European Commission

IRENA
International Renewable Energy Agency

Joint IRENA – JRC Expert Workshop

“Benchmarking long-term scenario comparison studies for the clean energy transition”

Virtual event – Thursday 10 and Friday 11, September 2020

Housekeeping

- Mute mics (muted by default)
- Questions may be submitted to panellists through the Webex Q&A function.
- All presentations and recordings will be shared after the workshop on the IRENA website
- Day 1: Presentation day (10 September 2020, 3:00 - 5:40 p.m. CET)
- Day 2: Discussion day (11 September 2020, 3:00 - 5:00 p.m. CET)

Welcome remarks

European Commission

IRENA
International Renewable Energy Agency

Dolf Gielen

Director, Innovation and Technology Centre, IRENA

Dolf Gielen is the Director of the Innovation and Technology Centre of the International Renewable Energy Agency (IRENA). He oversees the agency's work on advising member countries on energy scenarios and planning, power sector transformation, cost and markets, technology status and innovation outlooks, and project development guidelines.

Stathis Peteves

Head of Unit, Knowledge for the Energy Union, Joint Research Centre of the European Commission

Stathis Peteves is the Head of Knowledge for the Energy Union in the Energy, Transport and Climate Directorate. He leads the Commission`s Strategic Energy Technologies Information System (SETIS), the scientific and technical support tool to the decision making of the SET-Plan governance; the monitor and assessor of EU's energy technology innovation progress.

Scene-setting and keynote presentations

Asami Miketa

Senior Programme Officer, Power Sector Investment Planning, IRENA

Asami Miketa is a Senior Programme Officer at the Innovation and Technology Centre, IRENA in Bonn and leads the program to support long-term energy planning activities, alongside the campaign on Long-term Energy Scenarios for Clean Energy Transition under Clean Energy Ministerial.

Long-term Energy Scenarios (LTES) for the Clean Energy Transition

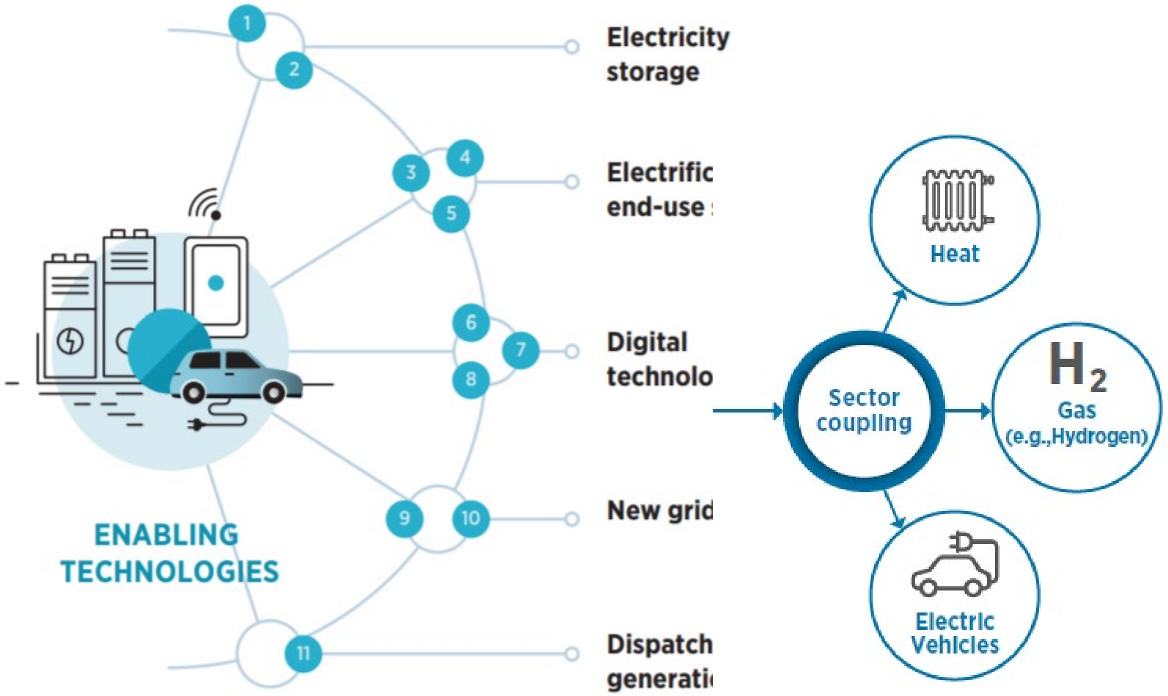
– CEM campaign and IRENA Network –

Joint IRENA – JRC Expert Workshop
“Benchmarking long-term scenario comparison studies for the clean energy transition”
10-11 September 2020, Virtual event

Why long-term energy scenarios (LTES)?

- **Fundamental tool for policy making and planning**
  - National policy making
  - Global policy debates / public opinion

- **What is new?**
  - Global decarbonisation (NDCs - Paris Agreement)
  - Renewable technologies are cost effective, reliable components of energy sytems
  - Innovation within and around the energy sector



- **Long-term visions for clean energy transition**
  - Avoiding risks of making poor, short-sighted decisions – stranded assets.
  - Represent transformative changes of energy systems (e.g., VRE, hydrogen, power-to-X, etc.)

Artificial intelligence

Blockchain

Platform business model

IoT

The LTES Campaign and Network

IRENA
International Renewable Energy Agency

Promote the effective use and development of "long-term energy scenarios" (LTES) to guide the clean energy transition

LTES Network

IRENA
International Renewable Energy Agency

Government planning offices (or equivalent)

Technical institutions supporting government

LTES LONG-TERM SCENARIOS FOR THE ENERGY TRANSITION
A CAMPAIGN OF THE CLEAN ENERGY MINISTERIAL

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

13 CEM member countries

Brazil, Canada, Chile, Finland, Denmark, Mexico, Germany, Japan, The Netherlands, United Arab Emirates, United Kingdom

7 Technical partners

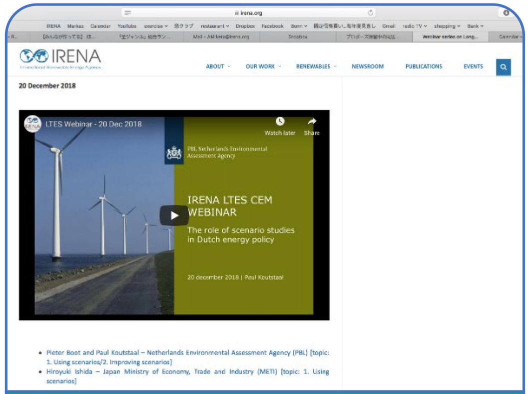
International Energy Agency — Secure Sustainable Together
etsap
CNREC China National Renewable Energy Centre
国家电网有限公司 State Grid Corporation of China
European Commission — The European Commission's science and knowledge service — Joint Research Centre
JISEA Joint Institute for Strategic Energy Analysis
World Energy Council

Activities of the LTES Campaign and Network

Hundreds of scenario users and developers have been engaged through the LTES Campaign and Network's activities to exchange experiences and best practices.

International Forums

Thematic side events



Webinar series

Best practice reports

https://www.irena.org/energytransition/Energy-Transition-Scenarios-Network

Key recommendations from the LTES campaign

- A collection of over 50 best practices and examples from over 20 countries and technical institutions worldwide on the use and development of LTES.

- Recommendations and experiences stemming from the discussions in the LTES Campaign and Network activities (2018 - 2020).

Strengthening Development	**○ Establishing a good governance structure** **○ Expanding the boundaries of scenarios**
Improving Use	**○ Clarifying the purpose of scenario building** **○ Transparent and effective communication**
Approaches to Institutional Capacity	**○ Building the right type of scenario capacity within governments**

Issues of interest to government planners

- **Stock-taking of modelling tools used for the official government scenario development**
- **Scenario communication and stakeholder engagement**
- **Stock-taking of official government scenarios**

Issues of interest to government planners

- **Stock-taking of modelling tools used for the official government scenario development**
- **Scenario communication and stakeholder engagement**
- **Stock-taking of official government scenarios**
  - Narratives and policy drivers
  - Scenario boundaries
  - Global and regional trends

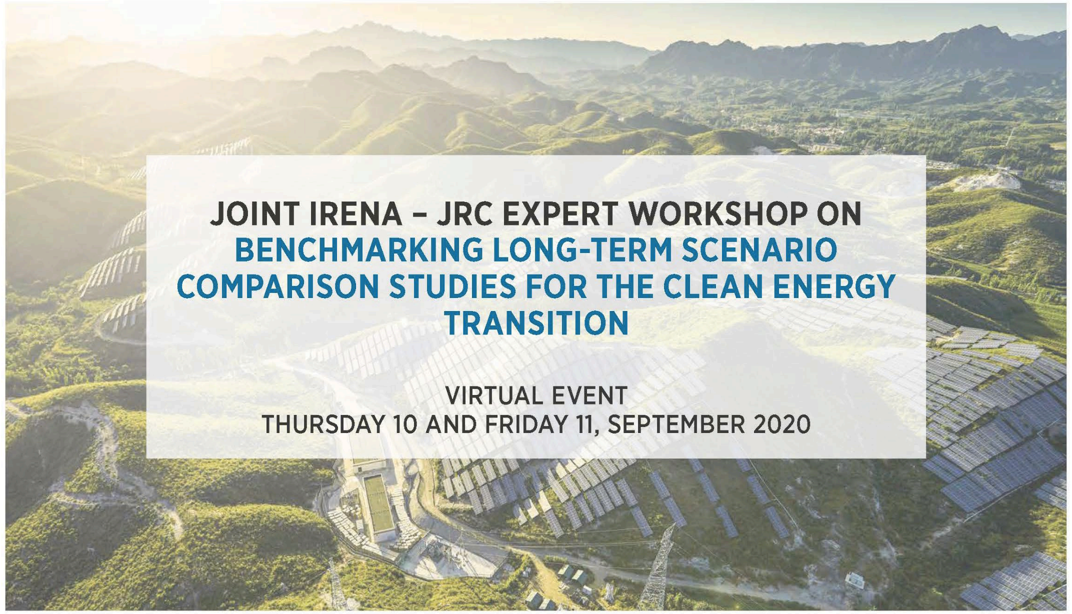
What are the key parameters/assumptions that define clean energy transition scenarios?

Outcome of this workshop

- **Workshop proceedings**

- **Follow up webinar**

  Net-zero emission by 2050: a high-level dialogue on the role of long-term energy scenarios in guiding ambitious climate targets (November 2020)



WOUTER NIJS
Project Officer, Joint Research Centre of the European Commission

CHRISTOF VAN AGT
Director of Energy Dialogue, International Energy Forum (IEF)

ANASTASIA BELOSTOTSKAYA
Associate Director, Scenarios and Special Projects, World Energy Council

EDWARD BYERS
Research Scholar, Institute for International Applied System Analysis (IIASA)

PABLO CARVAJAL
Associate Programme Officer, Clean Energy Transition Scenarios; IRENA

EWELINA DANIEL
Policy Analyst - Economic Officer, European Commission, Directorate General for Energy

Mathias Kimmel
Lead Analyst, Bloomberg New Energy Finance

ANDRIES HOF
Senior Researcher, Netherlands Environmental Assessment Agency (PBL)

CHRISTOPH JUGEL
Director, Energy Systems, Deutsche Energie-Agentur GmbH (DENA)

JÜRGEN P. KROPP
Department Head, Climate Resilience, Potsdam Institute for Climate Impact Research

TRIEU MAI
Senior Energy Analyst, National Renewable Energy Laboratory

ANAHI MOLAR-CRUZ
Research Associate, Technical University of Munich

JAMES NEWCOMB
Managing Director, Emerging Solutions, Rocky Mountain Institute

DANIEL RAIMI
Senior Research Associate, Resource for the Future (RFF)

SHEILA SAMSATLI
Prize Fellow and Assistant Professor, University of Bath (UoB)

WILLIAM ZIMMERN
Head of Global Macroeconomics/Lead Economist, Energy Transition, BP

Thank you!

Asami Miketa
amiketa@irena.org

Wouter Nijs

Project Officer, Joint Research Centre of the European Commission

Wouter Nijs is a Project Officer at the Joint Research Centre (JRC) of the European Commission and has more than fifteen years of experience in energy consultancy and energy related research. Together with the JRC colleagues, Wouter was the first to open a European multi-sectoral energy system model named JRC-EU-TIMES.

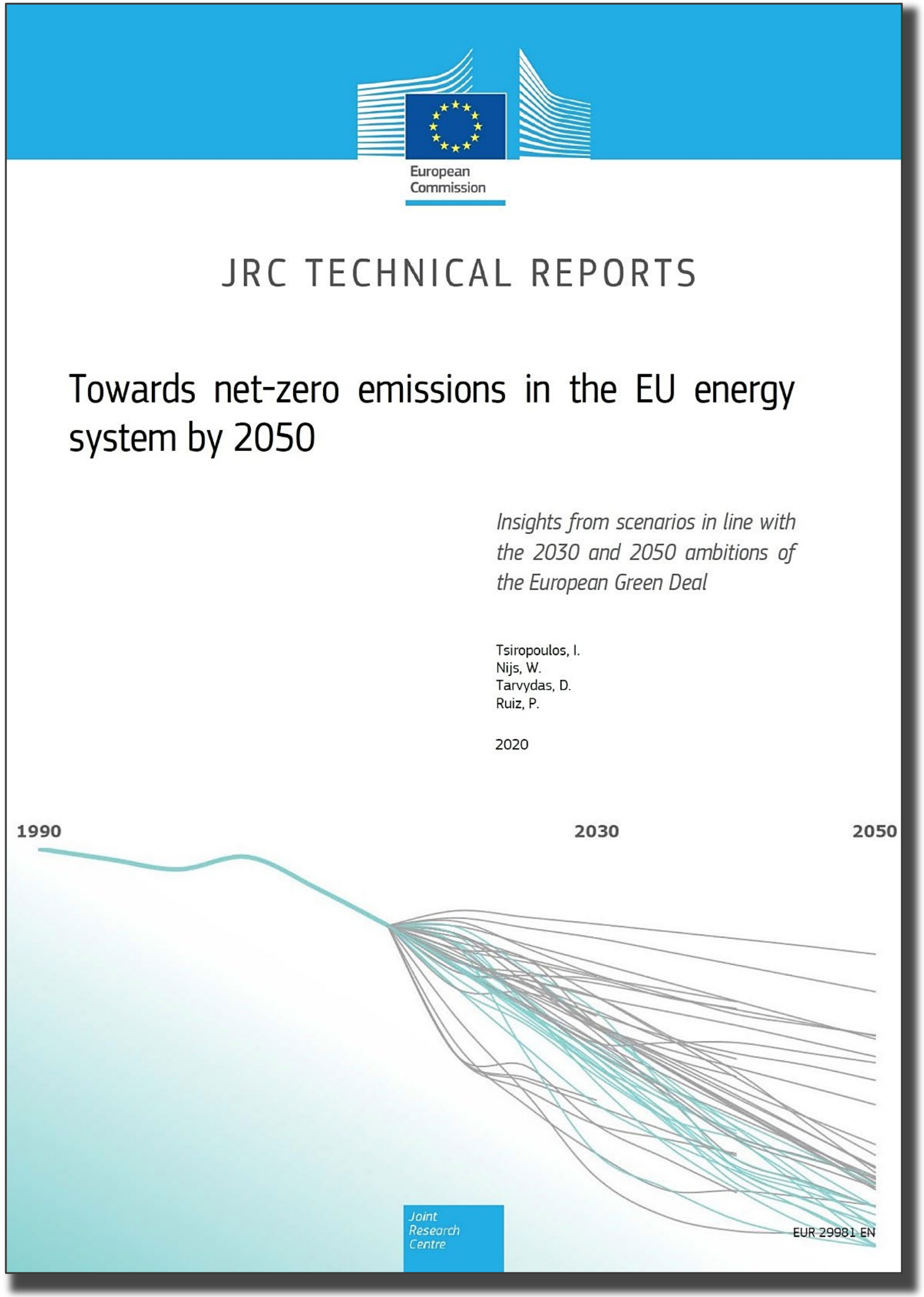
Towards net-zero emissions in the EU energy system

Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal

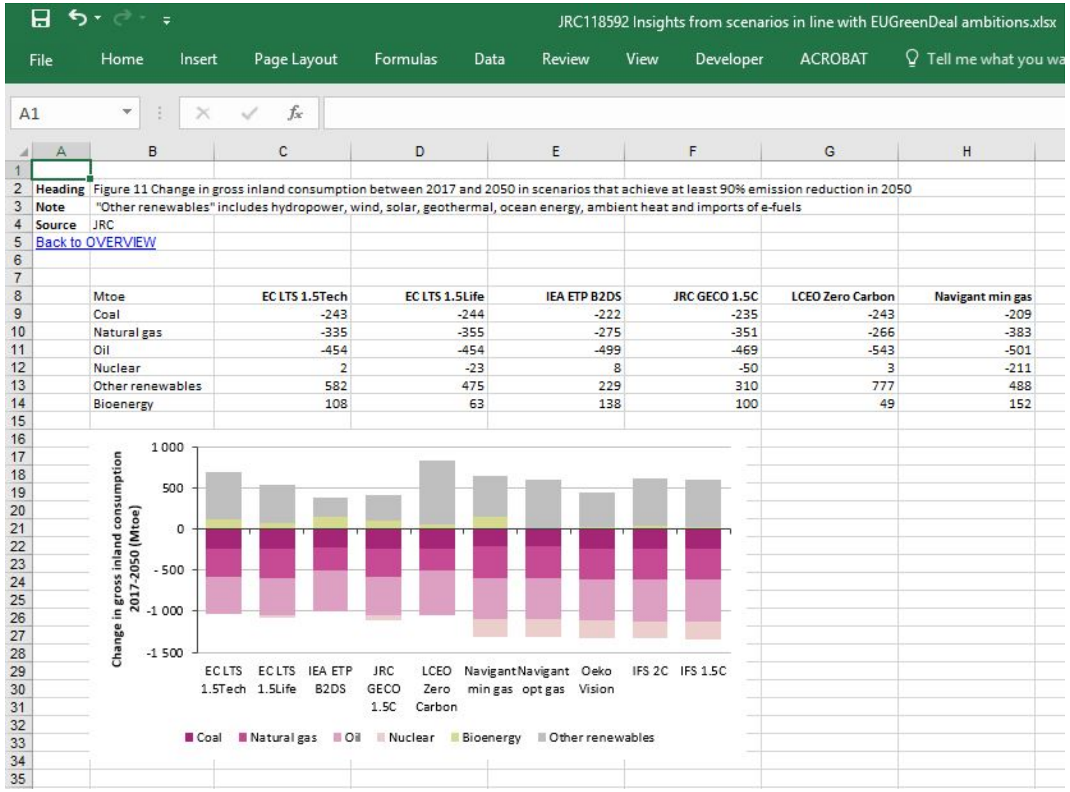
Wouter Nijs, JRC.C7, Knowledge for the Energy Union

Keynote IRENA–JRC Expert Workshop on Benchmarking long-term scenario comparison studies for the clean energy transition, 10 September 2020

Authors: I. Tsiropoulos, W. Nijs, D. Tarvydas & P. Ruiz



+



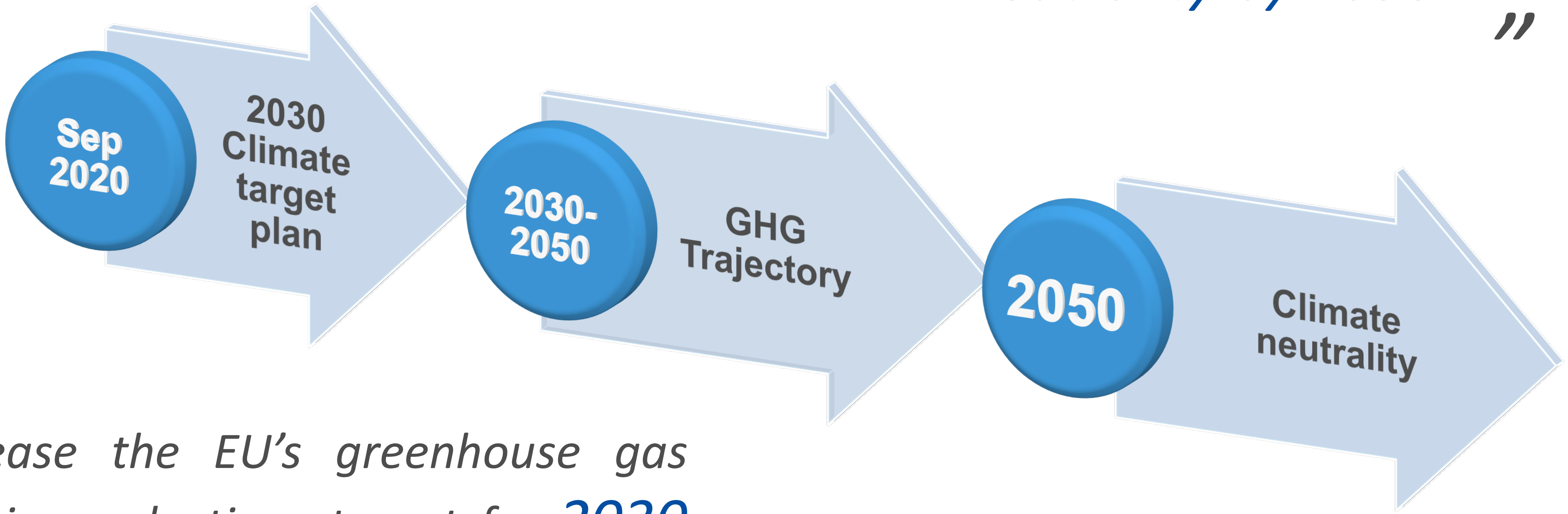
Mtoe	EC LTS 1.5Tech	EC LTS 1.5Life	IEA ETP B2DS	JRC GECO 1.5C	LCEO Zero Carbon	Navigant min gas
Coal	-243	-244	-222	-235	-243	-209
Natural gas	-335	-355	-275	-351	-266	-383
Oil	-454	-454	-499	-469	-543	-501
Nuclear	2	-23	8	-50	3	-211
Other renewables	582	475	229	310	777	488
Bioenergy	108	63	138	100	49	152

Data behind the graphs, Towards net-zero emissions in the EU energy system by 2050, JRC118592, licensed under CC BY 4.0., © European Union, 1995-2020.

European Commission

European Green Deal

"...supporting a cost-effective transition to ***climate neutrality by 2050****..."*



"...increase the EU's greenhouse gas emission reductions target for ***2030*** *to* ***at least 50% and towards 55%*** *compared with 1990..."*

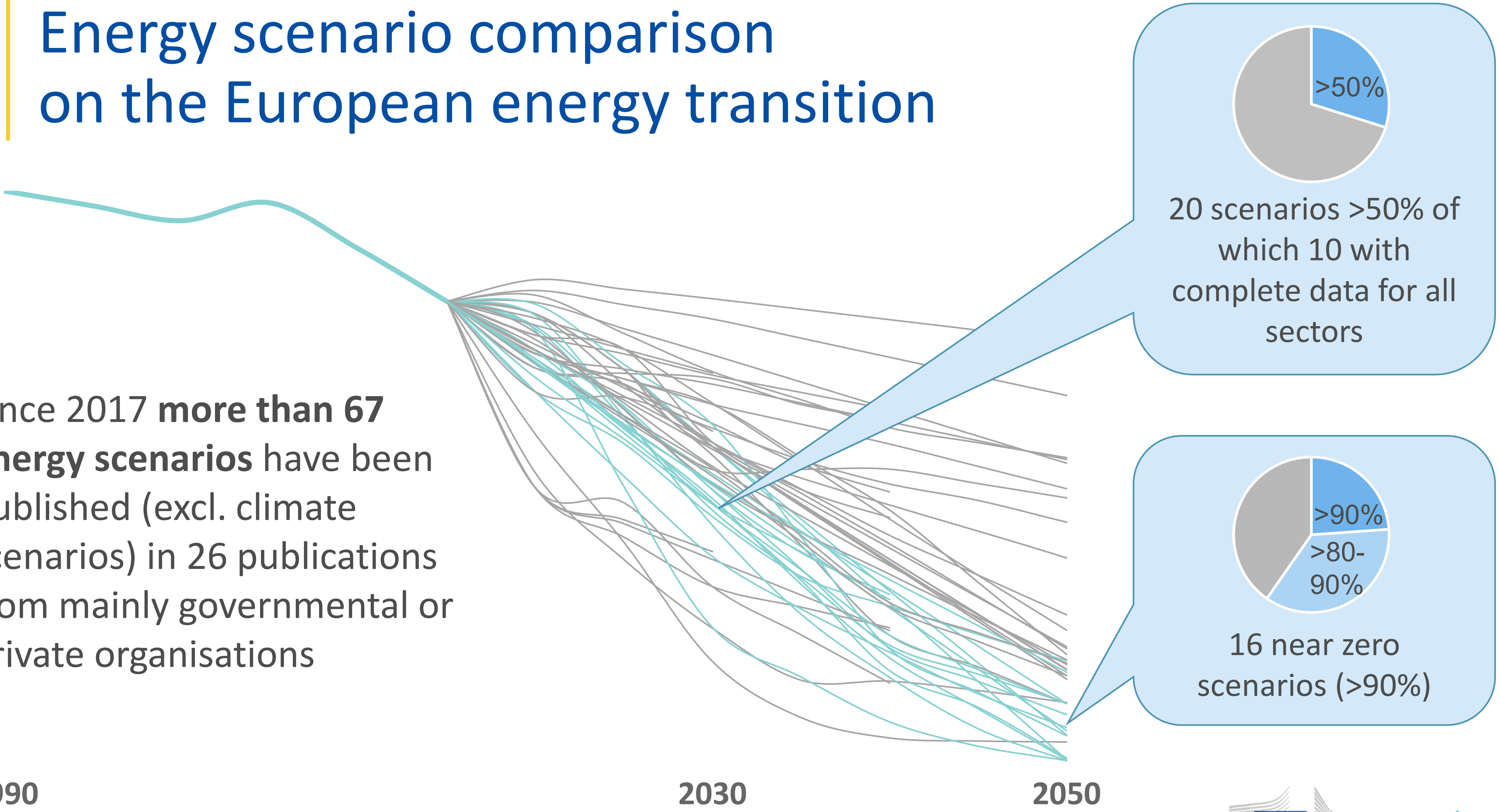
COM(2019) 640

COM(2020) 80 final

European Commission

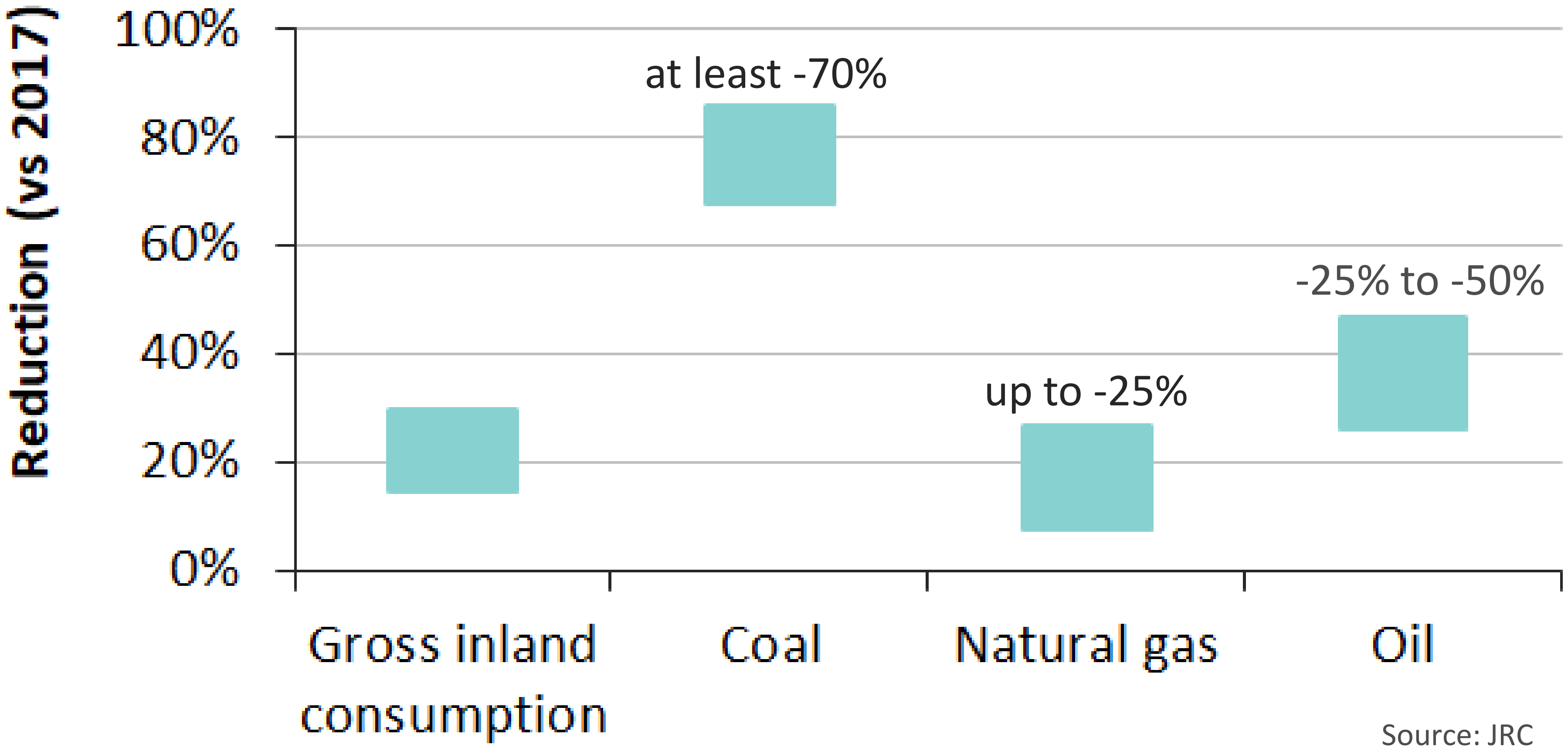
Energy scenario comparison on the European energy transition

Since 2017 **more than 67 energy scenarios** have been published (excl. climate scenarios) in 26 publications from mainly governmental or private organisations



Emission trajectories based on energy-related and process CO_2; scenarios highlighted in blue have been reviewed by JRC.

Sufficiently narrow ranges for fossil fuel use across scenarios with -50 to -56% CO_2 by 2030

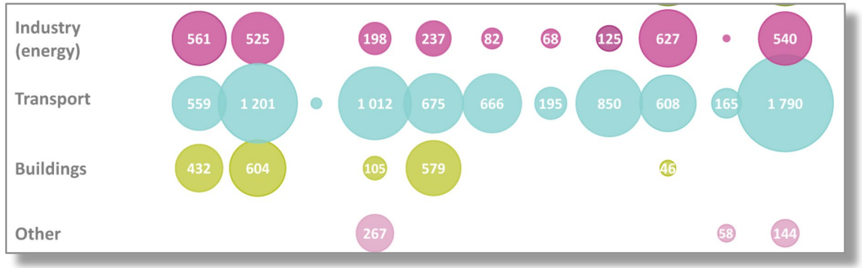


Source: JRC

European Commission

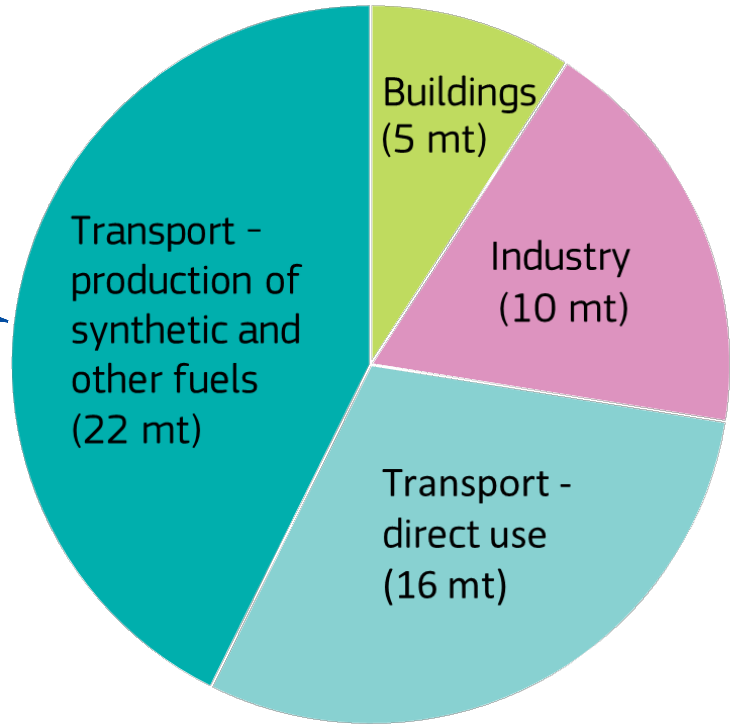
Even when ranges are large strong conclusions can be made

On average,
40% of the hydrogen is used
as feedstock for the
production of other fuels



Consumption of hydrogen (TWh)
Source: JRC, "Hydrogen use in EU decarbonisation scenarios"

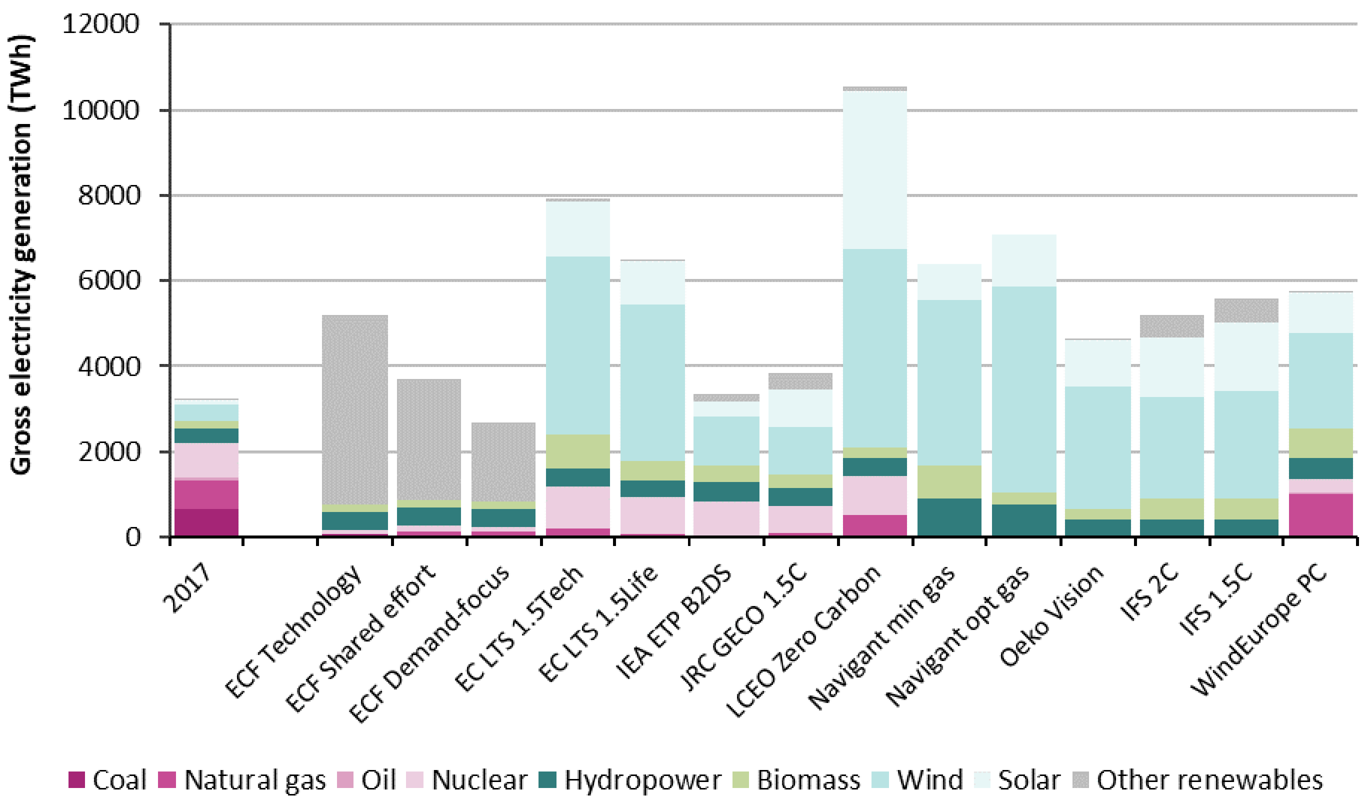
Average 2050 hydrogen use (million tonnes)



1 mt = ± 3 mtoe = ± 30 TWh
Only for transport hydrogen is split into direct use and synfuels;
Only scenarios with more than 15 mt total hydrogen use;
Source: JRC116452 and JRC118592.

European Commission

Electricity generation up to 2050 from no growth up to an increase by a factor 3



Source: JRC

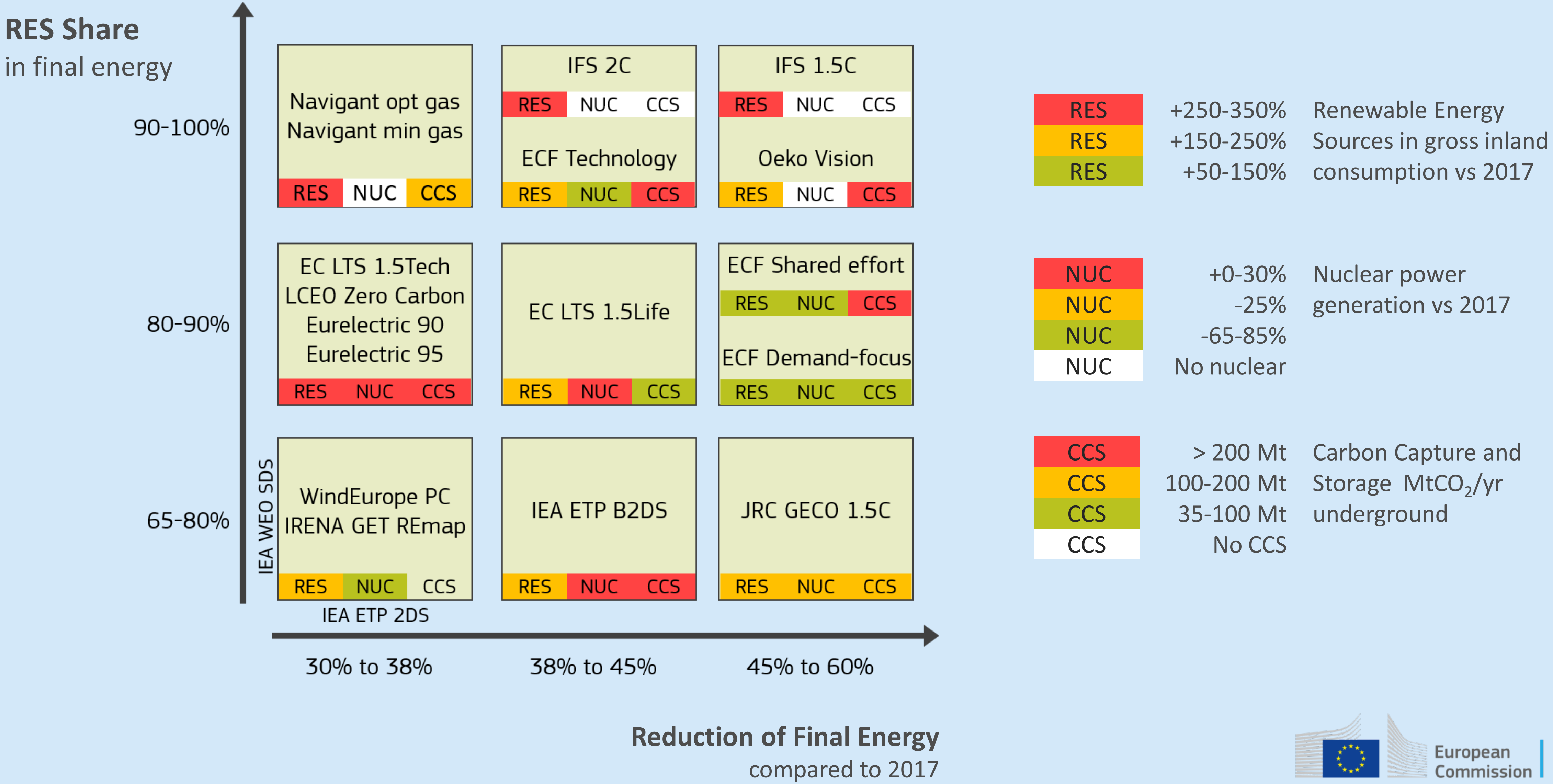
Renewables provide 75% to 100% and there is undisputed growth of wind and solar power. However growth for each varies from a factor 3 to 13. Why ?

1. Energy efficiency - "*Electrification* in all sectors, but not necessarily *more electricity* in buildings and industry"

2. The amount of hydrogen/e-fuel versus CCUS deployment

European Commission

Scenario grouping helps to identify key indicators



Source: JRC

What to focus on for climate neutrality ?

Similarities can create a predictable environment for investors, showing what needs to be done and at what speed.

Fast transitions requiring large investments

- Coal, oil and finally natural gas nearly phase-out
- Electrification and ZEV
- Underground storage of CO_2

The overall energy system, sector integration and new fuels

- Refocusing from "integrating of renewables" to "new ways of using renewables"

Differences can identify key drivers and can underpin choices for transformations with long lead times

Energy efficiency and the size of the energy system

- More robust estimation of markets and material needs
- Buildings deep renovation

Technology pathways and innovation

- The extent to which enabling technologies, (e.g. electrolysers, CCUS, solutions for aviation) will be deployed

How to improve ?

Approaches

Harmonisation
- Regions
- Indicators
- Derived indicators if missing

Transparency on critical assumptions; grouping
- Technology costs, CO_2 prices
- Industrial output, materials
- Renovation rates
- Utilisation rates of vehicles

Transparency on results
- New indicators
- Subsector details
- Feedback to the models

Communication

Transparency on approach
- Methodology description key for gaining trust

Link with policy
- Recognising and applying the different process, including linking with policies
- Visualisation

Selection of indicators
- Meaningful representation

Quantify growth and reductions; negative priorities	Deep energy renovation rate	% houses that change heating system	Car sales or car stock	Market size; annual investments	Hydrogen and e-fuel production	Number of CO_2 storage facilities


The European Commission's science and knowledge service
Joint Research Centre
Water depth 100-1000m Floating
Water depth 60-100m Floating
Water depth 30-60m
Water depth 0-30m
12nm zone, water depth 0-100m
EEZ zones included
PRASEODYMIUM
Pr
DYSPROSIUM
Dy
INDIUM
In
GRAPHITE
C
COBALT
Co
LITHIUM
Li
What is the problem and how urgent is it?
EU ENERGY USE TODAY AND IN 2050
-80% GREENHOUSE GAS EMISSIONS
FINITE RESOURCES
RENEWABLES

Thank you

wouter.nijs@ec.europa.eu
@wouternijs

European Commission

Keep in touch

EU Science Hub: ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub – Joint Research Centre

EU Science, Research and Innovation

Eu Science Hub

Executive presentations

William Zimmern

Head of Global Macroeconomics, BP

William Zimmern is the Head of Global Macroeconomics and the Lead Economist of the energy transition at BP. He manages the Energy Outlook, BP's view of long-term energy markets, and leads the economic analysis on the energy transition.

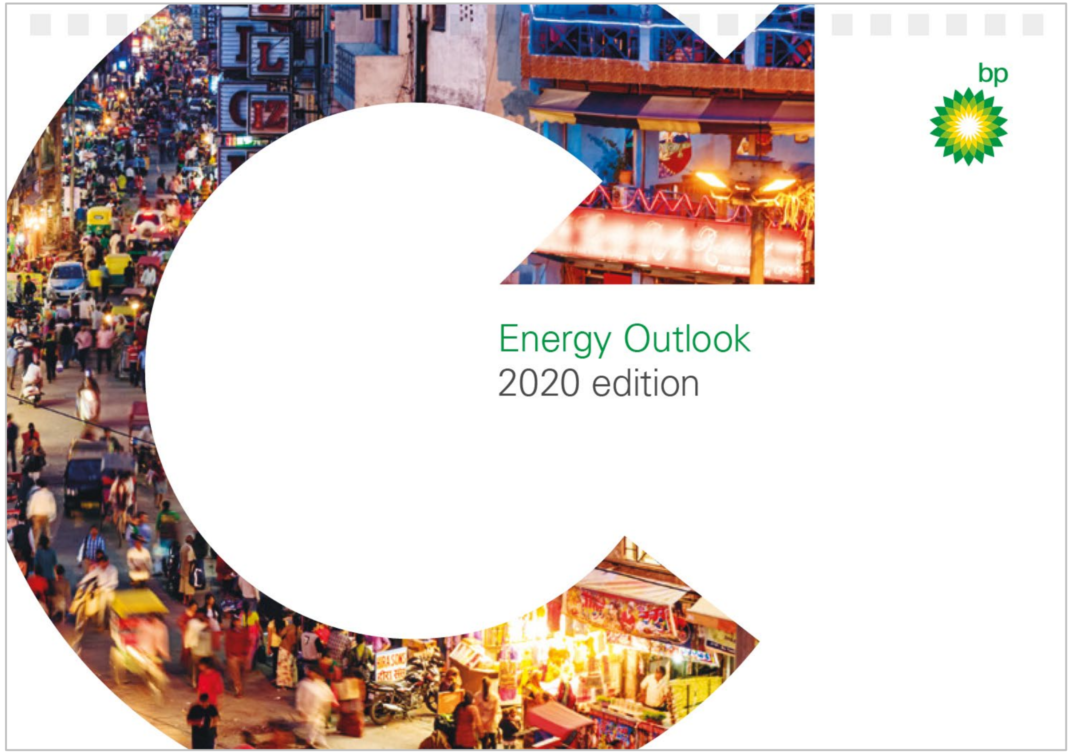
BP Energy Outlook

William Zimmern

Joint IRENA – JRC Expert Workshop on
“Benchmarking long-term scenario comparison studies for the clean energy transition”
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

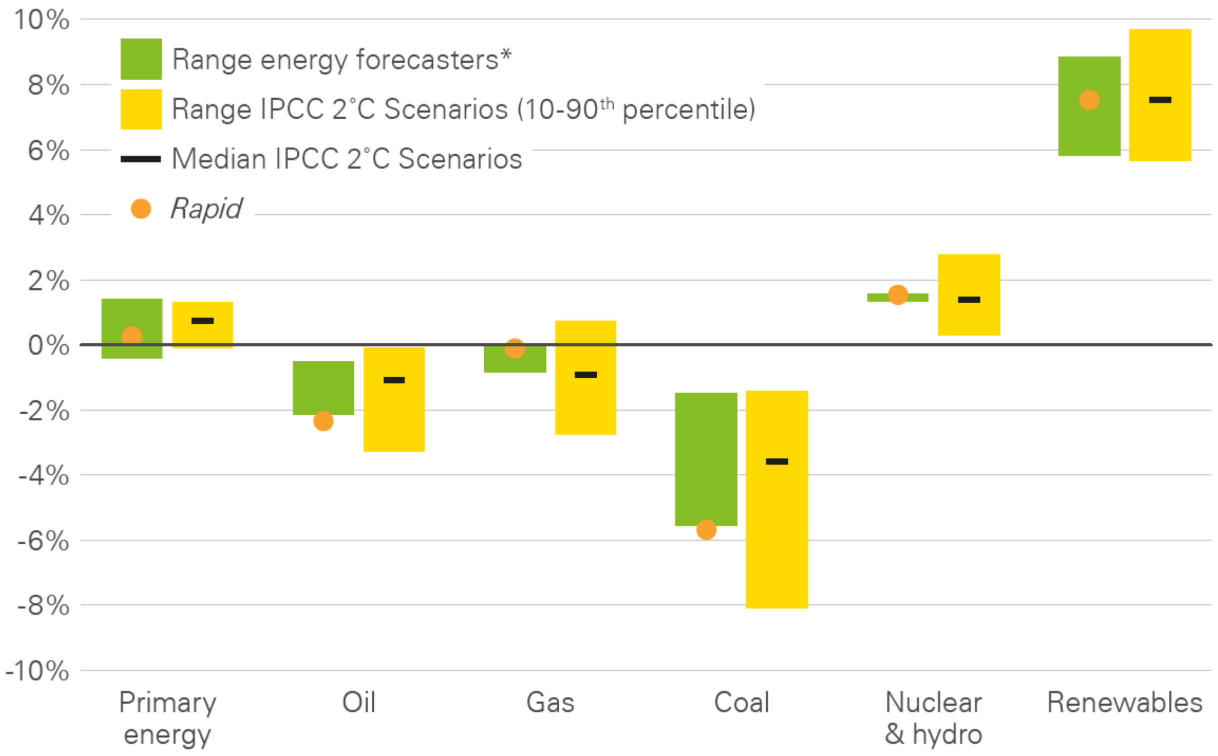
- Name of study
  - BP Energy Outlook
- How is it used?
  - Strategy development
  - Business planning
  - Communicating with stakeholders
  - Brand awareness
- What scenarios?
  - Varies by edition
  - Launch Monday 14 September
  - www.bp.com



2. Key indicators

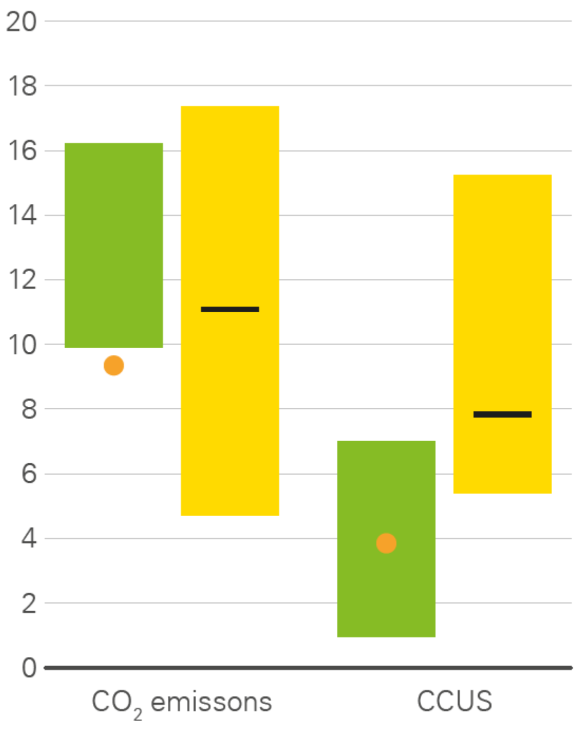
Growth in primary energy by source, 2018-2050

% per annum



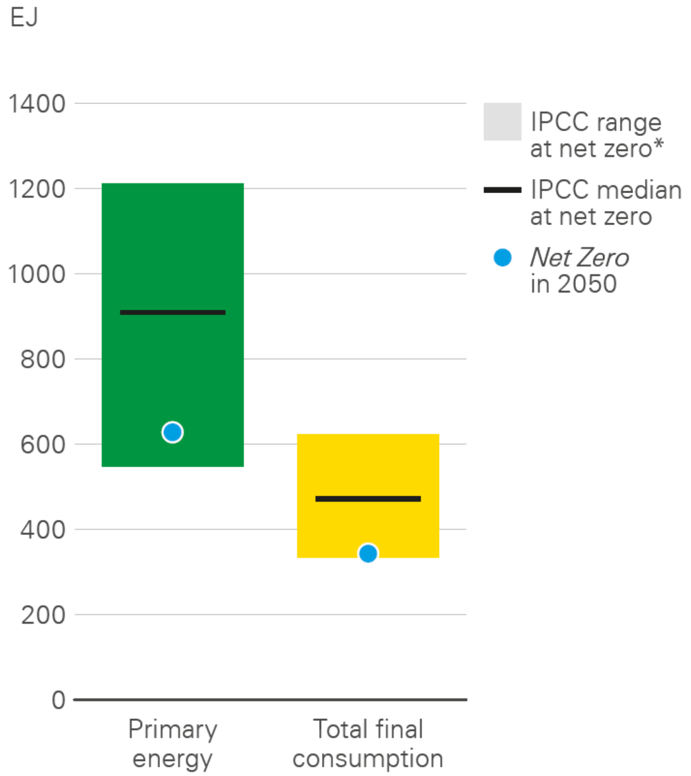
CO_2 emissions and CCUS in 2050

Gt of CO_2



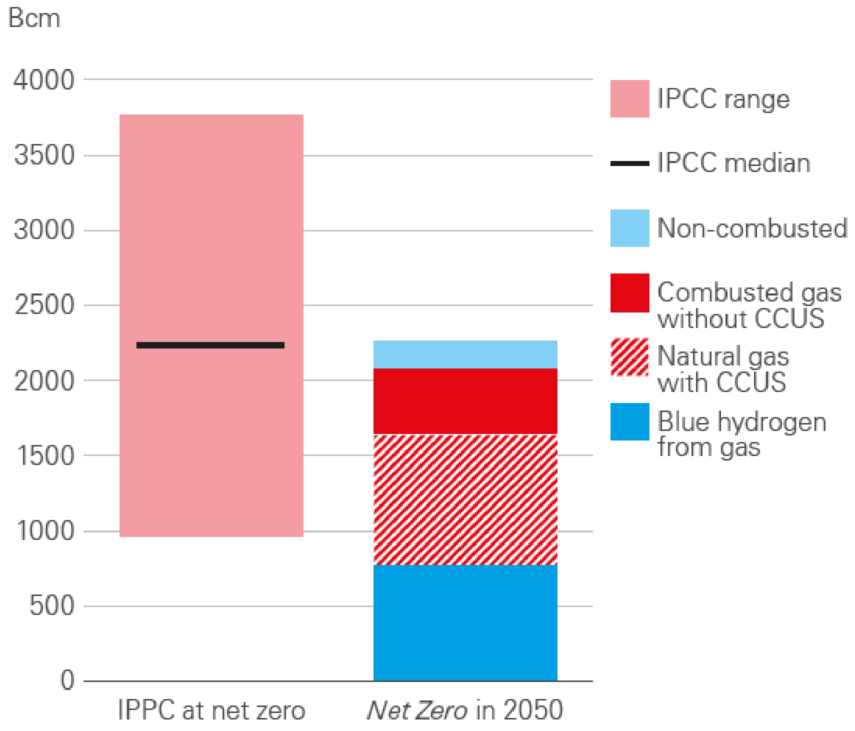
3. Other findings

Global energy demand in IPCC scenarios and *Net Zero*



*Ranges show 10th and 90th percentiles of IPCC scenarios

Natural gas consumption in IPCC scenarios and *Net Zero*



Thank you

Christoph Jugel

Director, Energy Systems, German Energy Agency

Christoph Jugel is Director of Energy Systems at the German Energy Agency (dena). He is responsible for projects on the further development of electricity grids, digitalization of the energy sector, urban energy transition and decarbonization of the energy system. In addition, he leads the dena "Lead Study Integrated Energy Transition program."

European Commission

IRENA
International Renewable Energy Agency

Comparison of three fundamental „2050“ studies on the feasibility of the energy transition in Germany

Christoph Jugel / dena

Joint IRENA – JRC Expert Workshop on
“Benchmarking long-term scenario comparison studies for the clean energy transition”
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

Comparison study: „Expertise bündeln, Politik gestalten – Energiewende jetzt!“ (Acatech, BDI, dena, 2019)

Motivation:

- learn from **differences in assumptions**
- identify common and **robust insights**
- work out political **recommendations** from a broad stakeholder basis

Scope: Integrated scenarios and transformation pathes across all sectors
to achieve the energy transition goals for Germany until 2050.

Compared Studies:

- **German Energy Agency**: *dena-Study Integrated Energy Transition (2018)*
- **ESYS/Acatech** – National Academy of Science and Engineering:
  Coupling the different energy sectors – Options for the next phase of the energy transition (2017)
- **BDI** – Federation of German Industries: *Klimapfade für Deutschland (2018)*

2. Evolution of key indicators

- What indicators are focus for comparison of studies?
  - installed RES capacity wind & PV
  - capacity flexibility options, storage and back-up plants
  - demand synthetic fuels & share of imports
  - building refurbishment rates
  - reduction of emissions in the industrial sector
  - additional costs vs. business as usual

- For which indicators/assumptions was “need for further insights” identified?
  - ratio import of synthetic fuels vs. production in Germany
  - LCOE synthetic fuels
  - green vs. blue hydrogen
  - overall electricity consumption and share of RES
  - role of CCS

3. Key findings and policy messages

- Key findings of the study
  - all studies show the necessity for quick political measures
    to achieve the political goals (-80 % to -95%)
  - important role of powerfuels as a missing link for the energy transition
  - a long term perspective and a continuous social dialogue
    will be needed for the deep structural changes

- Policy messages (amongst others)
  - develop RES faster
  - ensure security of supply: demand side management & back-up power plants
  - develop markets and technologies for renewable synthetic fuels
  - increase refurbishment rate in the building sector
  - address emissions in the industrial sector with energy efficiency, RES & new processes
  - holistic management of the energy transition (e.g. CO_2 price for all sectors)

- How to improve comparison studies for policymaking?
  - transparency of assumptions and data
  - method criticism & systemic boundaries: clearer view on what can / cannot be derived
  - interlink studies with stakeholder discourse

European Commission

IRENA
International Renewable Energy Agency

Thank you

Matthias Kimmel

Lead Analyst, Bloomberg New Energy Finance

Matthias Kimmel is a Senior Analyst on Bloomberg NEF’s Energy Economics team. He is the lead analyst of the New Energy Outlook, Bloomberg NEF’s long-term analysis of the global power sector.

Comparing Long-Term Energy Outlooks

Joint IRENA – JRC Expert Workshop on "Benchmarking long-term scenario comparison studies for the clean energy transition"

Matthias Kimmel, BloombergNEF

September 10, 2020

BloombergNEF

1. Overview and motivation

- **Name of comparison study**
  - **“Comparing Long-Term Energy Forecasts”**
  - Annual note series since 2015, typically published in the summer
  - Last edition: ”Comparing Long-Term Energy Forecasts 2019”
  - Smaller update at the end of the year focused on comparison with IEA WEO
- **Motivation and scope**
  - Compare and understand differences between BloombergNEF *New Energy Outlook* (NEO) and other long-term scenarios, provide valuable insights to clients, understand change of outlooks over time, learn
  - Focus of analysis on “central” (or: most comparable to NEO) and climate scenarios of different outlooks
  - Power sector-focused (changes as NEO becomes all-energy focused analysis)
  - Visuals-focused research note; interactive online comparison tool
- **Time horizons compared**
  - 2000-2050
- **Scenarios**
  - BloombergNEF NEO, IEA WEO, EIA IEO, BP Energy Outlook, Equinor Energy Perspectives, ExxonMobil for Energy, Shell Scenarios

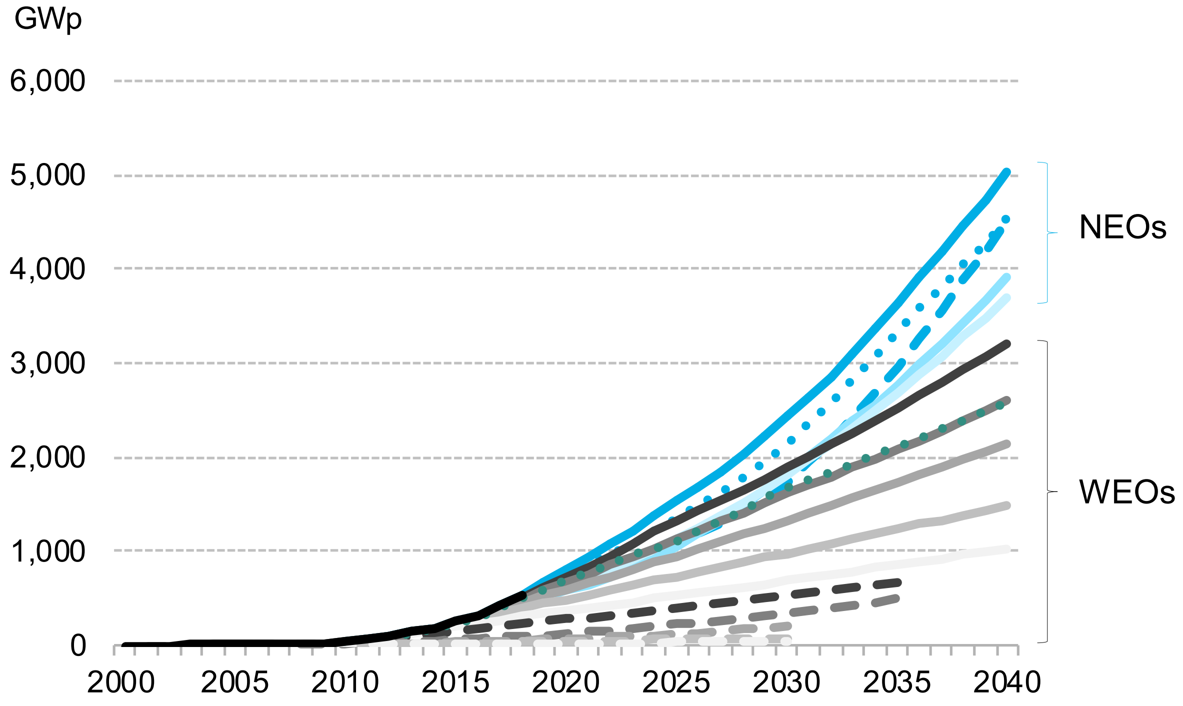
2. Evolution of key indicators

- **What indicators are compared in the study?**
  - Electricity demand: total generation, generation by fuel, technology/fuel mix
  - Power generating capacity (cumulative, additions) with special focus on PV, wind & batteries
  - Power sector emissions
  - Primary energy consumption for electricity generation by fuel
  - *IEA only: LCOE, CAPEX*
  - Future: Cover all energy, not just power
- **How do they change in the future and what are important future indicators?**
  - “Consesus“ on shift to renewables in power. Next step: greater focus on flexibility & storage (power)
  - Investigate underlying forecasts: e.g. steel, aluminum, cement demand; electric vehicles
  - Greater focus on climate scenarios and associate challenges: “how to decarbonize the last 10% of demand“, role of enabling technologies, such as hydrogen, short- and long-term storage
  - Identify indictors for sector interaction/coupling
  - Compare assumptions on electrification
  - Generally: better understading of others‘ assumptions/inputs/modeling platform to explain results

3. Key findings

- **Key findings of the study**
  - Scenarios become have become much more bullish on PV & wind over time
  - BloombergNEF NEO expects greatest decline of coal, strongest growth in renewables in power of all “central“ scenarios considered
  - Similar electricity demand forecasts; no one really bullish on nuclear
  - Shell somewhat of an “outlier“, both in central and climate scenarios (electrification)
  - Limited coverage of/lack of data on (electricity) storage in most outlooks
  - Limited information on cost inputs in different outlooks
  - Challenge: comparing like-for-like (fuel conversion assumptions, final vs primary energy etc.)

Cumulative installed solar capacity, NEO v WEO (outlooks from different years)



Source: BloombergNEF, IEA

BloombergNEF

Copyright and disclaimer

Disclaimer

The BloombergNEF ("BNEF"), service/information is derived from selected public sources. Bloomberg Finance L.P. and its affiliates, in providing the service/information, believe that the information it uses comes from reliable sources, but do not guarantee the accuracy or completeness of this information, which is subject to change without notice, and nothing in this document shall be construed as such a guarantee. The statements in this service/document reflect the current judgment of the authors of the relevant articles or features, and do not necessarily reflect the opinion of Bloomberg Finance L.P., Bloomberg L.P. or any of their affiliates (“Bloomberg”). Bloomberg disclaims any liability arising from use of this document, its contents and/or this service. Nothing herein shall constitute or be construed as an offering of financial instruments or as investment advice or recommendations by Bloomberg of an investment or other strategy (e.g., whether or not to “buy”, “sell”, or “hold” an investment). The information available through this service is not based on consideration of a subscriber’s individual circumstances and should not be considered as information sufficient upon which to base an investment decision. You should determine on your own whether you agree with the content. This service should not be construed as tax or accounting advice or as a service designed to facilitate any subscriber’s compliance with its tax, accounting or other legal obligations. Employees involved in this service may hold positions in the companies mentioned in the services/information.

The data included in these materials are for illustrative purposes only. The BLOOMBERG TERMINAL service and Bloomberg data products (the “Services”) are owned and distributed by Bloomberg Finance L.P. (“BFLP”) except (i) in Argentina, Australia and certain jurisdictions in the Pacific islands, Bermuda, China, India, Japan, Korea and New Zealand, where Bloomberg L.P. and its subsidiaries (“BLP”) distribute these products, and (ii) in Singapore and the jurisdictions serviced by Bloomberg’s Singapore office, where a subsidiary of BFLP distributes these products. BLP provides BFLP and its subsidiaries with global marketing and operational support and service. Certain features, functions, products and services are available only to sophisticated investors and only where permitted. BFLP, BLP and their affiliates do not guarantee the accuracy of prices or other information in the Services. Nothing in the Services shall constitute or be construed as an offering of financial instruments by BFLP, BLP or their affiliates, or as investment advice or recommendations by BFLP, BLP or their affiliates of an investment strategy or whether or not to “buy”, “sell” or “hold” an investment. Information available via the Services should not be considered as information sufficient upon which to base an investment decision. The following are trademarks and service marks of BFLP, a Delaware limited partnership, or its subsidiaries: BLOOMBERG, BLOOMBERG ANYWHERE, BLOOMBERG MARKETS, BLOOMBERG NEWS, BLOOMBERG PROFESSIONAL, BLOOMBERG TERMINAL and BLOOMBERG.COM. Absence of any trademark or service mark from this list does not waive Bloomberg’s intellectual property rights in that name, mark or logo.

BloombergNEF (BNEF) is a leading provider of primary research on clean energy, advanced transport, digital industry, innovative materials, and commodities.

BNEF’s global team leverages the world’s most sophisticated data sets to create clear perspectives and in-depth forecasts that frame the financial, economic and policy implications of industry-transforming trends and technologies.

BNEF research and analysis is accessible via web and mobile platforms, as well as on the Bloomberg Terminal.

Coverage.

Clean energy
Advanced transport
Commodities
Digital industry

Get the app

On IOS + Android
about.bnef.com/mobile

BloombergNEF

Matthias Kimmel,
mkimmel6@Bloomberg.net

Client enquiries:

Bloomberg Terminal: press <Help> key twice
Email: support.bnef@bloomberg.net

Learn more:

about.bnef.com | @BloombergNEF

Sheila Samsatli

Assistant Professor, University of Bath

Dr Sheila Samsatli is a Prize Fellow and an Assistant Professor at the Department of Chemical Engineering, University of Bath, UK. She is an expert in developing large, high fidelity optimization models for energy systems and value chains.

The importance of representing hydrogen and other emerging technologies in energy scenarios

Dr Sheila Samsatli
Asst. Professor and Prize Fellow
Department of Chemical Engineering, University of Bath, UK

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

- Name of comparison study or analysis

  Quarton, C, Tlili, O, Welder, L, Mansilla, C, Blanco, H, Heinrichs, H, Leaver, J, Samsatli, N J, Lucchese, P, Robinius, M, & Samsatli, S* (2020). **The curious case of the conflicting roles of hydrogen in global energy scenarios**. *Sustainable Energy & Fuels*, *4*(1), 80-95
- Motivation and scope
  - Hydrogen can help overcome security and flexibility challenges with the transition to low-carbon energy systems.
  - Historical absence of hydrogen in global energy scenarios
  - Recent scenarios are beginning to include hydrogen but the roles that it plays are inconsistent
  - Examined reasons for inconsistency and provide recommendations on how to represent emerging technologies, such as hydrogen, in energy scenarios
  - Energy systems are becoming increasingly complex, and it is within these complexities that new technologies such as hydrogen emerge
- Time horizons compared
  - Varies between 2040 and 2100
- What scenarios?
  - Focused on global scenarios: model-based as well as qualitative studies to provide a counterpoint based on expert and stakeholder views

2. Evolution of key indicators

- What indicators are compared in the study or platform?
  - Prevalence and contribution to final energy demand of hydrogen and other emerging technologies across various sectors
  - Spatial and temporal representation of energy system models used to derive scenarios
  - Objectives/criteria used (e.g. economic, environmental and social)
  - Level of decarbonisation ambition
  - Type and quality of model, data and assumptions
- How do they change in the future?
  - Models should be used to generate a large number of scenarios that would represent how the indicators/criteria can change in the future to obtain a good measure of uncertainty and determine robust scenarios
- What are the most important indicators to focus on in the future? (including key assumptions)
  - Accuracy (level of detail) versus complexity (computational burden)
  - Trade-offs between economic, environmental and social objectives
  - Marginal costs of achieving more ambitious targets (towards net-zero)
  - Quantifying "soft" metrics and including them in models (e.g. consumer behaviour, inequality)
  - Resolving the disconnect between global, national and regional scenarios
  - Uncertainty and reliability of models, data and assumptions
  - Resiliency and representation of technologies and markets for flexibility
  - Defining and using a set of standard terminologies to improve consistency, communication and transparency

3. Key findings and policy messages

- Key findings of the study
  - Insights on why differing scenario results arise
  - Guidelines for scenario developers to ensure hydrogen and other flexibility options, e.g. storage technologies, demand-side response, electricity grid expansion, interconnectivity, are appropriately represented
- Policy messages resulting from the study

  There is a variety and sometimes conflicting set of policy messages resulting from energy scenarios. Scenarios need to improve and provide a more consistent set of policy messages in order to support policy decisions with more confidence.
- How to improve comparison studies for policymaking?
  - Scenarios must be designed appropriately and use appropriate modelling tools:
    - Appropriate level of ambition
    - Multiple objectives/criteria
    - Sufficient temporal and spatial detail
    - Broad range of technologies and sectors
    - Inter-sectoral connectivity
    - Complexity of consumer behavior
    - Consistent and substantiated data assumptions
    - Transparent methodology, data and assumptions
    - Manageable, user-friendly and easy to communicate

European Commission

IRENA
International Renewable Energy Agency

Thank you

European Commission

IRENA
International Renewable Energy Agency

Trieu Mai

Senior Energy Analyst, National Renewable Energy Laboratoy

Trieu Mai is a Senior Energy Analyst at the National Renewable Energy Laboratory (NREL). He has led and conducted research in renewable grid integration, clean energy policy, energy system transformation, and electrification. His research utilizes an array of power system models and energy-economic analysis tools.

European Commission

IRENA
International Renewable Energy Agency

Variable Renewable Energy in Long-Term Planning Models: A Multi-Model Perspective

Trieu Mai & Wesley Cole
National Renewable Energy Laboratory USA

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

- Model comparison for leading U.S. power sector models: IPM, NEMS, REGEN, ReEDS
- Why? Modeling high VRE systems is hard because wind and solar resources are variable, uncertain, and geographically dispersed and technologies are inverter-based with zero marginal costs. Can we improve leading U.S. national-scale models?
- 2 workshops, 2 papers, many model experiments
  - *Variable Renewable Energy in Long-Term Planning Models: A Multi-Model Perspective.* www.nrel.gov/docs/fy18osti/70528.pdf
  - *The role of input assumptions and model structures in projections of variable renewable energy: A multi-model perspective of the U.S. electricity system.* https://doi.org/10.1016/j.eneco.2018.10.019
- 2050 Scenarios: Reference (2017), High VRE (55%-by-2050), Low Carbon (67% below 2005) – all with harmonized and native inputs

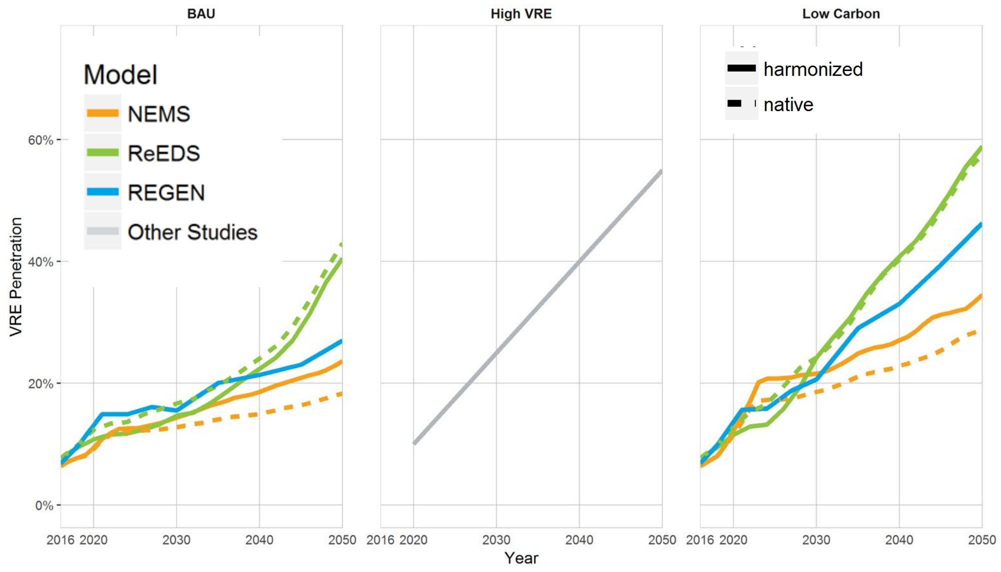
Research sponsored by the U.S. DOE and U.S. EPA

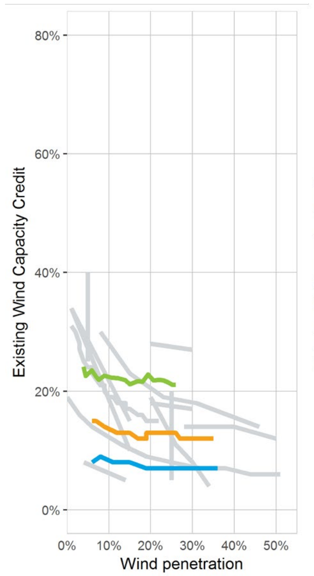
2. Evolution of key indicators

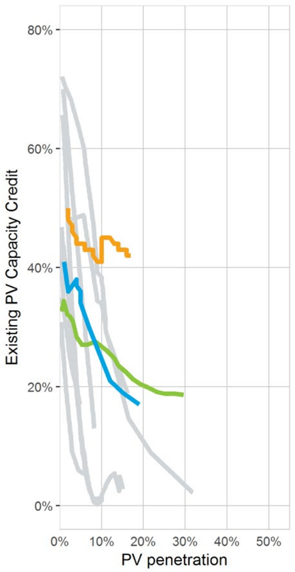
- Indicators: tech cost and performance assumptions; amount, mix, and location of VRE; capacity credit and curtailment

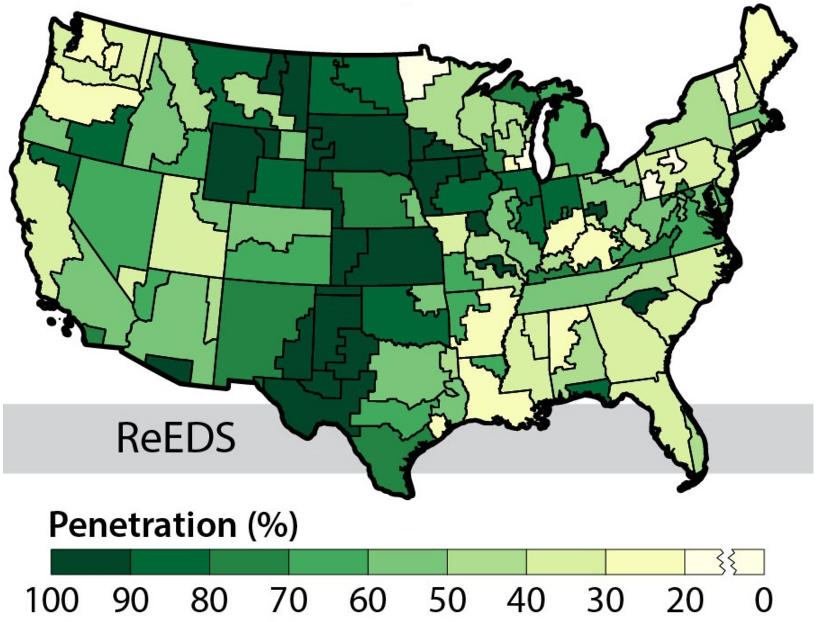
- Trends:
  - Growth in VRE anticipated even absent new policies, but level varies significantly between models even with harmonized inputs
  - Declining capacity credit and increasing curtailment with VRE penetration
  - Multiple VRE technology pathways identified by the different models (e.g., wind vs. solar, utility vs. distributed, onshore vs. offshore)

- Future work: complementary technologies (e.g., storage, transmission), non-VRE techs (e.g., nuclear), sector-coupling





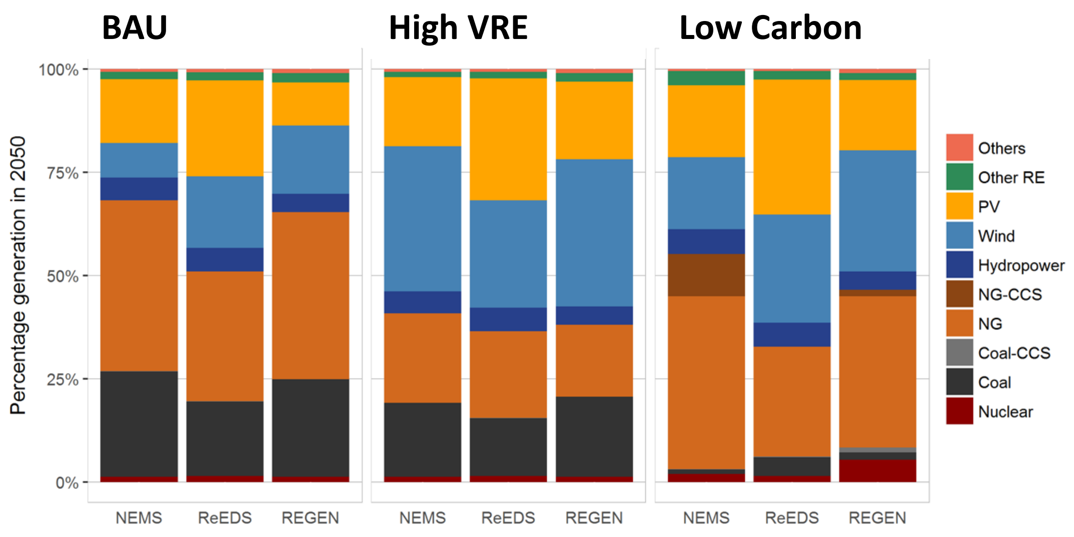




3. Key findings and policy messages

- Models already have sophisticated treatment of VRE, but room for improvement remains ← important work given the growing consensus of VRE's sizeable role in a low-carbon grid

- Spatial and temporal resolution are important, but significant model innovation is happening "outside of the optimization"



- Recognition that some model assumptions or formulations can substantially drive model outcomes, but limited emphasis placed on their comparison or presentation. Examples: financing assumptions, planning reserve margin, weather year(s), resource supply curves and VRE integration parameters

- To improve scenario studies we need to evaluate **<u>why</u>** scenarios or models differ, not just how much they differ

Thank you

Trieu.mai@nrel.gov

Anahi Molar-Cruz

Research Associate, Technical University of Munich

Anahi Molar-Cruz is a Research Associate at the Chair of Renewable and Sustainable Energy Systems of the Technical University of Munich. She has experience in modeling and optimization of energy systems. Her research focuses on the integrated modeling of energy systems and the assessment of possible pathways for a sustainable urban future.

European Commission

IRENA
International Renewable Energy Agency

Intermodel comparison: North American Energy Trade and Integration (EMF 34)

Anahi Molar-Cruz
Technical University of Munich (TUM)

Joint IRENA – JRC Expert Workshop on
“Benchmarking long-term scenario comparison studies for the clean energy transition”
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

Main study
North American Energy Trade and Integration (EMF 34) with several substudies:

- Key findings
- Energy storage and uptake of VRE
- Regional coordination of RE targets
- Deployment of CCUS, …

Motivation
How do Canada, Mexico and the U.S. energy systems respond to external factors and coordinated policies? - A focus on crude oil, nat. gas and power

Time horizon | 2015 – 2050

13 core scenarios

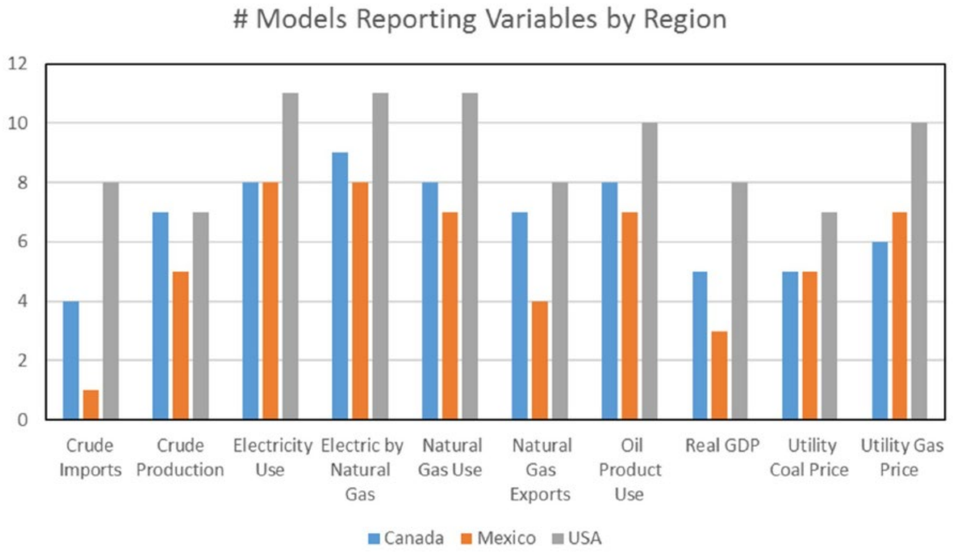
1. Reference (Modeler's choice)
2. Low Oil Price
3. High Gas Supply
4. High Macro Growth
   1. North America
   2. Canada
   3. Mexico
   4. U.S.
5. High Penetration of VRE
6. Cross-border Energy Infrastructure
   1. Inc. electricity transmission capacity
   2. Dec. crude oil transport capacity
   3. Dec. nat. gas transport cost
7. Carbon policy (US $35/ton + 5% annual inc.)
   1. Carbon tax in North America
   2. Carbon tax only in Canada and Mexico

2. Evolution of key indicators

Number of models | 17

Number of indicators to report | 63

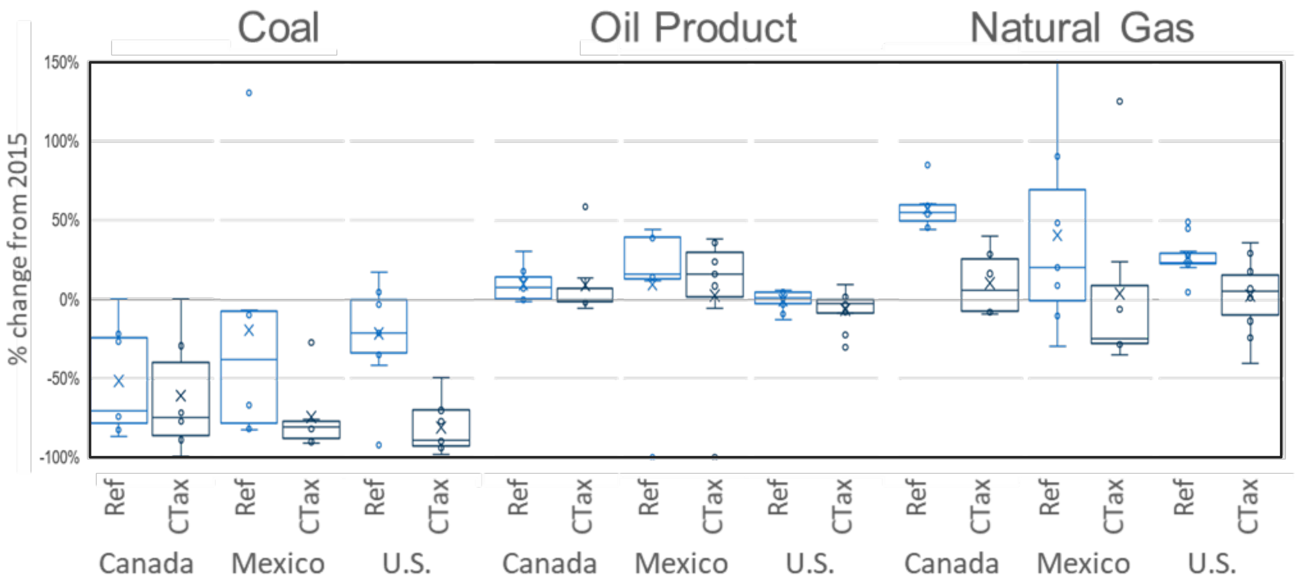
- Production, consumption, trade and prices for crude oil, natural gas and electric power
- Electric generation by fuel or renewable energy source
- Energy infrastructure



Indicators vary across models…

Example: Change in fuel consumption from 2015 to 2050 for Canada, Mexico and the U.S.

Reference vs Carbon policy with carbon tax of US $35/ton (2015) and US $137/ton (2050)



… but key insights and commonalities are found in the long-term trend.

3. Key findings and policy messages

Key findings

- Cross-border trade for natural gas, power and crude oil are expected to rise over time.
- Oil and natural gas production are modestly responsive to energy prices.
- Carbon tax favors renewables at the expense of coal and some natural gas.
- Uptake of intermittent renewables is favored by the cost reduction of energy storage technologies only when coupled with renewable mandates or carbon taxes.*

Policy messages

- Critical need for modeling frameworks that integrate across major energy sources and across North American countries.
- Emphasis in spatial and temporal modeling of cross-border energy infrastructure.
- Quality of policy depends on quality of data collected, active exchange and transparency.

Comparison studies

- More flexibility in the baseline conditions makes the derived policies more robust to a wider set of outcomes.
- Set of core variables (+ scenarios) serves as basis for other studies.
- Understanding major modeling differences is crucial for interpreting the results.

* From substudy on the role of energy storage in the uptake of VRE

European Commission

IRENA
International Renewable Energy Agency

Thank you

Christof van Agt

Director of Energy Dialogue, International Energy Forum (IEF)

Christof van Agt is the director of energy dialogue at IEF; advancing producer-consumer country collaboration through IEF ministerial fora, and stakeholder meetings with partner organizations. His work includes coordination of the trilateral work programme with IEA and OPEC, as well as collaboration on energy security, market transparency, smart and inclusive transitions with other institutions, industry stakeholders, national agencies, and research centers.

European Commission

IRENA
International Renewable Energy Agency

IEA-IEF-OPEC Outlook Comparisons Update

Christof van Agt, International Energy Forum

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

European Commission

1. Overview and motivation

IRENA
International Renewable Energy Agency

- Elevate and inform inclusive producer-consumer dialogue
- Make outlooks readily comparable on a voluntary basis
- Short term(~18 months) medium, and long-term (five-year intervals), including
- Current and Stated Policies, Reference Case, Sustainable Development, and Alternative Case Scenarios
- Align Historical Baselines, Categories, Metrics and share assumptions where practical and possible.
- Place findings in broader context of global perspectives (e.g. IRENA, GECF, Companies, regional & national agencies)


TENTH IEA IEF OPEC SYMPOSIUM ON ENERGY OUTLOOKS

INTERNATIONAL ENERGY FORUM

AN INTERNATIONAL ENERGY FORUM PUBLICATION 19 FEBRUARY 2020

INTRODUCTORY PAPER:

A COMPARISON OF RECENT IEA AND OPEC OUTLOOKS

International Energy Forum in partnership with Resources for the Future

RESOURCES for the FUTURE

10 ANNIVERSARY

10TH ANNIVERSARY IEA IEF OPEC SYMPOSIUM ON ENERGY OUTLOOKS

This introductory paper was prepared by the IEF and Resources for the Future, in consultation with the IEA and OPEC

2. Evolution of key indicators

- Demand supply trends of fuel types and primary energy consumption by sources, across scenarios, and countries groupings
- Change is a function of policy and technology pathways and breakthroughs and viewpoints/assumptions of models
- Focus is on baseline data discrepancies, alignment of regional groupings, and consistent liquid fuel type and energy classifications.
- Other issues concern metrics for primary energy demand and making data and key assumptions transparent.

3. Key findings and policy messages

- Data driven and inclusive dialogue on energy scenarios becomes more important in an era of change and energy sector transformations

- This enhances market transparency and predictability for investors across the entire energy spectrum allowing them to move forward faster

- Improving comparability broadens policy options to progress along diverse but mutually reinforcing pathways in interconnected markets

Thank you

Edward Byers

Research Scholar, Institute for International Applied Systems Analysis

Dr. Edward Byers is a Research Scholar in the Energy (ENE) program at IIASA, with research interests in infrastructural systems, water and climate change risks, the water-energy nexus and development using global impact, hydrological and integrated assessment models. He currently leads the global vulnerability hotspots assessment as part of the GEF-IIASA-UNIDO.

European Commission

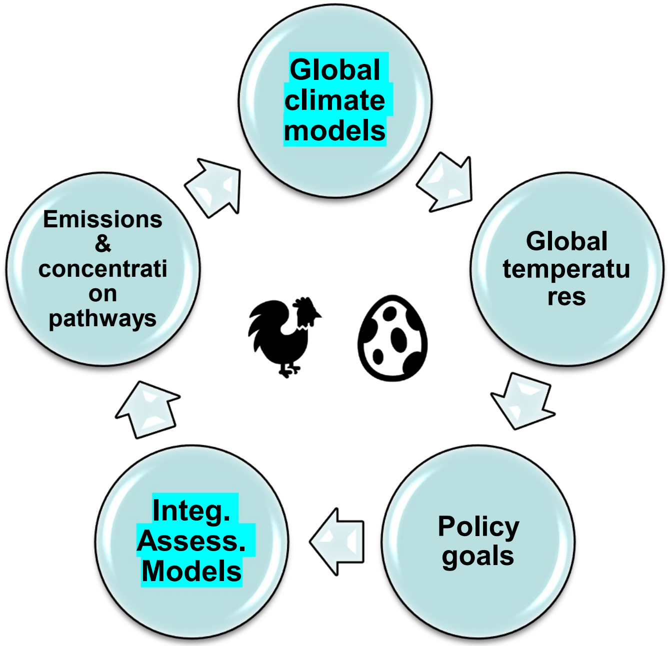
IRENA
International Renewable Energy Agency

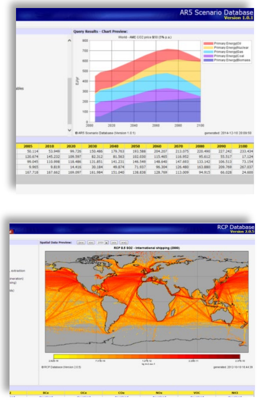
Processes for Integrated Assessment (Model) Scenarios in support of climate policy

Edward Byers
International Institute for Applied Systems Analysis

Joint IRENA – JRC Expert Workshop on
“Benchmarking long-term scenario comparison studies for the clean energy transition”
Thursday 10 and Friday 11, September 2020

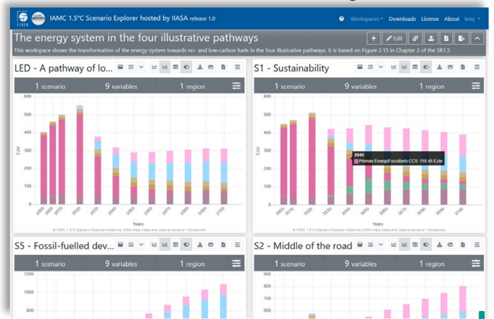
1. Overview and motivation

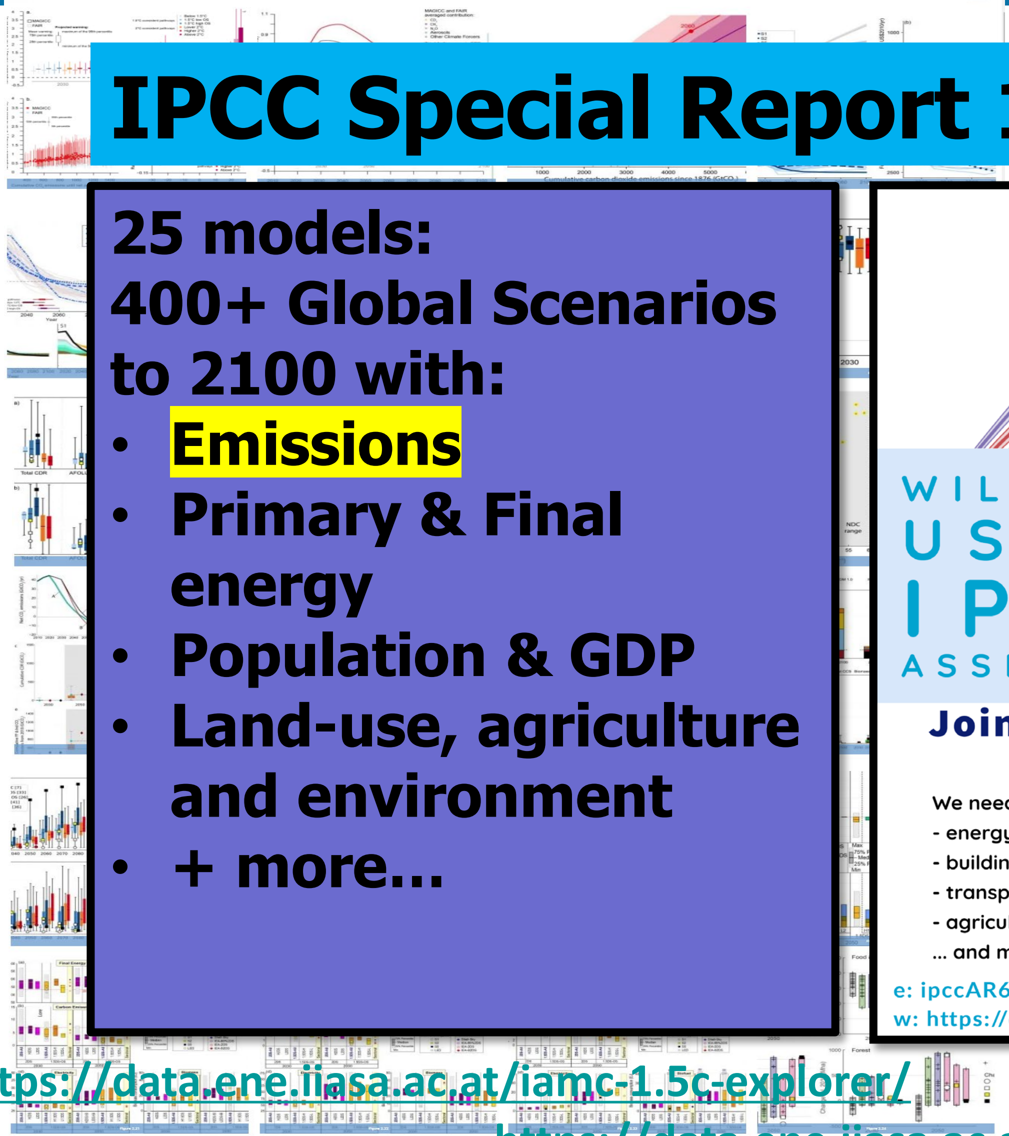




RCP
AR5
SSP
+more

SR1.5 scenario explorer

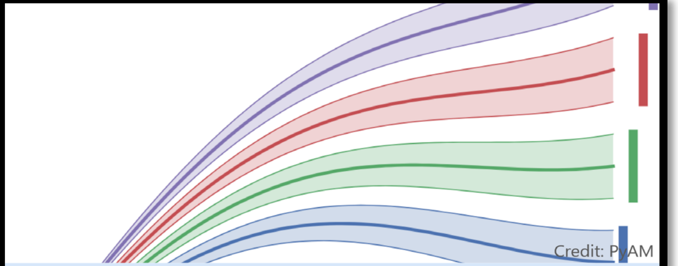




IPCC Special Report 1.5° C (Ch2)

25 models:
400+ Global Scenarios to 2100 with:

- **Emissions**
- **Primary & Final energy**
- **Population & GDP**
- **Land-use, agriculture and environment**
- **+ more...**



WILL YOUR DATA BE USED IN THE IPCC 6TH ASSESSMENT REPORT?

Join our webinars to learn how *you* can help

We need national, sectoral and global scenarios on:
- energy supply demand and service levels
- buildings
- transport & industry
- agriculture and land-use
... and more

e: ipccAR6db.ene.admin@iiasa.ac.at
w: https://data.ene.iiasa.ac.at/ar6-scenario-submission

https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/
https://data.ene.iiasa.ac.at/ar6-scenario-submission

2. Stronger science, stronger policy

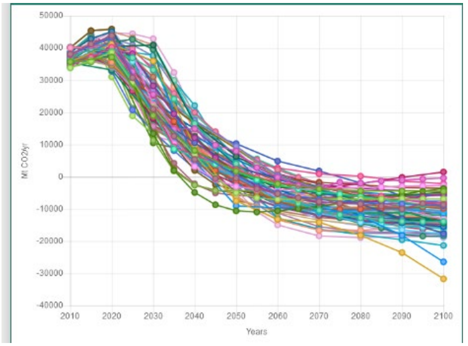
Researchers

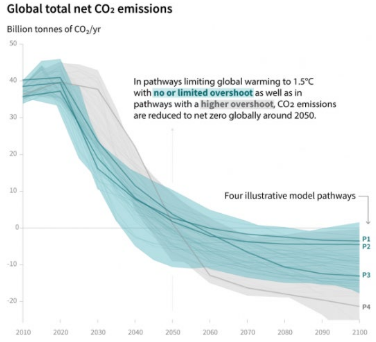
- Version control
- Quality control & vetting
- Post-processing pipelines
  - Emissions-Temp. response
  - Feasibility, SD indicators
- Python package *pyam* for analysis
- Continuous development rollout through funded projects

https://climatescenarios.org/finder/

Public end-users

- Interactive visualization
- Data download
- Accessible documentation about models, assumptions and scenarios
- Scenario Finders and meta
- Mirror figures in reports





3. Key findings and policy messages

Be a quality resource, not a data dumpster

- Vetting & quality control of the data
- **Add value** to the data with meta / categorization

Be a *one-stop shop* and make transparency and re-use easy

- Document the workflow:
  - Data sources, Github, Notebooks, doi, version control, licenses, documentation
- Make data **FAIR and open**
- Coordinated efforts yield efficiency and maintain quality

Quantative scenario assessment

- **Good scenario design** facilitates comparison and understanding model uncertainty
- Use **illustrative scenarios** to tell stories about *what is possible*
- Use clusters to highlight robust findings /uncertainties about *what is probable*

Cost of not having FAIR & Open data in the EU:

€ 10 billion/yr

EU-PwC report 2019

Thank you

Jürgen Kropp

Department Head for Climate Resilience, Potsdam Institute for Climate Impact Research (PIK)

Prof. Dr. Jürgen Kropp is the deputy for Research Department II: Climate resilience and heads the working group on Urban Transformations, at PIK and a professor for climate change and sustainable development at the Dept. of Environmental Sciences and Geography, University of Potsdam. He recently finished the European Calculator Project which developed a new energy society model that helps to identify trade-offs and co-benefits of sectoral decision-making

Prof. Dr. Juergen P. Kropp

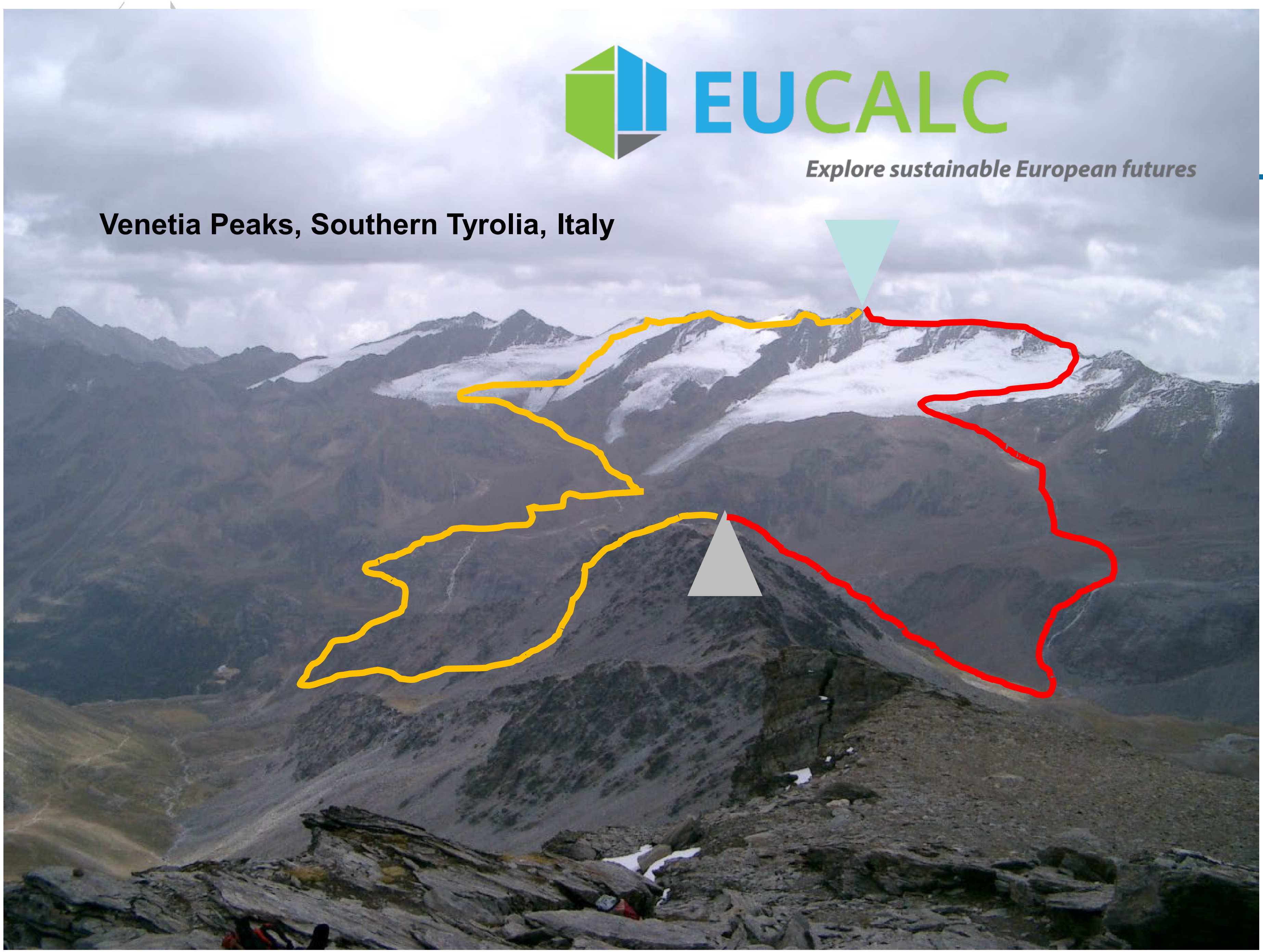
Potsdam Institute for Climate Research
Urban Transformations

University of Potsdam
Dept. Environmental Sciences & Geography
Climate Change & Development

EUCALC received funding from the European Union's Horizon 2020 research and innovation program under grant agreement # 730459.

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

IRENA
International Renewable Energy Agency

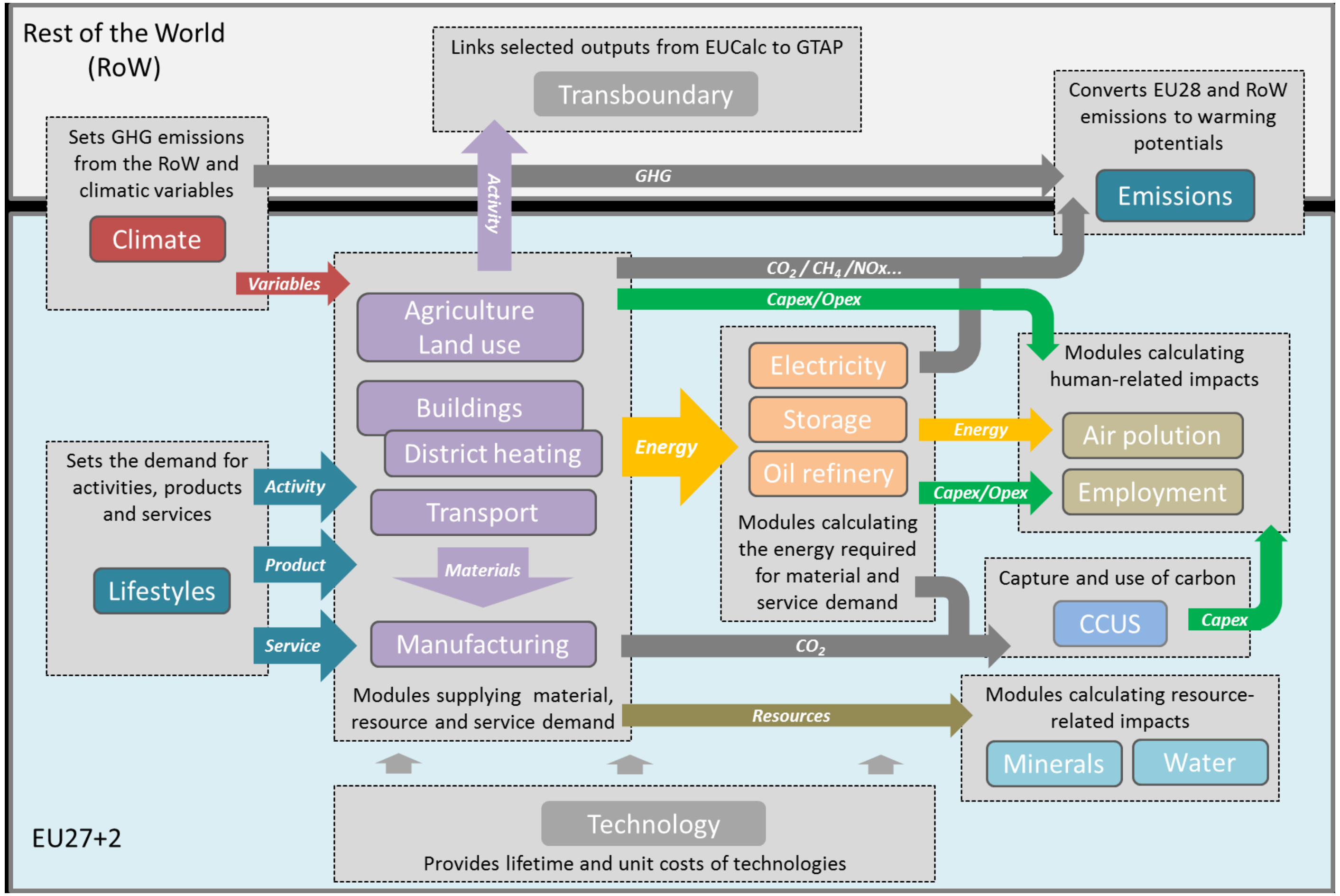


EUCalc:
Exploring Different Pathways

1. Overview and motivation: opening the modeling space for lay people

- European Calculator Approach

- Evidence based reasoning, i.e. experts (> 1.000), literature reviews
- Carbon pathways for Europe and member countries
- Time horizon 2000-2050
- > 50 “sectors” including lifestyles
- allows to intersectoral trade-offs and co-benefits
- Dynamics is partly represented in so-called levers
- Compared to LTS Life, Tech, Combo, EUREF
- Needs still improvements of country pathways and sector modules



2. Example of used indicators: manufacturing and production

Keep it simple, but not too simple: form example industrial production depend on various other “sectors”

INPUTS

Lifestyle

- Packaging demand
- Paper and sanitary

Buildings

- Floor area (new and renovated)
- Appliances

Transport

- Cars, Trucks, Ships, …
- Transport infrastructure

Agriculture

- Fertilizer demand

Technology

- Costs
- Energy consumption (incl. feedstock)
- Emission factors (combustion and process)
- Material decompositiion
- Penetration rate

MANUFACTURING AND PRODUCTION MODULE

Iron & Steel (4)
Non-metallic minerals (5)
Non-ferrous metals (3)
Chemicals (2)
Paper & Pulp (2)
Other industries (6)

OUTPUTS

CCUS

Carbon captured

Climate

GHG emissions

Minerals

Material demand

Supply

Energy demand by fuel

Agri. & Land-use

Bioenergy demand

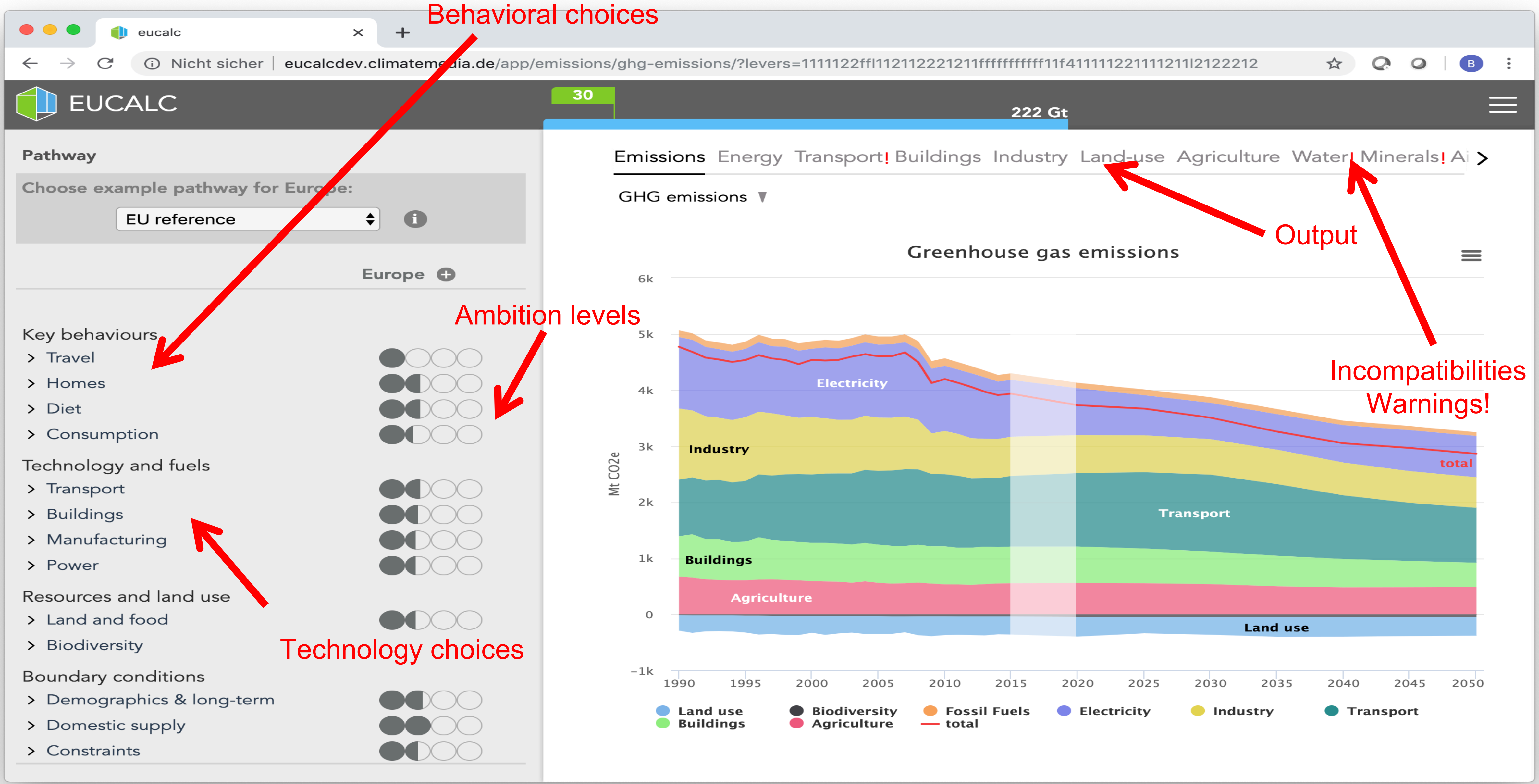
Air quality

PM emissions

Socio-economic

- Costs (CAPEX, OPEX)
- Jobs

Transition Pathways Explorer: visible end of the model approach



3. Key findings and policy messages

Key findings

A simplified approach with a larger sector coverage and access for newbies is possible – however – approach is complex, needed coherent steering and many compromises

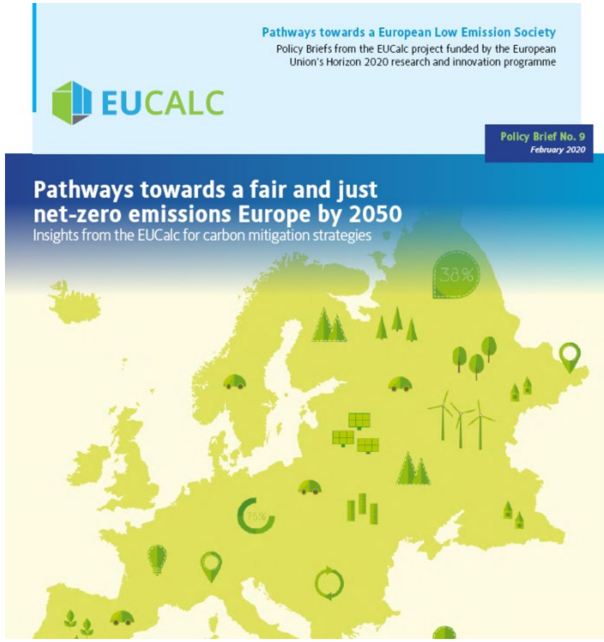
Key policy messages

Lifestyles: changes in individual behaviour (transport, homes, diet and consumption) have the potential to decrease GHG emissions in Europe by 38% in 2030 and 63% in 2050 relative to 1990.

Carbon Leakages: Our simulations show a carbon leakage rate of 61.5% for the most ambitious pathway, i.e. for each tonne of CO2e emissions avoided or sequestered within the EU, the RoW is calculated to increase its GHG emissions by 0.615 tCO2e. Independent, highly ambitious decarbonization efforts by the EU cannot effectively reduce global emissions, concerted action is needed.

Pathway intercomparisons

Internally – possible (calibrated to empirical data), with other approaches – would need a specific start protocols as based on a different model design



For details refer to policy brief #9 on www.european-calculator.eu which comprises all documents

Thank you

Contact

Potsdam Institute for Climate Impact Research (PIK)

Telegraphenberg A 31
14473 Potsdam - Germany

Prof. Dr. Jürgen P. Kropp

Deputy Chair: Research Domain II: Climate Resilience
Head: Urban Transformations

2.University of Potsdam, Institute for Environmental Sciences
Climate Change & Sustainable Development

3. Founding Dean: Environmental Management
Berlin School for Sustainable Futures
University of Applied Sciences (in formation)

E-Mail: nsp@pik-potsdam.de
Phone: +49 331 288 2526 or 2550

Follow

ORCID iD

EUCALC
Explore sustainable European futures
http://www.european-calculator.eu

European Commission

IRENA International Renewable Energy Agency

Andries Hof

Senior Researcher, Netherlands Environmental Assessment Agency (PBL)

Andries Hof is a senior Researcher at the Netherlands Environmental Assessment Agency (PBL). He is a guest researcher at Copernicus Institute of Sustainable Development at Utrecht University. His special interests are the costs and benefits of climate change adaptation and mitigation, climate agreements, the use of integrated assessment models in informing climate policy decisions, and synergies and trade-offs with other sustainable development goals

Comparing key transition indicators of 2°C scenarios

Andries Hof,
PBL Netherlands Environmental Assessment Agency

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

1. Overview and motivation

- Name of comparison studies:
  - Insight into Energy Scenarios - A comparison of key transition indicators of 2 ^{o}C scenarios (Sep 2019)
  - Paris-aligned energy transition pathways for India (July 2020)

- Underlying research question: How important is it to reduce fossil fuel use, in the short term, for achieving the goal of the Paris Agreement?

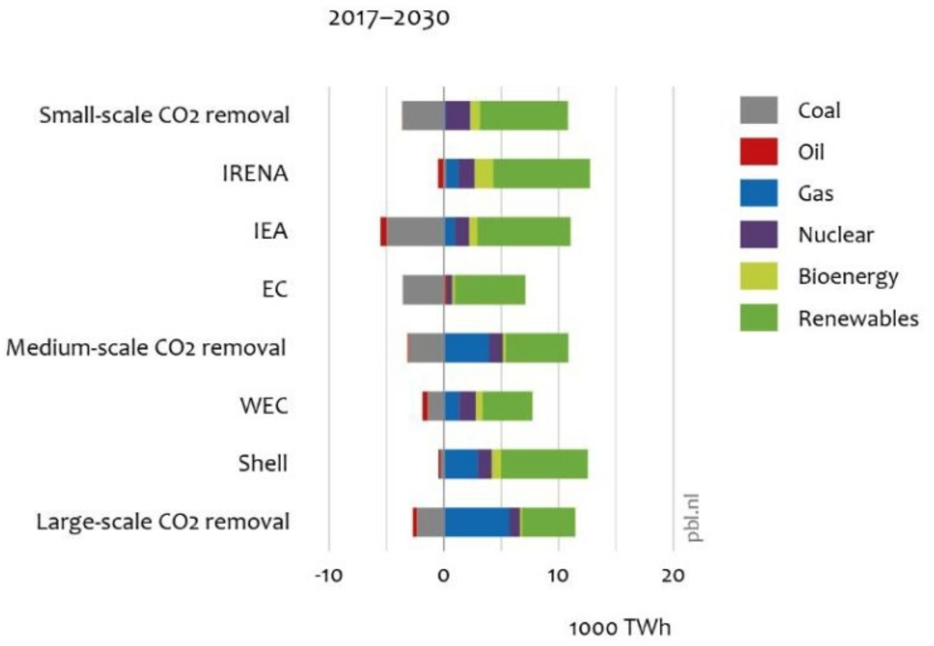
- Time horizons: 2017-2030; 2017-2040; 2017-2050

- Scenarios included: IRENA REmap/TES; IEA scenarios; Shell Sky; WEC Unfinished Symphony; BP Rapid Transition; EC 2 and 1.5 ^{o}C; IPCC RCP2.6/2.0. For India, also 3 national scenario studies.

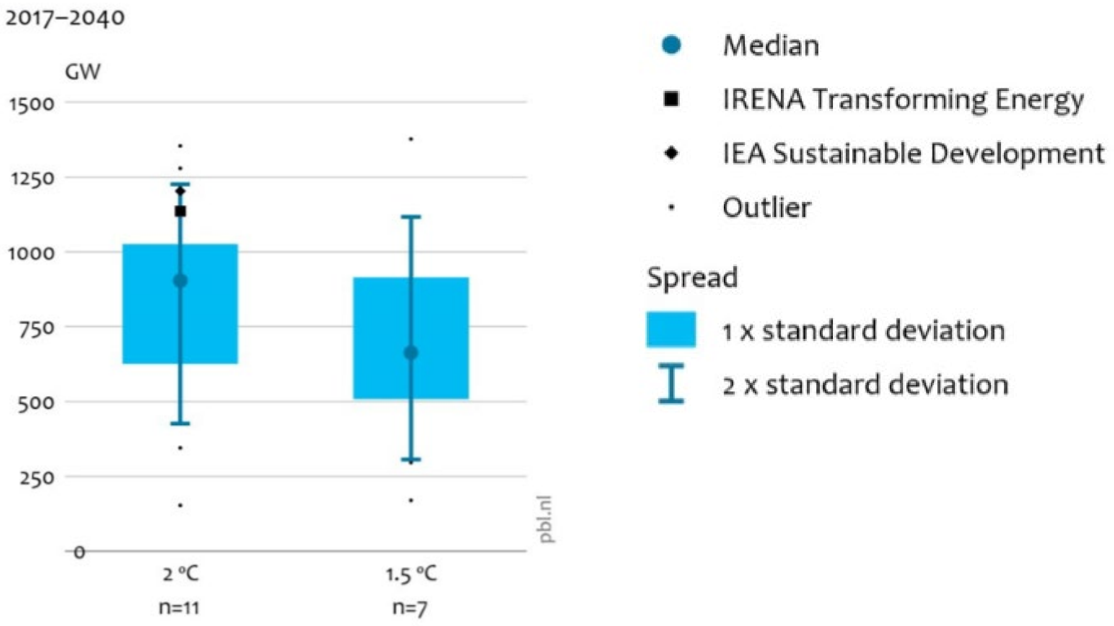
2. Evolution of key indicators

- Indicators: Change in i) CO_2 emissions, ii) energy demand (by sector), iii) energy mix (by sector)
- From viewpoint investment choices, important to really focus at *changes* in energy indicators

Power generation, global



Power generation capacity, India



3. Key findings and policy messages

- Key findings:
  - IRENA and IEA scenarios show rapid CO_2 reductions (through efficiency improvements and strong scaling up of renewable energy)
  - Shell and WEC show more gradual emission reductions, relying heavily on CO2 removal in the second half of the century
  - All scenarios agree on rapid phaseout of coal, a strong increase in renewable energy, and a fast electrification of the economy
  - Scenarios that avoid a heavy reliance on CO2 removal show an absolute decline in oil use, between 2017 and 2030.
- Policy messages (cooperation with India):
  - Assisting the transition from coal-fired power plants
  - Increasing onshore wind and solar PV
  - Promoting energy efficiency in industry

Thank you

James Newcomb

Managing Director, Rocky Mountain Institute (RMI)

James Newcomb is Managing Director at RMI, where he directs the Emerging Energy Solutions program. He also serves as senior advisor to the Institute's India and Electricity programs. James helped to develop RMI's Electricity Innovation Laboratory (eLab), which brings together leading industry actors to develop, test, and scale new solutions that enable greater adoption of renewable distributed energy resources.

Route Mapping to 1.5C

James Newcomb, Managing Director, Rocky Mountain Institute

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

THE MAP IS NOT THE TERRITORY

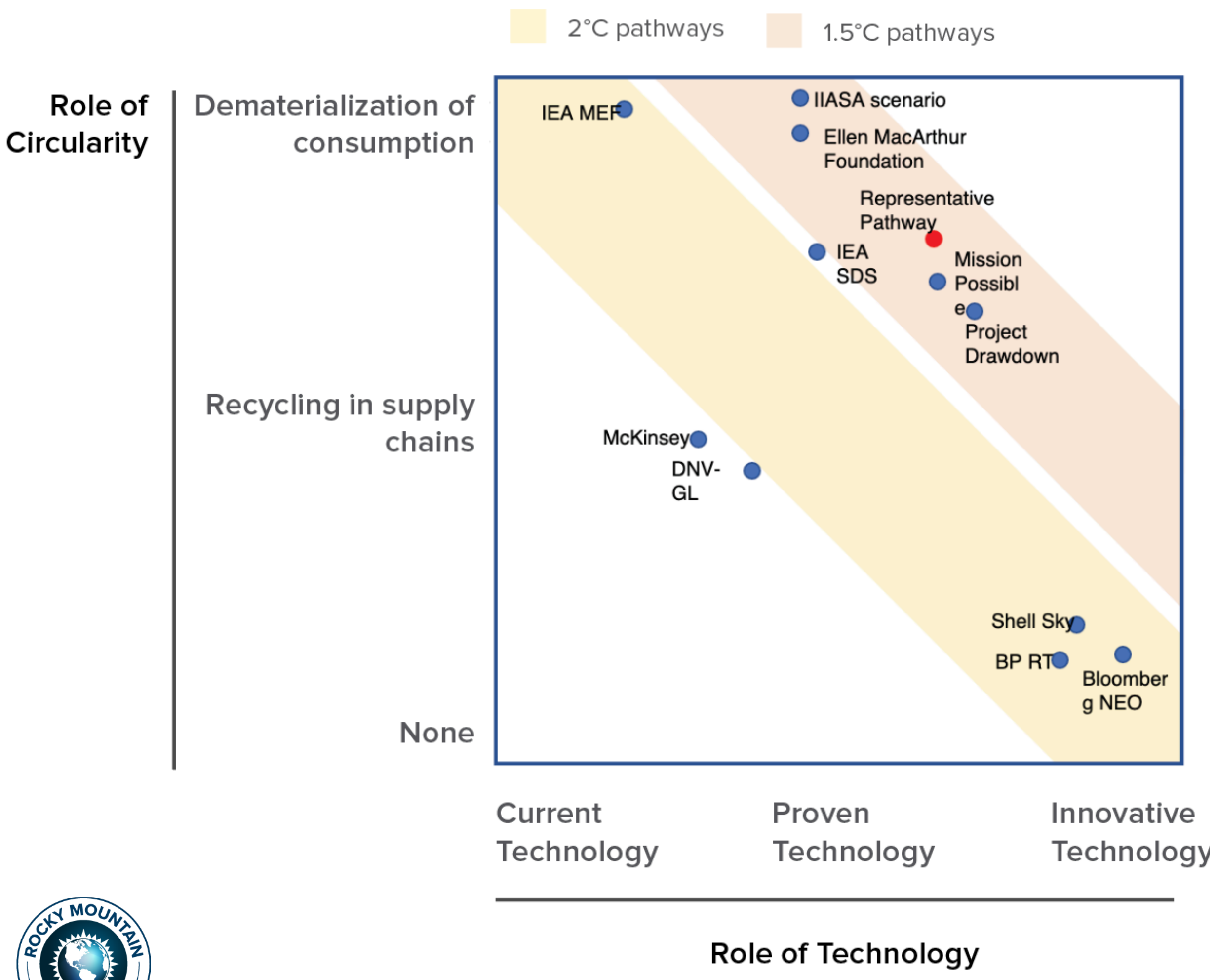
Benchmarking similar scenarios may not improve insight or actionability and may reinforce existing biases.

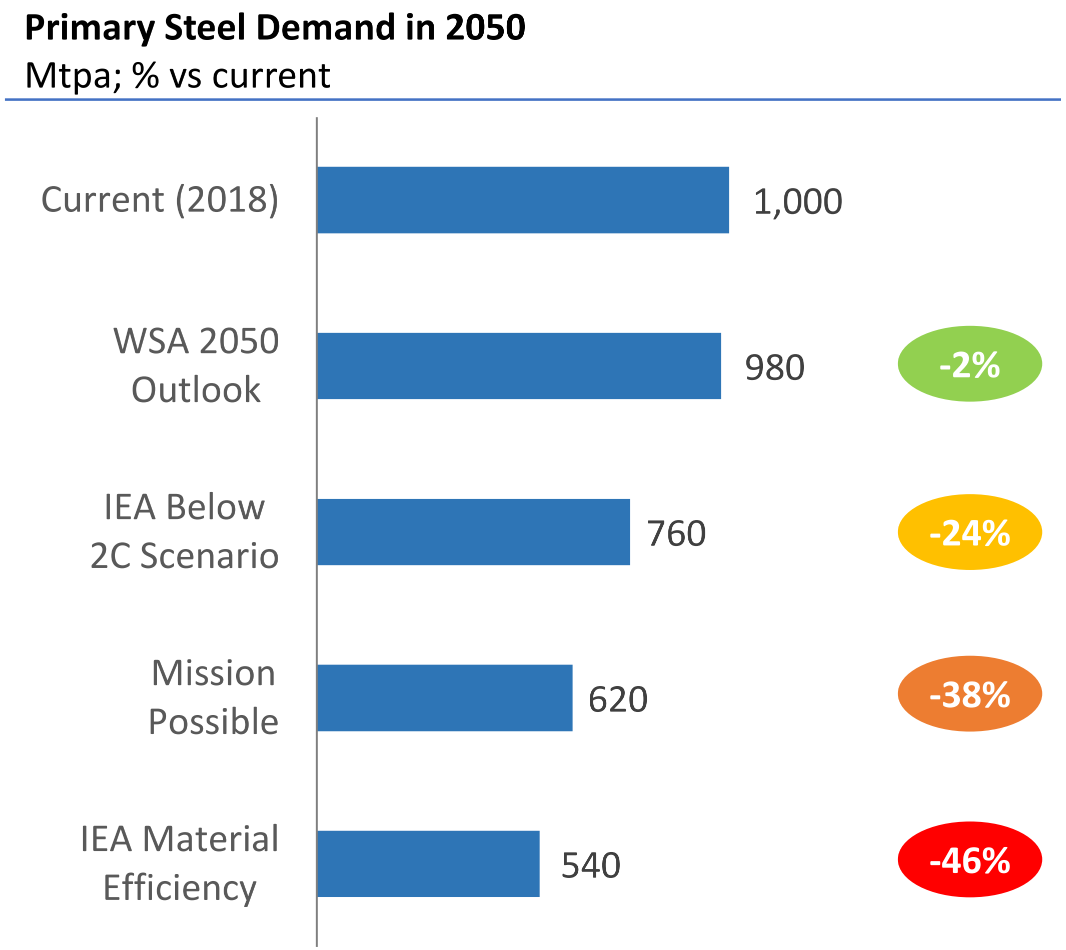
Challenge areas for existing models include:

- Demand-side solutions
- Technology advances achieved via steep learning curves or breakthroughs
- Circular economy
- Whole system design solutions
- Social or behavioral tipping points

PRIMARY STEEL DEMAND IN 1.5 °C PATHWAYS

Transition relies on circularity with slow deployment of new technology

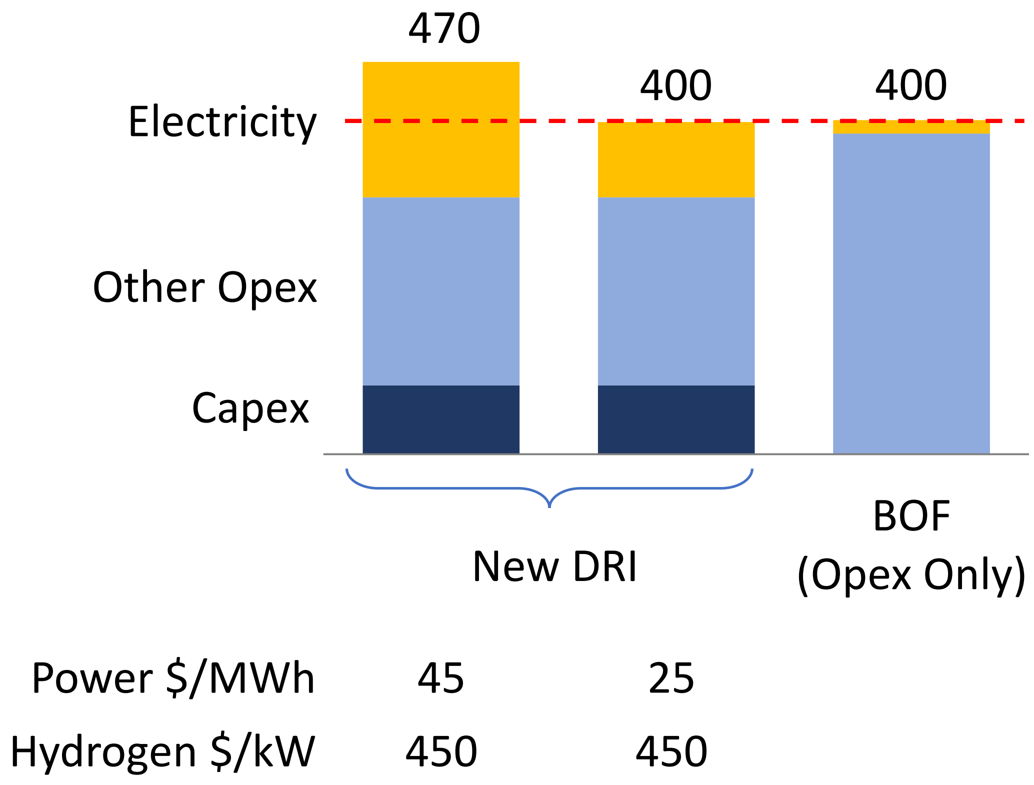




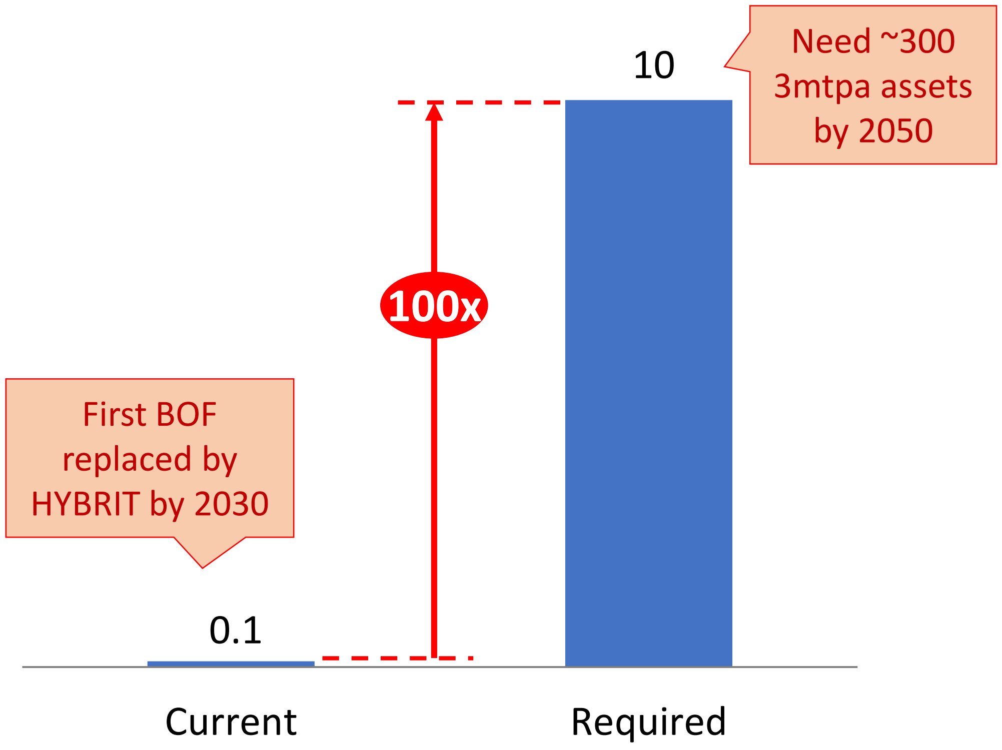
THE CASE FOR ACCELERATED TECHNOLOGY ADOPTION

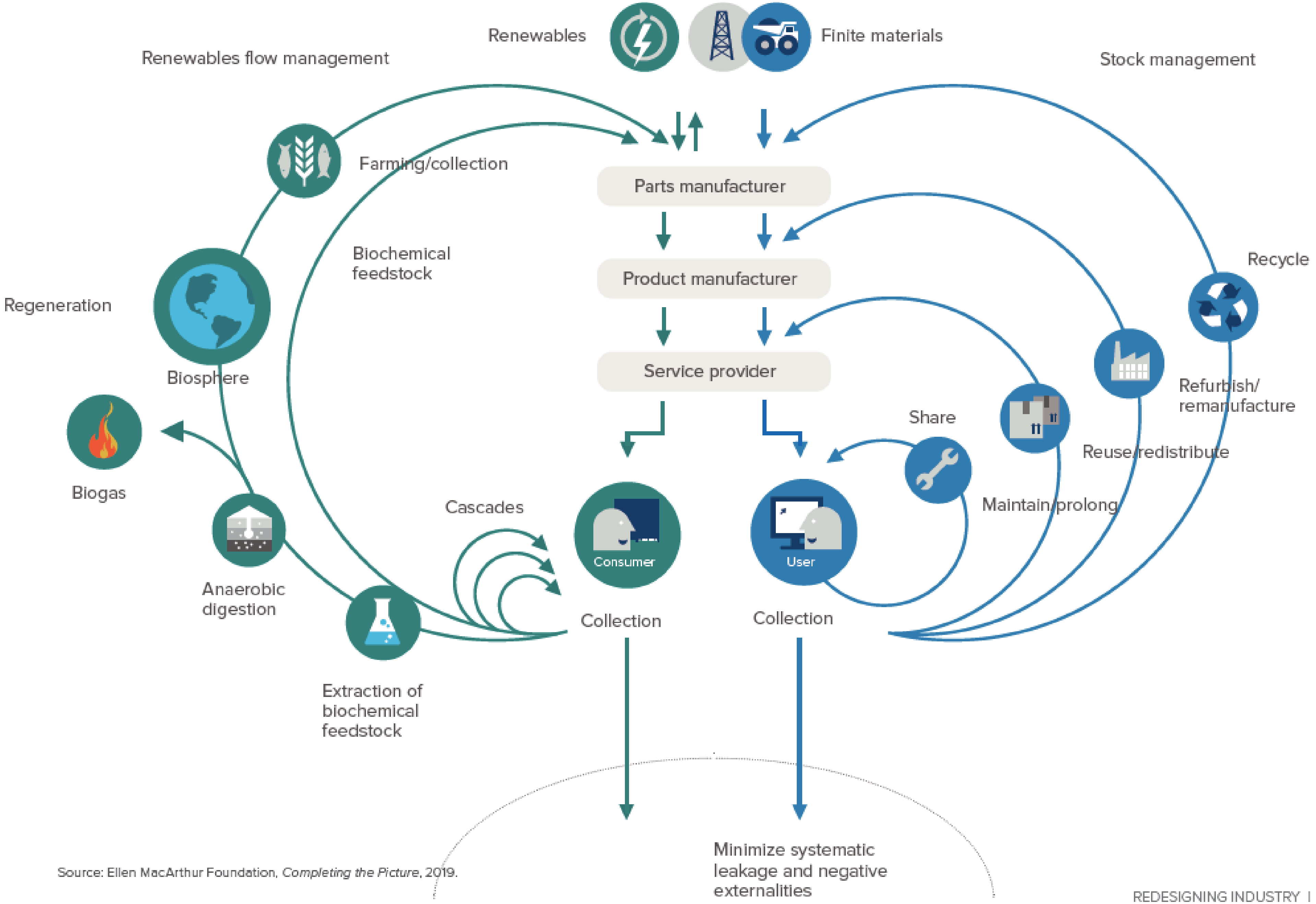
Green steel might compete, but can it scale fast enough?

Production cost
USD / ton crude steel



Pace of change
Steel blast furnaces replaced per year





Source: Ellen MacArthur Foundation, *Completing the Picture*, 2019.

WHAT'S NEEDED NOW

We need to work together to:

- **Remedy the gaps in global energy analyses** that obscure the most dynamic and transformative elements of the transition that is taking place in the real economy.
- **Build actionable energy and climate pathways** featuring real economy indicators that can be used for climate action strategy.
- **Sharpen messages about benefits**, including economic competitiveness, financial risk reduction, access to energy, jobs, equity, and resilience.
- **Combine forces among organizations** with diverse change models and geographical reach to communicate more effectively about the energy transition.
- **Combat misinformation and disinformation** about climate action with rigorous and credible rebuttals.

Anastasia Belostotskaya

Associate Director of Scenarios and Special Projects, World Energy Council

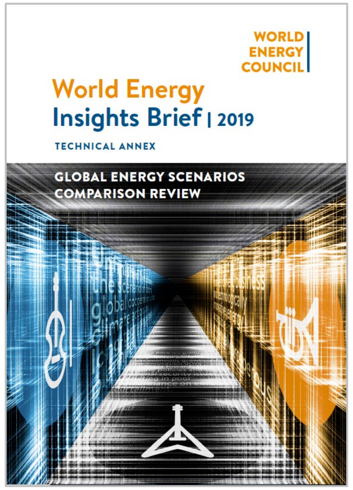
Anastasia Belostotskaya is Associate Director of Scenarios and Special Projects at the World Energy Council (WEC). Anastasia is managing a scenarios programme at the Council, combining scenario building initiatives and global experts' engagement. She focuses on developing scenarios insights and application tools to promote a deeper strategic conversation on energy futures and enable global energy leaders to better understand and drive successful energy transitions.

Global Energy Scenarios Comparison Review

Anastasia Belostotskaya,
Associate Director Scenarios, World Energy Council

Joint IRENA – JRC Expert Workshop on
"Benchmarking long-term scenario comparison studies for the clean energy transition"
Thursday 10 and Friday 11, September 2020

1. Overview and motivation



Released by Council in April 2019
https://www.worldenergy.org/publications/

WHY

- Energy transition part of a wider Grand Transition, which is not all about energy
- What can we learn by contrasting the increasing richness of energy futures thinking?
- How can we better support energy leaders to act under uncertainty?

WHAT

- **Plausibility-based** scenarios, **outlooks**/projections, normative **visions**
- Comparing **assumptions, narratives and numbers**

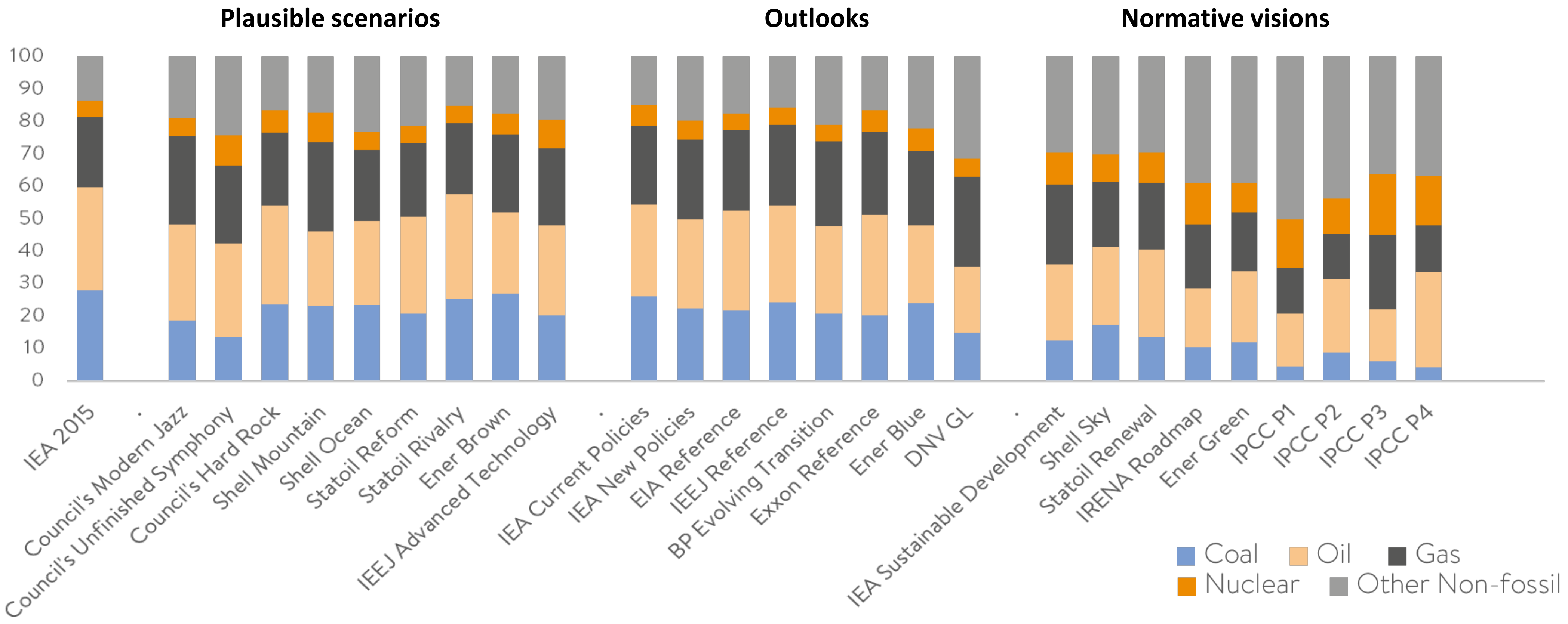
HOW

- Geographical focus: **global sets of scenarios** with no specific regional focus
- Minimum time horizon: **no earlier than 2030**
- Quantification and illustrative numbers: **no limitation to models used**
- Release date: resent reports published **no earlier than 2013**
- Energy system: representing **the whole energy system**

2. Key indicators

- Narratives
- Key assumptions – across 4'D's
- Numbers – primary energy demand, energy mix, electricity demand, coal, oil, gas, nuclear, solar and wind, CO2 emission

Example: Primary energy mix by 2040 (%)



3. Key findings

Every system is more **dynamic and diverse**, and transition is evolving in a much **messier context** than before

Accelerating **digitalisation** is a common assumption – impact of **digital productivity is still uncertain**

New **geopolitics of energy** no longer pivot on oil – not explored in many global energy scenarios

The **economics of energy transition** do not reflect new realities of **non-linear energy systems transition**

New and emerging **social, behavioural & environmental feedbacks loops** not reflected easily in numbers

Increasing role of **more internationally coordinated action,** supported by **agile regulatory frameworks**

Improving scenarios comparison, building and using

- The need to work with narratives and numbers to promote whole systems thinking
- Stress testing normative visions and outlooks through plausibility scenarios
- Design scenarios for use – moving beyond scenarios reports to actionable insights and impact

European Commission

WORLD ENERGY COUNCIL

IRENA
International Renewable Energy Agency

Thank you

Daniel Raimi

Senior Research Analyst, Resources for the Future

Daniel Raimi is a Senior Research Associate at Resources for the Future (RFF) and a lecturer at the Gerald R. Ford school of Public Policy at the University of Michigan. He works on a range of energy policy issues with a focus on oil and gas regulation and taxation, and climate energy policy

RESOURCES *for the* FUTURE

Global Energy Outlook

RFF’s annual comparison of long-term energy outlooks

www.rff.org/geo

Daniel Raimi
RFF Senior Research Associate

Joint IRENA – JRC Expert Workshop on “Benchmarking long-term scenario comparison studies for the clean energy transition”

September 10, 2020

The Global Energy Outlook

- Our goal is to provide an easy-to-understand report that illustrates the wide range of potential energy futures to decision-makers
  - Part of this work has been developed with the International Energy Forum
- We harmonize across key assumptions to provide an “apples-to-apples” comparison of long-term energy outlooks, such as:
  - Primary energy assumptions for combusted- and non-combusted fuels
  - Energy groupings (e.g., biofuels and other renewables)
  - Regional groupings
- We publish an annual report and an interactive online tool (rff.org/geo)
- We include historical data back to 1800, with projections through 2100
- Sources: BP, EIA, Equinor, ExxonMobil, Grubler (historical), IEA, IEEJ, OPEC, Shell
  - Forthcoming updates will include IRENA and select IPCC scenarios

Evolution of key indicators

- We include dozens of variables in our internal analysis. Our interactive data viewer focuses on:

Primary energy consumption	Electricity capacity & generation	Population	CO_2 and CCS	GDP (PPP and MER)

- Population, GDP, energy efficiency, and public policies are the key drivers of energy and emissions outcomes
- Our most recent report focuses on the relatively narrow band of GDP assumptions that many organizations make
- We highlight the discrepancy between historically observed GDP growth rates and assumed future GDP growth rates

Key findings and policy messages

- Key findings
  - Under almost all scenarios, future coal use plateaus or declines
  - Global energy demand shifts from the “West” to the “East”
  - Future oil and natural gas use are highly dependent on policy
- Major policy messages
  - More ambitious policies are needed to achieve long-term Paris targets
  - In the absence of ambitious climate policies, we are likely to see more energy “additions” rather than energy “transitions”
- How can we improve future comparisons?
  - Integrate additional scenarios from the academic literature
  - Further refine our harmonization approach, particularly in final energy consumption

RESOURCES for the FUTURE

Thank you!

Daniel Raimi
(raimi@rff.org)

- Find out more about RFF: **www.rff.org**
- Explore the data: **www.rff.org/geo**
- Follow us on Twitter: **@rff; @danielraimi**
- Subscribe to receive updates: **rff.org/subscribe**

Closing Remarks