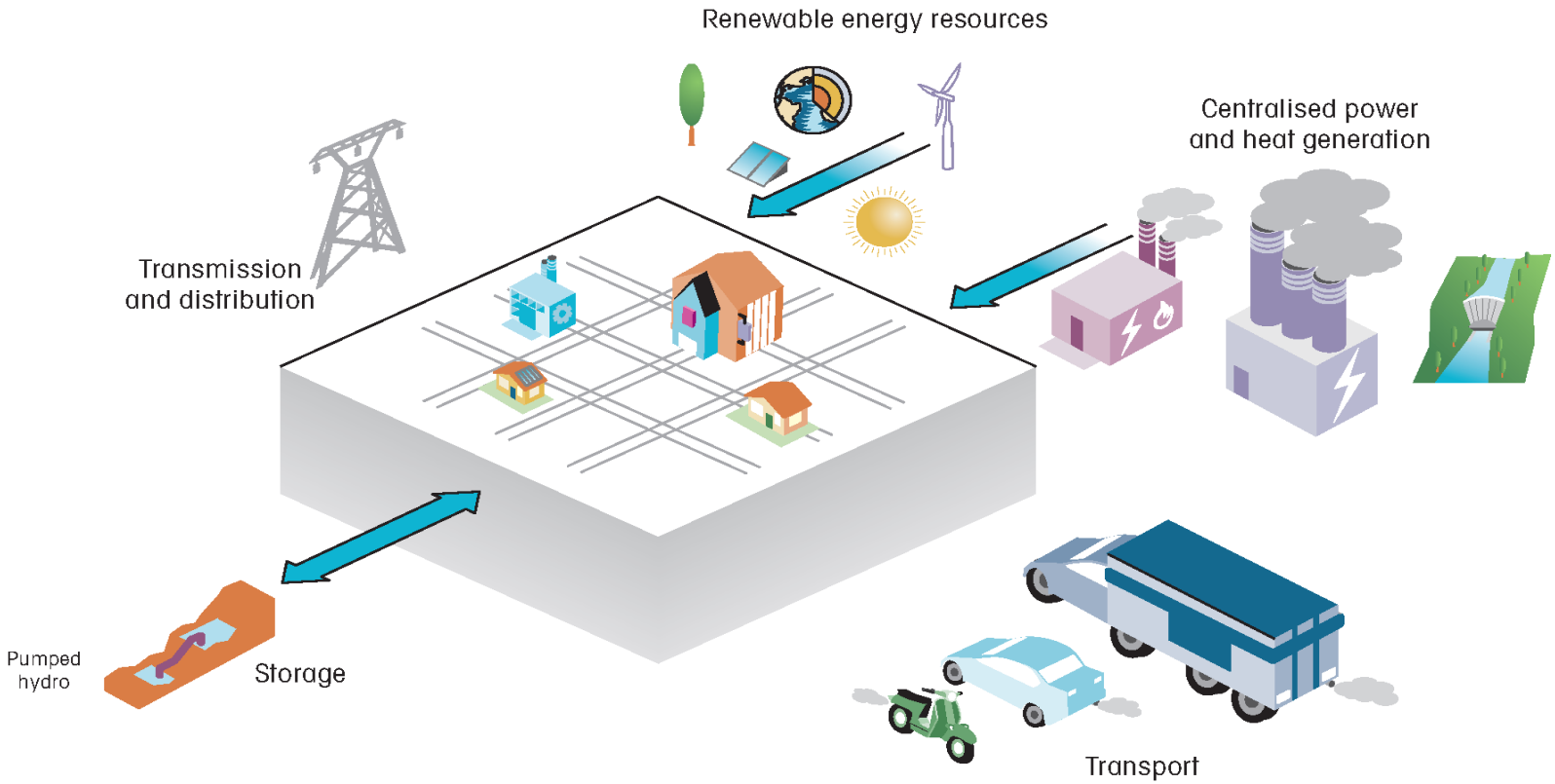
ENERGY

- Draft Summary Policy Recommendations
- Trade-offs
- Early Warning System Concept
- Phase II
- Discussion

- Additional Slides
  - Key Insights and Policy Recommendations – by Expert Group
  - Data and methodology
  - Timeline

ENERGY

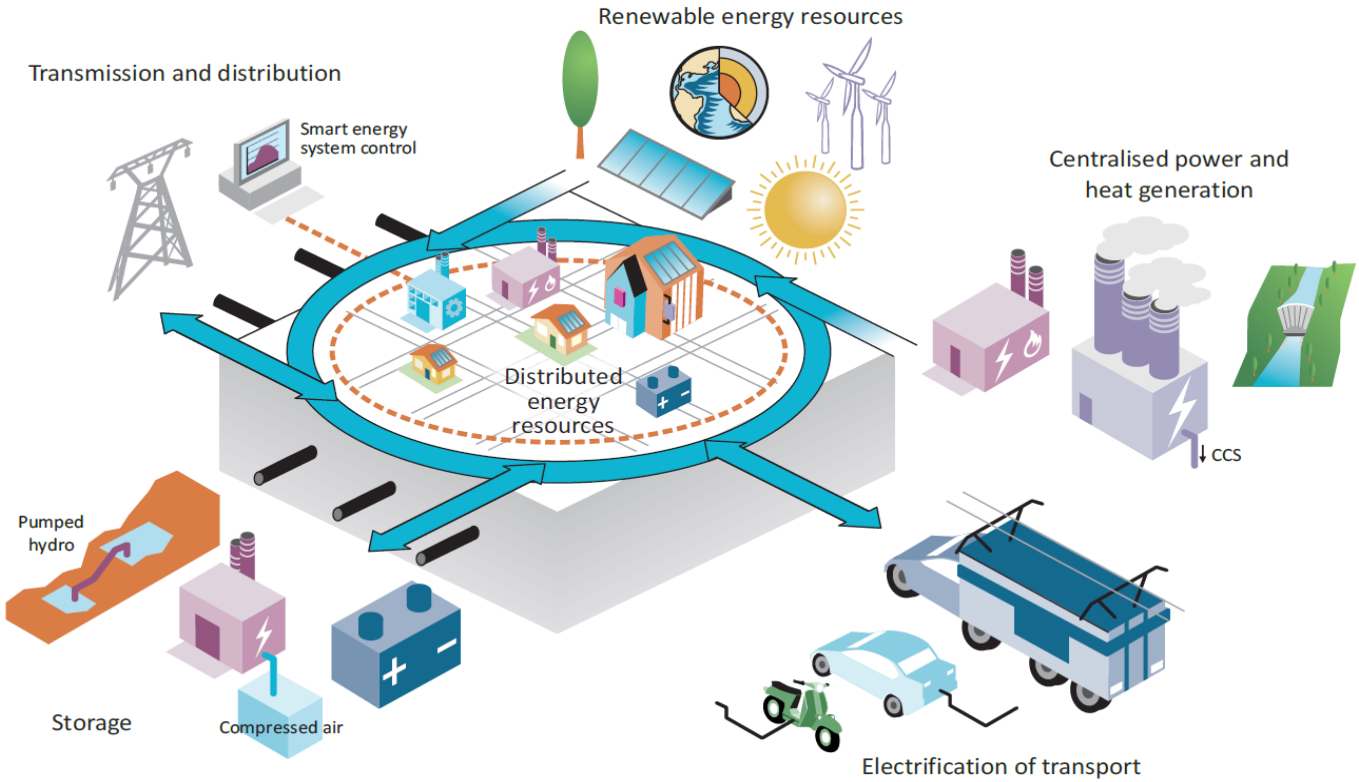
The traditional energy system is centralized and fossil-fuel based.



Source: IEA 2017

ENERGY

The energy transition towards more integrated, complex systems is on the way.



Source: IEA 2017

ENERGY

National Targets and Action Plans

- Clear targets for each country can drive the reduction of energy consumption according to established action plans (ex. 15% in 2050 compared to 2020).
- Set clear targets for investments in low-carbon energy.
- Develop roadmap for modernizing and phasing out energy intensive technologies.
- Regional and national early warning systems need to be developed to help track progress and indicate optimal pathways to achieve sustainable energy.

Energy Efficiency is the first fuel

- Develop progressive energy efficiency retrofit schemes for residential sector.
- Redo all the strategic documents with energy conservation and energy efficiency as a primary focus.
- Provide clarity on well-to-wheel mobility solutions (incl. modes of transport and using smart technology to reduce unnecessary travel and pursue progress in collaboration with cities.

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Reduce the Environmental Footprint of Energy

- Managing methane emissions along the entire value chain has societal, health, environmental, and economic benefits. Deploy and disseminate best practice guidance on Methane management.
- Develop and disseminate investment guidelines for low carbon technologies (high efficiency and low emission, carbon capture and storage) and modernize curent energy infrastructure to set a stage for a further shift to renewables or other low-carbon solutions.
- Regional mapping, monitoring of resources and recycling practices, such as the United Nations Resource Management System (UNRMS), need to be developed and disseminated.

Transform the Energy System

- Improvements in the legal and regulatory frameworks are necessary to enable further transformation of the energy system, it has to be transparent, include new disruptive technologies and support growth of new business models.
- Take holistic system approach to enable technology (use of ICT, energy as a service, distrubuted generation, storage and price elasticity

ENERGY

- **Promoting mutually beneficial economic-interdependence would accelerate attainment of the 2030 Agenda** through integrative, nexus solutions. For energy, it is critical to think in terms of an interconnected, complex system in which supply, demand, conversation, transport and transmission interact freely and flexibly.
- **Governments should develop new, transformative policy instruments**. Regulation must be appropriately modified to foster the rapid demand and supply of low-carbon technologies, for example, tightening the regulation of plastics could significantly reduce the rate of oil demand.
- **Energy security is achieved** by ensuring that energy supply, transformation, transport and demand make **optimal contributions to countries' social, economic, and environmental development.**
- **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. **Sustainable resource management practices** that embrace **circular economy** principles and that integrate the full spectrum of the 2030 Agenda's goals and targets should be on the forefront of countries' strategies.
- Early actions need to be taken to source these materials in a sustainable manner. Regional mapping, monitoring of resources and recycling practices, such as the **United Nations Resource Management System (UNRMS),** need to be developed and disseminated.
- **It is important to support technological and regional cross-border cooperation to strengthen best practice exchanges** and scale up low-carbon technologies and engage in joint investments.
- Practical pathways at scale can set framework conditions that allow industry to deploy its best capabilities (competence plus capacity) in ways that the capital market can finance. **There is need for dynamic and integrative public private partnerships (DIPPPs) involving governments.**

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Energy conservation first

- **Energy conservation efforts** should the first step in every national energy strategy**. Efficient energy management strategy of the energy system** needs to be implemented.
- **Smart grid and new digital technologies** are key for an efficient use of distributed energy resources. Inappropriate legal frameworks may hinder implementation of innovative technologies.

Energy transition towards a sustainable system

- **Modernizing and optimizing fossil-based infrastructure is essential** to achieve sustainable development. This is a long-term undertaking and must embrace all pillars of sustainable development seeking to leave nobody behind. Phasing out obsolete fossil-based infrastructure must be the ultimate goal, yet caution is required regarding rapid investments omitting to recognize the crucial role that this infrastructure has for the livelihoods of many.
- **Investments in clean fossil fuel infrastructure have to be possible if 2 degrees is the goal.** Internationally agreed investment guidelines for investing in clean fossil fuels could be a starting point, developed in collaboration with international development banks, the United Nations and environmental organizations. Countries should **adopt fiscal policies that provide CCS/CCUS/HELE technologies** with parity with other low carbon/no carbon electricity generation technologies. All energy sources must play a role as countries embrace a low-carbon future.
- Big data, smart grids and a **systematic approach** should be at the heart of a future energy transition, this creates opportunities for new entrants that need to be regulated.
- **Effective R&D can drive the integration of innovative technologies while adjusting policy frameworks to accommodate "disruptive" technologies**, some of which are today unknowable.
- Development and implementation of appropriate **legal frameworks** for transition requires long **lead time** and has to be developed in parallel with technological developments, e.g. CO2 transportation across borders for subsea storage. Governments also need to prepare the skill set for the implementation of the digital economy.

ENERGY

Driving towards low-carbon circular economy

- **Global governance** is required to ensure optimal usage of scarce resources and reduction of import dependency**. Promote innovation** for transition from a linear to a **circular model.**
- The 2 degree target cannot be achieved without **negative carbon technologies** to bridge the gap until innovative low or zero-carbon energy technologies will be deployed. **A price on carbon or carbon tax measures and incentives to reduce emissions** from a high carbon value chain (upstream and downstream) must come in effect to speed up the transition.
- None of the SDGs can be achieved without energy. Pressure on resources will continue to increase as demand for rare earth minerals to produce batteries on the back of widespread electification grows. **Resource curse** can be avoided if a dynamic systems approach and proper information architecture are used in studying the problems, proper tools could be developed. The UN Resource Management System is one such approach for circular economy, which can be adopted by all member States.
- Methane is an important energy resource and potent greenhouse gas. **Managing methane emissions along the entire value chain has societal, health, environmental, and economic benefits**, as it is also an energy carrier. Methane emissions continue even after mine closure and can be captured for industrial and energy usage. Countries can **pass legislation that clarifies ownership** and **promotes global recognition** of the importance of methane.
- **Emissions trading** groups should be formed between coal mines and consumers to promote methane emissions reductions at coal mines through projects financed by coal consuming industry, i.e, power, cement and steel producers and **emissions credits** used as offsets for the industrial consumer's emissions.

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Driving towards low-carbon circular economy

- **Natural gas** can provide the baseload requirements for introducing renewable energy sources into the grid sustainably. To maintain gas as a transition fuel in a sustainable system, emissions must also be managed. For this, countries must promote holistic, national, sustainable action plans.
- **Integration of fluctuating renewable energy** into power and heating grids is one of the **biggest challenges** towards fostering sustainable energy. Standards optimizing flexible power systems that rely on the **interplay of fossil fuels and renewable energy** and storage systems can play an important role in grid resilience and stability and are of vital importance **to balance the intermittency** of the wind and solar PV.
- **Renewable gases** (such as hydrogen and biomethane) are essential elements for advancing in the societal **decarbonisation through sector coupling and sectoral integration**. This framework should recognize the positive externalities of renewable and low-carbon gases.
- **Quality of life** can also be enhanced through improved **air quality** in big cities and much polluted areas. This should be done as quick as possible and in the most cost-efficient manner.
- **Development of storage technologies** should be pushed by governments, main game changer for renewable energy. Heat storage in molten salts and other forms of storage should also be investigated.

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Business models

- **Promoting innovative flexible business models and creating necessary regulatory frameworks should be fostered** for further **technological innovation and energy transition.** All technologies and business models must be cost effective and made widely available.
- **Business models that prioritize improvements in energy productivity of industrial processes and buildings performance have to be promoted**. Before investing in new production and supply infrastructure, countries should improve energy efficiency and productivity when cost-effective in the production, transmission, distribution and consumption of energy. **Alternative business models** are moving away from energy as commodity (push model/ customer communication as a one dimensional bill) to energy as service, where customer partners with (or even replaces) the provider.
- Increasing **urbanization** in the region requires alternative, low-carbon approaches in cities to meet the increasing energy demand. This spans transport, buildings, and services. Urbanization planning has to be based on optimized energy usage while enhancing quality of life, decreasing air pollution and improving transport systems.
- Renewable energy **potential** (power, heat, transport) **remains untapped in many UNECE countries**, particularly in the Caucasus, Central Asia, Russian Federation, and South East and Eastern Europe. Investments flows into this region must be increased drastically, and in partnership between the United Nations, international development banks and local stakeholders.
- Particular attention must be given to a forward looking **“just transition“ approach seeking to involve all societal stakeholders to develop new business models** that can support regional restructuring and avoid a desertification.

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The core issue: How to balance the requirements both to develop sustainable energy and also to combat climate change. Their pathways are not identical, with much depending on the financial costs of specific measures and approaches.

The core question for gas: How to develop a strategy that embraces a requirement to rely on gas for the next ten or fifteen years, and possibly increase the use of gas in such a timeframe, with a requirement to reduce gas use thereafter in order to attain such targets as the EU's goal of 80-95% carbon emission reduction by 2050. In sum, how to avert the possibility of stranded infrastructure.

- How do the **UNECE region** and its sub-regional **elements balance SOx emission reductions and CO_2 reductions**?
- For how long will gas be the **dominant fuel for power**?
- For how long will gas be the **dominant fuel for heat**?

Regional and Governmental:

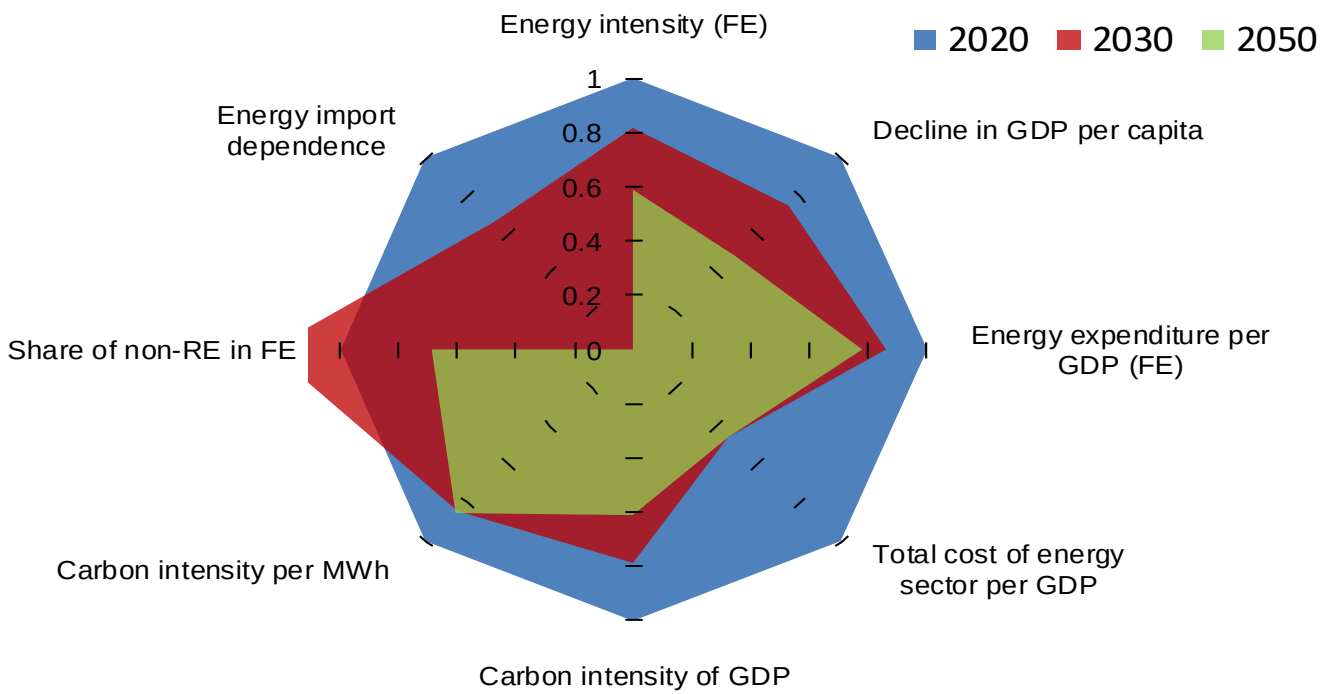
- Does the EU need to intensify/accelerate its efforts to meet its 2050 target of reducing CO_2 emission levels by 80-95% from the 1990 level?
- Is more government aid needed in order to promote biogas over natural gas?
- Can the affordability/environment/security 'trilemma' primarily be addressed by reliance on competitive markets?
- How do we ensure that knowledge and experience gained in one part of the UNECE region is widely shared throughout the UNECE region?
- How do we address the social and economic issues involved in transitioning from fossil fuels to renewables, particularly in countries and communities with a high dependence on fossil fuel extraction?

Modeling Results: Indicators

Tradeoffs and synergies: BMU

ENERGY

Energy and environment indicators - BMU REF Scenario



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

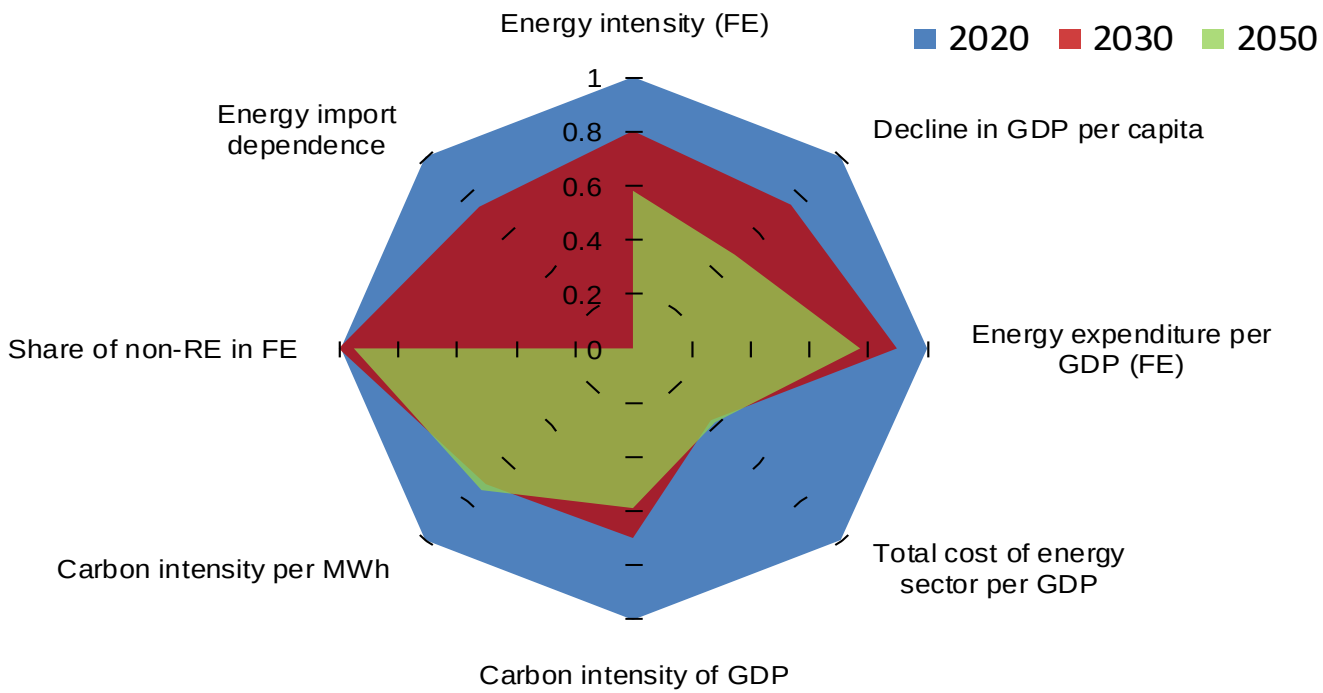
- Indicators are scaled relative to 2020 (2020=1), and any *improvement in an indicator will result in values lower than 1*
- If the shape of polygon becomes smaller compared to 2020, it shows improvement in the indicators

Modeling Results: Indicators

Tradeoffs and synergies: BMU

ENERGY

Energy and environment indicators - BMU NDC Scenario



- *In the absence of ambitious NDC targets only slight improvements in the share of RE*
- *Marked improvement of CO_2/MWh (more pronounced than carbon intensity of GDP), primarily due to lower coal and oil exports*
- *Declining domestic coal use as well as coal exports require lower upstream investments and thus result in an improvement of the Total cost of energy sector per GDP*
- *No notable change in GDP per capita compared to REF*

- Indicators are scaled relative to 2020 (2020=1), and any *improvement in an indicator will result in values lower than 1*
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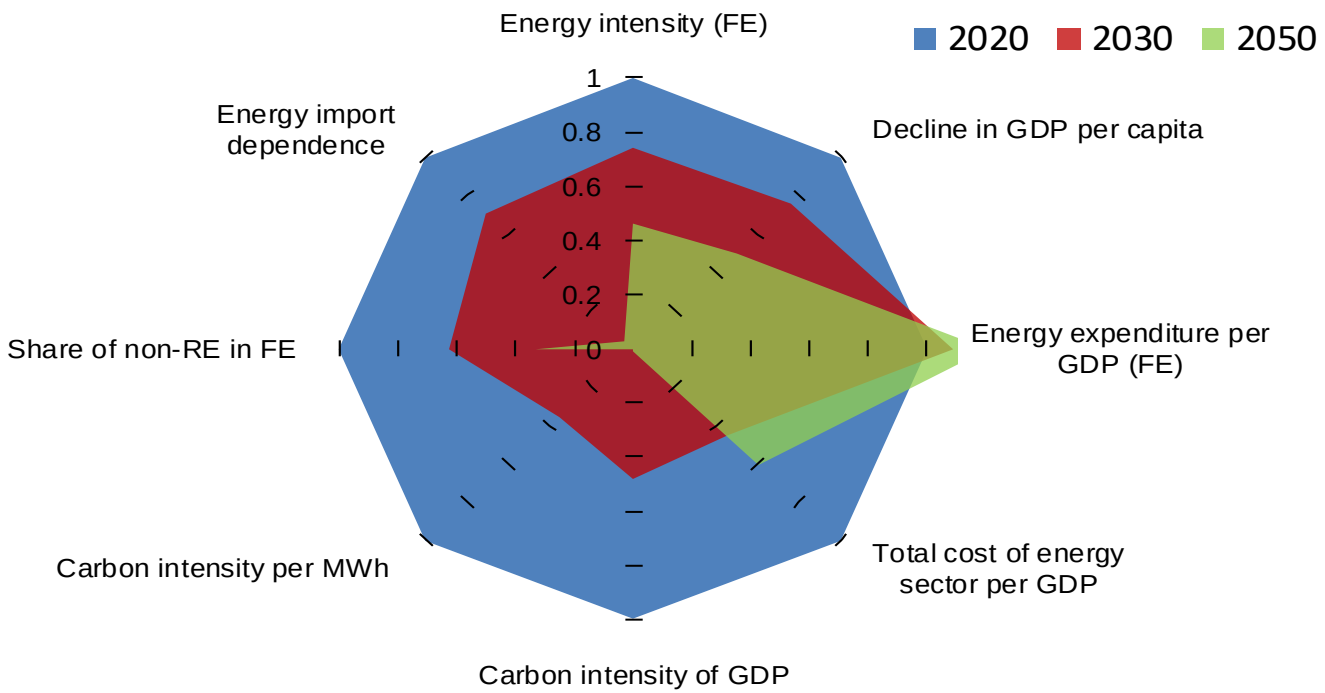
Modeling Results: Indicators

Tradeoffs and synergies: BMU

ENERGY

Energy and environment indicators - BMU P2C Scenario



- *Energy system transformation clearly discernible by 2050*
- *Significant change in energy expenditures by 2030 (> 1) and remain thereafter at substantially higher level than in REF and NDC*
- *Drastic improvement of the CO_2/MWh indicator (>95% compared to 2020) outpacing carbon intensity of GDP*
- *Energy intensities decline along with the unprecedented investments in efficiency measures*
- *Total energy sector costs reduced due to higher non-fossil domestic energy use and increased gas exports*

- Indicators are scaled relative to 2020 (2020=1), and any *improvement in an indicator will result in values lower than 1*
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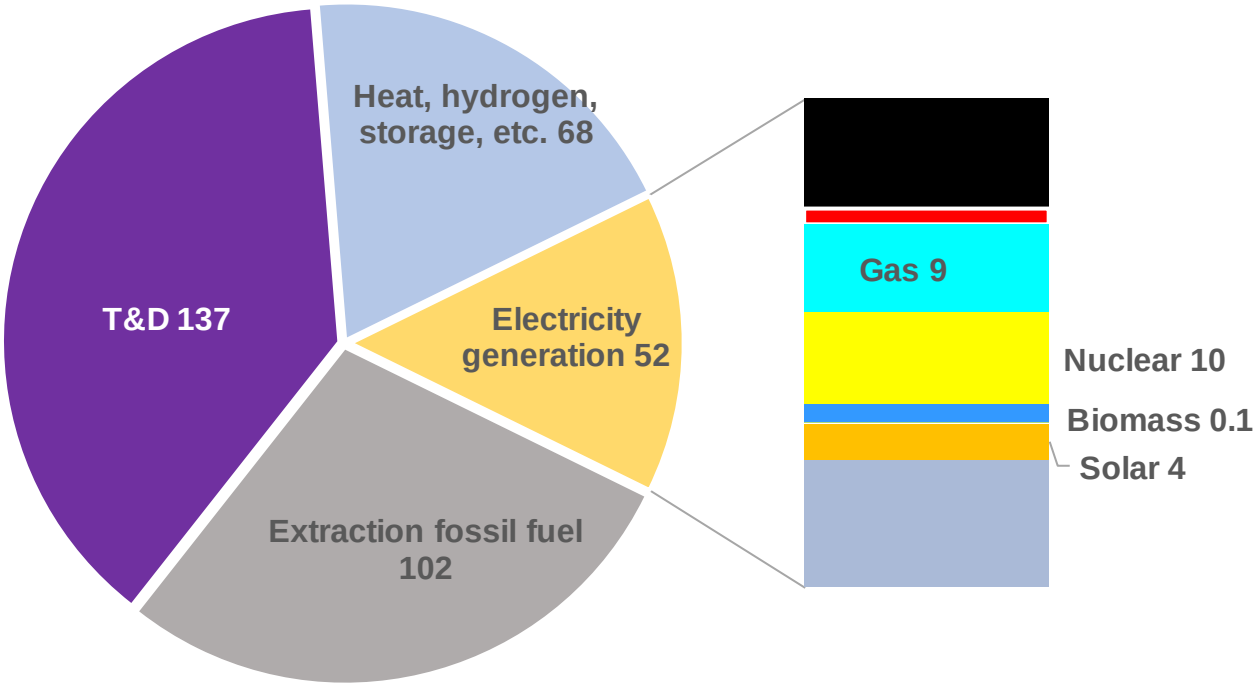
Modeling Results: Indicators

Investment needs: BMU

ENERGY

Cumulative investments 2020-2050: *358 billion US$*
REF - BMU



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

- *Fossil fuel extraction absorb 80% of total energy sector investments – in large part export driven (more than doubling over the period*
- *T&D commands twice as much capital than investments in electricity generating equipment*
- *Generation investments are dominated by lowest carbon emitting nuclear and hydro plants (more than twice the investments in coal and natural gas)*
- *Hydro power (traditional) and onshore wind (new) dominate investments in renewables*

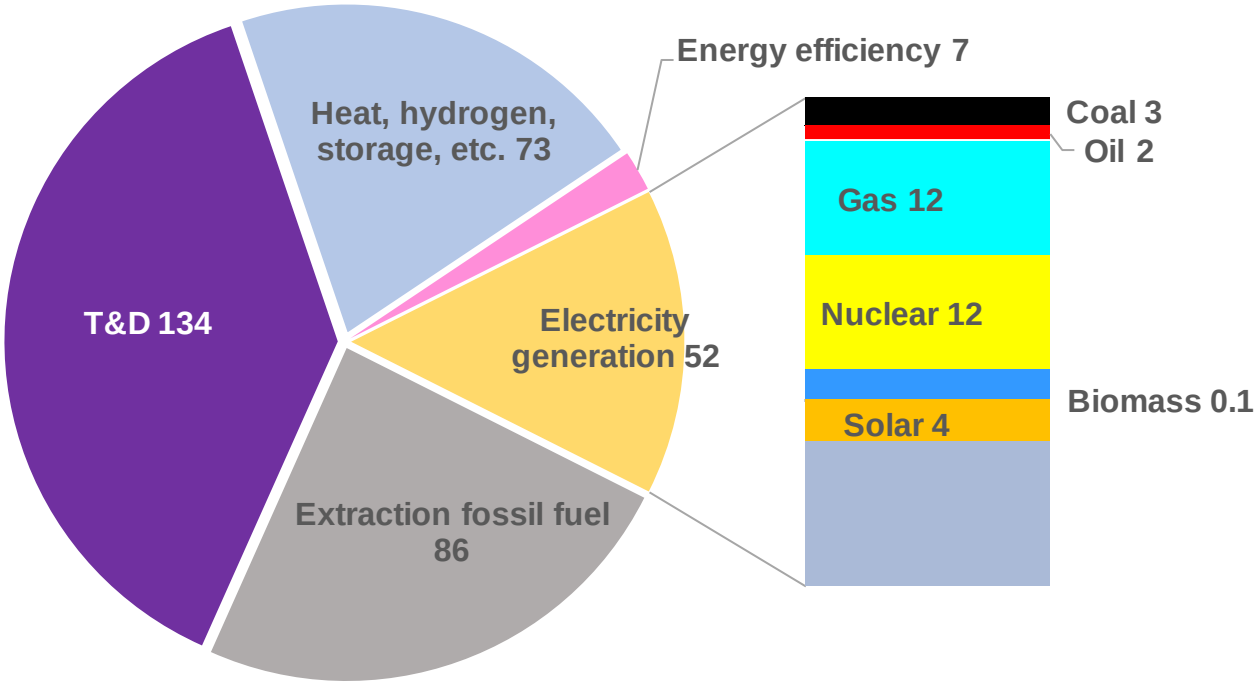
- T&D: transmission and distribution of electricity and district heat
- Investments in US$ at 2010 prices and exchange rates

Modeling Results: Indicators

Investment needs: BMU

ENERGY

Cumulative investments 2020-2050: *353 billion US$*
NDC - BMU



- *Lower upstream fossil fuel investments (than REF) due to reduced coal and oil exports*
- *Energy efficiency measures are gradually introduced – predominately after 2030*
- *Investments in gas and nuclear generation replace declining coal*
- *Solar and wind pick up momentum (though modestly by international standards)*

Extraction fossil fuel
Oil
Gas CCS
Biomass
Solar
Heat, hydrogen, storage, etc.
Coal
Oil CCS
Nuclear
Biomass CCS
Wind
Energy efficiency
Coal CCS
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Hydro
Geothermal
T&D

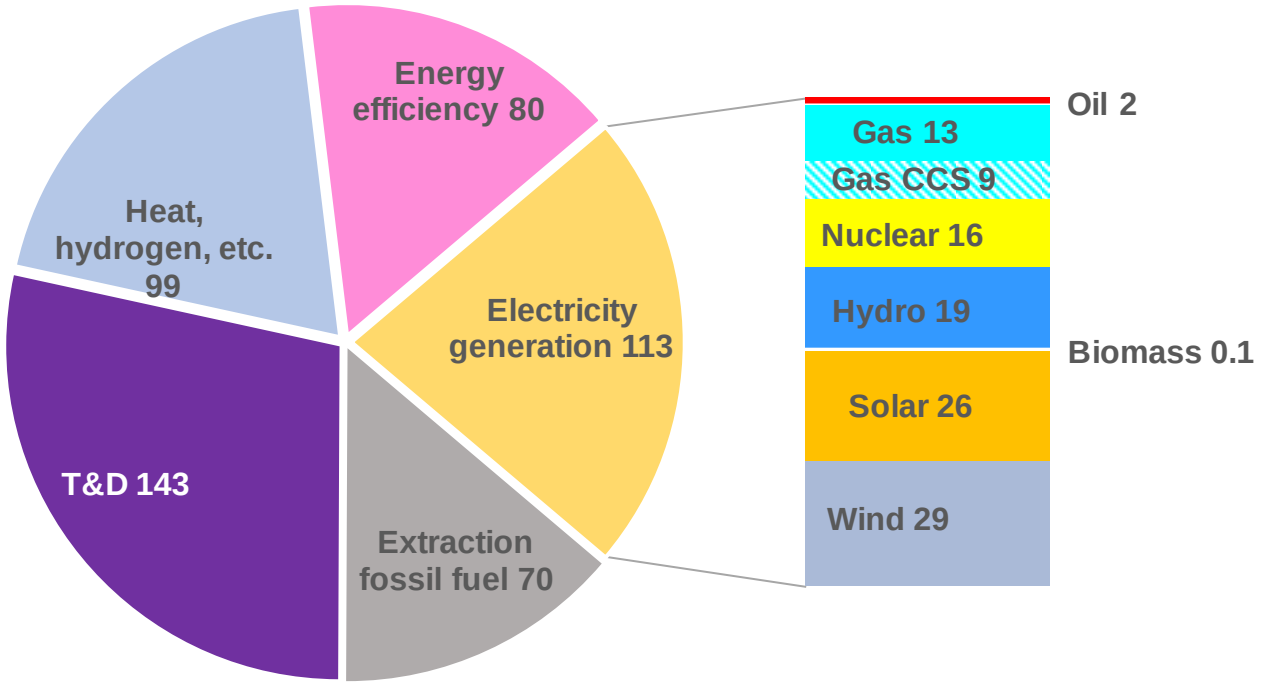
- T&D: transmission and distribution of electricity and district heat
- Investments in US$ at 2010 prices and exchange rates

Modeling Results: Indicators

Investment needs: BMU

ENERGY

Cumulative investments 2020-2050: *506 billion US$*
P2C - BMU



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- Coal CCS
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- Hydro
- Geothermal
- T&D

- *Significant change in overall investment structure*
- *Upstream investments considerably lower - in terms of $ expenditures, the decline in upstream investments is equivalent to the increase in efficiency investments*
- *Energy efficiency becomes the second largest investment category*
- *No other significant investments in fossil electricity generation but gas*
- *Gas generation with CCS exceeds gas without CCS*
- *Generation commands 50% higher capital investment (45% of the total for renewables)*
- *Nuclear power remains largest single generating investment category*

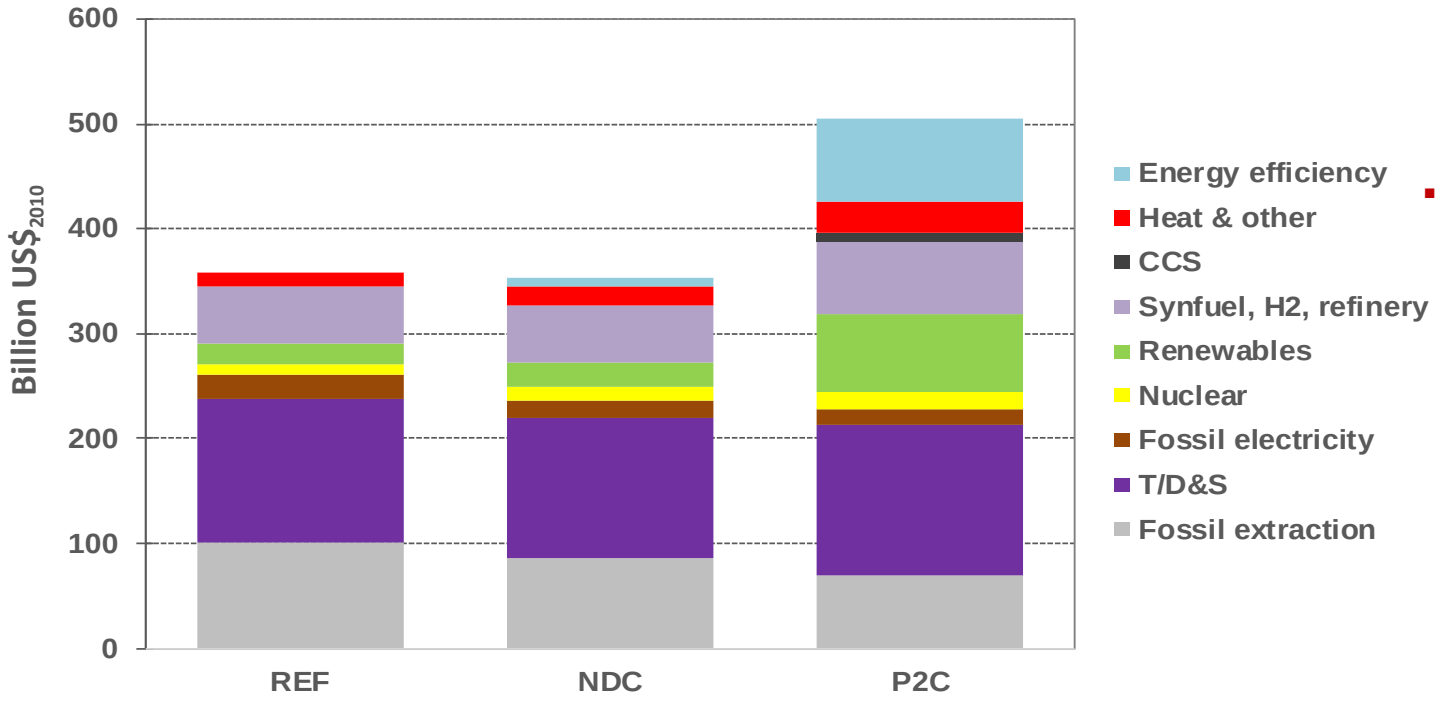
- T&D: transmission and distribution of electricity and district heat
- Investments in US$ at 2010 prices and exchange rates

Modeling Results: Indicators

Investment needs: BMU

ENERGY

Comparing investment requirements - BMU REF, NDC and P2C scenarios



- *NDC commitments only marginally affect the overall investment structure (exception: Fossil fuel extraction due lower export demand for oil and gas)*
- *Total capital demand in P2C just slightly higher than in REF (replacement of inefficient capacities with BAT)*
  - *upstream investments continue to dominate RUS energy sector investments*
  - *Energy efficiency measures absorb the investments not demanded by upstream activities*
  - *Strong market penetration of wind and solar generating capacities in P2C*

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

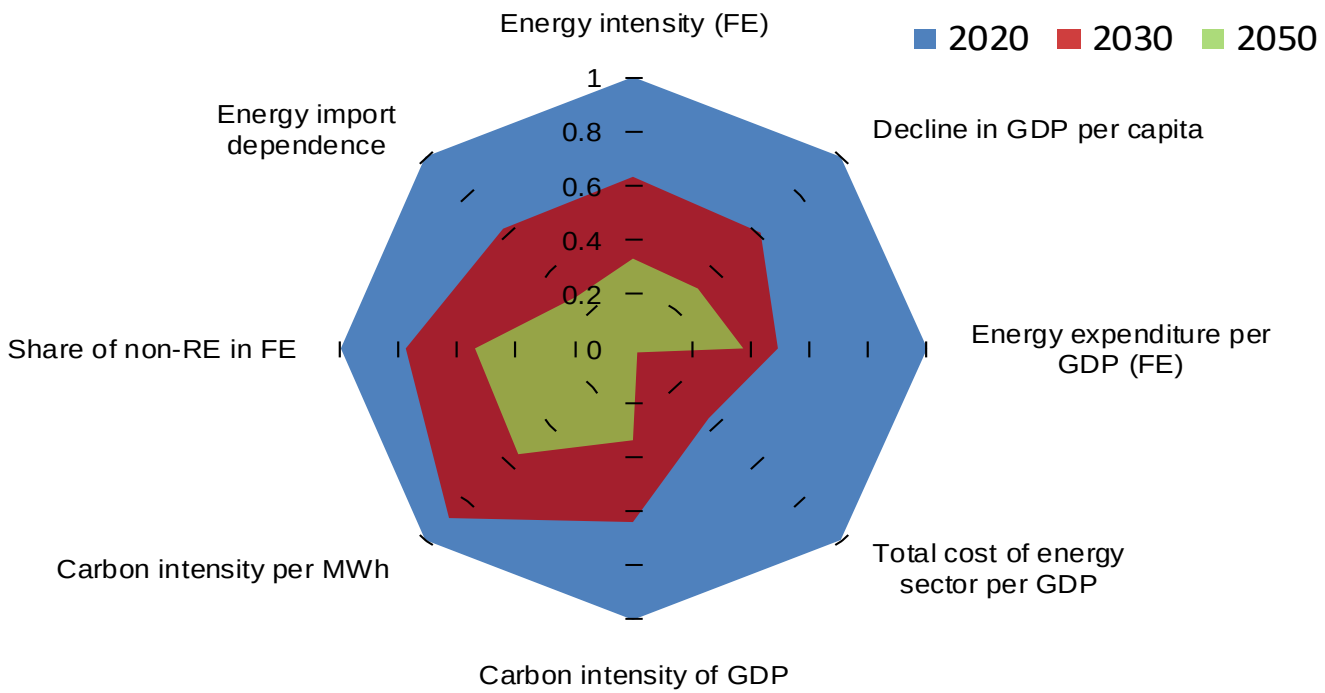
Modeling Results: Indicators

Tradeoffs and synergies: CAS

ENERGY

Energy and environment indicators - CAS REF Scenario

- *Analysis to follow*



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Modeling Results: Indicators

Tradeoffs and synergies: CAS

ENERGY

Energy and environment indicators - CAS NDC Scenario

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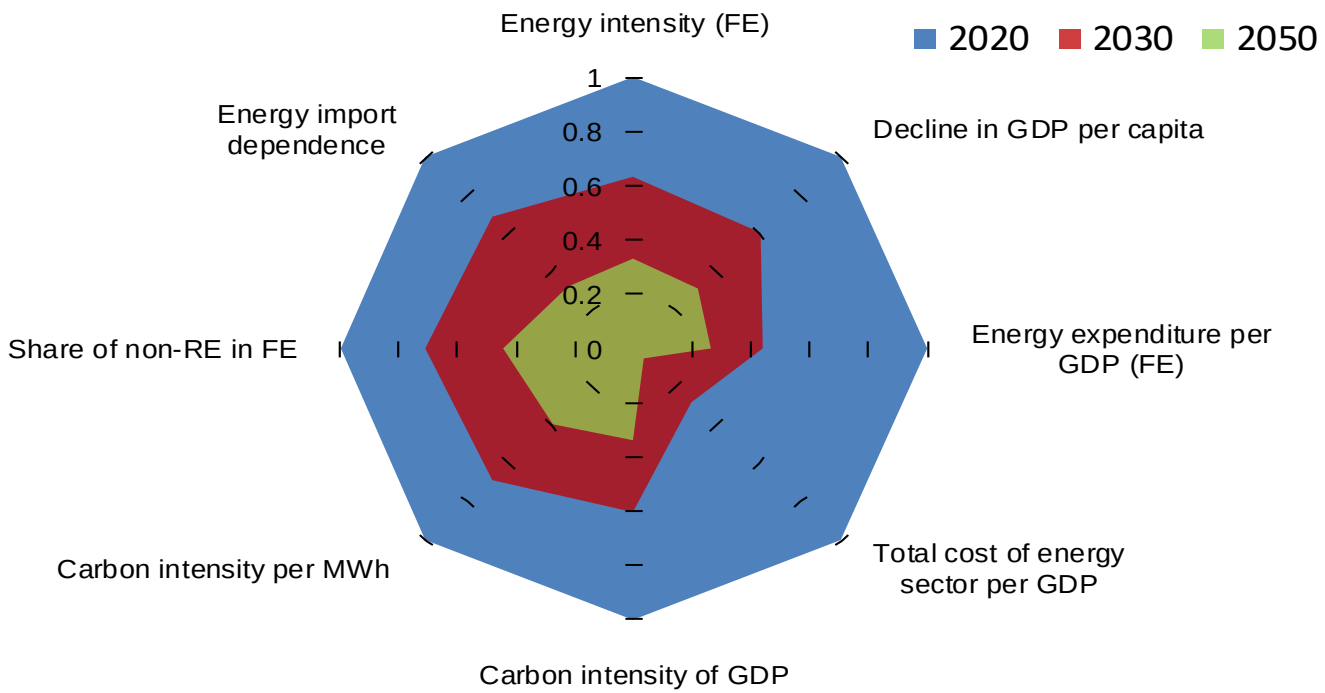

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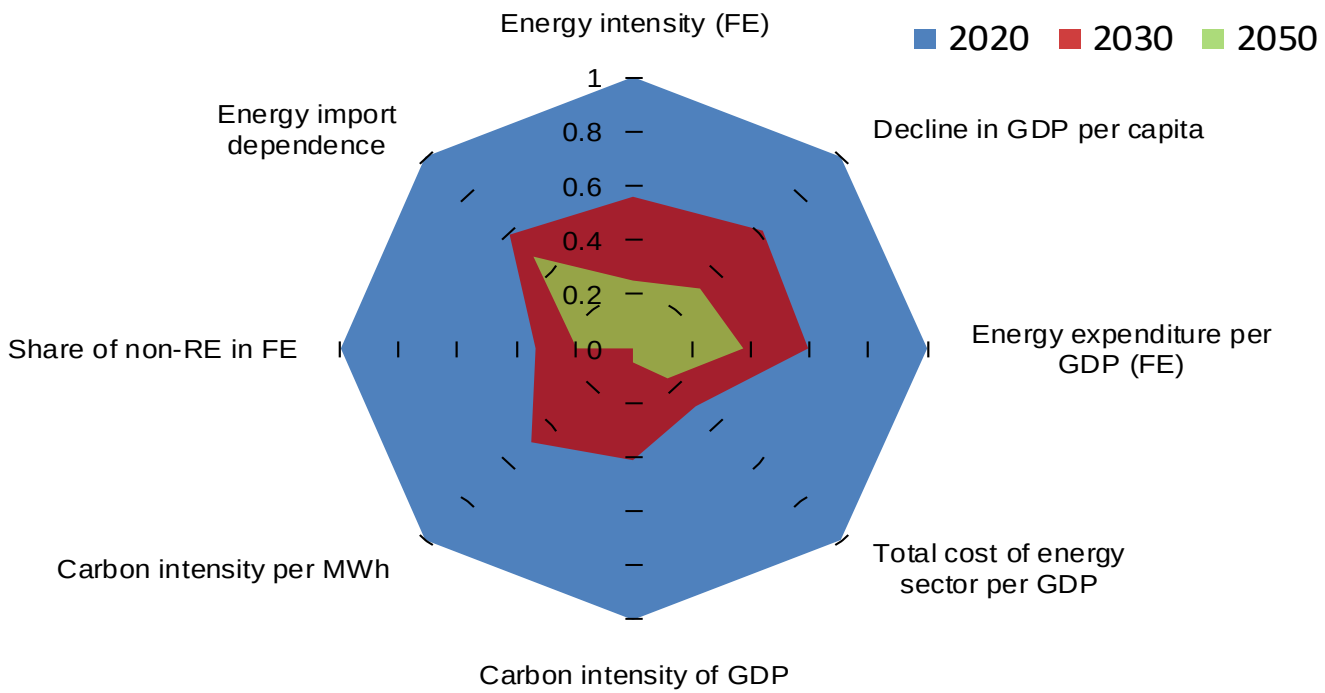

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Modeling Results: Indicators

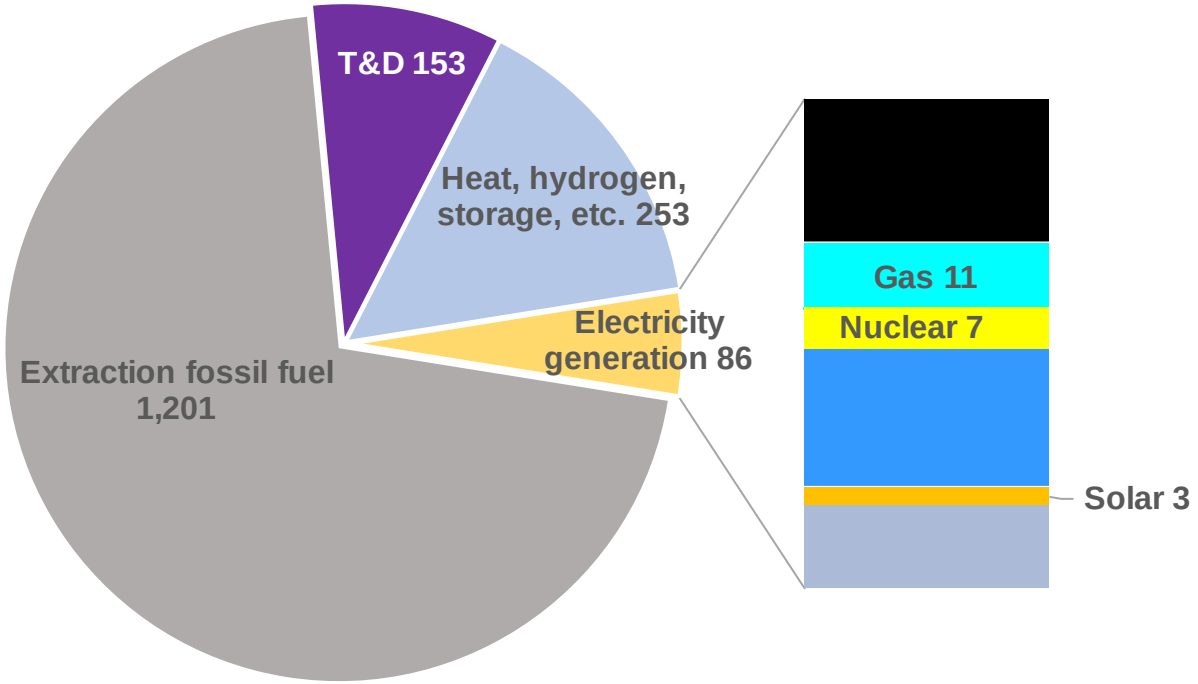
Investment needs: CAS

ENERGY

Cumulative investments 2020-2050: *1,693 billion US$*

REF - CAS

- *Analysis to follow*



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

Modeling Results: Indicators

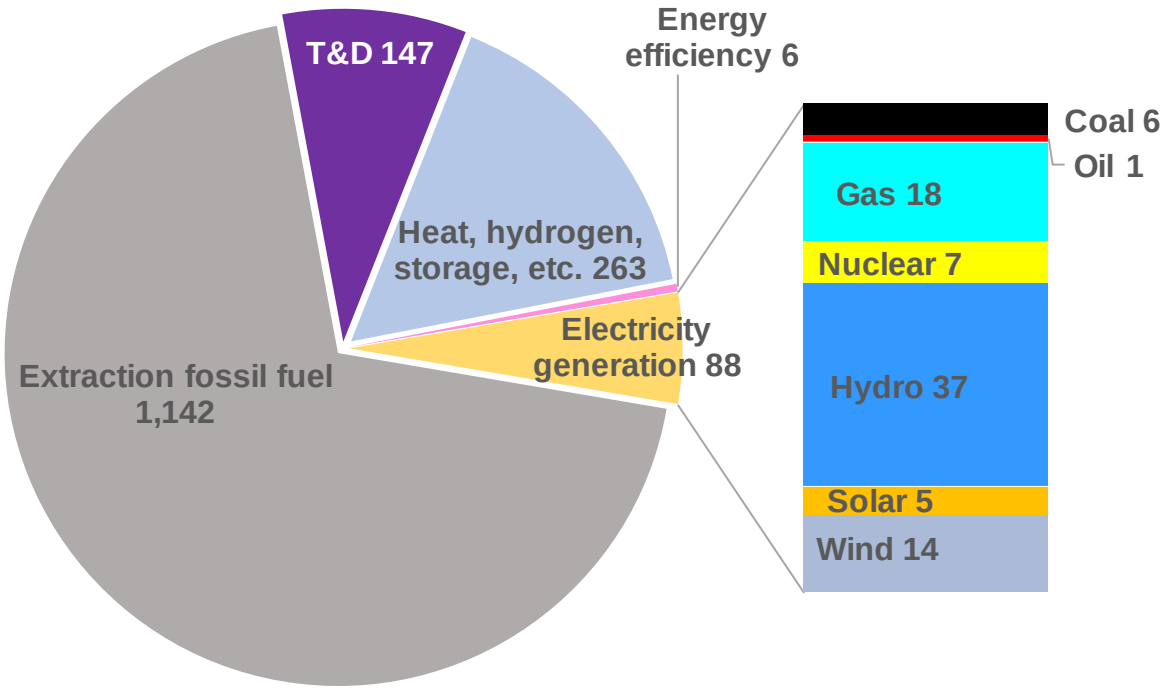
Investment needs: CAS

ENERGY

Cumulative investments 2020-2050: *1,646 billion US$*

NDC - CAS

- *Analysis to follow*



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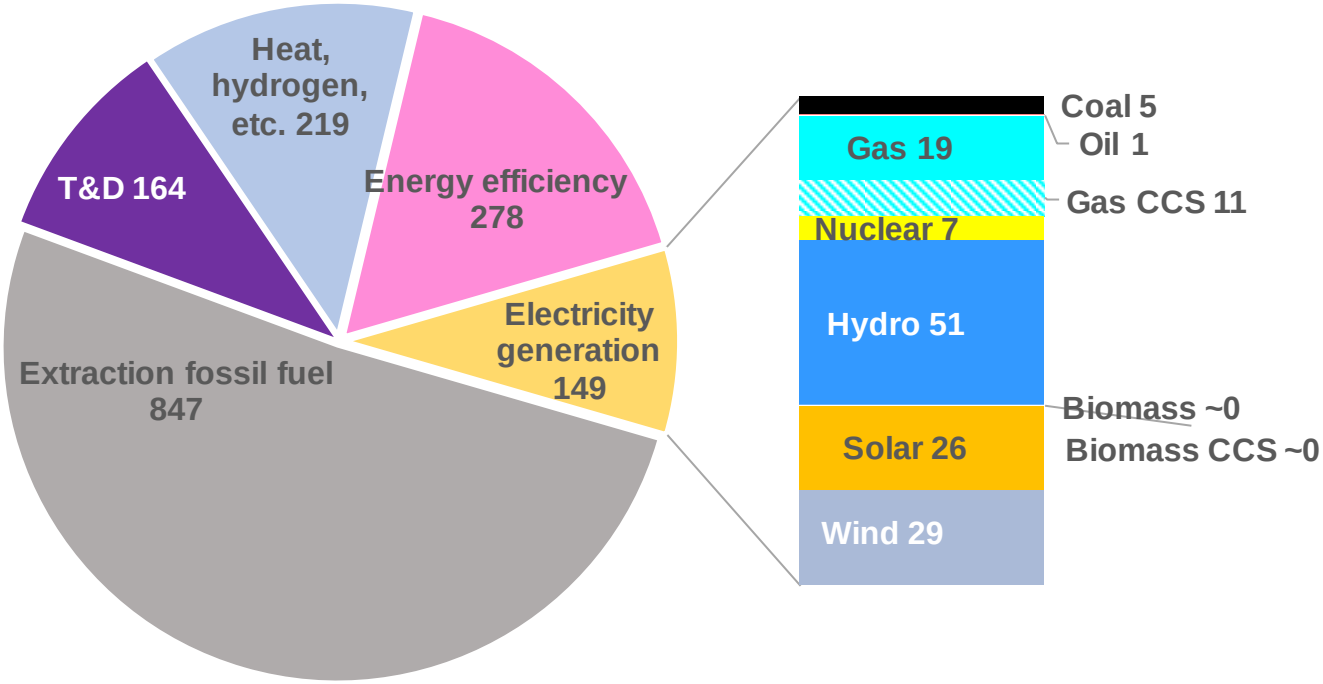
Modeling Results: Indicators

Investment needs: CAS

ENERGY

Cumulative investments 2020-2050: *1,657 billion US$*
P2C - CAS

- *Analysis to follow*



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Modeling Results: Indicators

Investment needs: CAS

ENERGY

Comparing investment requirements - CAS REF, NDC and P2C scenarios

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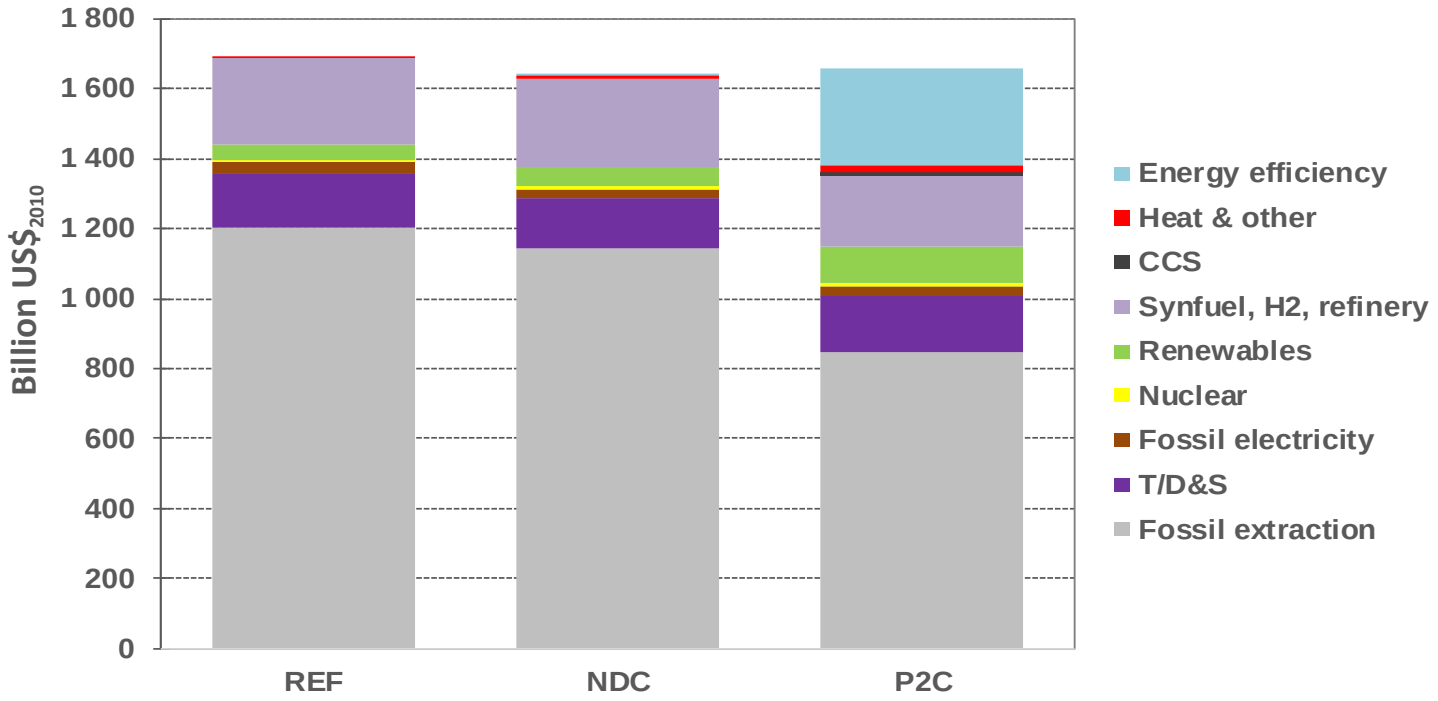

- T/D&S: transmission, distribution and storage of electricity and district heat
- CCS: carbon capture and storage
- H2: hydrogen
- BAT: Best available technology

Draft Summary Policy Recommendations
Subregional level

ENERGY

- Affordability issue and energy poverty
- Trade off between energy security and climate policy
- Energy water food nexus
- Investment needs
- Need for partnerships and dialogue on subregional level
- Awareness rising campaigns and role of civil society
- Need for improvement of the legal and regulatory framework
- Need for institutional and structural reform
- Market development
- Subregional and national deep dives

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- SDG 7 and SDG 13
- Investments into fossil infrastructure
- Costs of transition, social implications
- Land use and water resource management for large scale renewable energy projects

Definition of an Early Warning System

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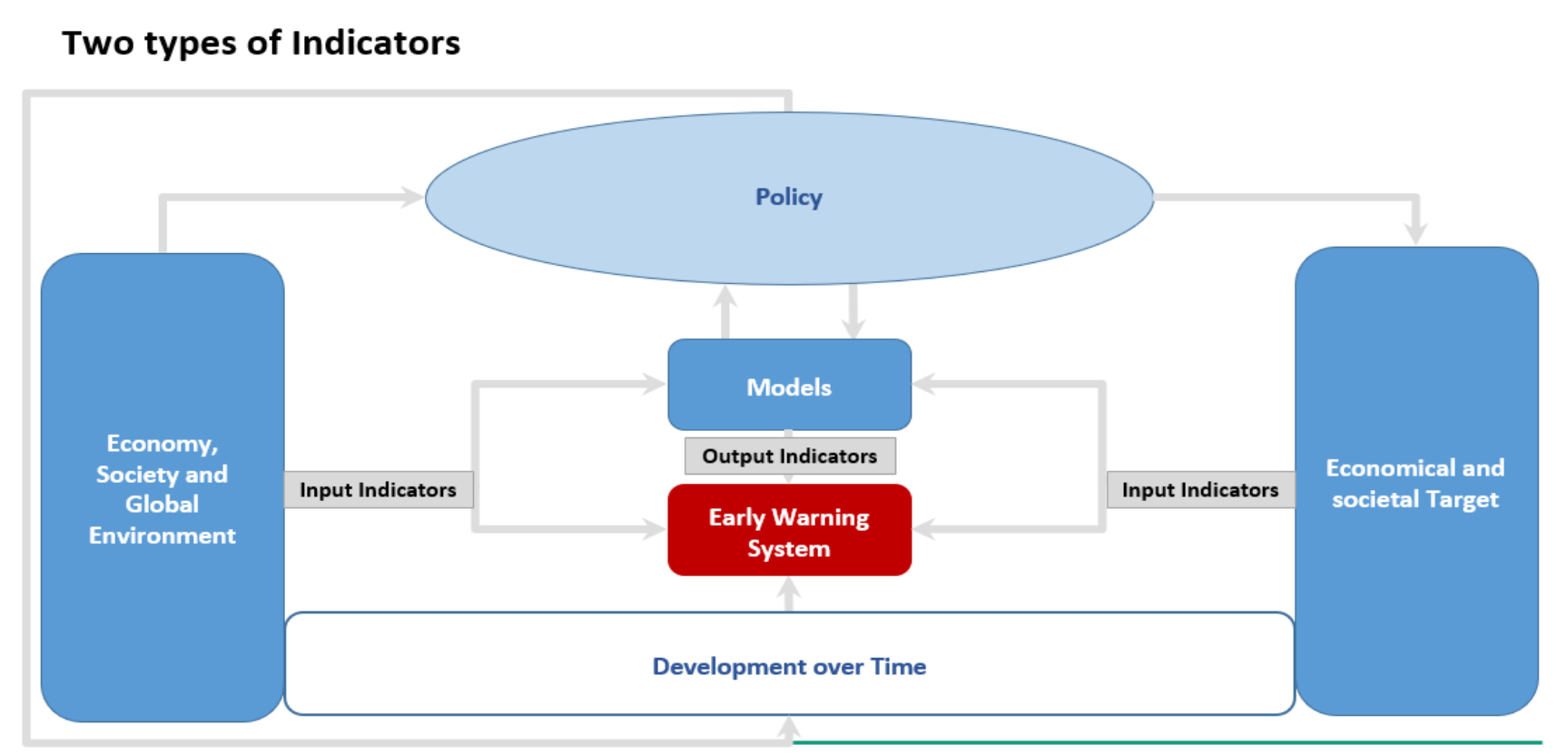
- "Early": There is still time to react to an incident and reduce the potential damage
- "Warning": Communication protocol, a statement or event that warns of something
- "System": Standardized set of principles or procedures according to which something is done



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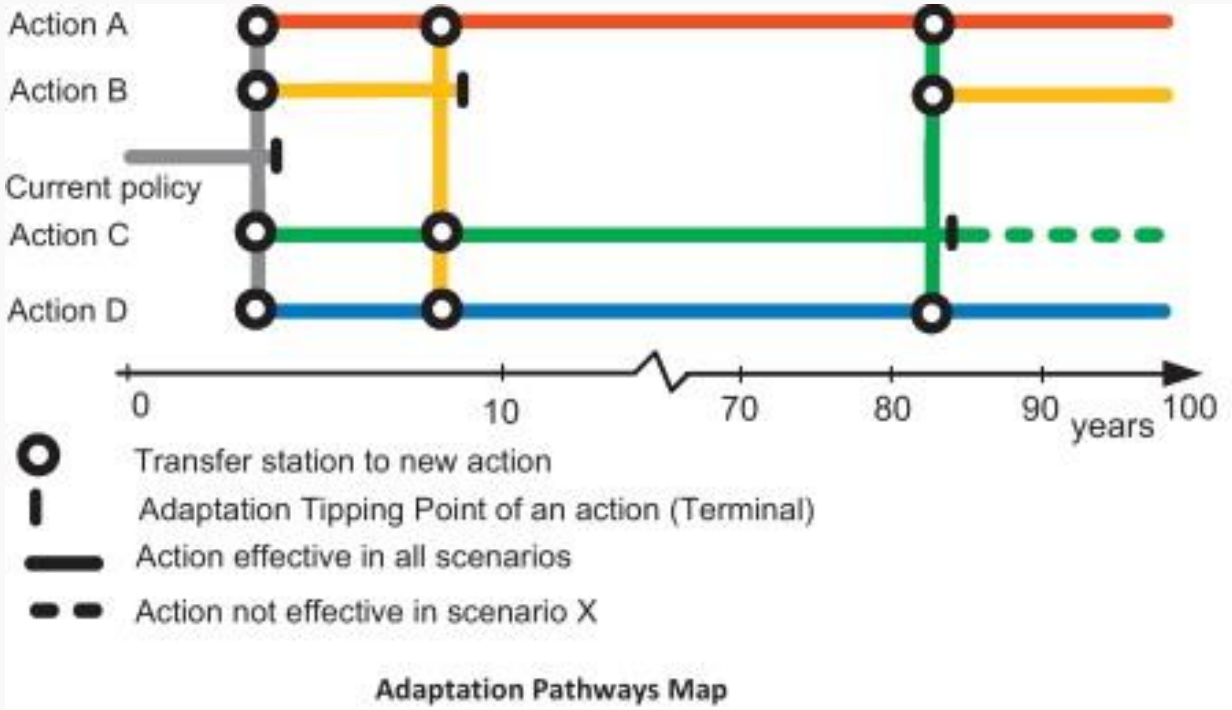
- Different technologies or policy scenarios
- Trigger/Tipping points -> current path must be adapted in order to reach the goal
- Crossroad points -> crossroads between scenarios that have the potential to reach the target (e.g. CCS vs. renewables)



Elements of an Early Warning and *Planning* System

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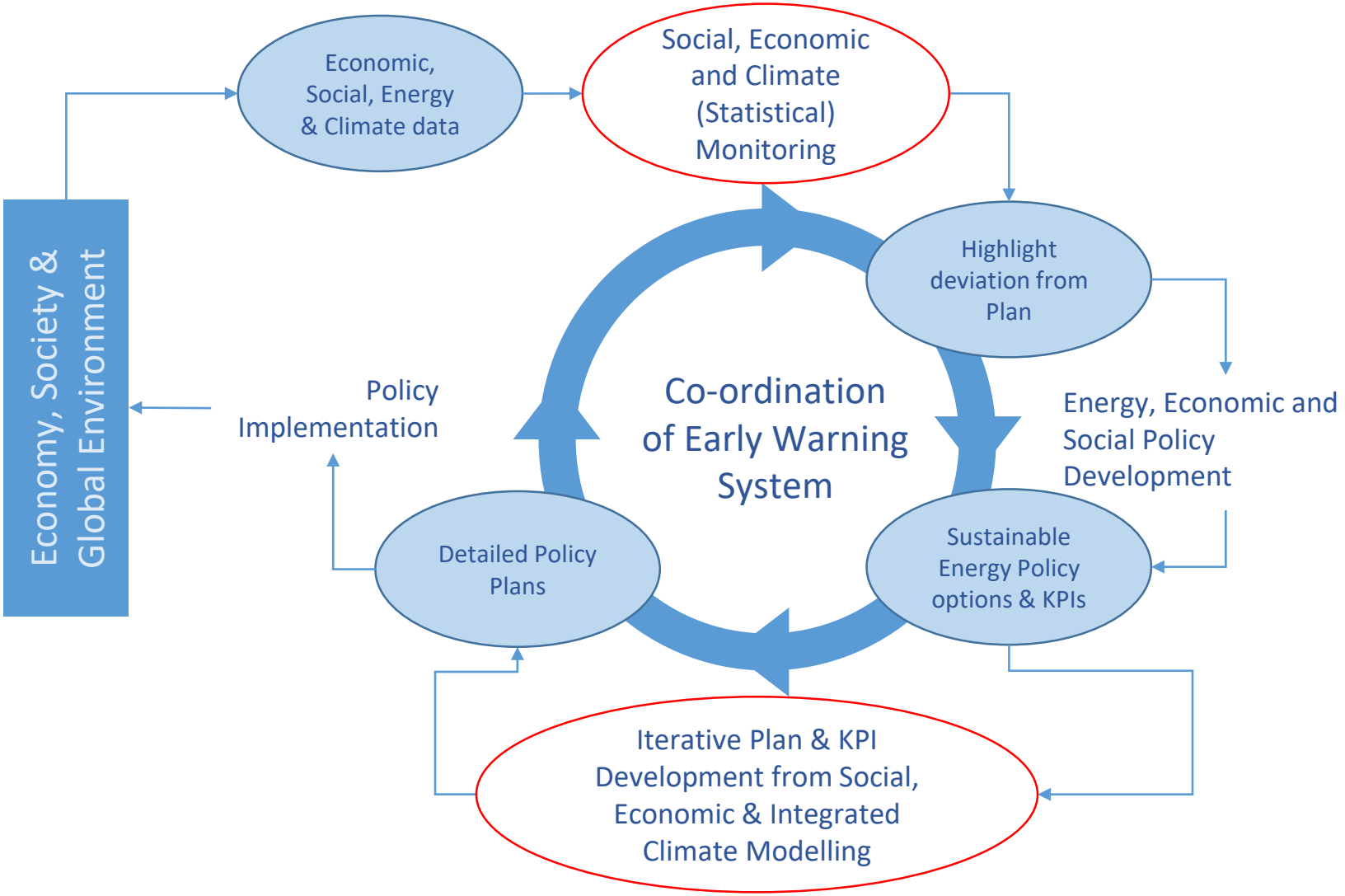

Concept for Layered Early Warning and Planning System

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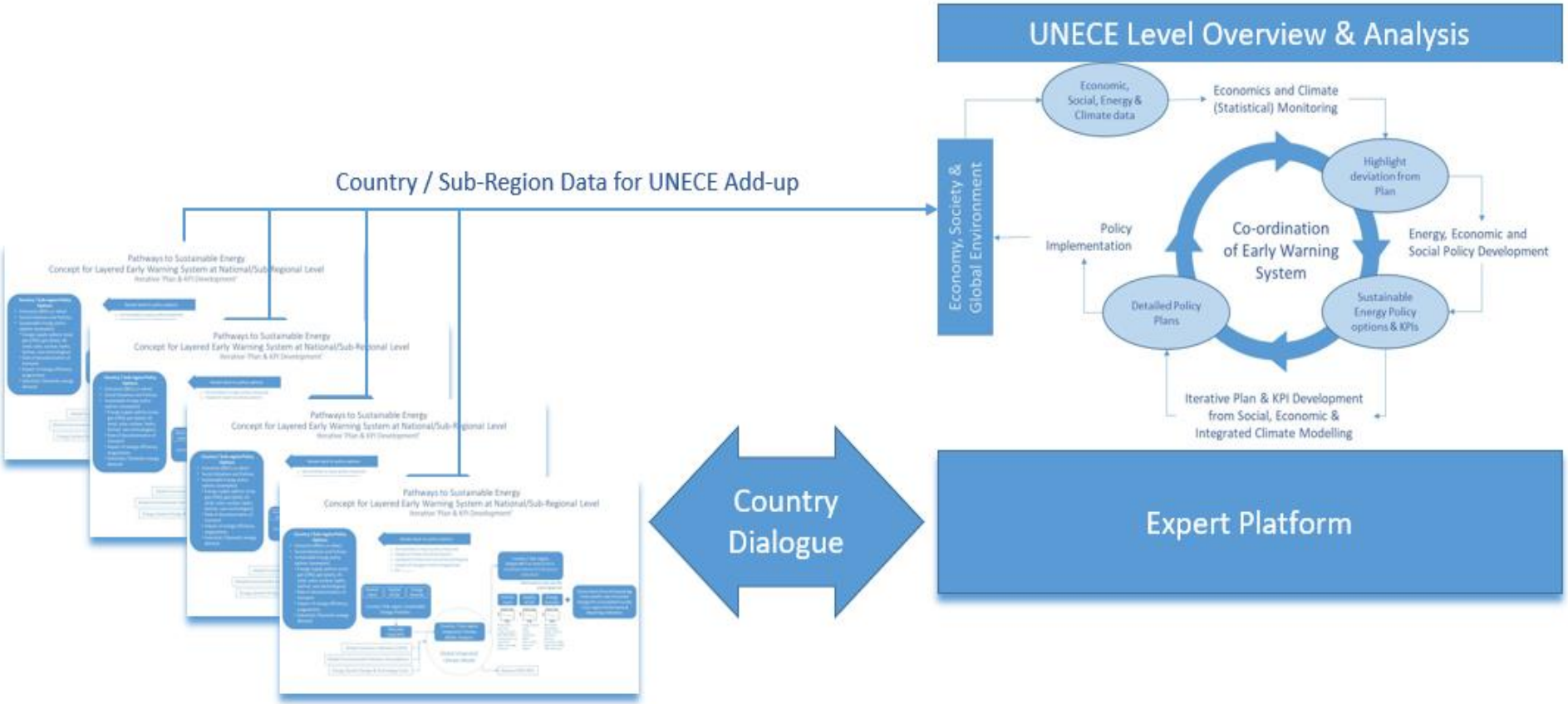

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Adopting a sustainable energy approach in combination with the developed models will have several advantages:

- **Access to the latest, most refined integrated climate and energy models**
- **Participation in an expert platform that can be used to model their own country's progress to sustainable energy** with relevant information on other countries activities
- **Facilitation of a UNECE overview of progress towards Sustainable Energy**

ENERGY

- **Early Warning and Planning System**

- **Deep dives on technology portfolios**, e.g. “the role of xxx in a sustainable energy system”
  - Market analysis
  - Coal, gas, hydrogen, nuclear, low-carbon, renewable energy, solar, wind etc, power to X, sector coupling, storage
  - Impacts of investing in clean fossil structures on the system
  - Impacts of methane management on the system
  - Energy efficiency potential and implementation (buildings, industry)
  - Technology specific policy recommendations and briefs for the region

- **Subregional investigations**
  - Caucasus and Central Asia, BMU, South East Europe, others
  - Interegional trade

ENERGY

- **Non-quantifiable research**
  - Energy as a complex system
  - Social learning and pressures, raising awareness and changing people behaviour
  - *Just* transition frameworks (see parallel project on modernizing energy infrastructure)
  - Quality of life

- **Nexus areas**
  - Transformational pathways / From technology to pathways
  - Energy transition: risk and uncertainties, aka critical raw materials, access, scale up, implementation
  - Water and energy, agriculture and health
  - Affordability, ambition and fairness, price of energy, electricity
  - Resource management, circular economy and critical raw materials in the energy transition
  - Subsidies
  - Other

Additional slides
Groups of Experts

Key Insights from the Perspective of GEEE:

- Water-Energy-Food Nexus is possible only by efficiency:
  - **Energy efficiency as the first fuel** – Before investing in new production and supply infrastructure, the countries should look in to improving energy efficiency as much as they can.
  - Energy efficiency improvements should to be both **cost-effective** (in comparison with new infrastructure) and **widely available** (technology exchange)
  - **Business models** that prioritize energy efficiency: investments that can deliver **more services** for the **same amount** of energy input, or the **same services** for even **less** energy input. **Pricing of negawatt**.
  - EE policy action in Industry Sector : Lower energy intensity, increased efficiency and **rethink** technologies that are energy intensive.
  - EE policy action in Transport Sector : **Rethink** large freight transport, electricity commuting, **reorganize** cities.
  - EE policy action in Buildings Sector : Building codes, **NZEB** promotion, appliance standards and integrating **flexible business models** for residential sector.
  - **Energy efficiency potential remains untapped**. It should be in **every** scenario.

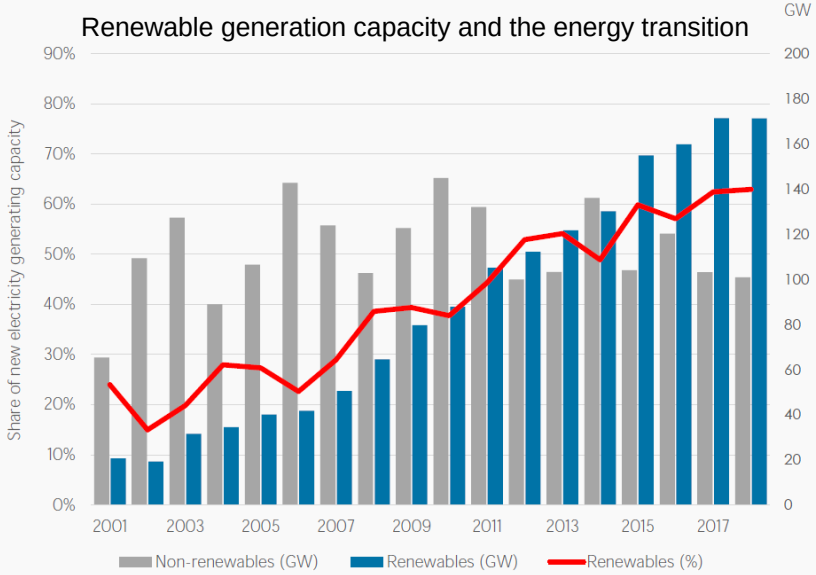
Policy Recommendations:

- Energy efficiency as the first fuel:
  - Governments need to commit to look at investing in EE before any investments in production and supply infrastructure.
  - Set clear targets for each country to reduce energy consumption according to established action plans (ex. 15% in 2050 compared to 2020)
  - Develop business models with focus on increased energy efficiency and savings. Negawatt pricing. Carbon saving pricing.
  - Industry sector: Set targets for energy intensity, phase-off inefficient technologies, obligatory EMS and increase R&D for energy intensive technologies.
  - Transport sector: Phase-off all oil vehicles according to action plans (ex. 80% by 2050, 100% by 2060), phase-off all urban public transportation on oil according to action plans (ex. 80% by 2030, 100% by 2040), increase R&D for large freight transport and rural area transportation. Develop progressive vehicle standards.
  - Buildings sector: Mandatory new buildings to be 40kWh/m^2/year by 2035 and NZEB by 2050, all public buildings to be NZEB by 2035. All energy intensive appliances to be programable based on open standards framework.

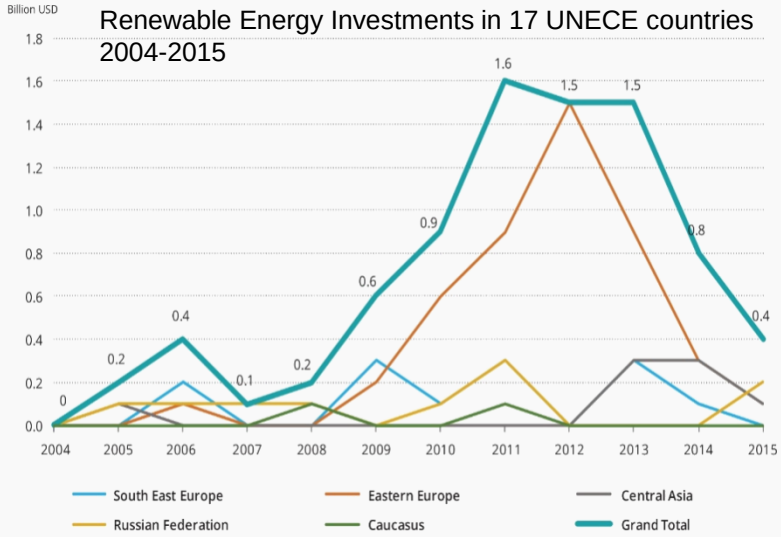
Key Insights:

Opportunities to scale up renewable energy in UNECE region

- At the end of 2018, global renewable generation capacity amounted to 2 351 GW
- 7.9% Growth in renewable capacity, 171 GW Increase in global renewable generation capacity
- 84% Wind and solar share of new capacity in 2018
- UNECE 17 Countries: Decline of investments despite high potential



IRENA Capacity Statistics 2019



REN21 UNECE Renewable Energy Status Report 2017

Policy Recommendations:

Create a suitable environment for renewable energy investments through:

- Energy reforms to remove barriers;
- Improve normative, regulatory and financial framework on holistic and integrated approach, also to address environmental and nexus related issues;
- Establishment of renewable energy funds;
- Innovative mechanisms to develop cost-effective renewable energy on a sustainable, reliable and affordable manner;
- Future energy system based on country-specific conditions;
- Strengthening technological and regional/cross-border cooperation: exchange of country experiences, trade and effective use of infrastructure, joint/ regional investments
- Increased cross-sectoral cooperation within a future energy system: trade-offs and synergies between renewable energy and gas for multiple objectives

Next Steps and Priorities in the UNECE Region

- UNECE has a significant untapped renewable energy potential
- Tracking of RE development: UNECE REN21 RE Status Report 2020
- Exchange of experiences & practices for common and faster action
- A holistic and integrated approach for inter-sectoral and cross-sectoral cooperation taking into account nexus criteria and added societal benefit, e.g. trade-off and synergies between RE & Gas; RE & Water management.
- Support member States in finding solutions to overcome existing barriers in the RE sector through multi-stakeholder dialogue – since 2016, UNECE RE Hard Talks in Georgia, Ukraine, Azerbaijan, Kazakhstan, Bosnia and Herzegovina, Serbia. Next Renewable Energy Hard Talk in the Russian Federation, 18-19 June 2019.

Key Insights:

- Many **UNECE** Member States **will continue to use fossil fuels for power generation** for decades (i.e., coal; natural gas; petroleum derivatives up to 2050 and beyond)
- An **opportunity exists** to assure that this **utilization** occurs with the **highest possible efficiency and lowest possible emissions.**
- **Deployment of digital technology** can improve operational efficiencies that must be considered in integrated system planning, engineering and construction.
- **Smart buildings; smart cities and smart grids** will deploy technologies that are not currently contemplated by today's legal and regulatory frameworks.
- **Cleaner Electricity Systems will be the centerpiece** of achieving nearly all of the UN SDG's. Consequently, it will be a pivotal factor in the work of the UNECE CSE. All groups of experts; and a key building block on the Pathway to Sustainable Energy.

Policy Recommendations:

- UNECE Member States should **adopt fiscal policies that provide CCS/CCUS/HELE technologies** with parity with other low carbon/no carbon electricity generation technologies.
- UNECE Member States should **support development/adoption of recommendations leading to standards for efficiency of power generation**, initially coal; then other fossil fuels; eventually renewables and other alternatives as new, advanced technologies enter the marketplace. Recommendations should be targeted at International Financial Institutions as well as commercial lenders.
- UNECE Members States should **support R&D into innovative technologies while adjusting policy frameworks to accommodate "disruptive" technologies**, some of which are today unknowable.
- UNECE members should **strive for deeper bi-national and regional energy market integration.** In doing so, they must be mindful of the need to harmonize conflicting real-world realities, such as environment, economic and social concerns.

Next Steps and Priorities

- **International collaboration is the key to sustainable energy** – both within the UNECE regions and with other regions.
- **Keeping all energy options open** – for existing and emerging technologies is crucial.
- Energy access, affordability, safety, security, reliability, and environmental responsibility are essential to reaching UN SDG
- Future activities should include:
  - **Defining and quantifying energy subsidies**;
  - **Identification of barriers to energy efficiency** – in some countries energy went from an era of scarcity to an era of abundance – and in some examples prices have moderated. We could reinforce the value of EE.
- Further work on integrated traditional systems with alternatives is warranted.

Key Insights from the Perspective of CMM:

- Coal Mining Lifecycle
  - Coal will be a prime energy fuel for decades to come, and **global emissions of methane will continue to increase** as mining continues to access deeper resources.
  - Coal and methane are co-located resources in many parts of the world and key coal producing nations often mine coal in gassy regions emitting greater than 750 million tonnes of CO_2e or 52.5 billion cubic meters of methane per year. Much of this is emitted as a low concentration methane in air mixture.
  - **Methane emissions do not cease at the time of mine closure**. Methane escapes through abandoned mine openings (perfect seals are not possible), through natural and mining related fractures and other conduits. **Surface mines** also emit methane, additional study is needed to verify estimates of emissions.
- Mitigation of emissions
  - **Mitigation is possible** and some projects are operating to reduce methane emissions at active and abandoned mines.
  - Annual emissions from one large underground coal mine in the USA can emit 2 million tCO_2e per year, or more, a mitigation project at similar size mine rivals CCS projects at power plants

Policy Recommendations:

- Encourage member States to **pass legislation that clarifies ownership** and **promotes global recognition** that coal associated methane is an important energy resource and a powerful greenhouse gas. This will enable beneficial use and mitigate emissions.
- Encourage preferential **access to pipelines and power grids** for gas and electricity produced from methane sourced at active and abandoned coal mines.
- Natural gas and electricity **pricing should be preferential** for energy produced from, CMM e.g. feed in tariffs and preferential dispatch.
- Introduce **tax incentives** to support CMM projects or pass legislation to **tax carbon** emissions.
- **Emissions trading** groups should be formed between coal mines and consumers to promote methane emissions reductions at coal mines through projects financed by coal consuming industry, i.e, power, cement and steel producers and **emissions credits** used as offsets for the industrial consumer's emissions.
- Establish government backed loans to **finance** development of coal mine methane emissions reductions projects. Encourage the development of a revolving fund to finance a broader array of projects

Next Steps and Priorities

- Greenhouse gases emitted during the coal mining lifecycle can be reduced if confronted
  - The **barriers** to reducing GHG emissions throughout the coal mining life are **not technological** but are caused by **gaps in policy and lack of financial support**
  - **Methane** emitted during coal mining can be used to **produce heat and electricity**, **chemical feedstocks** and **motor fuel**
    - It can be **employed to supply energy** for water purification at coal mining sites and local communities (SDG8)
    - Rather than become a fugitive and powerful GHG emission, it should be recognized as a **valuable resource** that can be **captured and used responsibly**(SDG12)
    - As coal mines inevitably close, coal associated gas may continue to be **produced and used to fuel for alternative industry development** if the value is recognized and innovation is supported by appropriate and targeted policy and infrastructure (SDG8) and (SDG9)
    - Coal mining world wide is inextricably linked with the surrounding cities and communities. Mine closures stress the fabric of the community but though **innovative business model development, community leadership, and innovative finance**, these disruptions can become **opportunities for rebuilding and growth** (SDG11)
    - The **CMM GoE** has a strong relationship with the **Global Methane Initiative**, it must forge other **partnerships to disseminate and promote** the capture and use of this gas (SDG17)
  - Coal is likely to be a part of the world energy mix for decades to come but its role in a sustainable energy future of coal is a matter of expert dispute
    - The coal mining industry needs to adopt low emissions mining operations that emphasize higher safety standards and zero fatalities
    - I**ndustrial coal consumers** must assume some responsibility for environmental degradation that occurs throughout the coal mining life cycle and work toward **energy efficient—low emission consumption**
    - Countries and communities must prepare for the **end of life phase of coal mining** as **resources are depleted** and **usage patterns and markets change**
  - CSE Expert Groups should work together to develop a *Best Practice Guidance to a Sustainable Energy Future*
  - Additional **scenarios** should be tested in Phase 2 of the Pathways Project to **test various options for energy infrastructure transformation**; the results should be used to help **guide the future work programmes** of the Expert Groups

Key Insights from the Perspective of GEG:

- Natural gas (NG) as a key tool to advance in the decarbonization of the UNECE. NG is particularly relevant for the **SDG 7** to increase access to affordable, reliable and sustainable energy, to accelerate the uptake of renewable energy and to improve energy efficiency.
- Sustainable pathways cannot be achieved without the right level of **energy infrastructure**. The **gas infrastructure can deliver high storage and transmission capacity** in a very efficient and cost-effective way.
- **Decarbonization projects (Power to Gas & Energy Storage) and renewable and Low Carbon Gases implementation** (Green/blue hydrogen and biomethane) decrease environmental impact and carbon footprint of the energy sector
- Conducting **methane emissions mapping** exercises help to understand the real impact of methane on climate change and to close the knowledge gap in terms of detection, quantification and mitigation of methane emissions along the gas value chain.
- Replacing more polluting fuels with gas, especially in sectors such as in electricity generation, heating and, as much as possible transportation, is an effective way of addressing the issue of **air pollution**

Policy Recommendations

ENERGY

Policy Recommendations:

- **The pathways should be technology-neutral** and always the **most cost-efficient**, bearing in mind that the energy future under COP21 agreement will be a combination of renewable/low carbon electrons and renewable/low carbon molecules.
- Promote the **necessary energy (gas and electricity) infrastructure and energy interconnectivity** among markets to enabling energy supply competition, liquidity, price convergence, diversification of energy supplies, renewable integration, etc., resulting in more competitive and **affordable prices** for consumers
- Ensure a **cost-efficient energy storage system** for the short, medium and long-term is therefore essential. In this regard, the role of gas system should be acknowledged. Via Power-to-gas technologies electricity can be stored in the form of gas within the gas system at minimum costs. . The gas system can deliver high storage and transmission capacities in a very efficient and cost-effective way. **Gas infrastructure is well positioned to help overcome the challenges of decarbonization**
    - Ejemplos: https://www.entsog.eu/index.php/innovation-transition
- Include in the power and gas grids development plan the effects of integrating growing shares of variable renewable (wind and solar). Wind and Solar will impose high requirements in terms of flexibility and peak demand from conventional generation technologies (i.e. gas)

Policy Recommendations

ENERGY

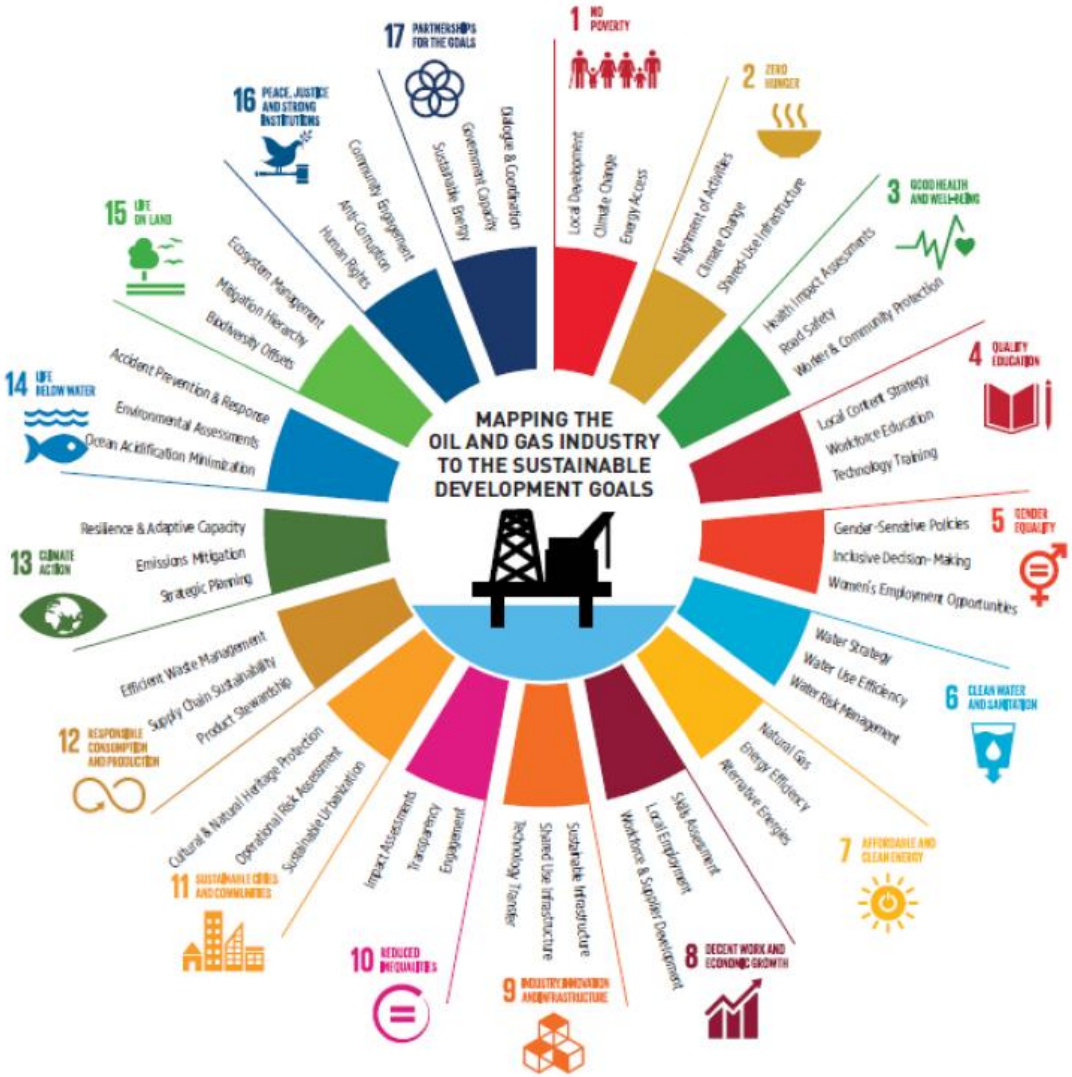
Policy Recommendations:

- Recognise the importance of **renewable gases** (such as hydrogen and biomethane). **Sector coupling and sectoral integration** are essential elements for advancing in the **decarbonisation**. This framework should recognize the positive externalities of renewable and low carbon gases:
  - For instance in biomethane, from an ecological perspective, using the digestate, which is a biomethane production by-product, instead of chemical fertilisers, reduces pollution of ground water. Fast growing energy crops, planted and harvested between two main crops and then used to produce biogas, contribute to carbon storage and do not compete with land for food usage. Economically, biomethane production creates local jobs and provides an income supplement for farmers that are involved in the process. From a security of supply point of view, large quantities of biomethane can be produced within Europe reducing the import dependency of the European energy system.
  - Ejemplos: https://www.entsog.eu/index.php/innovation-transition
- Policies to manage **methane emissions** across the value chain should enable the role of gas in the future global energy mix by helping governments achieve their climate goals, instilling stakeholder confidence with respect to gas´ environmental value and term predictability that allow industrial planning and investment
- Implement measures to improve quality of life by enhancing **air quality** in big cities and much polluted areas. This should be done as quick as possible and on the most cost-efficient manner. Gas is well-positioned to tackle this challenge. As for example: Beijing, Shanghai, Urumqi, Santiago de Chile, New York, Istanbul, Toronto, Berlin, Dublin, Krakow and Rotterdam

Other Messages

ENERGY

Gas supports Sustainable Development Goals



Source: Mapping the oil and gas industry to the Sustainable Development Goals: An Atlas, 2017, IPIECA, IFC, UNDP.

Key Insights

ENERGY

- **Oil & gas still leading the transition.** RE and nuclear will not displace them unless further financial/policy drivers exist. Oil should be replaced by gas, RE and nuclear for heating and transport, and kept for petrochemicals.
- **RE alone will not suffice** to achieve 1.5/2.0 ºC target:
  - Gradual phase out of coal and replacement by gas, cleaner coal technologies, greater focus on energy efficiency.
  - Hydrogen not an effective solution yet. Should seek a sustainable energy mix rather than focusing on fuels/technologies in an isolated manner.
- **Nuclear energy can play a key role in decarbonising the electricity sector** towards meeting the Paris Agreement targets.
- **Synergies between fossil fuels and RE**. Increasing role of natural gas as a bridging fuel leading to 2030.
- **Contrasting views on CCS**. Viable technology if costs decrease. Huge investments required, which may have a negative social impact, currently no policy incentives provided.
- **Use of natural resources has more than tripled from 1970** and continues to grow. Over 80 elements in the periodic table are required for energy production today. This high levels of resource production are responsible for:
  - 5% of total greenhouse gas emissions
  - 90% of biodiversity loss
  - 90% of water stress
- **Massive amounts of critical raw materials** required (e.g. for batteries and RE technologies, such as lithium, cobalt and nickel) **for sustainable energy**, which could be a limiting factor also due to induced import dependency bottlenecks (with large amounts of materials supplied by China, Japan, etc.). Alternative technology, acceptable international standards and adoption of circular economy can reduce material demand and increase resource security.
- **Systems-thinking approach.** Whole life-cycle of resource production and consumption should be considered both from producers and consumers' side. End-users become more aware about environmental and social issues, which can potentially lead to large shifts of behaviour.
- **Business models and disruptive technologies**: Shale oil disruptive force in recent years, better storage technologies, decentralized RE production. Growing interest for small modular reactors (SMRs) due to their lower costs, improved safety, increased flexibility and potential new applications for further decarbonisation of industry (through high grade heat for industrial processes) and transport.

Policy recommendations

ENERGY

- **Governments should develop new, transformative policy instruments**. Regulation appropriately modified to foster the rapid demand and supply of low carbon technologies. System-thinking approach can induce high impact. For example, tightening the regulation of plastics could significantly reduce the rate of oil demand.
- **Role of nuclear** as a source of low carbon baseload electricity should be recognized by governments and promoted within SDGs as part of the low carbon solution. Key component of the power mix, especially if uranium and thorium resources available from the country.
- **Alternative business models** moving away from energy as commodity (push model/ customer communication as a one dimensional bill) to energy as service, where customer partners with (or even replaces) the provider.
- **Development of storage technologies** should be pushed by governments, main game changer for RE. Heat storage in molten salts and other forms of storage should also be investigated.
- **Global governance required to ensure optimal usage of scarce resources and reduction of import dependency. Promote innovation** for transition from a linear to a **circular model.**
  - Set raw materials efficiency targets (at global, national and industry level), develop national plans for sustainable use of natural resources, adoption of policy mixes (such as regulations, market-based instruments) tailored to national context;
  - Pressure on resources will continue to increase. 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. This methodology should be adopted by all UNECE member States;
  - Waste management should be part of the initial development plans. Zero waste principal should be built into incentives.
- **Resource curse** can be avoided if a dynamic systems approach and proper information architecture are used in studying the problems, proper tools could be developed. The UN Resource Management System is one such approach.

Next Steps and Priorities

- Deep dive in circular economy, resource efficiency and sustainable consumption and production and their role in energy system transformation. Rate of recycling and reuse of materials can vary from 1 to over 80%. Business opportunities and policies that can promote circular economy. Synergies with SDG12 and SDG9.

- Deep dive on battery storage as a key game changer for accelerating uptake of renewables and EVs. Impact of import dependency for access to critical raw materials used in low carbon energy technologies. Synergies with SDG9.

- Investigate impact of electrification, digitisation and decentralisation as main drivers for decarbonisation of energy system. Business opportunities, policies and access to finance.

- By 2030, global demand for water, food and energy will increase between 40% and 50%. Interdependencies among resources (food, water and energy stress nexus) and impact on sustainable energy could be investigated at regional and sub-regional level. Determine how policies should promote more balanced intersections between energy, environment, health, security, education and social justice. Synergies with SDG8, SDG12, SDG11.

- Deep dive on nuclear energy, quantification of potential impacts/benefits towards providing sustainable energy for all. Role of small modular reactors.

Additional slides
More thoughts

ENERGY

Role of Coal in a Sustainable Energy System

- Based on data, coal is anticipated to **retain its role** in the primary energy mix.
- As countries implement their climate change pledges, the role of **coal in power generation** is expected to **decline** steadily in all scenarios.
- **Phasing out of coal has vast negative socio-economic implications**. The social dimension of coal mining communities and the regional infrastructure based on the growth of basic industries like steel and cement must be at the heart of carefully managed, sustained, long-term governmental policies.
- GHG emissions associated with coal mining need to be treated carefully. **Managing methane emissions** throughout the whole value chain – from well to burner tip – is essential.
- **Coal-fired power plants** have undergone **modernisation** over the past decade experiencing improvements in operational efficiencies and emission control system performances.
- **Increasing the flexibility of coal power plants**' operations could allow for a **faster deployment of renewable energy** sources, thereby reducing the carbon intensity of electricity generation.
- **Deploying high efficiency, low emission** (HELE) coal-fired power plants is a key first step along a pathway to near-zero emissions from coal with **carbon capture, use and storage** (CCUS).

ENERGY

Policy Action

- Modernizing a fossil-based infrastructure is a long-term undertaking and must embrace all pillars of sustainable development seeking to leave nobody behind. Particular attention must be given to a forward looking **“just transition“ approach seeking to involve all societal stakeholders to develop new business models** that can support regional restructuring and avoid a desertification. Phasing out obsolete fossil-based infrastructure must be the ultimate goal, yet caution is required regarding rapid investments omitting to recognize the crucial role that this infrastructure has for the livelihoods of many.
- **Investments in clean fossil fuel infrastructure must be possible** and internationally agreed investment guidelines for investing in clean fossil fuels could be a starting point, developed in collaboration with international development banks, the United Nations and environmental organizations.
- The ambitious 2 degree target cannot be achieved without **negative carbon technologies** to bridge the time until a more rapid renewable energy and other innovative low-carbon energy technologies will be deployed. Deploying renewable energy only will not help achieve the 2 degree target by itself over the time period of this project.
- **A price on carbon or carbon tax measures and incentives to reduce emissions** from a high carbon value chain (upstream and downstream) must come in effect to drive a low-carbon energy transition.
- Methane is a potent greenhouse gas in its own right. **Managing methane emissions along the entire value chain has societal, health, environmental, and economic benefits**, as it is also an energy carrier. Methane emissions continue even after mine closure and can be captured for industrial and energy usage. Ownership of such methane flows should be clarified.

ENERGY

Role of Oil in a Sustainable Energy System

- The role of fuel oil in **power generation mix is marginal** compared to coal and increasing role of natural gas.
- The demand for **oil in transportation sector** is expected to **slow down** on the back of further electrification and gasification of mobility.
- The **demand for oil as a feedstock in industrial sector**, particularly in chemical and petrochemical industry, is anticipated to remain significant and to grow driven by increasing global demand for plastics, fertilizers and other petrochemical products.
- International oil companies (IOC) are **diversifying their portfolios by divesting upstream assets** and investing in downstream assets.
- The Paris Agreement signaled an **increase in ambition for targets**, which could **leave more assets stranded**. The value of ‘stranded assets’ might not be fully reflected in the value of companies that extract, distribute or heavily rely on fossil fuels which could result in a sudden halt if the climate-change risks were priced in.

ENERGY

Policy Action

- Accelerate the commercialization of hydrogen to support the transition toward low carbon feedstocks in chemical and petrochemical industry.
- **Decarbonize transportation** sector by **promoting further electrification and gasification of the mobility**. Invest in urban infrastructure to support faster uptake of electric vehicles.

ENERGY

Role of Nuclear in a Sustainable Energy System

- Nuclear reactors do not directly emit CO2 during their operation compared to fossil-fuel based power plants. However, **mining and refining of uranium ore** requires large amounts of energy which if produced by burning fossil fuels, **result in CO2 emissions**.
- Major environmental risk associated with nuclear energy refers **eternal cost of radioactive waste** and areas of the planet rendered uninhabitable by **nuclear contamination**.
- Nuclear energy may be considered as a viable option for filling the gap of reliable, low carbon electricity, especially if uranium and possibly thorium resources are available from the country's own natural resources. As these elements are frequently co-located with rare earth elements, there is a natural affinity between **managing critical materials for nuclear and renewable energy sources in an integrate and complementary manner.**
- Meeting the Paris Agreement target is expected to push the uptake of nuclear energy (reaching 452GW by 2050) in the whole UNECE region, to **provide low carbon baseload power**.
- Some UNECE countries have chosen **not to pursue nuclear energy** as their power sector decarbonization solutions due to the **underlying risk of accidents, public acceptance, waste management implications as well as high lifecycle costs**. France has set a target to reduce nuclear share in power generation mix from 75% to 50% by 2035. A referendum taking place in Switzerland banned any new construction of nuclear plants.

ENERGY

Policy Action

- Nuclear energy can be an enabler in the transition to sustainable energy offering reliable low carbon baseload power. **Small modular reactors could potentially be an option for remote regions** which do not have access to the gird and may be a solution to reduce the high upfront costs.
- **Environmental and safety risks, waste management, low social acceptability as well as high upfront costs** associated with deployment of nuclear energy have to be taken in account when considering nuclear energy as an option for filling the gap of reliable and low carbon energy.

ENERGY

Role of Gas in a Sustainable Energy System

- Natural gas is **increasingly gaining traction** in the primary energy mix and is anticipated to play a continuing role through to 2050. Due to **its moderate carbon content compared to other fossil-fuels**, fuel switching from coal and oil happens most naturally with natural gas.
- The lifecycle GHG emissions of gas-fired power generation are 40% lower compared to oil-fired and 50% lower compared to coal-fired. In spite of the low CO2 emissions, abundancy and cost-effectiveness of natural gas, **methane emissions associated with natural gas need to be managed carefully** across the value chain. Methane has severe impact on environment and climate change that needs to be addressed.
- The **flexibility and low capital investment** and maintenance of gas make gas an attractive source for fossil fuel **backup for baseload operations**.
- **Gas supply chain is flexible** on the back of **gas storage**, liquefied natural gas (**LNG**) and operational flexibility of **gas pipelines**. Potential for **hybrid of renewable and natural gas-based technologies** (e.g. hybrid solar gas power plants) and **leveraging gas infrastructure** for the synthetic gas produced from excess renewables imply the potential of the complementarity of natural gas to renewables.
- Decarbonization projects such as **power-to-gas and energy storage or renewable and low carbon gases implementation** (e.g. green/blue hydrogen and biomethane) decrease the environmental impact and carbon footprint of the energy sector. Power-to-gas technologies offer value creation for the electricity that cannot be used directly or stored in batteries but can be stored in the form of gas within the gas system at minimum costs.

ENERGY

Policy Action

- Natural gas can be a **fuel of choice if fugitive methane is managed**. It can provide the base load requirements for introducing renewable energy sources into the grid sustainably. For this, countries must promote holistic, national, sustainable action plans.
- The important interplay between traditional energy sources and new ones must be recognized. The **interplay of natural gas with renewable energy can provide solutions for the intermittency of renewable resources** and further help diversify countries' energy mix. Big data, smart grids and a systems approach will facilitate this transition.

ENERGY

Role of Renewable Energy Technologies in a Sustainable Energy System

- **Renewable energy is playing a key role in the transformation of energy system**. In 2016, the installed electricity capacity of renewable energy sources in the UNECE region amounted for about 869 GW accounting for almost half of the renewable electricity capacity installed worldwide.
- Increasing installed capacity of renewable energy technologies in many UNECE countries has driven the **reduction in capital costs and increased confidence in lifecycle costs, improving their economic viability.**
- **The role of renewable energy in the energy mix across the UNECE region remains imbalanced.** Whilst Europe and North America account for 23% and 16% of the total renewable generation capacity, the Russian Federation, South Caucasus and Central Asia 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. **Investment in transmission infrastructure is a prerequisite** in these countries for increasing the **uptake of renewable energy** technologies.
- **Integration of fluctuating renewable energy** into power and heating grids is one of the **biggest challenges** towards fostering sustainable energy. Flexible power systems that rely on the **interplay of fossil fuels and renewable energy** and storage systems, can play an important role in grid resilience and stability and are of vital importance **to balance the intermittency** of the wind and solar PV.
- Renewable energy technologies could **address some of the trade-offs between water, energy and food production**, bringing substantial benefits in all three sectors. They can moderate competition by providing energy services using less resource-intensive processes and technologies compared to conventional energy, especially in transboundary river basins in South East Europe, the Caucasus and Central Asia. The **energy-water-food nexus approach aims to support more sustainable renewable energy deployment** by building synergies, increasing efficiency, reducing trade-offs and improving governance among sectors. The emphasis is on **transboundary co-operation in both energy sector development and water management**.

ENERGY

Policy Action

- The important interplay between traditional energy sources and new ones must be recognized. The **interplay of fossil fuels with renewable energy can provide solutions for the intermittency of renewable resources** and further help diversify countries' energy mix. Big data, smart grids and a systems approach will facilitate this transition.
- Countries should **strengthen technological and regional cross-border cooperation by sharing best practices on developing renewable energy infrastructure** and scaling up the share of renewable energy in the energy mix and engage in joint investments.
- Increasing the renewable energy share can help to reduce water requirements in power generation; boost water security by improving accessibility, affordability and safety; and contribute to food security objectives. Countries should **recognize the benefits of the water-energy-food nexus and transboundary cooperation** and **promote** the development of **renewable energy** in South East Europe, the Caucasus and Central Asia basins to **support modernization of the energy system and water management**.

ENERGY

Innovation and technological developments are steering the direction of energy transition

- The ‘3D energy transition’ to a **decarbonized, decentralized and democratized energy system** is underway.
- The energy system as we know it is in flux. 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. **Grid operators will need to embrace new business models and increase cooperation with new market entrants** and community.
- Through **smart grids** electricity is distributed from producers to consumers on the back of digital technology through control automation, real-time monitoring and optimization in order to save energy, reduce cost and improve reliability. **Smart grid technology therefore provides the flexibility** needed to **integrate variable renewable energy** (wind and solar). Technology integration into the energy system, therefore, is a prerequisite for energy transition and modernization of the energy system.
- The **democratization of the whole system is underway**. Ongoing innovation and digitalization of the energy system is **creating a new generation of consumers**. People wish to actively manage their energy consumption. 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 are being more in control. Therefore, distribution companies need to move the center of gravity to customers.

ENERGY

Policy Action

- **Policy makers**, who seem to be the followers in the current fast-paced transition, now **have the unique opportunity to engage and develop policies and regulative framework to attract investment** and speed up the rise of renewable energy, energy storage and widespread system electrification.
- Smart grid technology is the key for an efficient use of distributed energy resources. **To achieve further commercialization of renewable energy and widespread use, an efficient energy management strategy of system needs to be addressed**. Smart grid developments are driven by both demand side – large utilities and demand side – customers. Growing installation of renewable energy resources require coordinated efforts across the whole value chain – from power generation to distribution, storage and consumption.
- **Promote flexible business models and creating necessary regulatory frameworks** is highly important for further technological innovation. Renewable and storage technologies improvements and innovation should be cost effective and made widely available.

ENERGY

Energy Efficiency is a low hanging fruit to support deep energy system transformation

- The **future energy system has to be designed with efficiency as its core value**. Optimizing energy usage, both at generation level as well as consumption level is a natural process that is already slowly occurring lead by technology development and behavioral changes. However, the rate of optimization of processes and consumption is lower than the rate of increasing of the energy demand. It is **necessary to rethink how we value energy efficiency and start thinking of it as an energy source of its own right**.
- **Energy efficiency in the industry sector** already has been proven that **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.
- **Residential sector is 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.
- **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 EVs, biofuels and hydrogen, are expected to drive further 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.

ENERGY

Policy Action

- **Business models that prioritize improvements in energy productivity have to be promoted**. Before investing in new production and supply infrastructure, countries should improve energy efficiency and productivity when cost-effective in the production, transmission, distribution and consumption of energy.
- Countries should **limit the energy intensity of industrial sector and invest in targeted R&D** for technologies that are energy intensive.
- Existing technology solutions already allow residential and commercial sector to transform buildings to align with the highest standards of health, comfort, well-being and sustainability, including improving energy productivity and reducing CO2 emissions. Countries should **enhance efficiency of residential building envelope and NZBE (nearly zero energy buildings) standards for all new public buildings after 2o5o have to be introduced.**
- In order to **improve energy efficiency of the transportation sector** the countries should **enforce environmental standards for vehicles and introduce mandatory planning of cities** based on commuter transport efficiency. **Investments in targeted R&D are necessary** for the decarbonisation of the large freight transport.

ENERGY

Circular economy

- Sustainable development is fundamentally linked to **access to critical raw materials**. Over 80 elements in the periodic table are required for energy production today. Rate of recycling and reuse varies from 1 to over 80%. Over 15 elements of the periodic table have achieved more that 50% recycling rates.
- Apart from price and quality, consumers want to know how and where and by whom the product has been produced. This **increasing awareness about environmental and social issues**. Even if resources could be identified as plenty, social, environmental, including carbon constraints makes a part of the resource-base inaccessible.

ENERGY

Policy Action

- Countries need to **institute sustainable resource management practices** that embrace **circular economy** principles and that integrate the full spectrum of the 2030 Agenda's goals and targets (i.e. nexus approaches).
- **UNFC methodology for assessing resources for circular economy** should be adopted by all member States. Pressure on resources will continue to increase as demand for rare earth minerals to produce batteries on the back of widespread electification grows. A comprehensive raw materials management system, such as the **United Nations Resource Management System** (UNRMS), will be necessary.

ENERGY

Investments on subregional level have to target opportunities to accelerate modernization of the energy system

- **Predictable environment** with forward looking policies is a **precondition for investments in energy innovation** which are essential for both economic growth and environment.
- **Investment in transmission infrastructure is a prerequisite** in the Caucasus, Central Asia, the Russian Federation, and South East and Eastern Europe countries for increasing the **uptake of renewable energy** technologies.
- **Public private partnership (PPP) schemes and public based investments** are useful to empower consumers and local community to be active participants in the transformation of the energy system. Distributed renewable energy can offer reliable and clean energy to both grid connected and non-grid connected communities

ENERGY

Policy Action

- Electrification and the need for more power generation increases the investment needs in the energy sector. **Investments in smart infrastructure** will be important to support integration of variable renewable energy technologies, along with innovations and disruptive technologies such as smart grids, energy storage, renewable heating and cooling.
- Countries need to **introduce carbon taxes and eliminate fossil fuel subsidies to provide the market signals** towards fostering more investments, increasing investors' confidence and decreasing cost of capital.

Additional slides
Methodology & Data

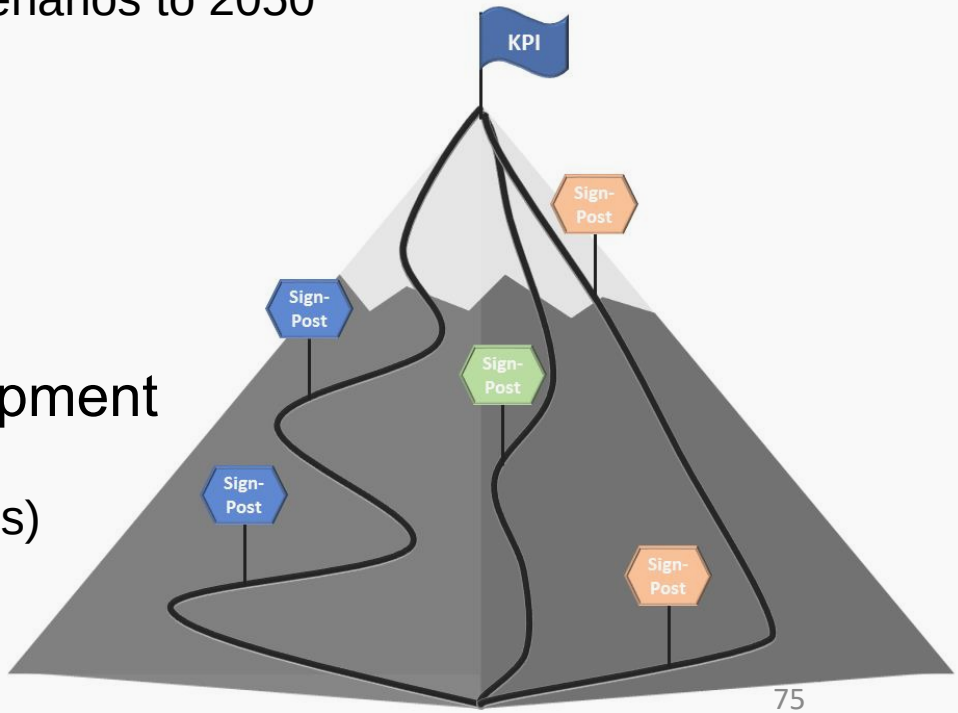
Project Overview

Pathways to Sustainable Energy

ENERGY

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

- Current Phase: May 2017 – Oct 2019 (further phases planned)
- 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" development
    - SE Targets
    - Key Performance Indicators (KPIs)
    - Signposts



https://www.unece.org/energy/pathwaystose.html

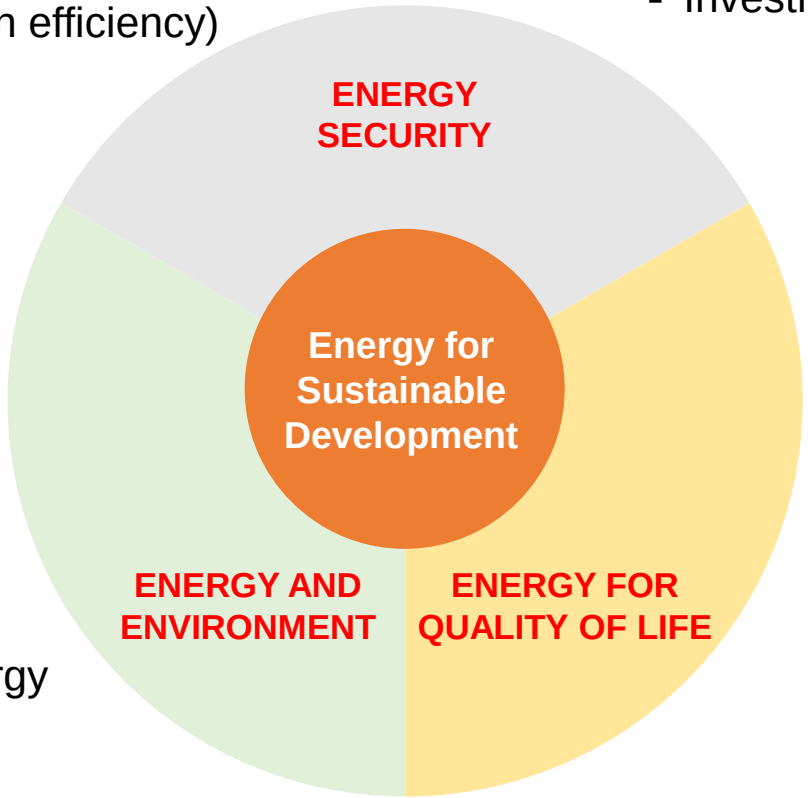
Pathways Project and Sustainable Energy

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)

Scenario development

Illustration of scenario design

ENERGY

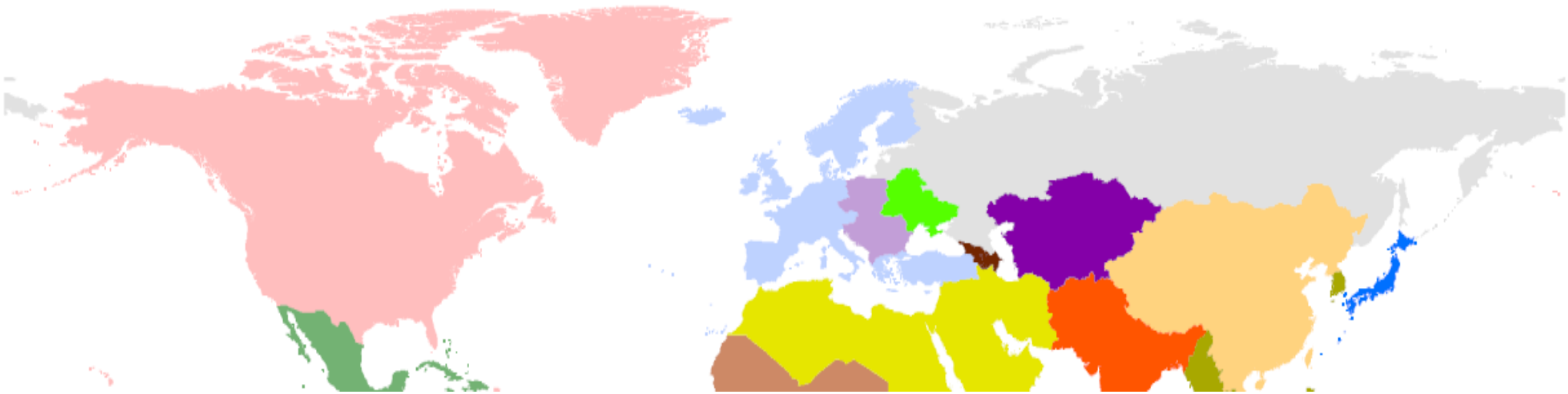
INPUT	Examples	MODEL	OUTPUT	Metric examples	Targets/Goals
Demographic	• Population by region	**Integrated Model** • Resource extraction, exports-imports, energy transformation and use • Markets • Capital • Labor • Agriculture • Land use • Carbon cycle • Atmosphere • Hydrology • Oceans	Energy Security	• Price of energy • Energy imports/exports • Electricity access • Energy/GDP	LPG/KPI
Productivity	• GDP per capita by region				
Technology	•Power plant conversion efficiency •Transport fuel economy, etc. •Crop yields, etc.		Quality of Life	• GDP per capita • Energy services per capita • Share calories from non-staples • Water stress	LPG/KPI
Resources	•Fossil fuel, uranium, solar, wind, geothermal, land, water and other				
Policies	•Pollution control •NDCs •Water use		Environmental Sustainability	• SO_2 NO_x O_3 concentrations • Deforestation/afforestation • Avg. Earth surface temp • Water withdrawals/recharge	LPG/KPI

Modeling Regions

MESSAGE model: 7 UNECE Sub-Region

ENERGY

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



Scenarios Review

Technology

- **Reference:** Middle-of-the-road scenario (SSP2*)
- **Advanced renewables:** Reduced capital costs for solar, wind, and geothermal
- **Low-cost nuclear:** Lower capital costs reflective of small modular reactors
- **Advanced CCS:** Improved capture rate, reduced storage costs

Policy

- **Reference:** No mitigation action
- **Paris NDC continued ambition:** regional CO_2 emissions caps based on national Paris pledges plus continued actions post-2030
- **Paris NDC continued ambition, global cooperation:** CO_2 mitigation as in NDC, implemented using a global carbon market
- **Paris to 2ºC:** regional CO_2 emissions caps based on national Paris pledges plus enhanced ambitions post-2030 to reach the 2ºC goal
- **Paris to 2ºC, global cooperation:** CO_2 mitigation as in P2C, implemented with a global carbon market

Technology \ Policy	Reference	Paris NDC continued ambition*	Paris NDC cont. ambition, global cooperation	Paris to 2°C	Paris to 2°C, global cooperation
Reference Technology	Ref-RefTech	NDC-RefTech	NDC_global-RefTech	P2C-RefTech	P2C_global-RefTech
Advanced Renewables	Ref-REAdv			P2C-REAdv	
Low-cost Nuclear (SMR)	Ref-NucAdv			P2C-NucAdv	
Advanced CCS	Ref-CCSAdv			P2C-CCSAdv	

More details on the SSP2 scenario (reference) can be found in: Fricko et al., 2017. The marker quantification of the Shared Socioeconomic Pathway 2: A middle-of-the-road scenario for the 21st century. Glob. Environ. Chang. 42, 251–267.

Technology assumptions

Technology		Reference assumptions	Advanced assumptions
Renewables	Solar	Capital costs decline about 25% by 2050	Capital costs decline more than 60% by 2050
	Wind	Capital costs decline about 20% by 2050	Capital costs decline more than 60% by 2050
	Geothermal	Capital costs less than 10% by 2050 Only hydrothermal resources	Capital costs decline about 20% by 2050 New enhanced geothermal system (EGS) resources (regional specific supply curves)
Nuclear		2010 $5,501/kw 2030 $5,307/kw 2050 $5094/kw	Lower capital costs that reflect the small module reactors (SMR) Advanced assumption is about 35% lower than the reference assumption
CCS		CO2 capture rate: 85% in 2020, increase to 95% by 2100	Higher CO2 capture rate: 99% Lower costs of carbon storage (region-specific) that are in line with SSP5 assumptions

Overview of results presentation

ENERGY

Performance of scenarios against Key Performance Indicators (KPIs) related to the three pillars of sustainable energy.

Energy Security

- Energy Demand
- Primary energy mix
- Energy Trade
- Final Energy Mix (at Subregional Level)
- Energy Intensity (at Subregional level)

Energy for Quality of Life

- Energy Access: electricity generation by technology
- Energy Affordability: electricity consumption per capita
- Energy expenditure as a share of GDP
- Gaps and Investment Requirements

Energy & Environment`

- GHG emissions
- CO_2 emissions per sector
- Water consumption in energy sector
- Mineral resource extraction

Stakeholder consultation

- Model outputs through KPIs (Reaction on the model results)
- Key messages
- Policy recommendations

Project Timeline

Engagement with the Expert Community

ENERGY

May 2017

Sep 2019

Modeller Kick-off Workshop
Oberhausen, May 2017

Kick-off & Expert Workshop at 8th IFESD
Astana, Jun 2017

Status update 26th CSE
Geneva, Sep 2017

Expert Workshop,
Vienna, 5-6 Mar 2018

Central Asia Workshop
Kyrgyzstan, 12-14 June 2018

Consultation and Information Workshop
Geneva, 25 Sep 2018

UNECE-wide Policy Dialogue Geneva, 26 Sep 2018

Expert Workshop at 9th IFESD
Ukraine, 12-15 Nov 2018

Consultation Workshop(s)
14-15 May
23-24 Sep (tbc)

Preparatory Meeting
High-Level Policy Dialogue
Geneva, 16 May 2019

High-level Policy Dialogue
25-27 Sep 2019

CSE = Committee on Sustainable Energy
IFESD = Internat. Forum on Energy for Sust. Dev.