SECCA
Sustainable Energy Connectivity in Central Asia

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REGIONAL TRAINING ON MODEL-BASED INTEGRATED ENERGY AND CLIMATE ANALYSES

Almaty, 24-27 September 2024

Rocco De Miglio, Energy Sector Modelling Expert

Stantec | intec GOPA International Energy Consultants MEMBER OF GOPA CONSULTING GROUP | ACTED | European University Institute ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES FSR ENERGY Florence School of Regulation

Intro

Training sessions for country “modelling units”

Workstream / Tasks	Jul	Aug	Sep	Oct	Nov	Dec
Energy systems modelling						
Establishing local "modelling units"						
Introductory meeting (remote)						
Preparation of the training sessions						
Regional seminar/training 1						
Regional seminar/training 2						
Regional seminar/training 3						
Continuous dialogue and co-working						

By the end of the sessions the trainees will have a good understanding of the theoretical background of complex integrated energy and climate analyses, will be able to critically analyse model-based studies and reports and to formulate comments, and will be able to organise data and key factors for simple national and regional modelling exercises.

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Training sessions for country "modelling units"

			PreWorkshop	Workshop1	*Homework*	Workshop2	*Homework*	Workshop3	*Homework*	Total
Name	**Position**	**N. days**			*up to*		*up to*		*up to*	
XYZ	Junior country expert - X	Home+Field		**4**	*5*	3	*5*	4	*4*	**25**

The specific tasks that will be carried are:

- *support the energy (and non-energy) data collection and analysis for quantitative model-based analyses;*
- *support the collection and interpretation of national energy and climate-related policies and factors (to design the storylines of the explorations);*
- *support the preparation of reporting material and presentations;*
- *maintain the share folders (or the equivalent collaborative repositories) where the material of interest (dataset, documents, elaborations) is stored and organised;*
- *provide feedback and ideas for the future developments of tools (next phase, if needed).*

work under supervision of SECCA Team Leader (TL) and in close cooperation with SECCA Experts

Agenda (flexible)

Day 1

9:30 – 12:30:

- Tour de table / ice-breaker activity
- The SECCA project - country modelling units

12:30 – 13:30 Lunch break

13:30 – 16:30:

- Introduction to energy and climate systems analyses
- Introduction to energy and climate systems modelling
- Discussion, Q&A, and wrap-up

to present the SECCA proposition (approach, workplan, scope)

Day 2

9:30 – 12:30:

- The Reference Energy System
- Key inputs / outputs

12:30 – 13:30 Lunch break

13:30 – 16:30:

- A model example: "Demo" model
- Discussion, Q&A, and wrap-up

to understand the underlying logic of model-based analyses of energy and climate systems

Day 3

9:30 – 12:30:

- Model-based analysis: demonstration
- Model-based analysis: demonstration

12:30 – 13:30 Lunch break

13:30 – 16:30:

- Guided exercise and homework (presentation of the assignment)
- Discussion, Q&A, and wrap-up

to practice the basic skills and principles of model-based analyses

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Training sessions for country “modelling units”

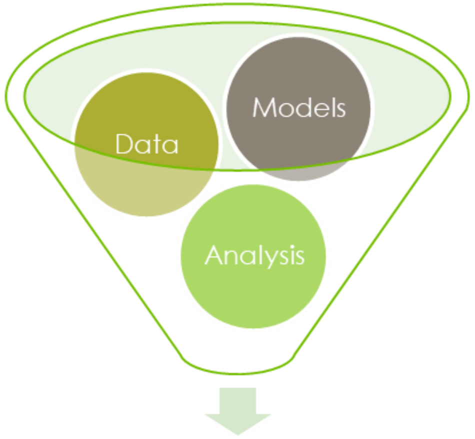
What are your critical strategic questions in the energy&climate domain?
The SECCA project can help you formulating and investigating them.

Think “out of the box”

Evidence-based decision making

Environment for Dialogue / Cooperation / Transparency

Inter- and Trans-disciplinarity



SECCA outcomes

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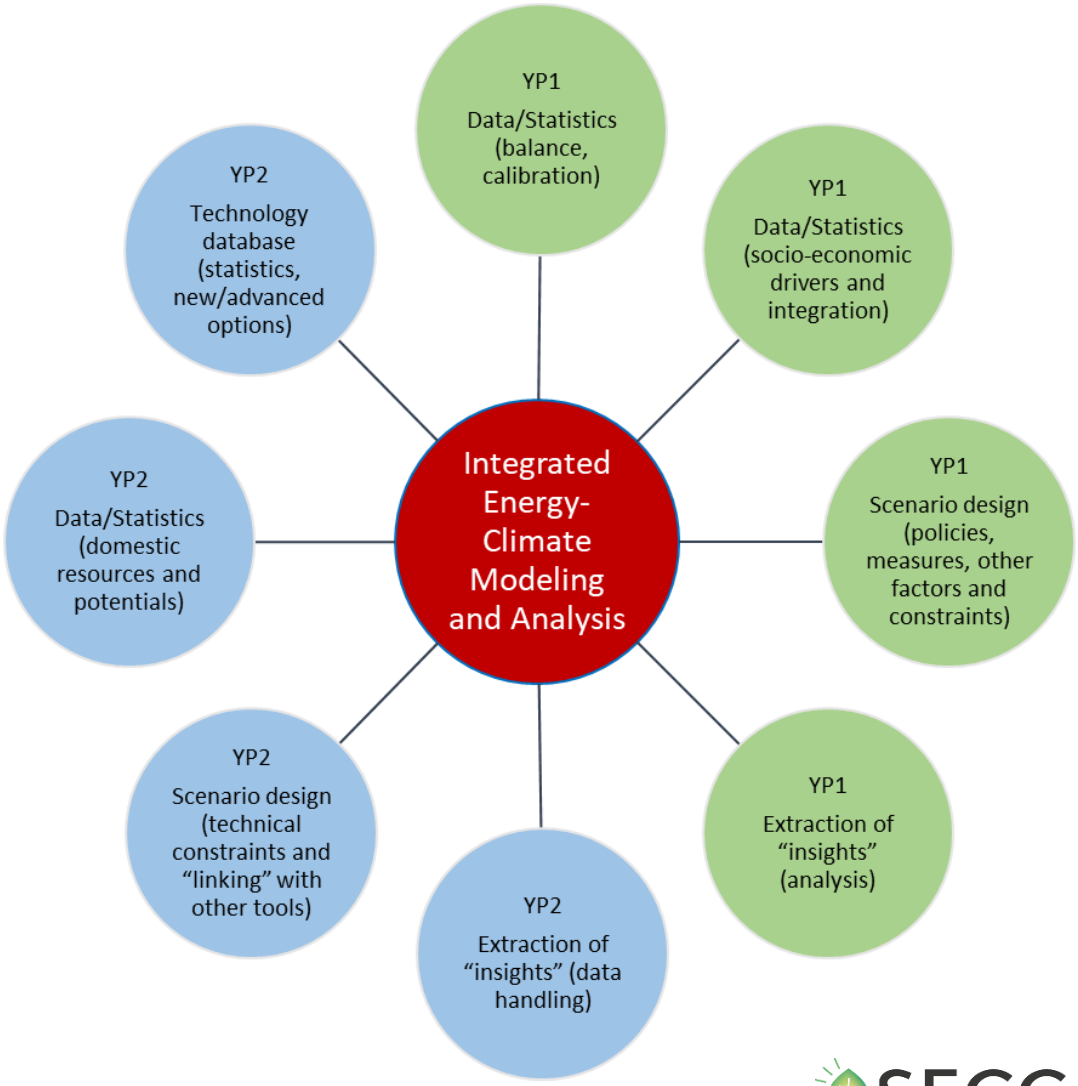
Modeling is not just about "modeling"

There is a variety of ways, approaches, (modelling) techniques to investigate the evolution of energy and climate KPIs over time. But despite the differences, all rely on a few fundamental basis and principles, like:

- *understand and interpret the complexity of real-world systems;*
- *collect, understand, organise and use data (quantitative analysis);*
- *analyse policy instruments that turn the system towards a desired state.*



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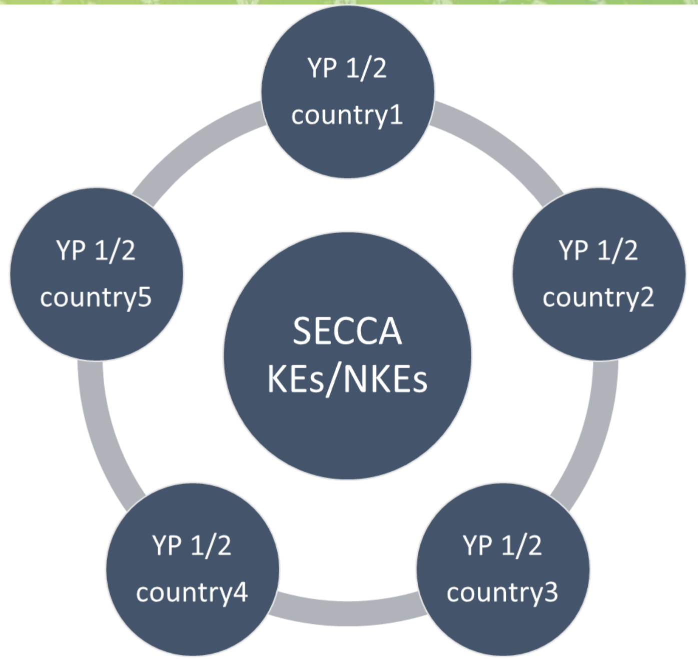
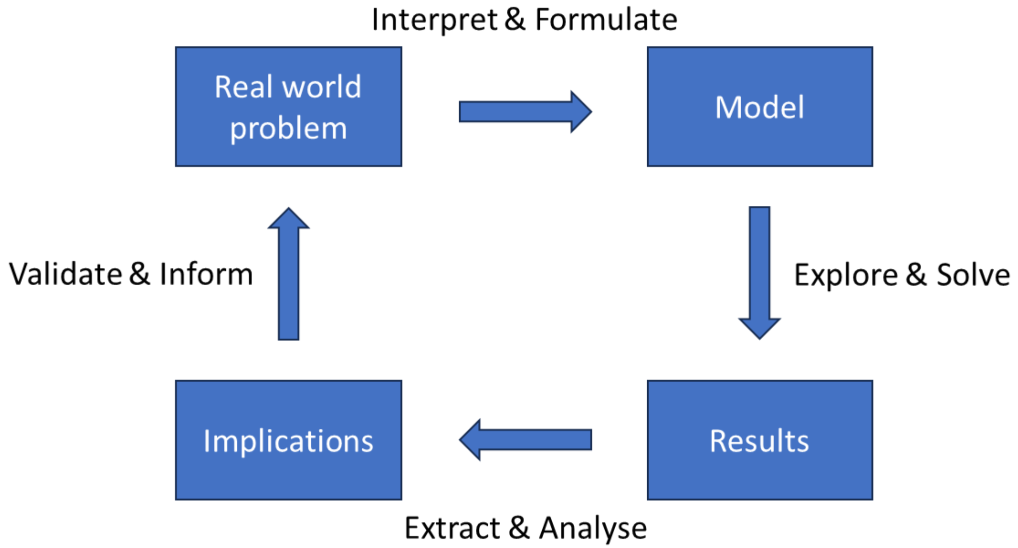
Country "modelling units"

- creating a long-lasting virtuous bridge between the SECCA project activities and the local decision makers;
- improving the local system-thinking and the knowledge based (data-driven) decision making in the energy and climate sectors;
- generating practical impacts that go beyond the duration of the SECCA project





<u>*The "way of thinking" is even more important than the "tools"*</u>

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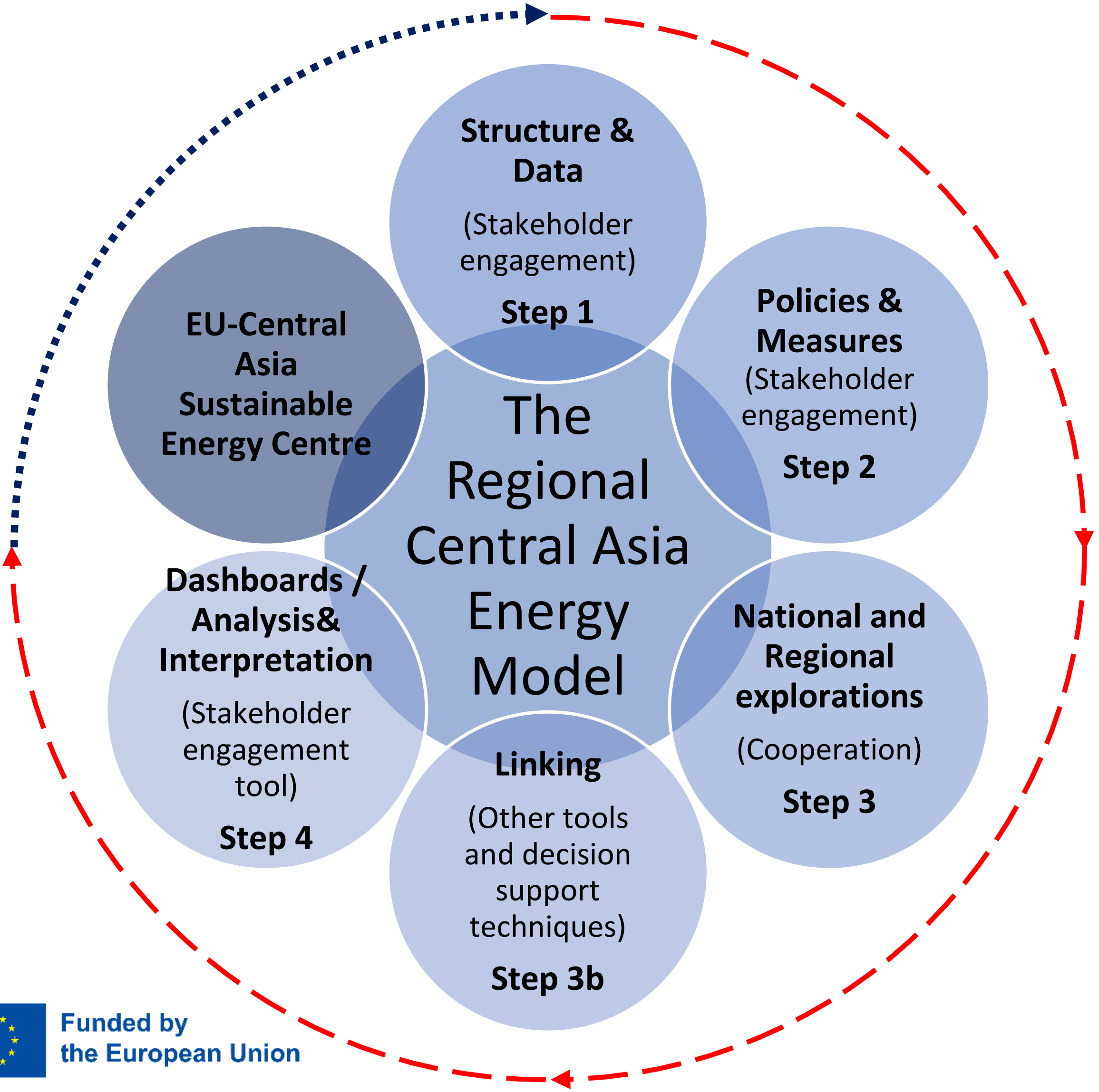
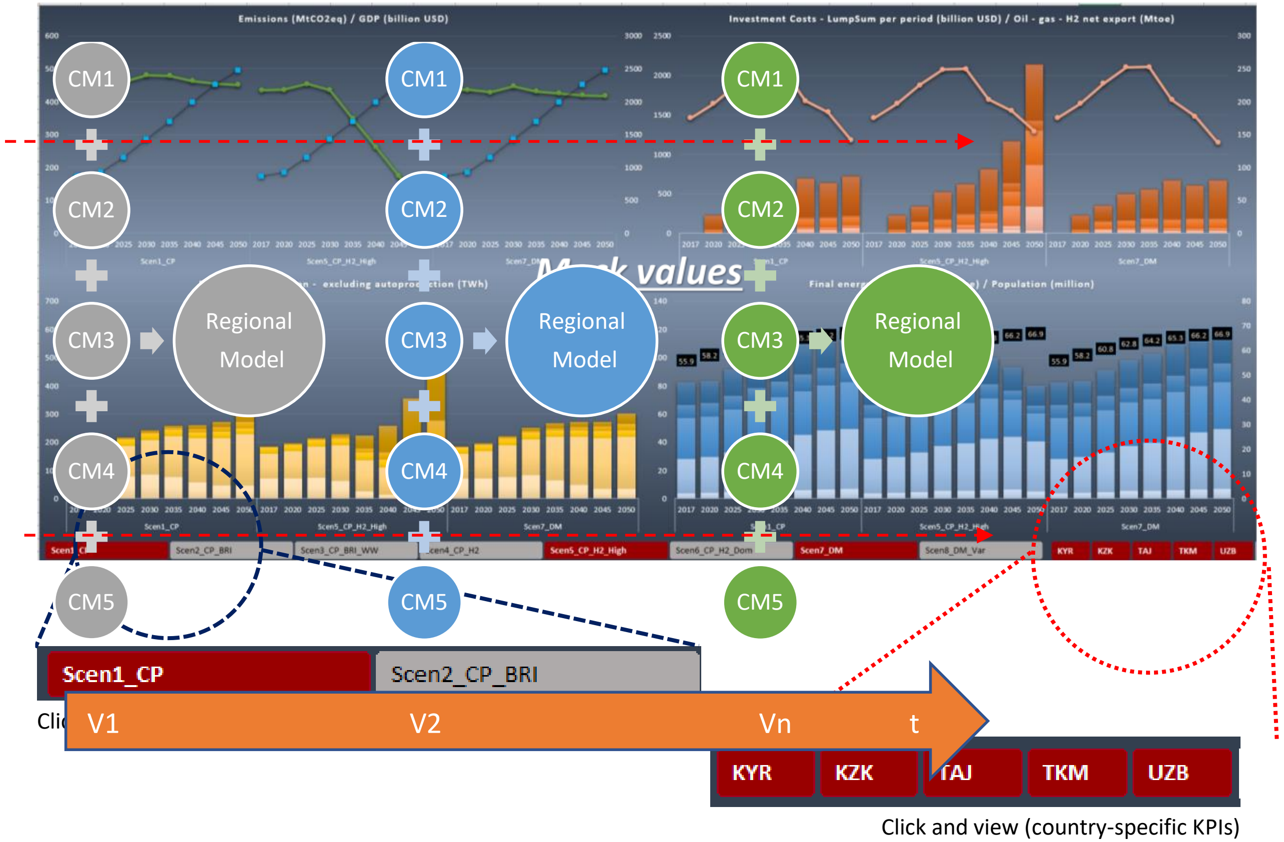
National and Regional analyses (*coordination/collaboration*)





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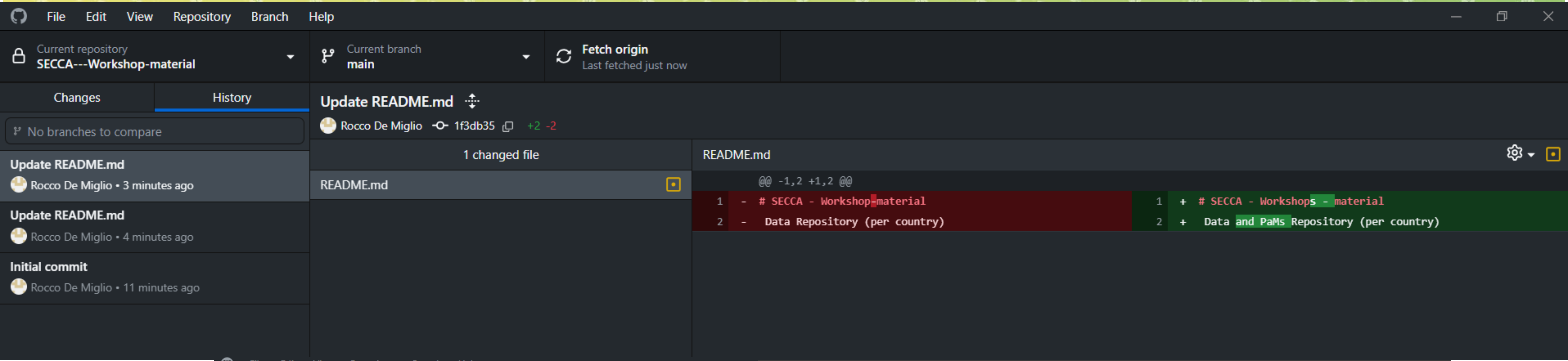
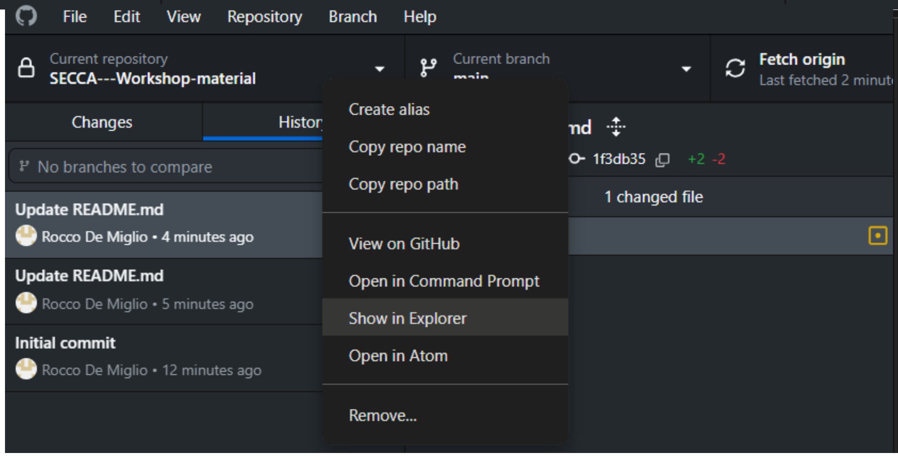
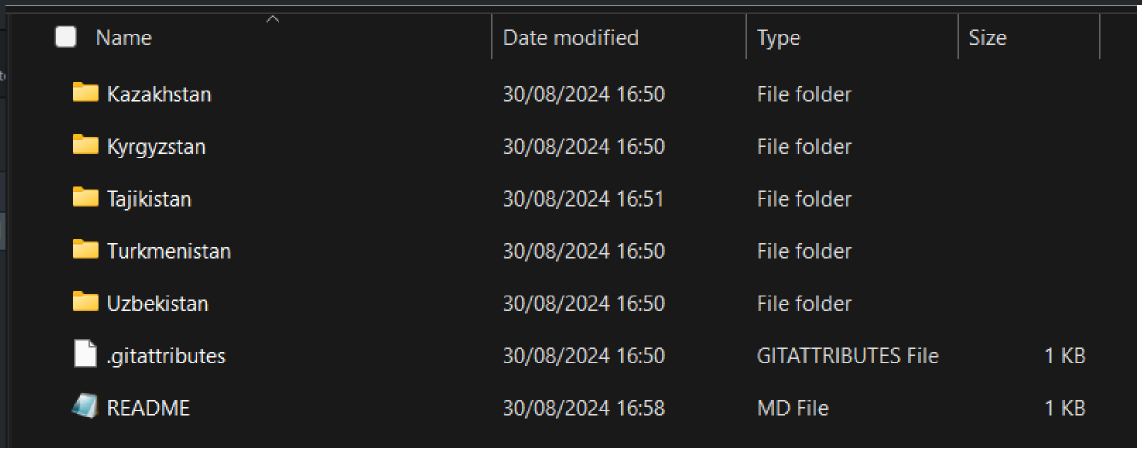
Country repositories (SECCA project) - Create a github account







https://docs.github.com/en/get-started/start-your-journey/creating-an-account-on-github

https://desktop.github.com/download/

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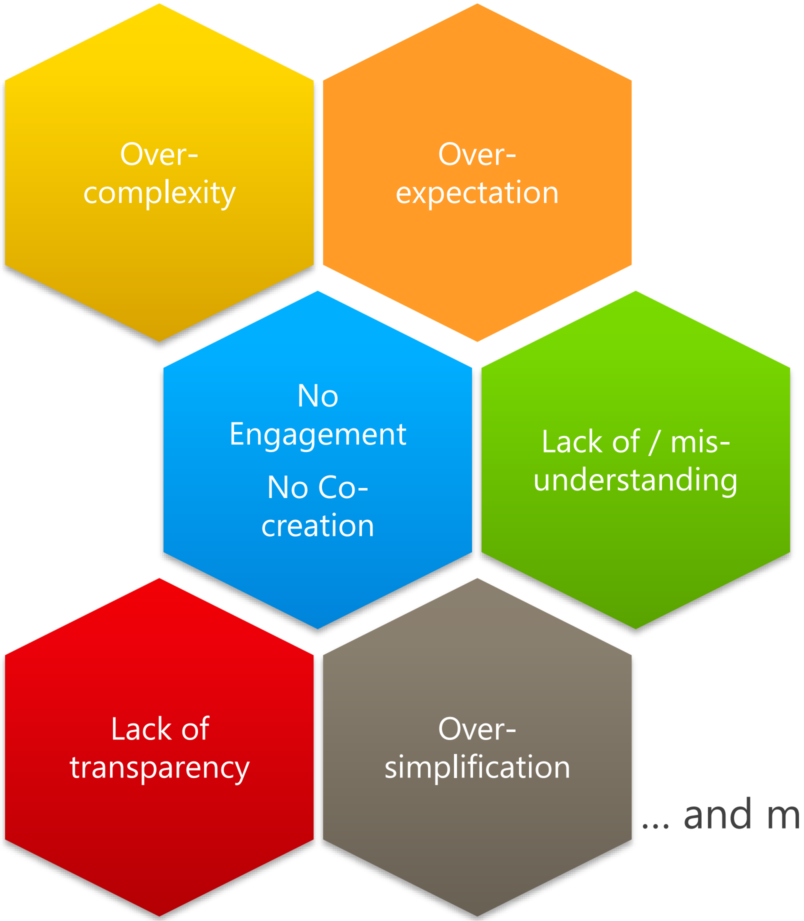
Model-based analyses - Fundamentals

Energy scenarios VS decision-makers

Issue: gap between
"theory and practice"

Goal: to share some elements/experience
for your further consideration and
discussion

Message: No (standard/unique)
methodology for developing model-based
scenarios *BUT*
some "weak" practices



... and many others...

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Decision Science

Decision Science is the collection of quantitative techniques used to inform decision-making at the individual and population levels.

Disciplines involved: risk analysis, cost-benefit and cost-effectiveness analysis, optimization / simulation modeling, and behavioral decision theory, microeconomics, statistical analysis, cognitive and social psychology, and computer and data science, …

Operations research (a field of mathematics) focuses on practical applications, it overlaps with other disciplines including industrial engineering and operations management.

Normative models advise people about how they should make "**choices**", or descriptive models, portraying how they actually make "**choices**".

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Model-based decision support

What we do

Explorations

~~Predictions~~

What we obtain

Insights

~~Forecasts~~

What we aim for

Knowledge

~~"Truth"~~

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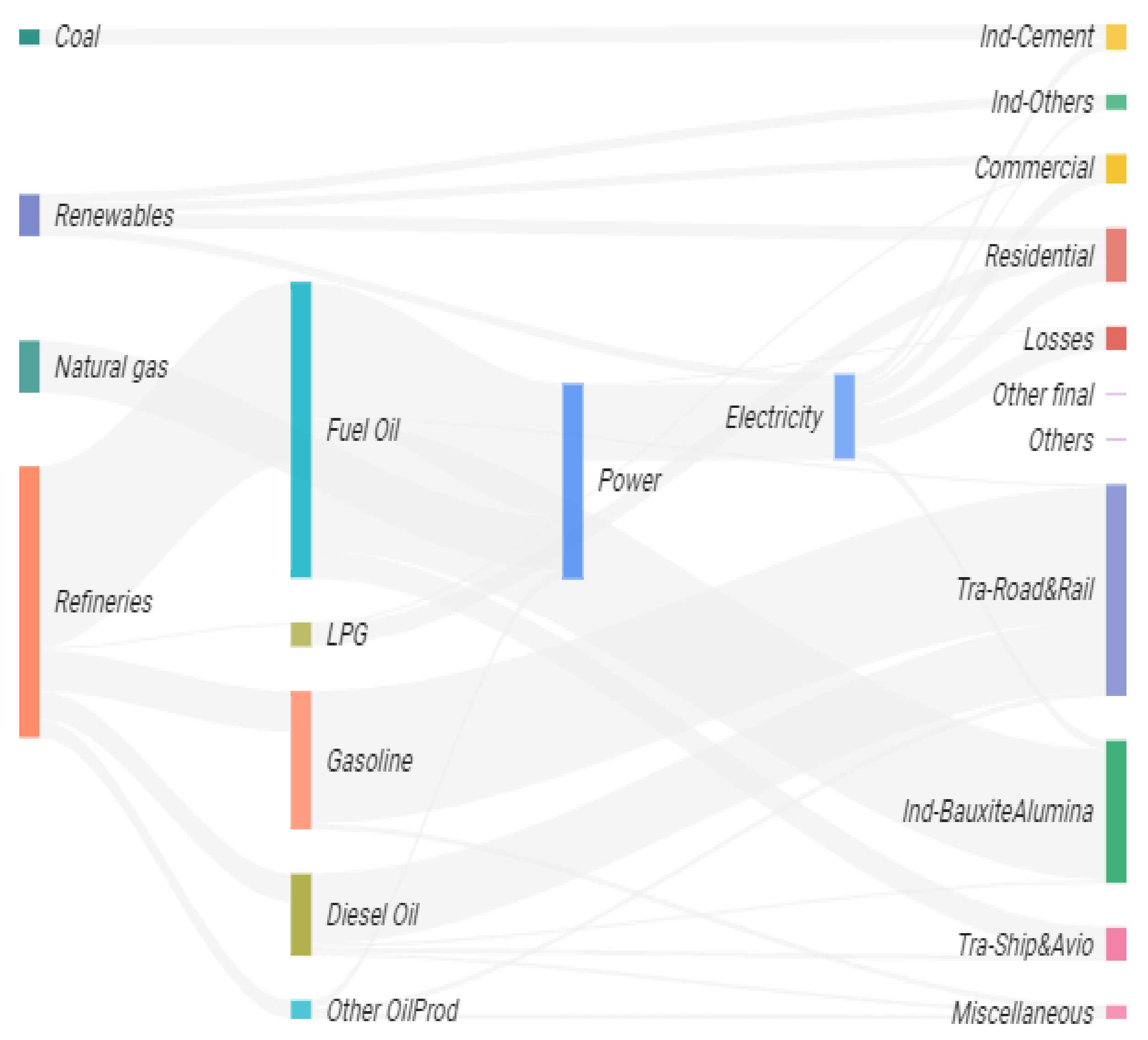
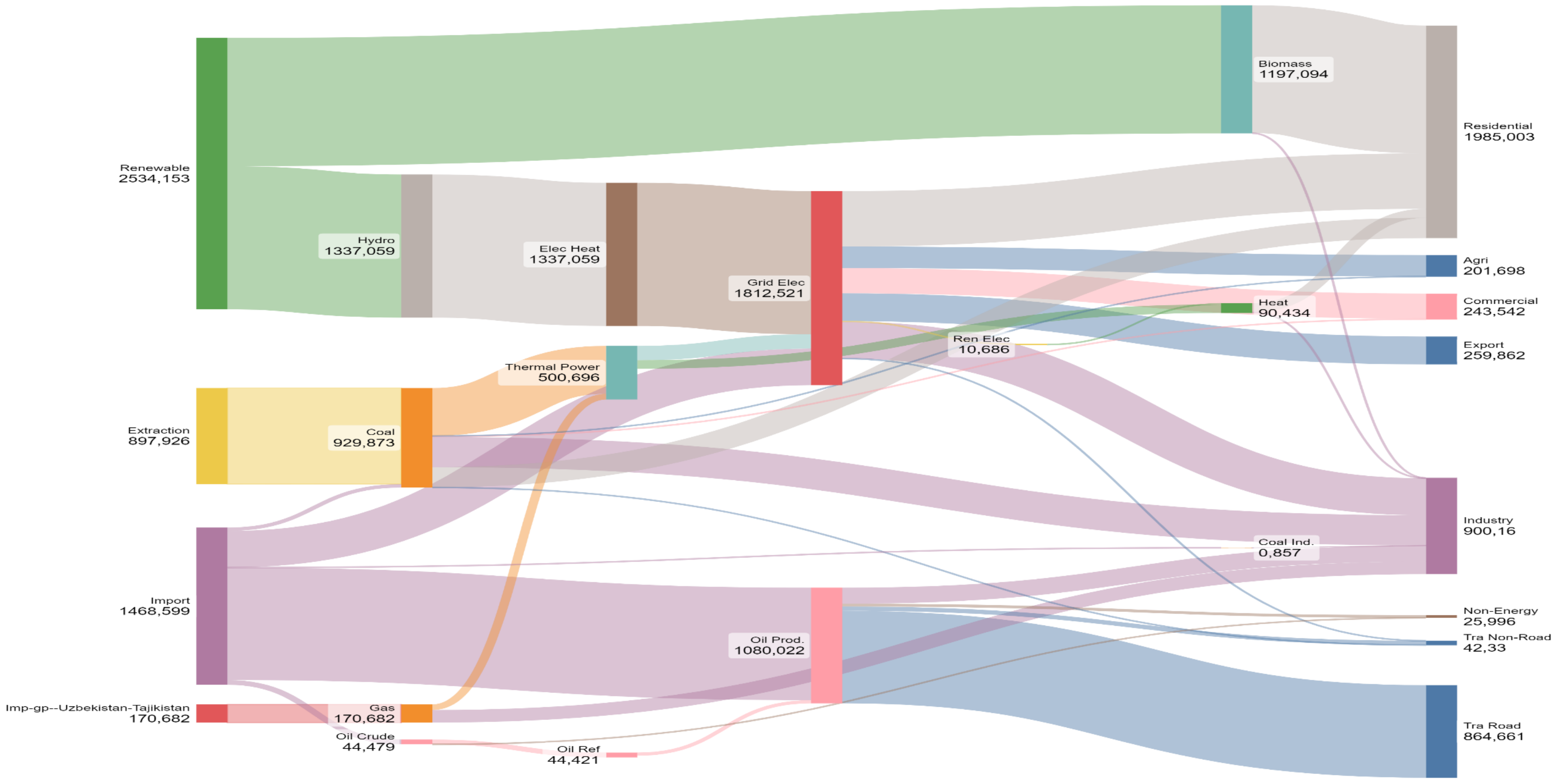
What the problem or issue is?



Key Issues	Possible Actions
Dominance of oil products in the system	Diversification of the mix
Import dependency (primary and secondary commodities)	Reduction of (financial and supply) exposure
Low share of renewable energy in the total primary energy supply (contribution of renewable energy in electricity generation accounts for around 10%)	Exploitation of domestic renewable resources
Transport and Industry are the major sectors of energy consumption	Sectoral transformations and advanced technologies
Significant electricity T&D losses (even greater than the electricity household consumption)	Refurbishment of the network and decentralised generation
Use of solid biomass for cooking (charcoal stoves)	Ensuring affordable and sustainable energy for all and improving air quality

Example: Sankey diagram – 2019 (ktoe) - Tajikistan



[Link]

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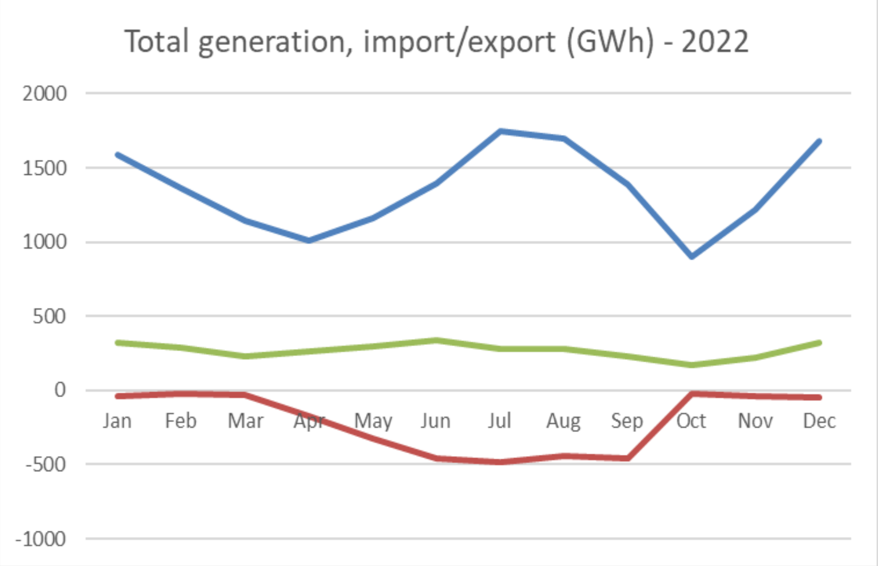
Example: Sankey diagram – 2019 (ktoe) - Tajikistan

Table 2.1 - **Targets for coal production in Tajikistan until 2040 (compilation of data from various strategic documents) and actual coal production in 2015 and 2020, million tonnes**

Source	2015	2020	2025	2030	2040
National Development Strategy of the Republic of Tajikistan, Industrial Scenario, 2016	1.0 (fact)	4.1 (target)	6.9 (target)	10.4 (target)	-
National Development Strategy of the Republic of Tajikistan, Industrial-Innovative Scenario, 2016	1.0 (fact)	5.3 (target)	10.3 (target)	15.1 (target)	-
Concept for the development of the coal industry, 2019	-	-	-	10.4 (target)	15.0 (target)
Accelerated Industrialisation Programme of the Republic of Tajikistan 2020-2025, 2020	-	2.1 (target)	2.4 (target)	-	-
National statistics	1.0 (fact)	2.0 (fact)	-	-	-

Sources: National Development Strategy of the Republic of Tajikistan until 2030, Tajikistan Coal Sector Development Concept until 2040, Accelerated Industrialisation Programme of the Republic of Tajikistan 2020-2025, data provided by the national consultant



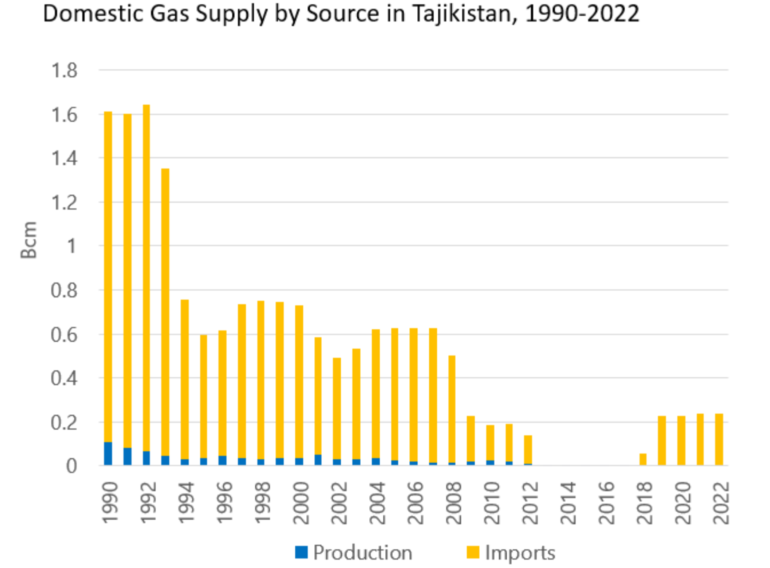
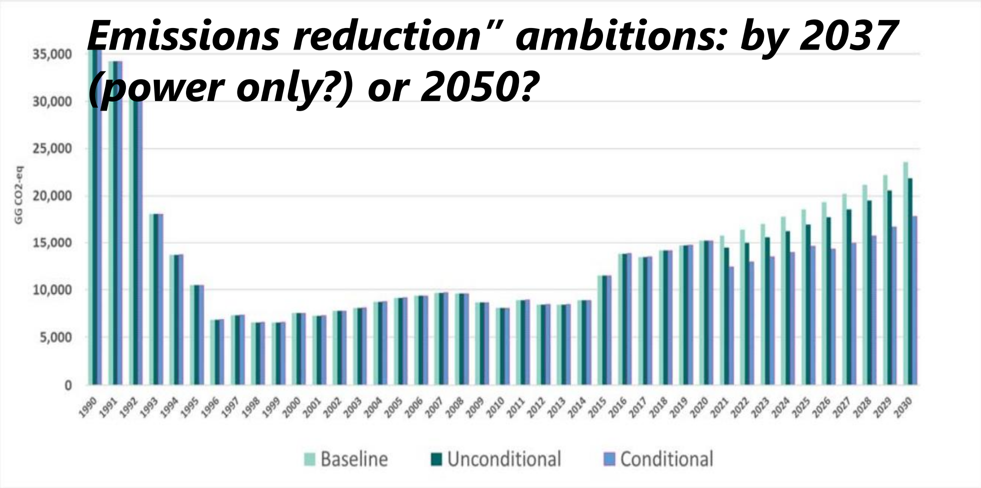
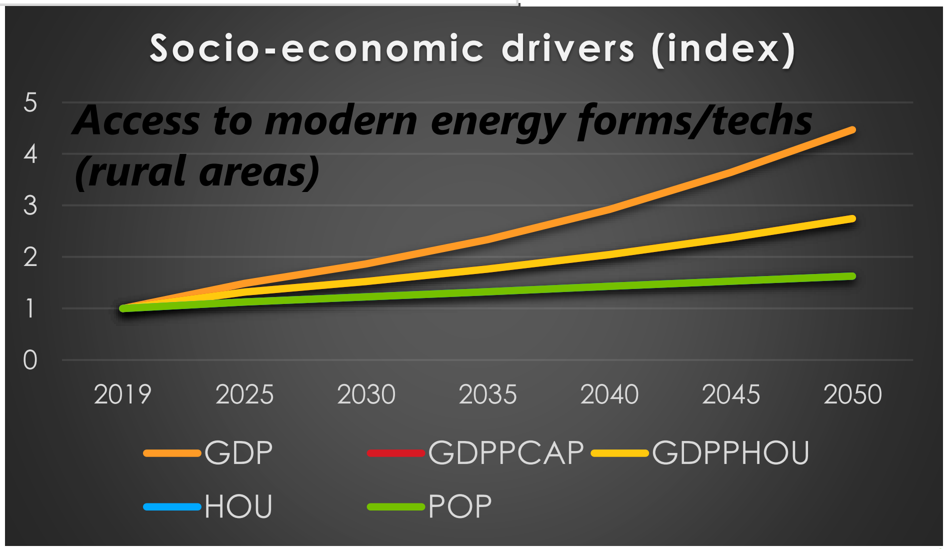


Figure 3: GHG Emissions of the Republic of Tajikistan by scenario





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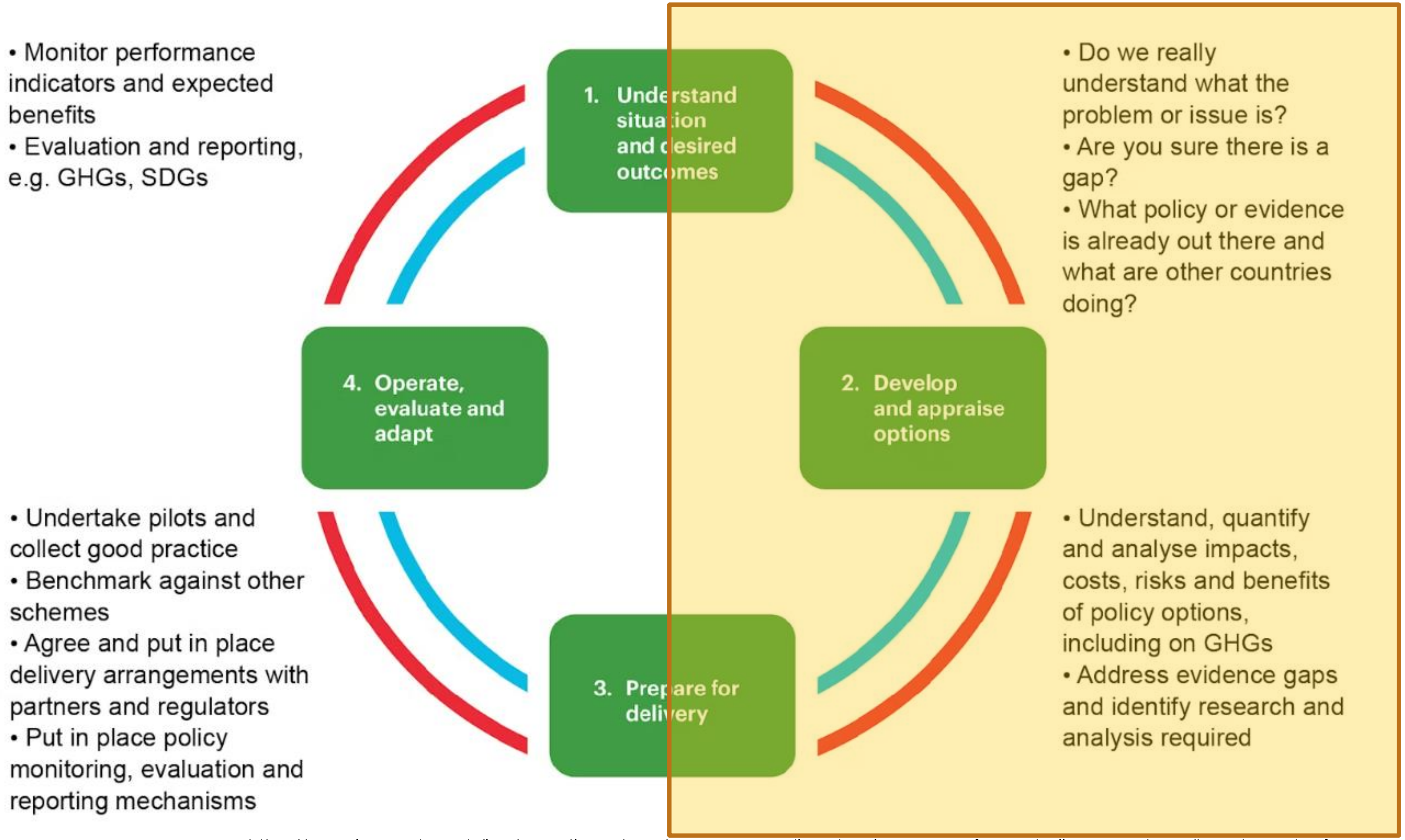
The Policy Development/Delivery Cycle



https://www.iea.org/reports/implementing-a-long-term-energy-policy-planning-process-for-azerbaijan-a-roadmap/key-elements-of-energy-policy-planning

In order to be able to properly assess and evaluate these strategic goals and move into the policy-making process, the DM must call on a variety of skill sets and expertise.

Policy making needs input from all analytical professions (statisticians, economists, operational and social researchers), engineers, technical energy specialists and policy advisers.

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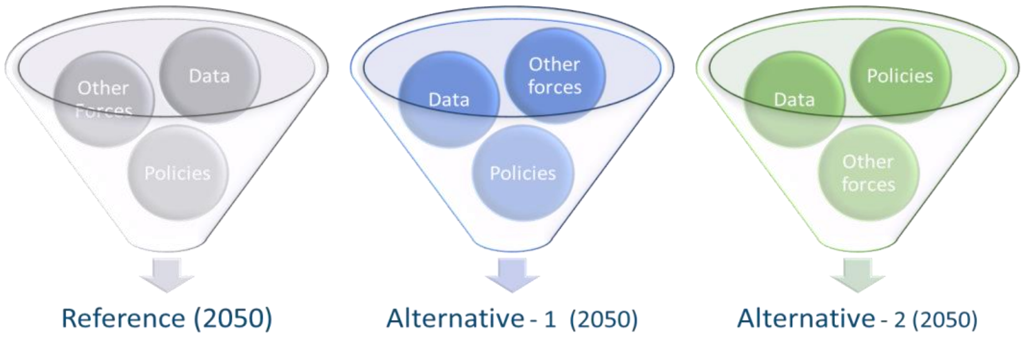
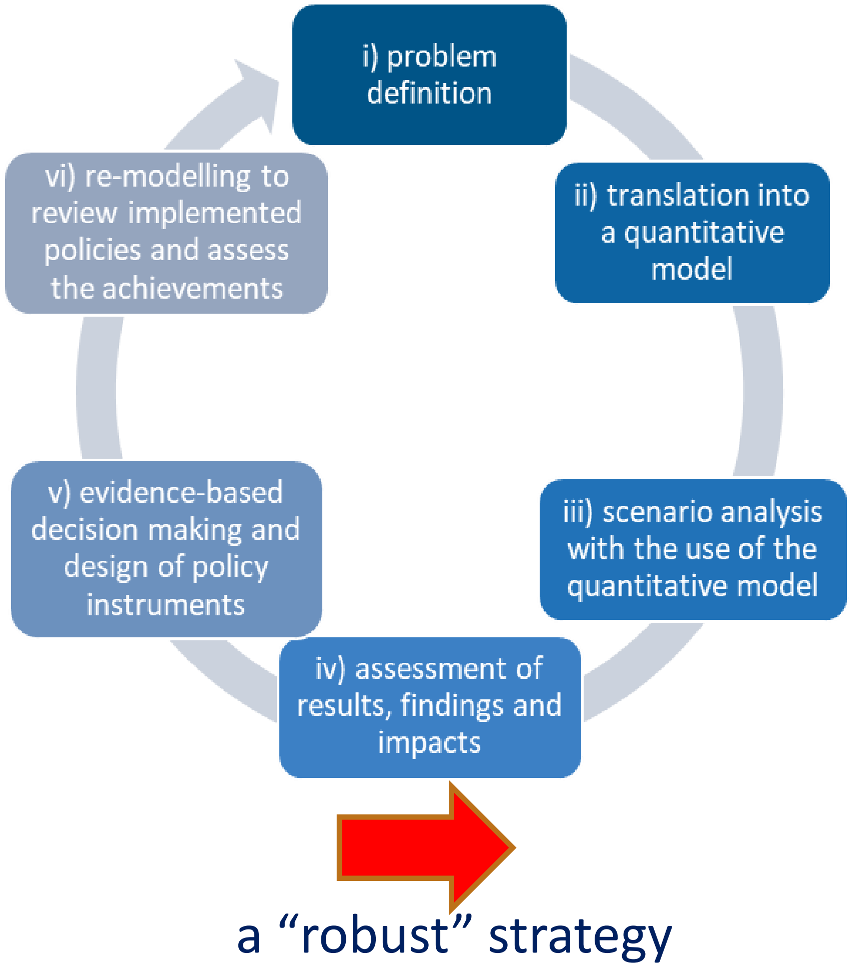
Modeling in policy development – Keyword: integration

Why do DM need/use models?
- To capture and interpret the complexity of the real world in an understandable (useful for specific scope) form
- To organise large amount of data and information (evidence-based and data-based decision making) in a structured manner.
- To (collectively) explore different assumptions and options under the same (consistent) framework/structure and trade-offs.



Multiple explorations: learning by exploring / learning by comparing`



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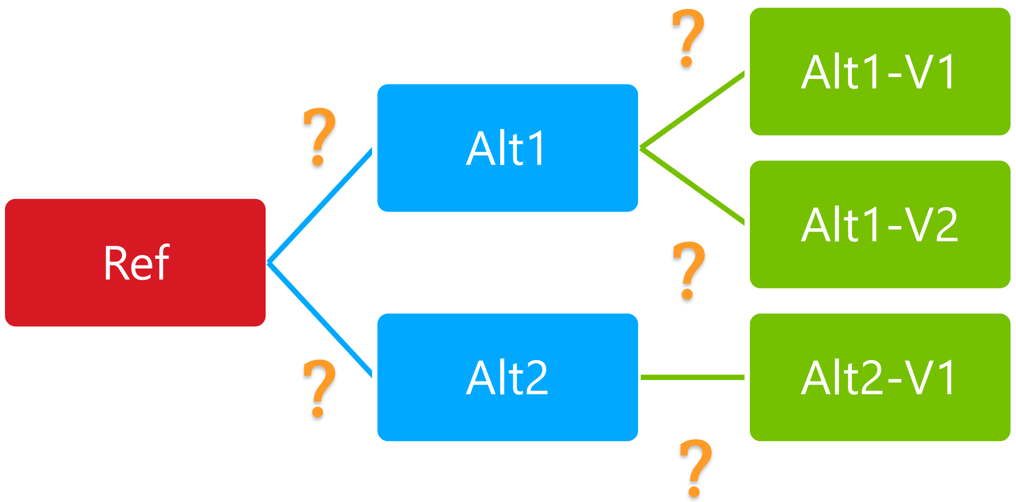
Model-based energy-climate scenarios



Energy scenarios serve as **points of comparison** to evaluate sensitivities and multiple outcomes.

Multiple explorations: learning by exploring / learning by comparing

- Integrated analysis: based on a holistic approach which addresses **simultaneously** as many perspectives or dimensions of the energy and climate dynamics as possible, and takes into account the cross-cutting nature and **interactions** between those dimensions.

  In the context of this analysis we may refer more particularly to the five dimensions of the Energy Union (*Decarbonisation, Energy efficiency, Energy security, Internal energy market, Research, innovation and competitiveness*).

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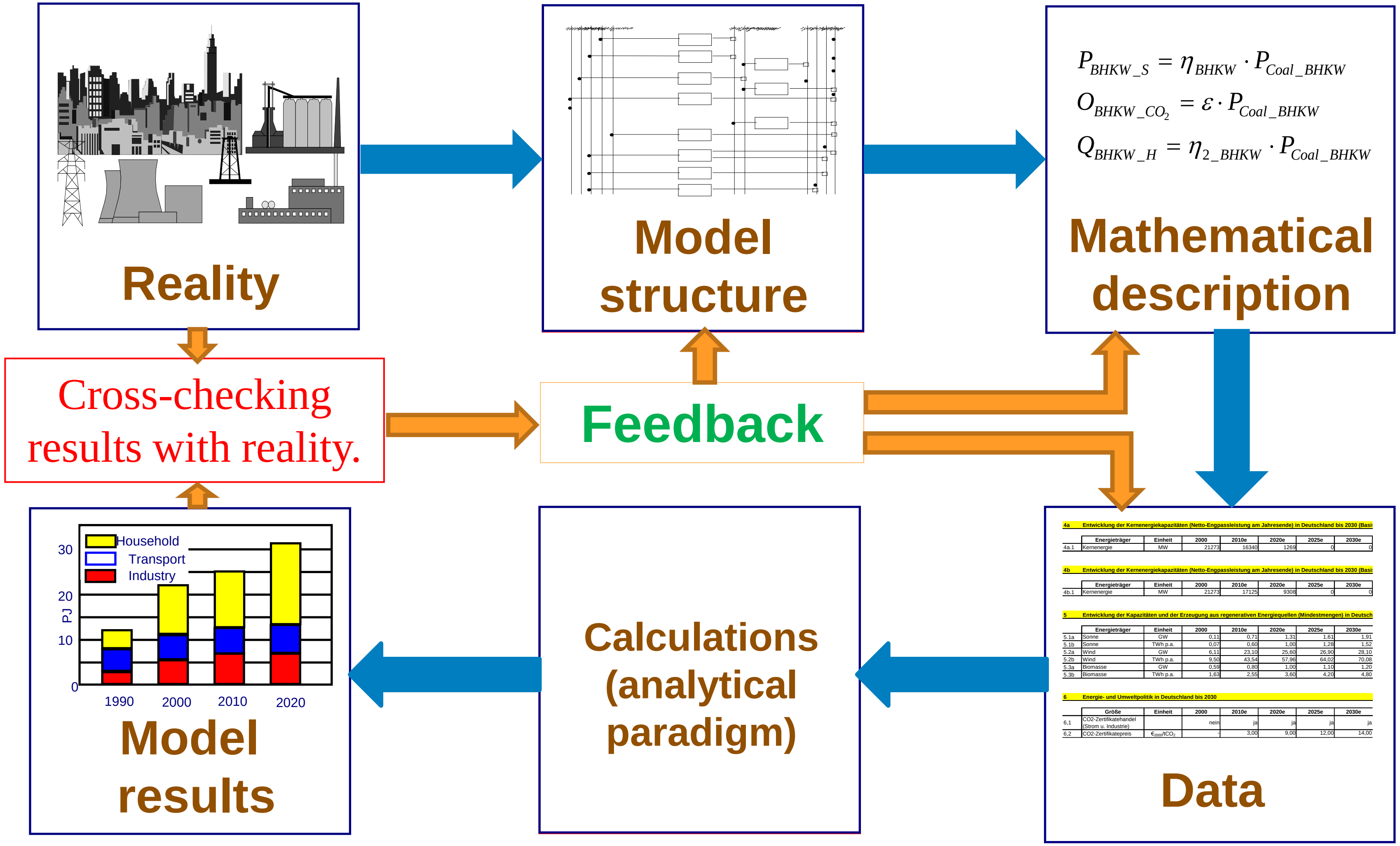
Energy system modelling – Iterative process

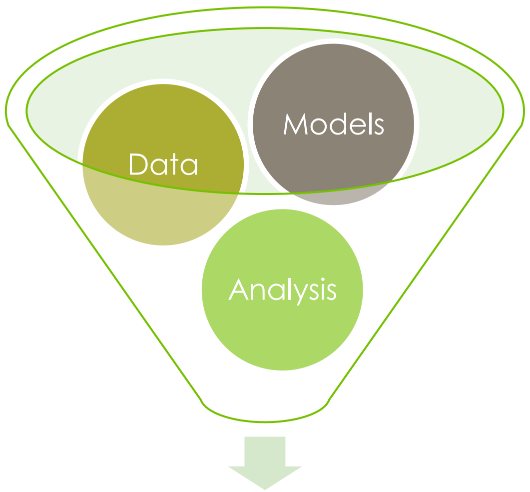


Not just about modeling

Integrated energy and climate analysis

- Data analysis and statistics
- Technology assessment
- Economic analysis
- Policy design (and simulation)
- Analysis of findings, KPIs, and visualisation
- Uncertainty analysis
- Benchmark with other studies
- …

Co-evaluation of the needs / priorities in the framework of this technical assistance
(at country- and regional-level)



SECCA outcomes

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Weaknesses / Hot topics

Country-specific / Multi-regional CA

Need for Integrated Analysis ***(against stand-alone/sectoral analyses)***	Energy security	Energy efficiency measures	Advanced Technology
"Watergy" (integration water-energy)	H2 market (I/E) Promotion of H2 domestic use	Integration with power system analyses (renewables)	Regional integration – cooperation Trades / Trading schemes
International funds (eg Belt and Road Initiative)	Risks (CBAM)	Tariffs (energy subsidies)	Variants/Uncertainties (prices, technologies, targets)

Analytic and Governance Principles – U4RIA

Energy Modelling for Policy Support (EMoPS) is more than simply an analytical activity

the **U4RIA** goals provide a set of guidelines and best practices:

Ubuntu: This "concept" describes a set of closely related Bantu African-origin value systems that *emphasize the interconnectedness of individuals with their surrounding societal and physical worlds* → communities should be engaged.

Retrievability: it should be easy to find and access data (though often it is difficult…)

Reusability: the model should be "re-usable"

Repeatability: it should be repeatable and user-friendly

Reconstructabilty: it extends the concept above; instructions on how to (re)build the model should be included

Interoperability: allows for scenario outputs to be both tested by other models or approaches as well as their compatibility to sub-sector or broader integration with other modelling for policy support

Auditability: allows to verify and evaluate the outcomes in a systematic and reliable manner. (Accountability is "the fact of being responsible for what you do and able to give a satisfactory reason for it, or the degree to which this happens)

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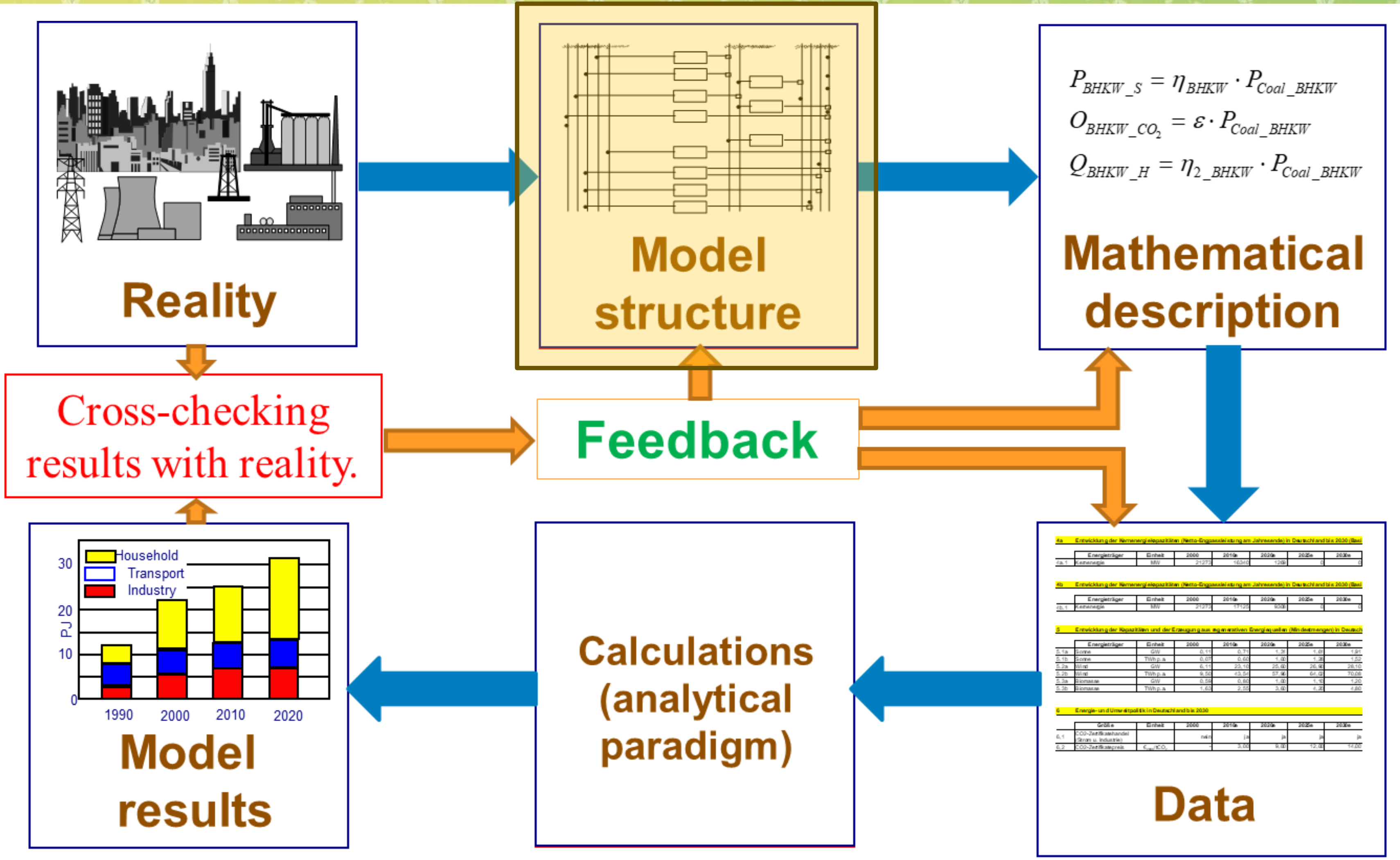
The RES



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The Reference Energy System - RES

The user creates an energy system as a network of processes and commodities, to a fully customizable level of detail.
The network shows resource supplies on the left-hand side, and end use demands on the right, with a variety of transformation pathways between.

Technologies (also called processes) are nodes in the RES network

- May represent physical devices: power plants, vehicles, refrigerators, transmission lines, as well as resource supplies
- May also be "dummy" processes used to change the names of commodities, track commodities for scenario analysis purposes, combine commodities, or otherwise modify network topology

Commodities connect processes in the model topology

- A commodity is produced by some process(es) and/or consumed by other process(es)
- May represent:
  - Energy carriers, such as fuels and electricity/heat
  - Energy services, such as lighting or space heating
  - Others, including: materials, monetary flows, and emissions

Flows are the links between processes and commodities

- Flows are attached to a particular process, and are used to track one input or one output of that process
- For example, electricity produced by wind turbine type A at period p, time-slice s, in region r, is a commodity flow
- This topology information creates the RES

The energy balance can be used as a starting point to draw the RES. The two key steps are: identification of the energy carriers and identification of the key technologies. → **WORKSHOP 2**

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The Energy Balance – Some definitions

Primary energy is energy as found in nature before it undergoes any transformation (crude oil, coal, gas, biomass, nuclear, wind, solar).

Secondary energy is energy after conversion processes, either chemical or physical (refined fuels like gasoline, electricity from a coal power plant).

Final energy is the energy as it is sold to end users (electricity, refined fuels like gasoline, gas for building heating).

Useful energy is the energy after conversion by the consumer, available to be used (heat in a home, light, mechanical work).

Energy services is what the consumer actually wants: a warm home, transportation from A to B, manufactured goods, etc

ktoe EU28	2016	Total all products	Solid fuels	Oil (total)	Gas	Total Renewables	Wastes (non ren.)	Nuclear heat	Derived heat	Electricity
+ Primary production	B_100100	755,389	131,850	74,354	107,238	210,708	14,537	216,703		
+ Primary production receipt	B_100110	9,397		9,397						
+ From other sources (Recovered products)	B_100200	4,522	404	3,818	300					
+ Recycled products	B_100210	1,044		1,044						
+ Imports	B_100300	1,483,219	134,902	941,564	357,102	16,395	385		6	32,865
+ Stock changes	B_100400	21,263	11,807	3,423	5,944	89	0			
- Exports	B_100500	579,508	38,239	411,746	87,613	10,574	29		5	31,301
- Bunkers	B_100800	44,152		44,151	1					
- Direct use	B_100112	10,559		10,559						
Gross inland consumption	B_100900	**1,640,615**	**240,724**	**567,142**	**382,969**	**216,618**	**14,893**	**216,703**	**1**	**1,564**
Transformation input	B_101000	**1,294,958**	**224,492**	**654,689**	**125,132**	**61,875**	**11,027**	**216,703**	**768**	**272**
+ Conventional Thermal Power Stations	B_101001	358,478	165,433	12,820	114,576	54,977	9,905		768	
+ Nuclear Power Stations	B_101002	216,703						216,703		
+ Coke-ovens	B_101004	36,597	36,215	355	27					
+ Blast-furnaces	B_101005	12,918	12,918							
+ Gas works	B_101007	695	674		21					
+ Refineries	B_101008	640,308		640,308						
+ District heating plants	B_101009	21,015	3,544	963	8,654	6,459	1,122			272
+ Patent fuel plants	B_101010	219	142	77						
+ BKB / PB Plants	B_101011	4,385	4,385							
+ Coal Liquefaction Plants	B_101012	901	901							
+ For Blended Natural Gas	B_101013	391		162		230				
+ Charcoal production plants (transformation)	B_101015	209				209				
+ Gas-to-Liquids (GTL) Plants (transformation)	B_101016									
+ Non-specified Transformation Input	B_101020	2,138	279	4	1,855					
Transformation output	B_101100	**963,032**	**31,378**	**640,125**	**20,223**	**62**			**59,192**	**212,054**
+ Conventional Thermal Power Stations	B_101101	181,172							41,319	139,854
+ Nuclear power stations	B_101102	72,303							103	72,200
+ Coke-ovens	B_101104	34,193	27,365		6,828					
+ Blast-furnaces	B_101105	12,918			12,918					
+ Gas works	B_101107	477			477					
+ Refineries	B_101108	640,125		640,125						
+ Patent Fuel Plants	B_101110	173	173							
+ BKB / PB Plants	B_101111	3,840	3,840							
+ Charcoal production plants	B_101115	62				62				
+ District Heating Plants	B_101109	17,770							17,770	
Exchanges and transfers, returns	B_101200	**2,969**		**2,969**		**-65,240**				**65,240**
Consumption of the energy branch	B_101300	**80,128**	**636**	**33,402**	**19,028**	**654**	**87**		**4,913**	**21,408**
Distribution losses	B_101400	**26,372**	**35**	**53**	**3,093**	**24**			**5,554**	**17,612**
Available for Final Consumption	B_101500	**1,205,158**	**46,938**	**522,093**	**255,939**	**88,886**	**3,780**		**47,957**	**239,565**
Final non-energy consumption	B_101600	**97,773**	**1,763**	**82,480**	**13,530**					
Final energy consumption	B_101700	**1,107,818**	**45,338**	**437,131**	**245,284**	**88,949**	**3,780**		**47,932**	**239,405**
+ Industry	B_101800	276,823	33,774	27,513	86,242	22,542	3,524		16,112	87,115
+ Transport	B_101900	367,272	12	344,648	3,284	13,840				5,488
+ Other Sectors	B_102000	463,723	11,552	64,969	155,758	52,567	256		31,820	146,801
+ Services	B_102035	150,043	923	15,668	46,281	4,889	255		9,274	72,754
+ Residential	B_102010	284,832	9,507	33,139	105,175	45,369			22,148	69,494
+ Agriculture / Forestry	B_102030	24,079	1,082	12,992	3,426	2,132	1		252	4,194
+ Fishing	B_102020	1,426		1,236	2	46				142

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From NEB to technologies

The National Energy Balance is the main source for the description of flows and technologies in the energy model.

→

Breakdown of the balance and calibration of the base-year system according to a «bottom-up» approach.

BALANCE	Commodity 1	Commodity 2	Commodity 3	Commodity 4	Commodity 5	Commodity 6
item 1	X 1,1	X 1,2	X 1,3	X 1,4	X 1,5	X 1,6
item 2	X 2,1	X 2,2	X 2,3	X 2,4	X 2,5	X 2,6
item 3	X 3,1	X 3,2	X 3,3	X 3,4	X 3,5	X 3,6
item 4	X 4,1	X 4,2	X 4,3	X 4,4	X 4,5	X 4,6
item 5	X 5,1	X 5,2	X 5,3	X 5,4	X 5,5	X 5,6
item 6	X 6,1	X 6,2	X 6,3	X 6,4	X 6,5	X 6,6
Service	**Commodity 1**	**Commodity 2**	**Commodity 3**	**Commodity 4**	**Commodity 5**	**Commodity 6**
item A,1	=30%*X 1,1	=50%*X 1,2	=10%*X 1,3	=0%*X 1,4	=30%*X 1,5	=20%*X 1,6
item B,1	=40%*X 1,1	=20%*X 1,2	=40%*X 1,3	=70%*X 1,4	=40%*X 1,5	=20%*X 1,6
item C,1	=30%*X 1,1	=70%*X 1,2	=50%*X 1,3	=30%*X 1,4	=30%*X 1,5	=60%*X 1,6
item A,2	=10%*X 2,1	=25%*X 2,2	=10%*X 2,3	=20%*X 2,4	=35%*X 2,5	=50%*X 2,6
item B,2	=60%*X 2,1	=55%*X 2,2	=60%*X 2,3	=40%*X 2,4	=35%*X 2,5	=15%*X 2,6
item C,2	=30%*X 2,1	=20%*X 2,2	=30%*X 2,3	=40%*X 2,4	=30%*X 2,5	=35%*X 2,6

Conversion factors (energy)

General conversion factors for energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	2.388×10^{2}	2.388×10^{-5}	9.478×10^{2}	2.778×10^{-1}
Gcal	4.187×10^{-3}	1	1.000×10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.187×10^{4}	1.000×10^{7}	1	3.968×10^{7}	1.163×10^{4}
MBtu	1.055×10^{-3}	2.520×10^{-1}	2.520×10^{-8}	1	2.931×10^{-4}
GWh	3.600	8.598×10^{2}	8.598×10^{-5}	3.412×10^{3}	1

Unit abbreviations

bcm	billion cubic metres	MBtu	million British thermal units
Gcal	gigacalorie	Mt	million tonnes
GCV	gross calorific value	Mtoe	million tonnes of oil equivalent
GW	gigawatt	MWh	megawatt hour
GWh	gigawatt hour	PPP	purchasing power parity
kb/cd	thousand barrels per calendar day	t	metric ton = tonne = 1 000 kg
kcal	kilocalorie	TJ	terajoule
kg	kilogramme	toe	tonne of oil equivalent = 10^{7} kcal
kJ	kilojoule	TWh	terawatt hour
kWh	kilowatt hour	USD	United States dollar

https://www.iea.org/data-and-statistics/data-tools/unit-converter

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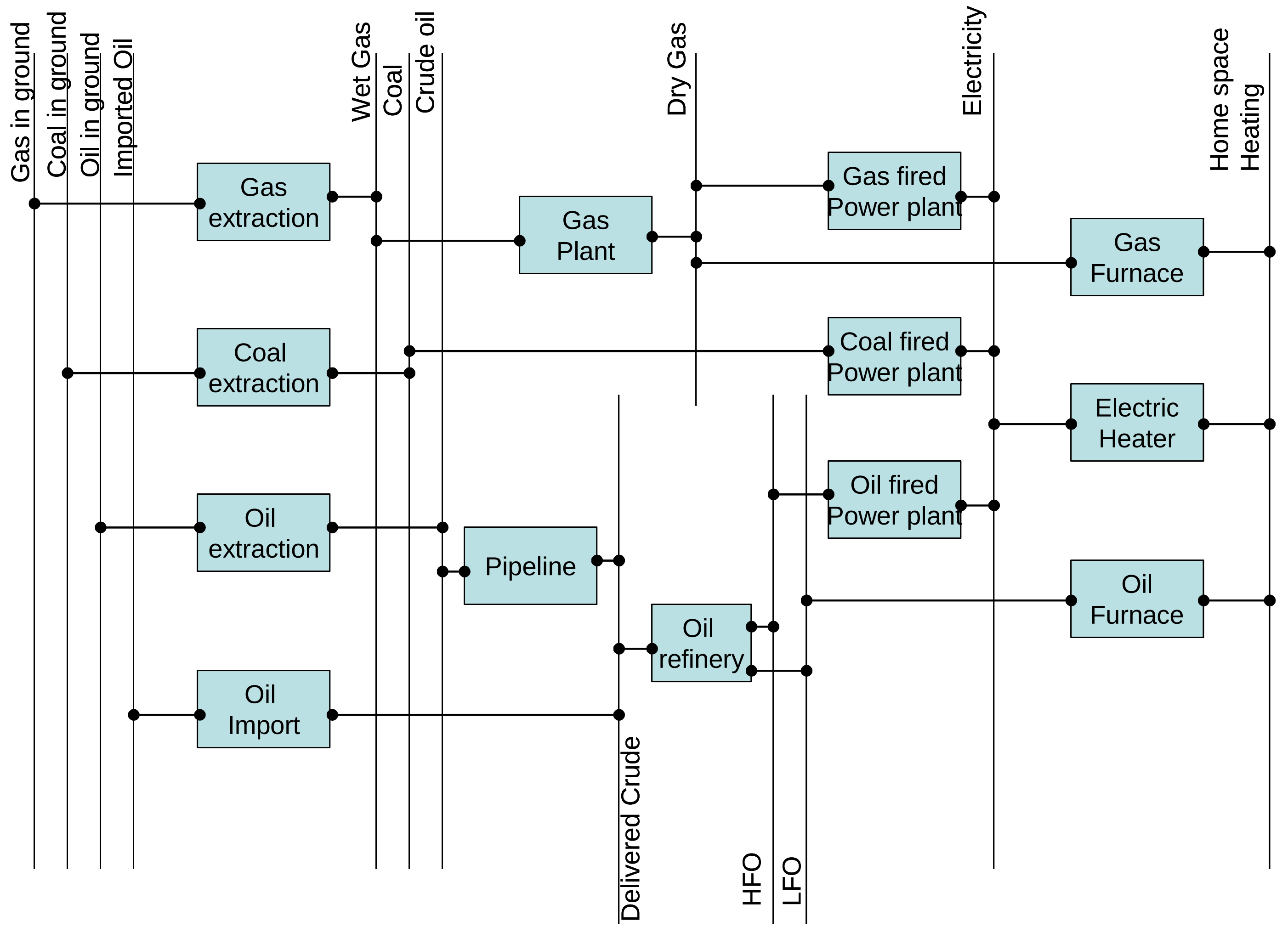
The Reference Energy System – RES – Examples (1)



Task: Translate a critical decision problem of your country into a RES scheme

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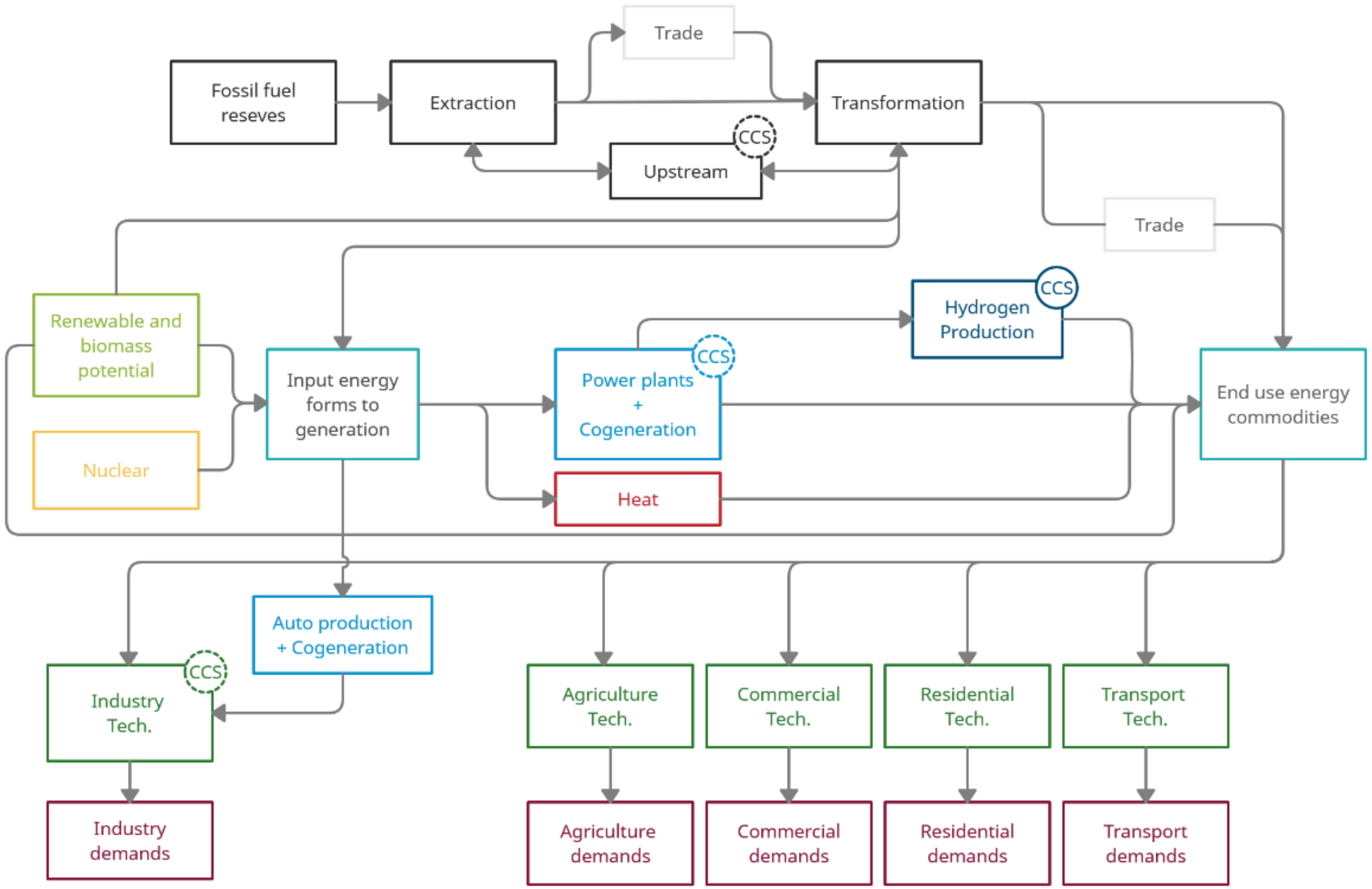
The Reference Energy System – RES – Examples (2)



Task: Translate a critical decision problem of your country into a RES scheme

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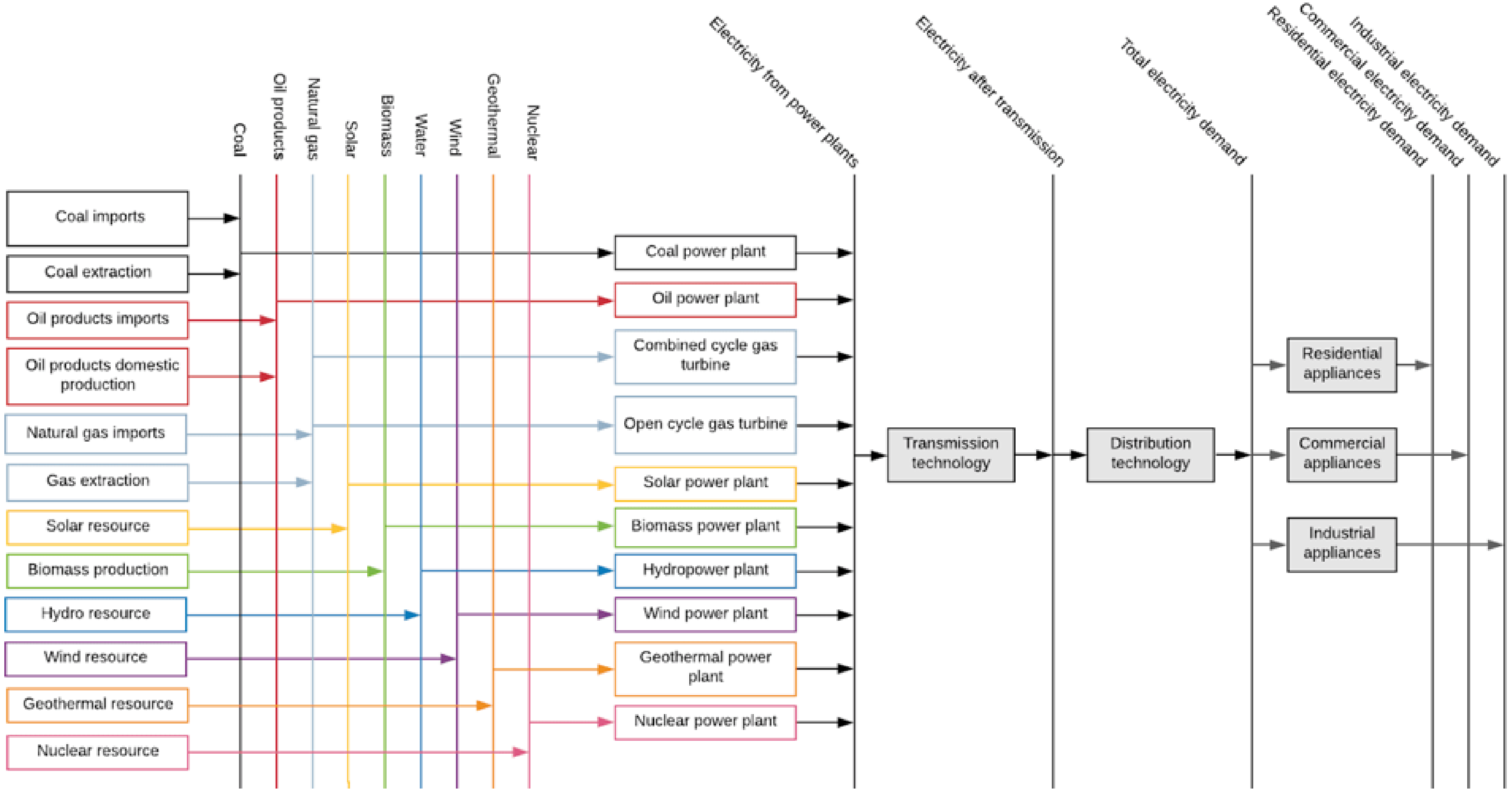
The Reference Energy System – RES – Examples (3)



Task: Translate a critical decision problem of your country into a RES scheme

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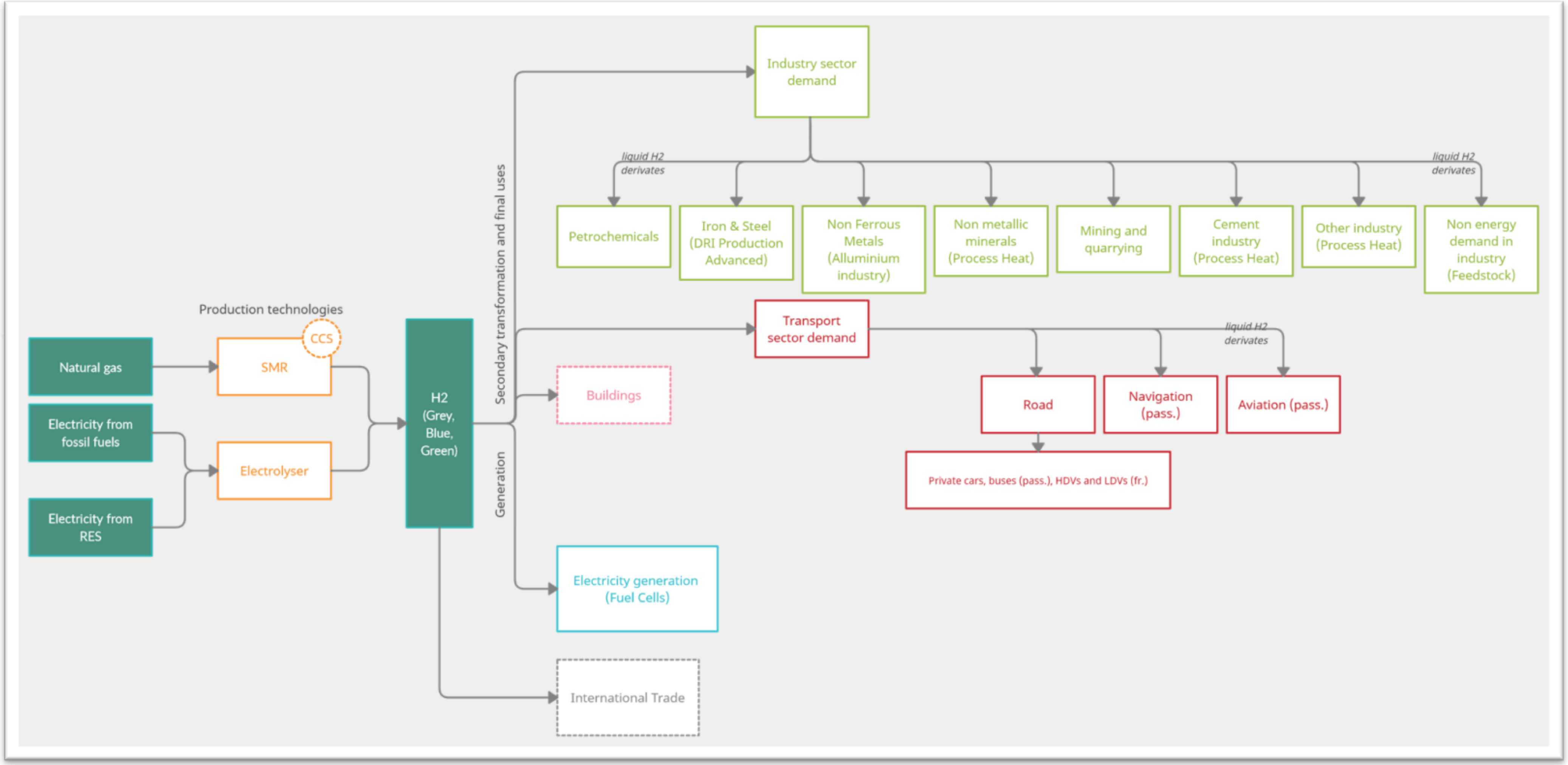
The Reference Energy System – RES – Examples (3)



Task: Translate a critical decision problem of your country into a RES scheme

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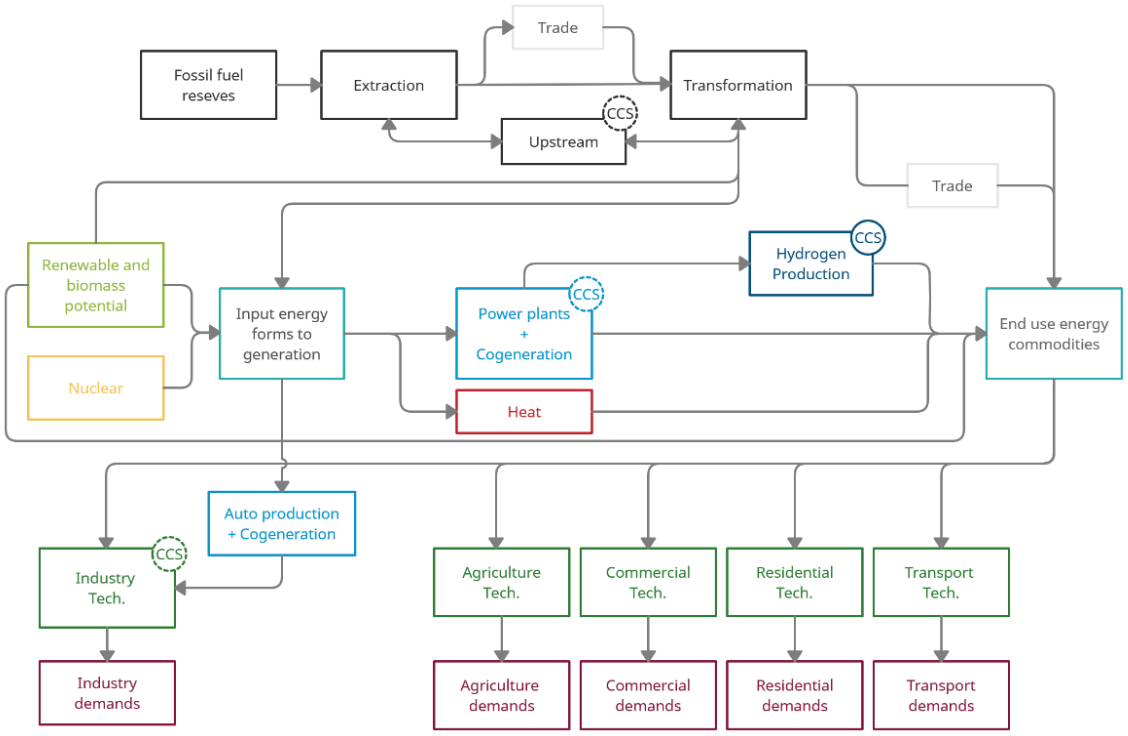
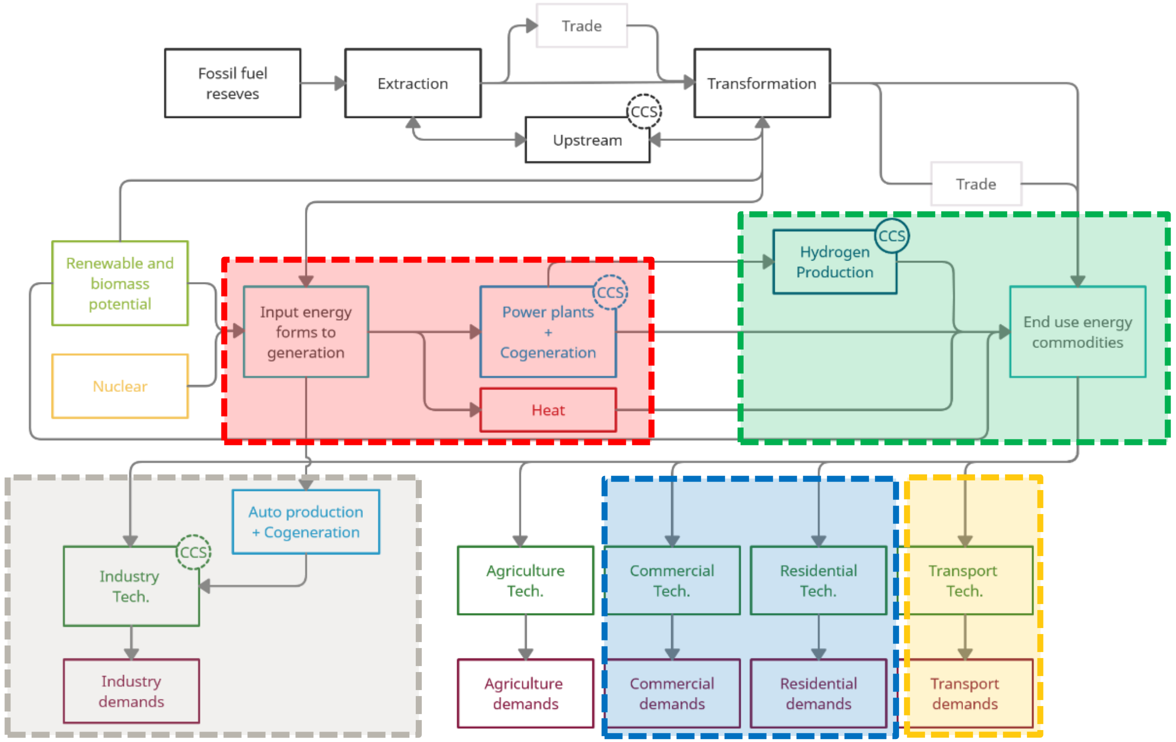
Energy systems modelling: System ≠ sum of the parts





System Analysis (Optimisation)

Energy flows and energy-related emissions per service/sector and for the whole system. Targets/measures can be analysed per service and/or sector and/or system.

Existing sector-specific analysis *(highlighted)*

Energy flows and emissions per each standalone sectoral level. No flows between/across sub-sectors.

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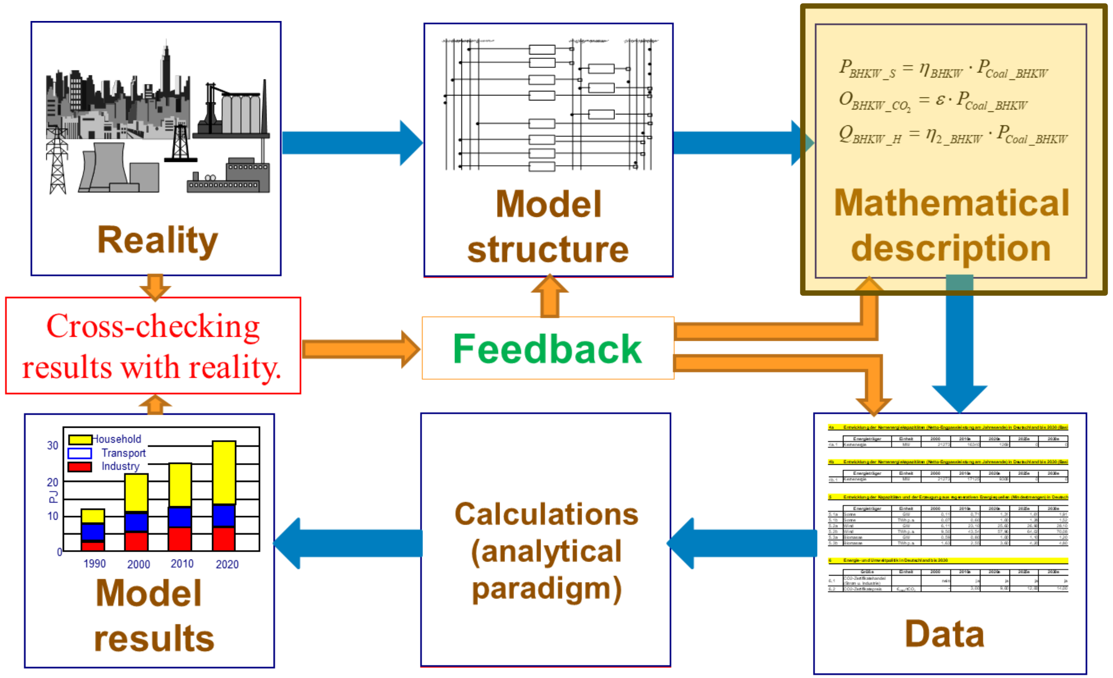
Mathematical description – Key Equations



Capacity transfer

Tracks total installed capacity for each process by period, vintage, and region

Use of capacity (process availability)

Limits process usage according to its installed capacity and availability

Process efficiencies and flow shares

Establishes efficiency relationships between outputs and inputs, and shares among the ouputs and/or among the inputs

Commodity balance

Limits commodity consumption in each region, period, and timeslice to its total production plus net import

Peak reserve requirement

Requires total capacity of all processes producing a commodity in each time period and region to exceed the average demand in the time-slice where peaking occurs by a specified percentage

User-imposed bounds and constraints

Carbon emissions rate limits

Rules for inter-regional allowance trade

Minimum share of generation and/or capacity that is dispatchable

Constraining the growth rate of a new technology

…

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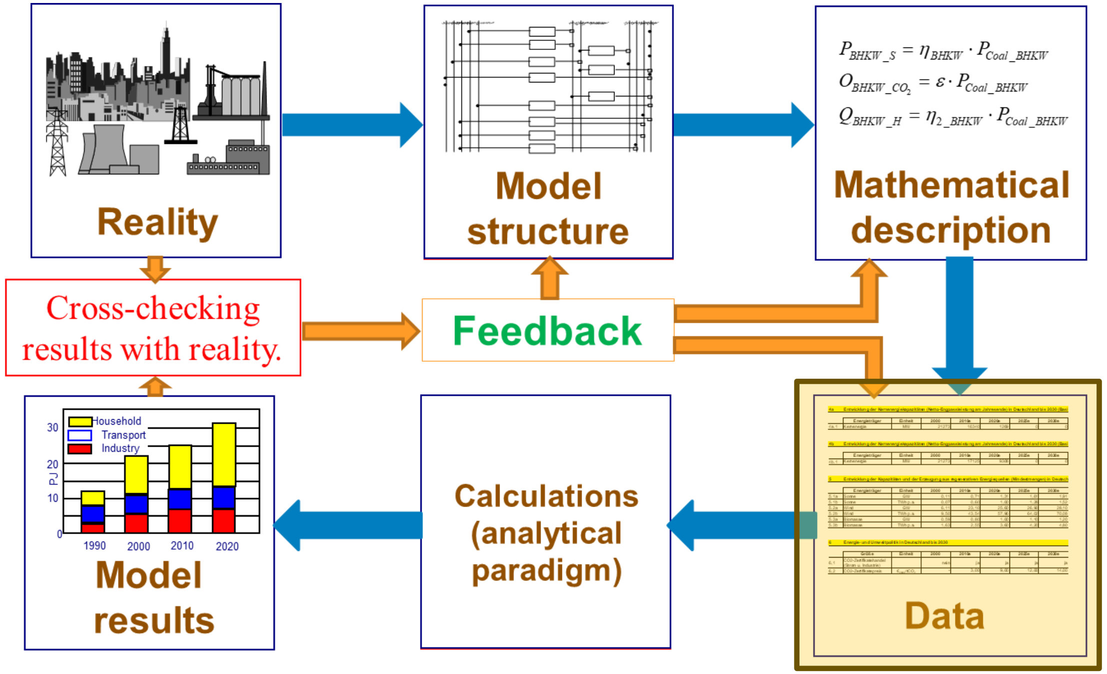
Mathematical description – Key Inputs



Base Year representation

- NEB 20XX
- Basic statistics (POP, #households, vehicles fleet, physical production of key industries)
- Power plants (stock, key operation parameters)
- Import and supply (coal, gas, oil products)
- Service-specific indicators / KPIs, in residential, tertiary
- Service-specific indicators in industry and transport, agriculture

Demand projections

- Population projections
- Other drivers/projections to be assumed

→ **Template**

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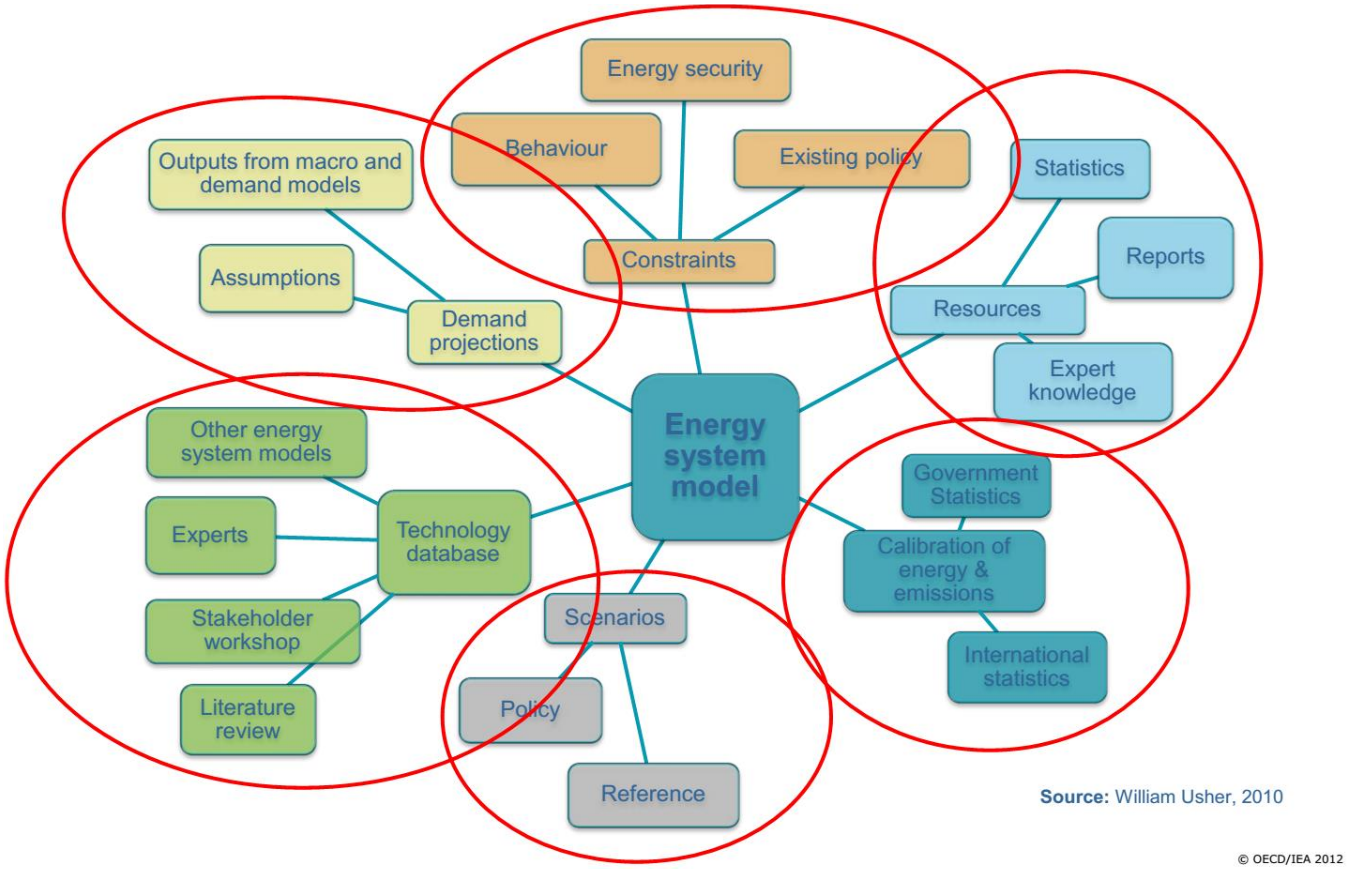
Mathematical description – Key Inputs



<u>Technology Database</u>

- Technology-specific data in residential, tertiary (existing and new)
- Technology-specific data in industry and transport, agriculture (existing and new)
- Technology-specific data in power sector (new)

<u>Resources</u>

- Potential of RES / minerals (wind, solar, biomass,…)

<u>Policy and measures and other factors</u>

- To be discussed

Energy system models - Description

Typical outputs

Greenhouse gas emissions trajectory: per sector (transport, industry, residential, commercial, agriculture, electricity generation, upstream/midstream oil and gas), per fuel (diesel oil, natural gas, lignite etc.), and calculation of key indicators (carbon intensity per unit energy, energy intensity etc.).

Final energy consumption and primary energy supply . Per energy commodity (electricity, lignite, natural gas, diesel oil, gasoline, HFO etc.) and per sector (transport, industry, residential, commercial, agriculture).

Technology mix and evolution over time. Installed capacities per technology type and fuel type in the power sector, capacities of technologies in the demand sectors (industry, residential/commercial buildings, transportation). Changes in technology utilization over time.

Investment costs (and other costs components). Over the year of the time horizon, by technology type and sector (ex-post analysis of breakdown between public/private investments)

Marginal prices. Marginal prices per energy commodity (electricity, lignite, natural gas, diesel oil, gasoline, HFO etc.) and per sector (transport, industry, residential, commercial, agriculture).

Grid electricity production/demand and imports/exports: per year, demand broken down per sector (transport, buildings, industry, agriculture) including the additional demand from electrification of transport, electrification of heating and cooling services, and electrification of industry.

KPIs. Several additional indicators (depending on the type of analysis and the detail of representation)

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Energy system models - Classification

Analytical paradigm	*Sectoral Coverage*	*Time horizon*	*Time resolution*
Geographical coverage	*Supra-national forces*	*Technology explicitness*	*Activity explicitness*
Muti-criteria/agents	*GHG emissions and environmental impacts*	*Microeconomic robustness*	*Capacity to represent macroeconomic feedback*
Capacity to represent non-market preferences	*Capacity to represent uncertainties*	*Data requirement*	*Computing requirements / Tools integration*

Key driving questions:

- For what???
- For whom???

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Energy system models - Description

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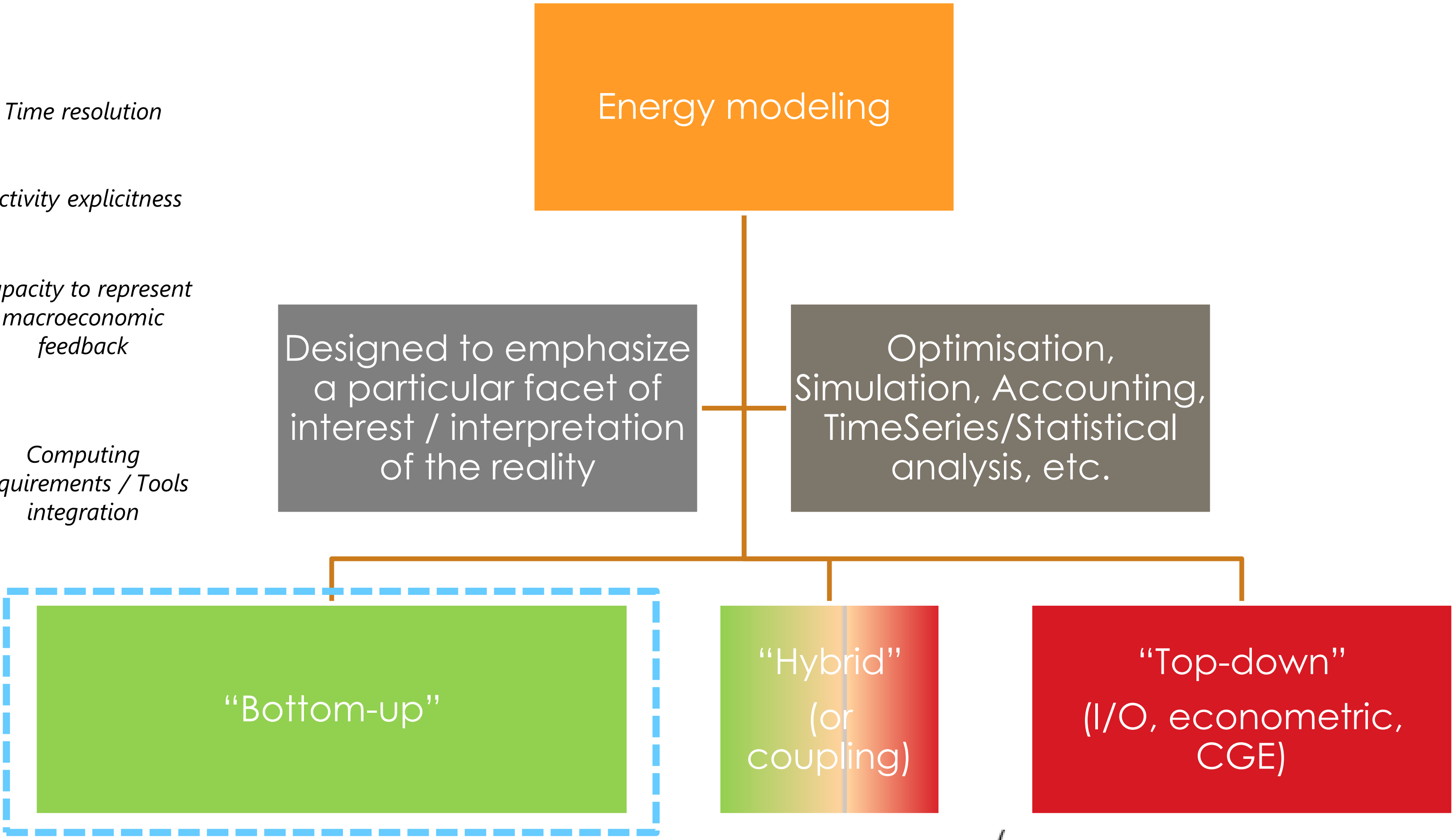

For each technology p, period t, vintage v, region r, and time-slice s

$$VAR\_ACT(r,v,t,p,s) \leq or = AF(r,v,t,p,s) * PRC\_CAPACT(r,p)) * FR(r,s) * VAR\_CAP(r,v,t,p)$$

$$X_s = A_0\left(B_K \cdot K_s^{\rho} + B_L \cdot L_S^{\rho} + B_E \cdot E_S^{\rho}\right)^{1/\rho}$$

X_S is the output of sector S,
K_S, L_S, and E_S are the inputs of capital, labor and energy needed to produce one unit of output in sector S,
ρ is the elasticity of substitution parameter,
A_0 and the B's are scaling coefficients.

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Energy system models - Description

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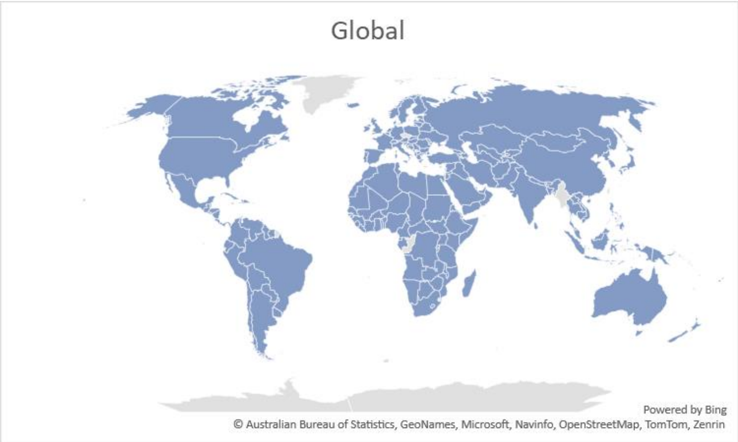
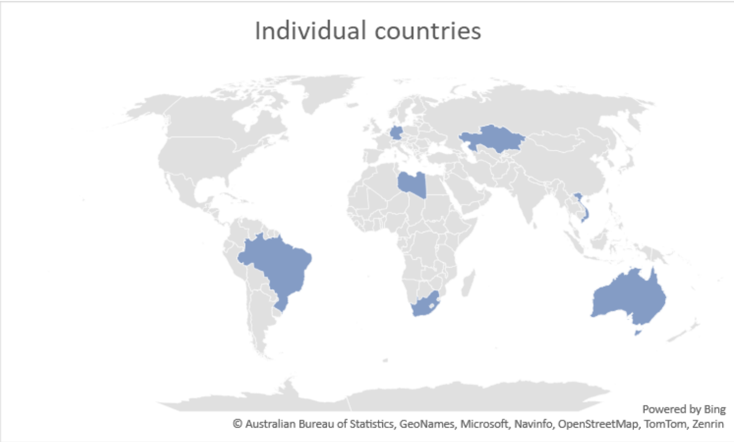
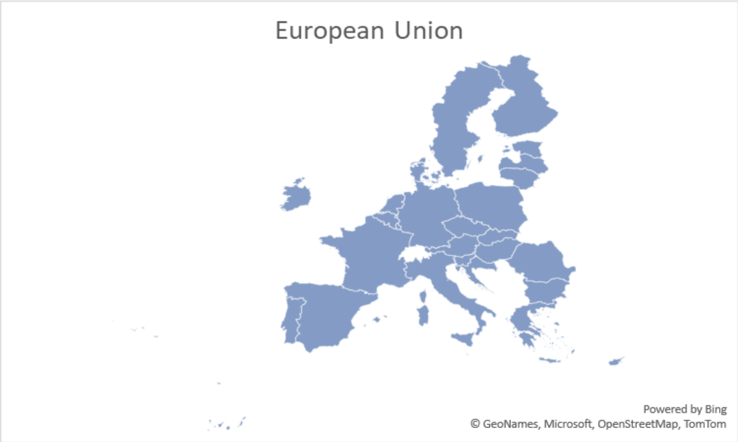
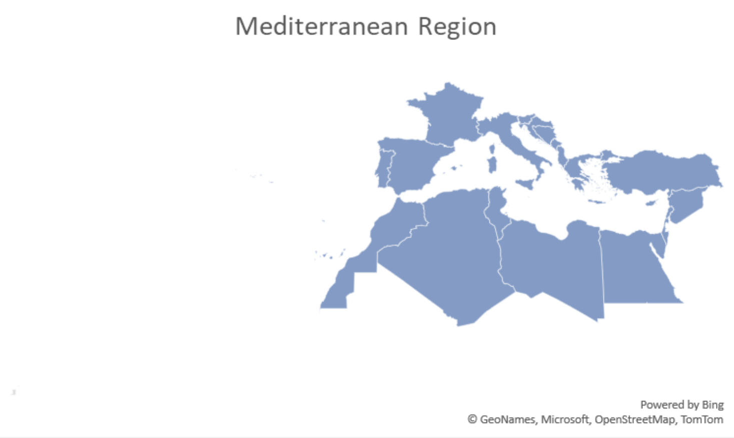
Capacity to represent non-market preferences	*Capacity to represent uncertainties*	*Data requirement*	*Computing requirements / Tools integration*

National / Sub-national / Supra-national
Single node / Multi nodes









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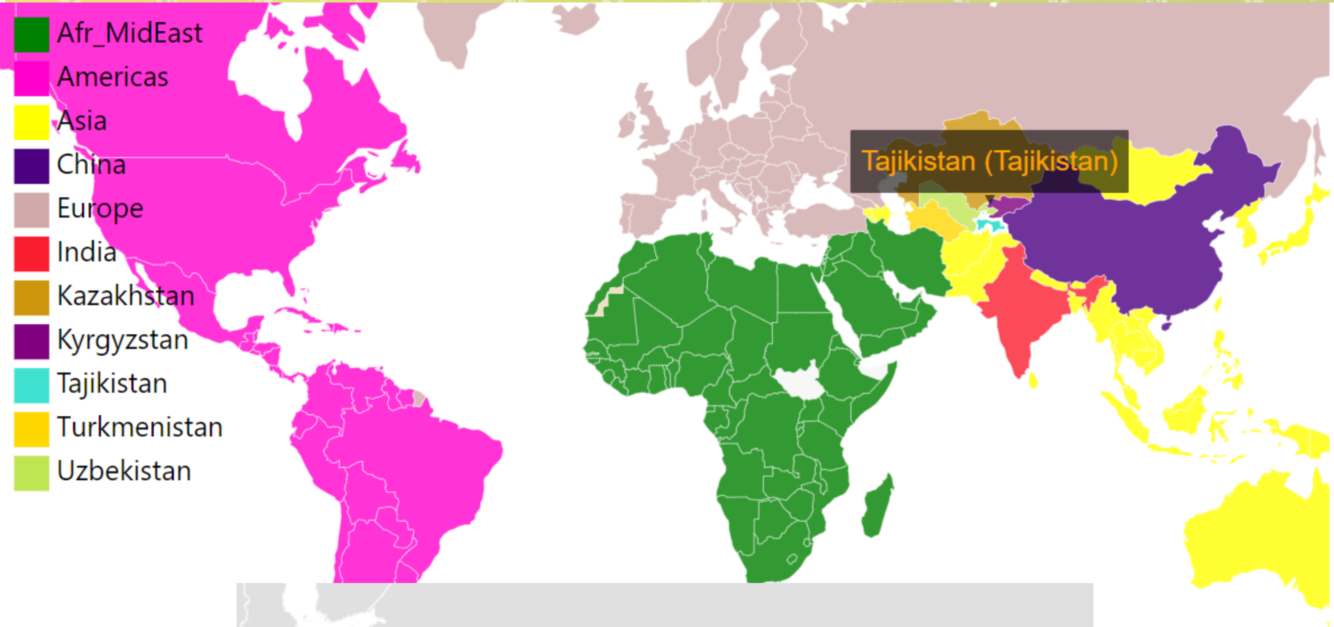
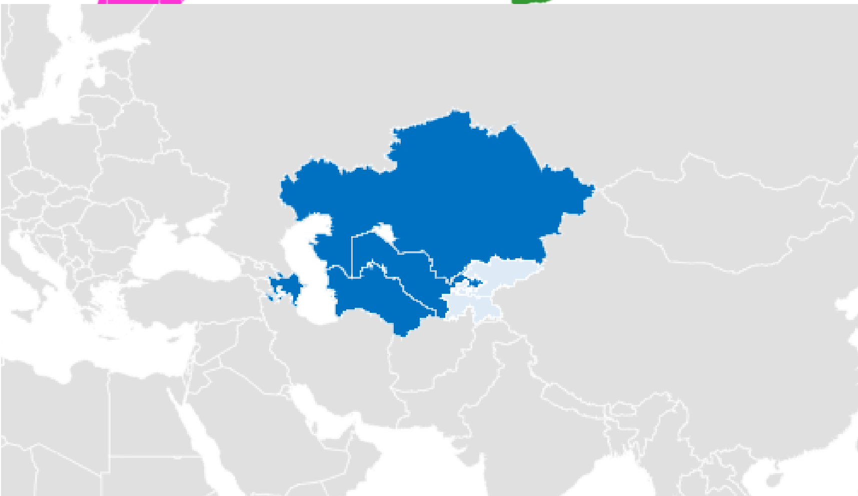
SECCA
Sustainable Energy Connectivity in Central Asia

Energy system models - Description



KINESYS-TJ
Global Energy System model based on the TIMES model generator.
All CA countries and key neighbouring countries are represented on a country level.
The remaining countries are grouped in model regions (e.g. Europe, America, …).



TIMES-CAC
Multiregional energy system model
Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan + (Tajikistan and Kyrgyzstan, implicit)

https://github.com/RDMgit77/TIMES-CAC_VO_Open.git)

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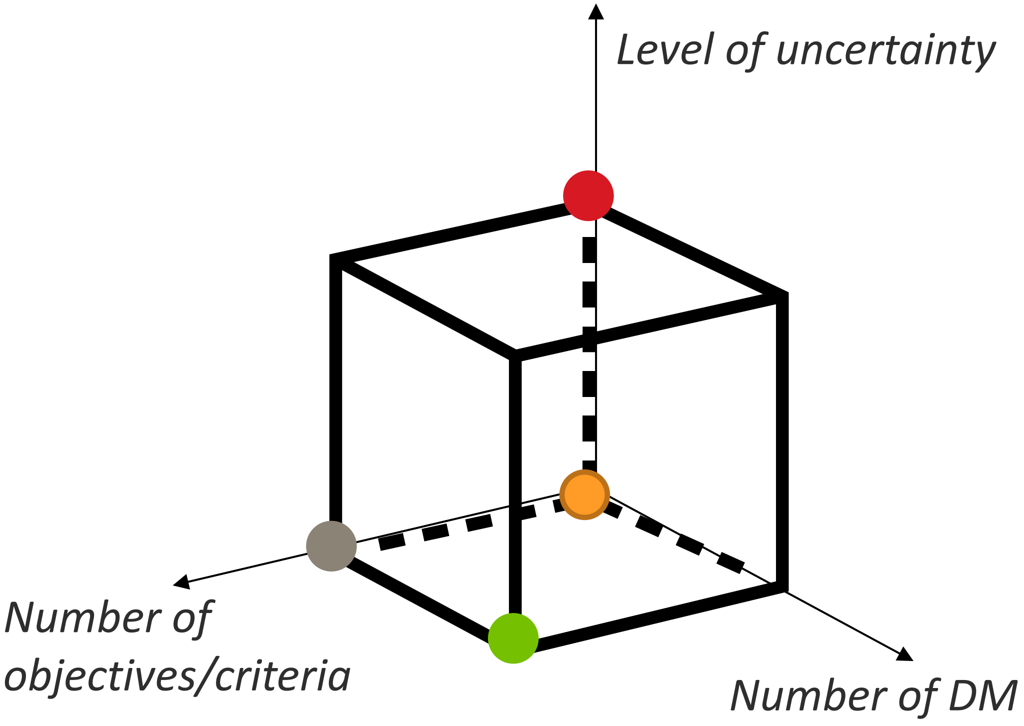
Energy system models - Description

Analytical paradigm	*Sectoral Coverage*	*Time horizon*	*Time resolution*
Geographical coverage	*Supra-national forces*	*Technology explicitness*	*Activity explicitness*
Muti-criteria/agents	*GHG emissions and environmental impacts*	*Microeconomic robustness*	*Capacity to represent macroeconomic feedback*
Capacity to represent non-market preferences	*Capacity to represent uncertainties*	*Data requirement*	*Computing requirements / Tools integration*

Why is it important?

- Many uncertain parameters
- Deep effect on projections, solutions, costs
- Decision makers are risk averse



- Mathematical programming
- Stochastic programming
- Multi-criteria analysis / Multi-objective programming
- Game theory
- …

Energy system models - Description

Analytical paradigm	*Sectoral Coverage*	*Time horizon*	*Time resolution*
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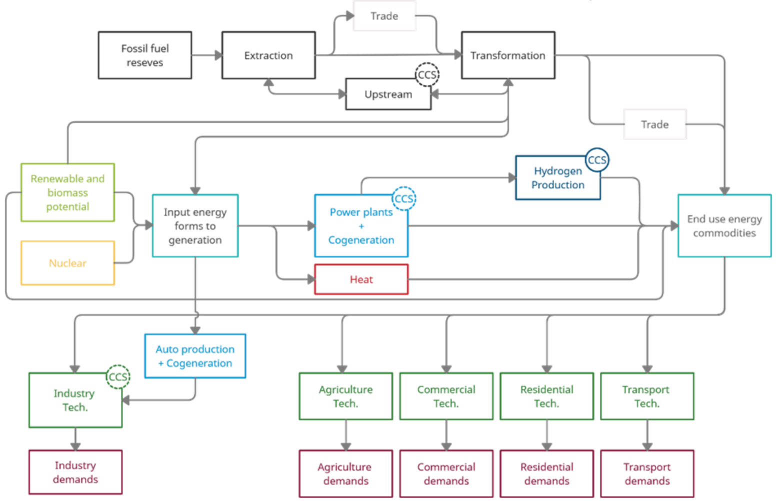

Why it is important?

To reflect the ability to explicitly model and assess policies and measures as a function of the technology details of the model.

It allows a finer analysis of the system (e.g. decomposition of emission reduction by type of change).

Why it is important?

"Targeted" policies and measures for key technologies and commodities.

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Energy system models - Description

Analytical paradigm	*Sectoral Coverage*	*Time horizon*	*Time resolution*
Geographical coverage	*Supra-national forces*	*Technology explicitness*	*Activity explicitness*
Muti-criteria/agents	*GHG emissions and environmental impacts*	*Microeconomic robustness*	*Capacity to represent macroeconomic feedback*
Capacity to represent non-market preferences	*Capacity to represent uncertainties*	*Data requirement*	*Computing requirements / Tools integration*

Why it is important?

Consumers' decisions are driven by non-economic factors, such as comfort, travel time, size of the car, etc.

Why it is important?

To reflect the ability to represent complex, financially constrained investments decisions.

Why it is important?

- Finite budget of consumers
- Rebound effect
- Effect on GDP, GVA, etc.

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Energy system models - Description

Analytical paradigm	*Sectoral Coverage*	*Time horizon*	*Time resolution*
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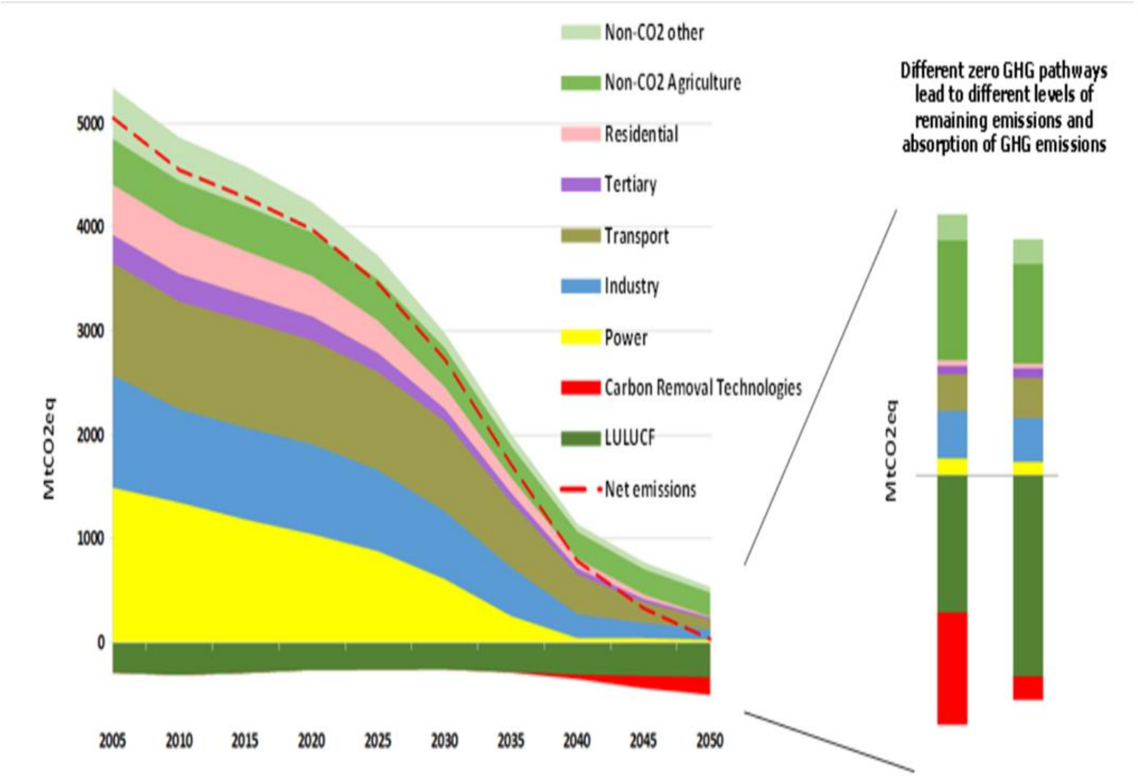

Why it is important?

- Decarbonisation ambitions (drivers for many technology changes)
- Water uses: resources extraction, energy crops, hydropower, thermal plants
- Climate vulnerability / Land Use (competition)

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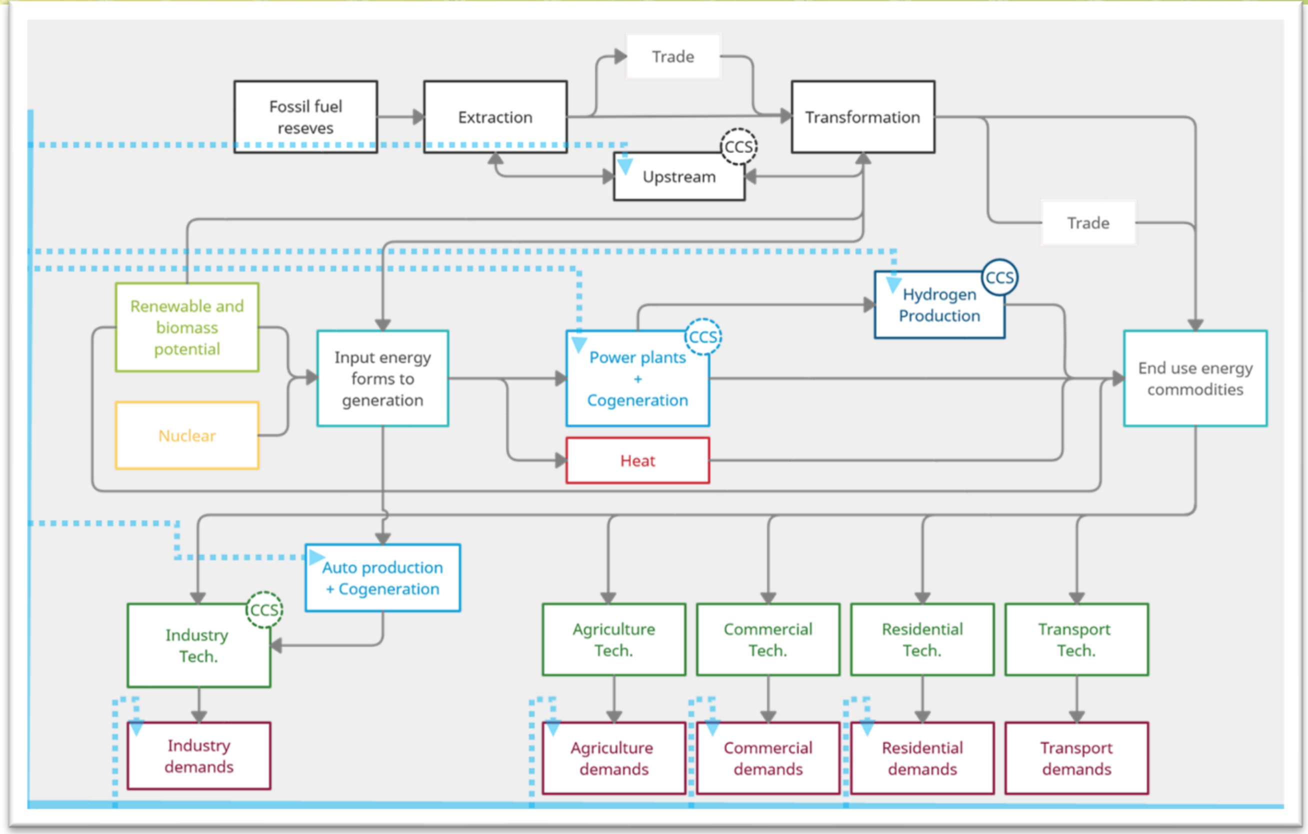
Integration with other dimensions-water

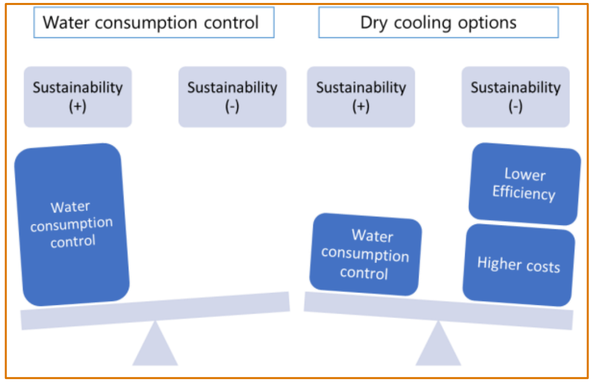


IF/HOW to integrate "water withdrawal" and "water consumption" constraints into the energy system analysis: OPEN point for discussion.

"Integration" can be limited to the power sector only, or extended to other critical technologies of the energy chain (H2, CCS, biofuels,etc).

- Water "constraints" can be *implicitly* considered (change in the storylines / deterministic parameters such as availability factors, supply curves, own consumption, etc., per each "water and energy" scenario).

  → Models "linking".
- Water "constraints" can be (to some extent) *explicitly* considered so to "endogenise" the water criterion in the optimisation process (*note that dry cooling options are less water greedy but generally more energy greedy – trade-off*).



Boundaries of the integration and other Pros and Cons (computation complexity) to be evaluated.

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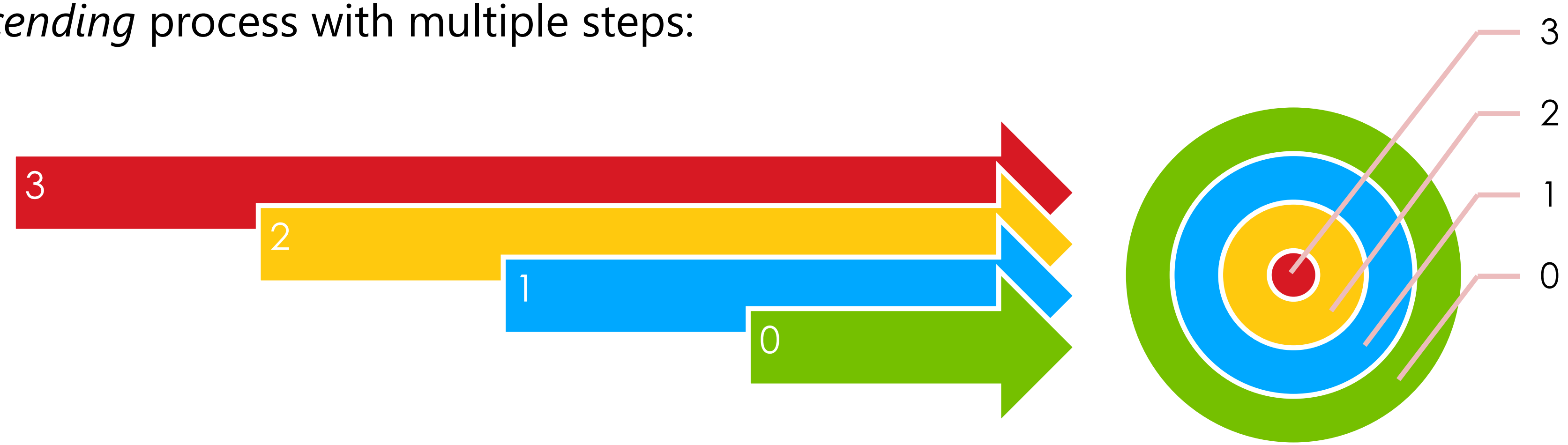
Modeling in policy development

A simplified *ascending* process with multiple steps:



0: organise a proper data collection and analysis (at sectoral level)

0 → 1: move towards a system-oriented approach and a more explicit representation of the key parts involved

1 → 2: design scenarios to explore different combinations of factors (eg goals, policies, uncertainties)

2 → 3: integration of non-energy sectors/components to consider multiple dimensions of the sustainability of the strategies.

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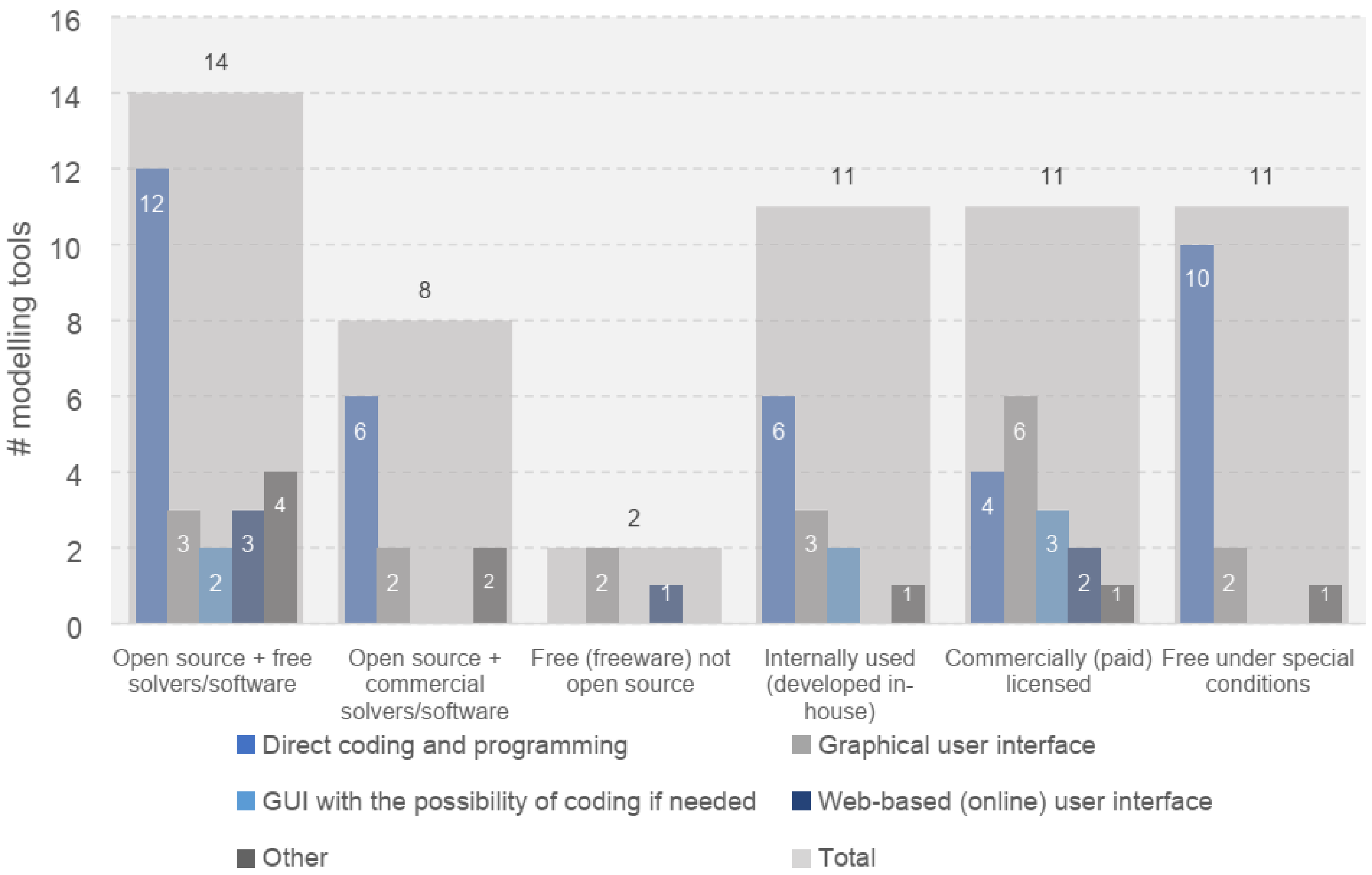
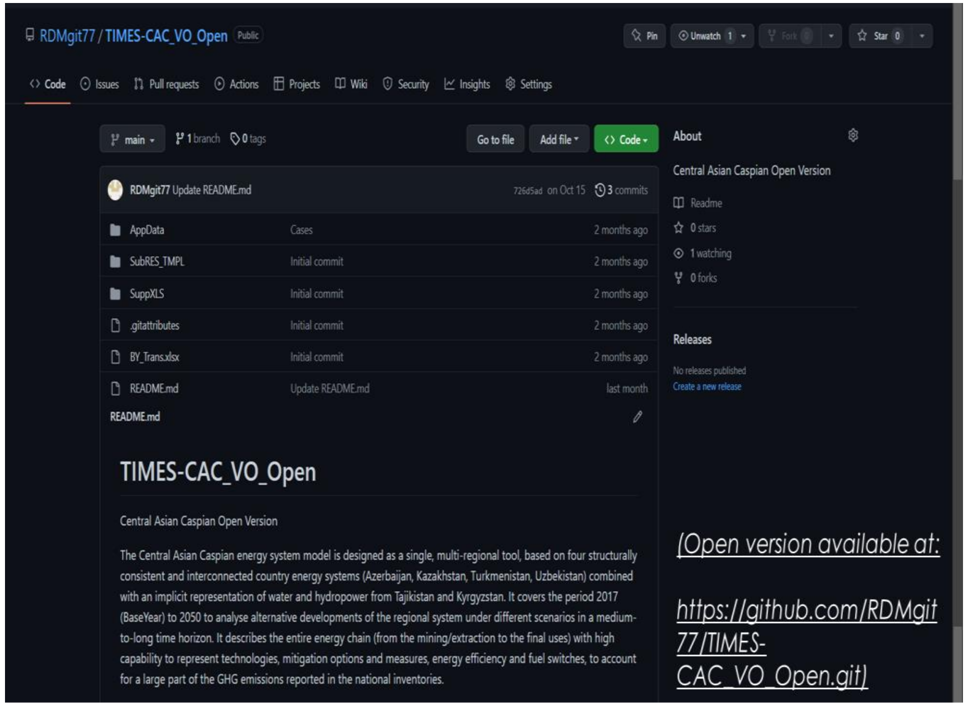
Energy system models - Description





https://github.com/RDMgit77/TIMES-CAC_VO_Open.git)

https://doi.org/10.1016/j.apenergy.2021.116731

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SECCA
Sustainable Energy Connectivity in Central Asia

Open Source and Open Data in energy modelling

openmod | Search | powered by Energypedia

https://wiki.openmod-initiative.org/wiki/Open_model_implementations

Navigation
- Main page
- Models
- Model implementations
- Data
- Grid data
- Learning materials
- Open Licenses
- Journals
- Eprints
- Events
- Berlin Workshop
- Glossary
- Openmod user list

Page | Discussion | Actions

Open model implementations

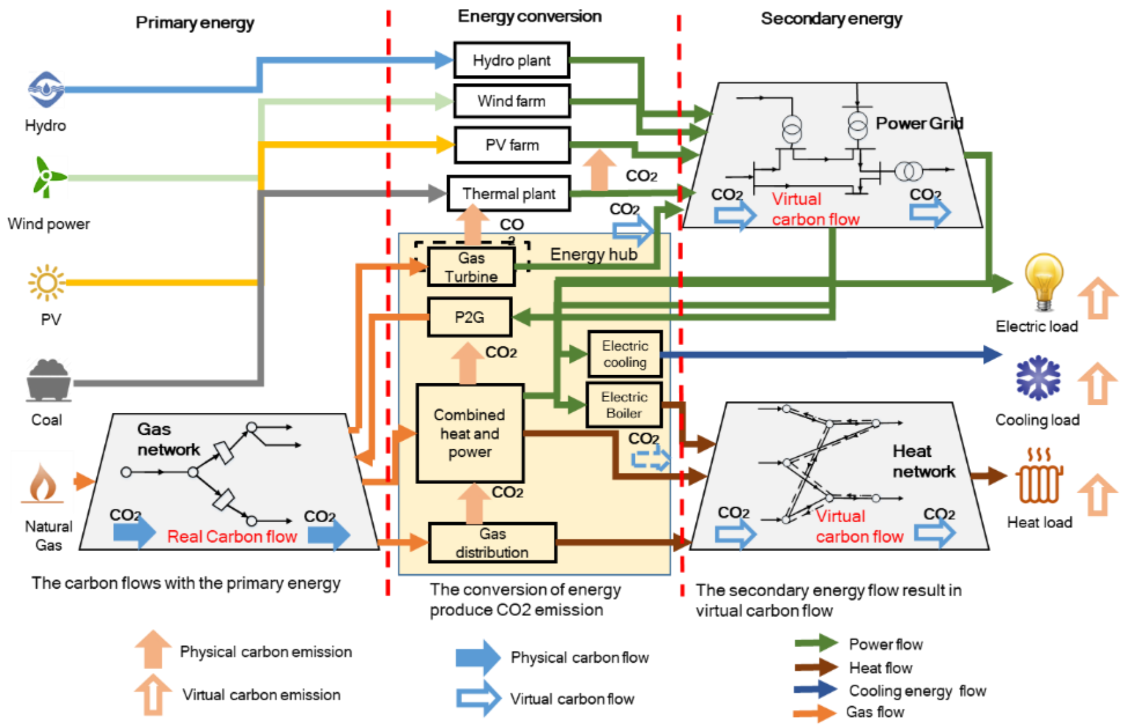
Contents [hide]

https://openenergy-platform.org/factsheets/frameworks/

MESSAGEix Integrated Assessment Model and the ix modeling platform	false	Apache license 2.0
Model Order Reduction for Gas and Energy Networks	false	Other
Mosaik	false	GNU Lesser General Public License v3.0
OMEGAlpes	false	Apache license 2.0
Open Electricity Grid Optimization	false	GNU Affero General Public License v3.0
Open Energy Modelling Framework (oemof-solph)	false	MIT
Potsdam Integrated Assessment Modeling Framework (PIAM)	false	GNU Lesser General Public License v3.0
Python for Power System Analysis toolbox (PyPSA)	false	Unknown
Renewable Energy Mix	false	Unknown
SecMOD	false	MIT
SPINE Toolbox	false	Unknown
The Integrated MARKAL-EFOM System (TIMES) Model Generator	false	GNU General Public License family

Under this license, users can: Use the code commercially: Companies can include the licensed code in proprietary software that they then sell to customers.

Energy Systems Integrations (complementarity)



http://www.ningzhang.net/MES.html

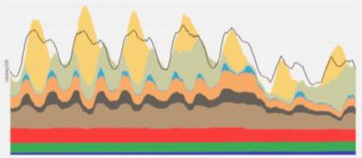
- Location problems (space resolution)
- "Watergy" (space and flow resolution)
- Economic structure (general equilibria)

- Power system (space and time resolution)

Energy Modelling

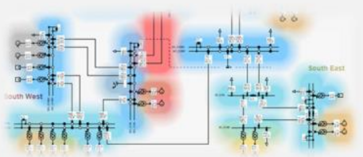
- Cross-sector analysis of optimal energy development in the country as well as through the region
- Possibility to compare the effectiveness of alternative energy development strategies in different future scenarios and define the most optimal long-term implementation pipeline
- Possibility to foresee the cross-sector economic and environmental impact of the energy development strategies

Least Cost Dispatch



- Simulating hourly demand and supply, estimating reserve requirements, generation flexibility issues and estimating the necessity of mitigation measures, storage or other technologies
- Optimization of available primary energy resources and analysis of generation adequacy for development scenarios
- With the complex dispatch model, calculation of the total cost of generation, operation, curtailment (if any), shadow prices and other indicators

Grid Modelling



- Identification of the most severe scenarios based on realistic assumptions and analyzing them with highly accurate non-linear steady-state and dynamic models
- Ensuring network loadings, voltages, system frequency, and power quality in globally applied permissible boundaries in normal and emergency cases
- Assessment of various smart grid technologies for ensuring stability and reliability in isolated as well as parallel regional operation

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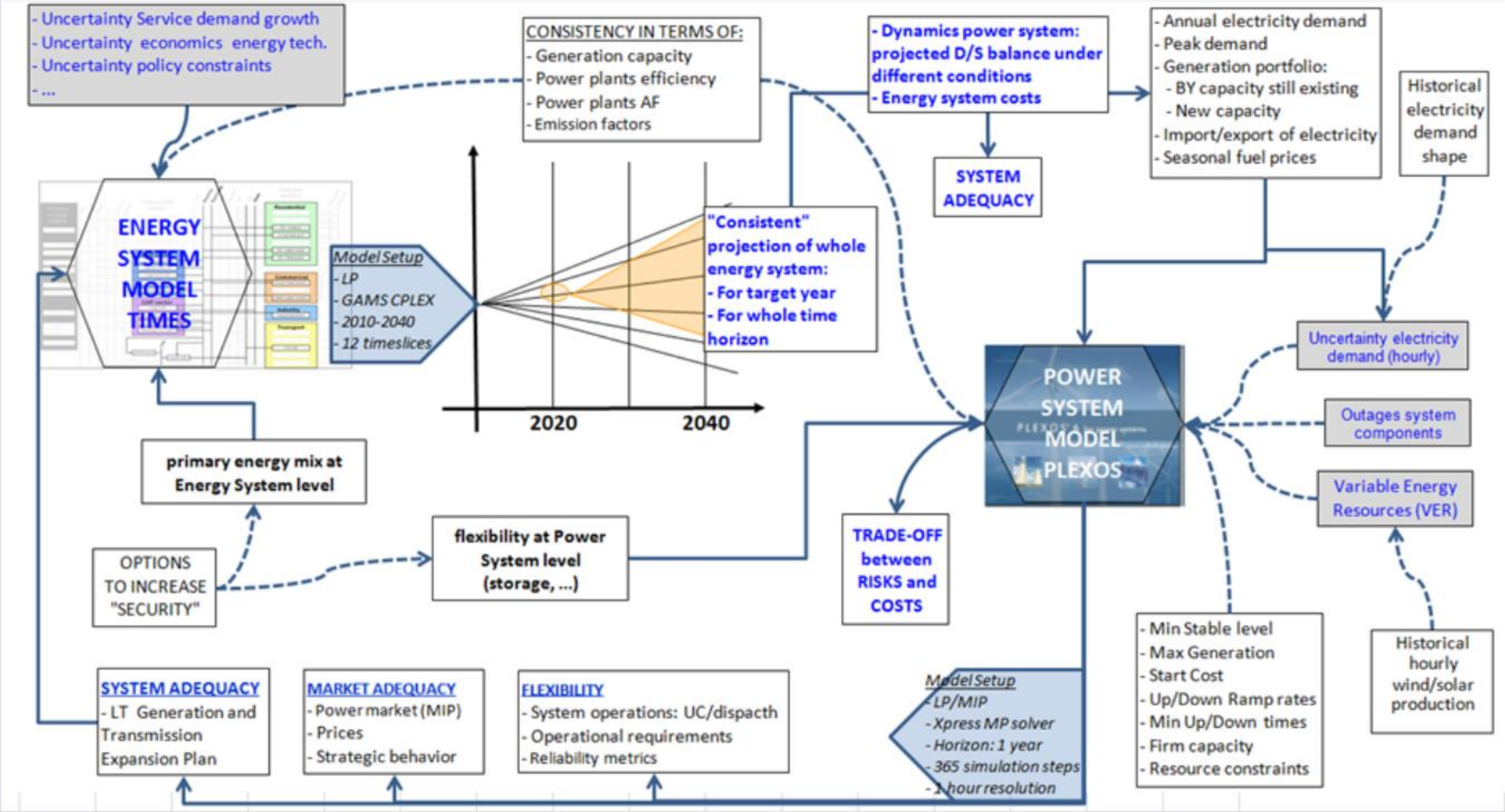
“Coupling” Energy System Models with Electricity market models



https://iris.enea.it/handle/20.500.12079/2226

“Coupling” models (pillars):

- Mapping
- Logic (what, what for, how..)
- Interface
- Iterations/Routine
- Criterion/criteria
- …

Model-based decision support

In the context of (model-based) long-term energy system analyses:

TO USE	*TO AVOID*
Exploration/Scenario	Prediction
Control variables	Forecast variables
Robust assumptions / Self-consistent storyline	Realistic scenario / Most-likely scenario, etc.
Scenario results: Useful/Utility	Scenario results: True/Truth
Support decision-making process	Replace decision-making process
Reference(s)	(BaU)

Modeling in policy development

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Modeling in policy development

Exploring the impacts of different factors

Supranational - elements

- International fossil fuel prices
- Behaviour of other players
- Technology costs
- International standards
- ….

National - elements

- Structure of the socio-economic sector
- Energy service demands
- Domestic energy resources
- Other factors and constraints (eg technologies, market, etc.)

National - objective and policies

- Targets (overall, sectoral, etc.)
- Measures (commodity, technology, etc.)
- …

Uncertainties

- ***Controllability (Decision Makers)*** **+**

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Modeling in policy development

National objectives and targets*

1 (what?)

Include "targets" which must be met in the scenarios

(e.g. EE target, RES target or Emission targets, etc.).

Policies and measures*

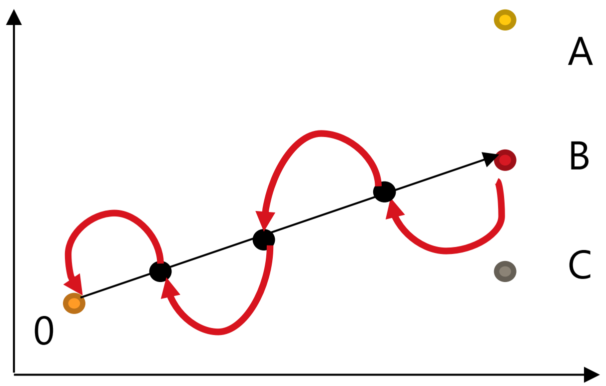
2 (How?)

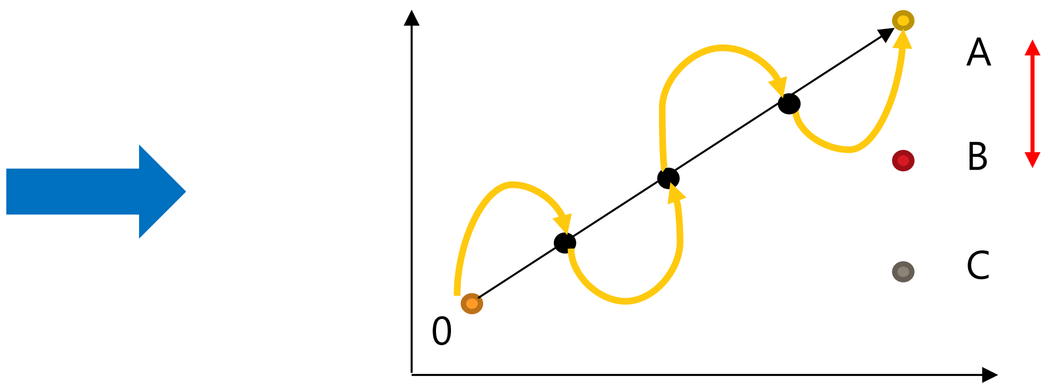
Include a set of policy "mechanisms"

(e.g. CO_2 tax, Feed-in tariffs, standards, etc.) and explore the effects on the energy- and environmental-related indicators.

***Targets** define specific quantitative "thresholds" that must be achieved.

***Measures** are instruments to implement the policies.





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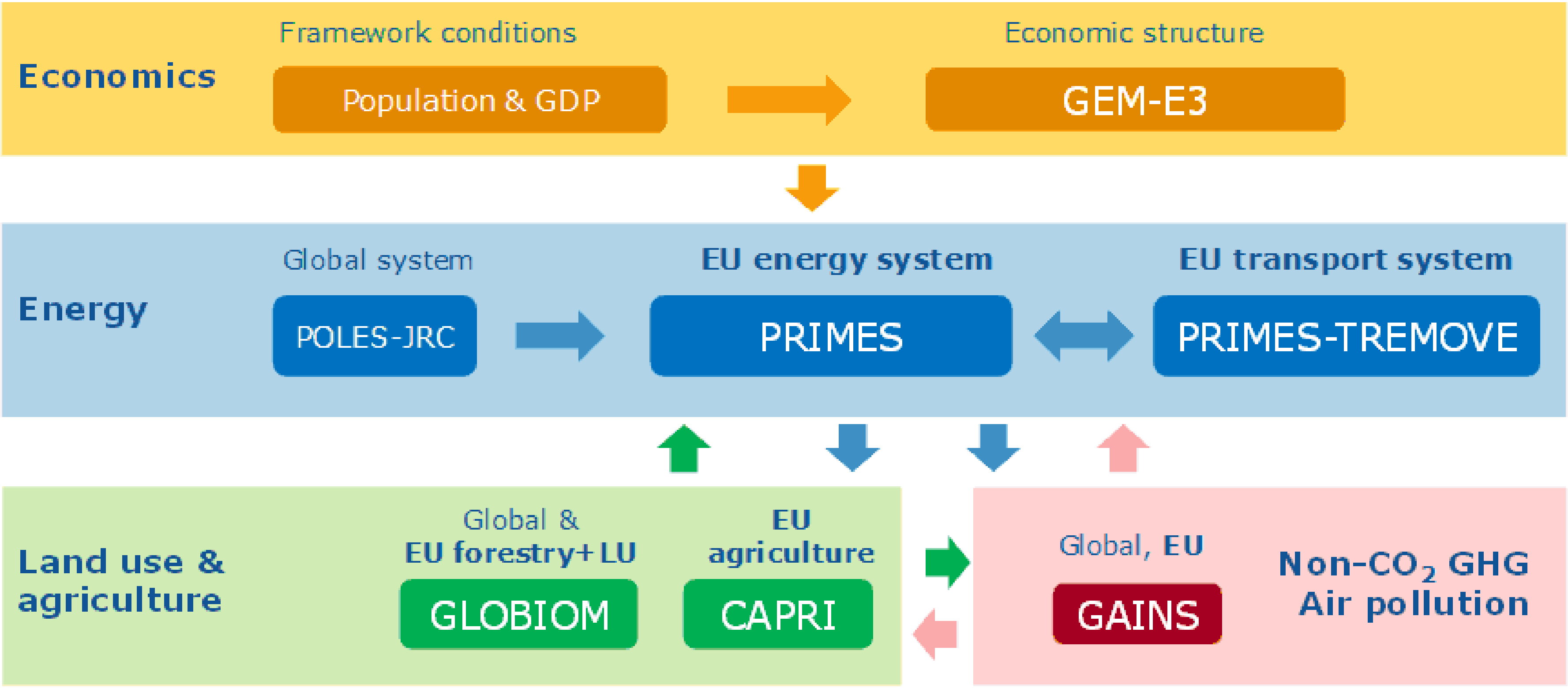
Modeling framework for energy-climate analyses - Example

Model-based scenario quantification supports the European Commission in impact assessments and analysis of "policy" options.

Tools are linked with each-other to ensure consistency ("integration")



https://climate.ec.europa.eu/eu-action/climate-strategies-targets/economic-analysis/modelling-tools-eu-analysis_en

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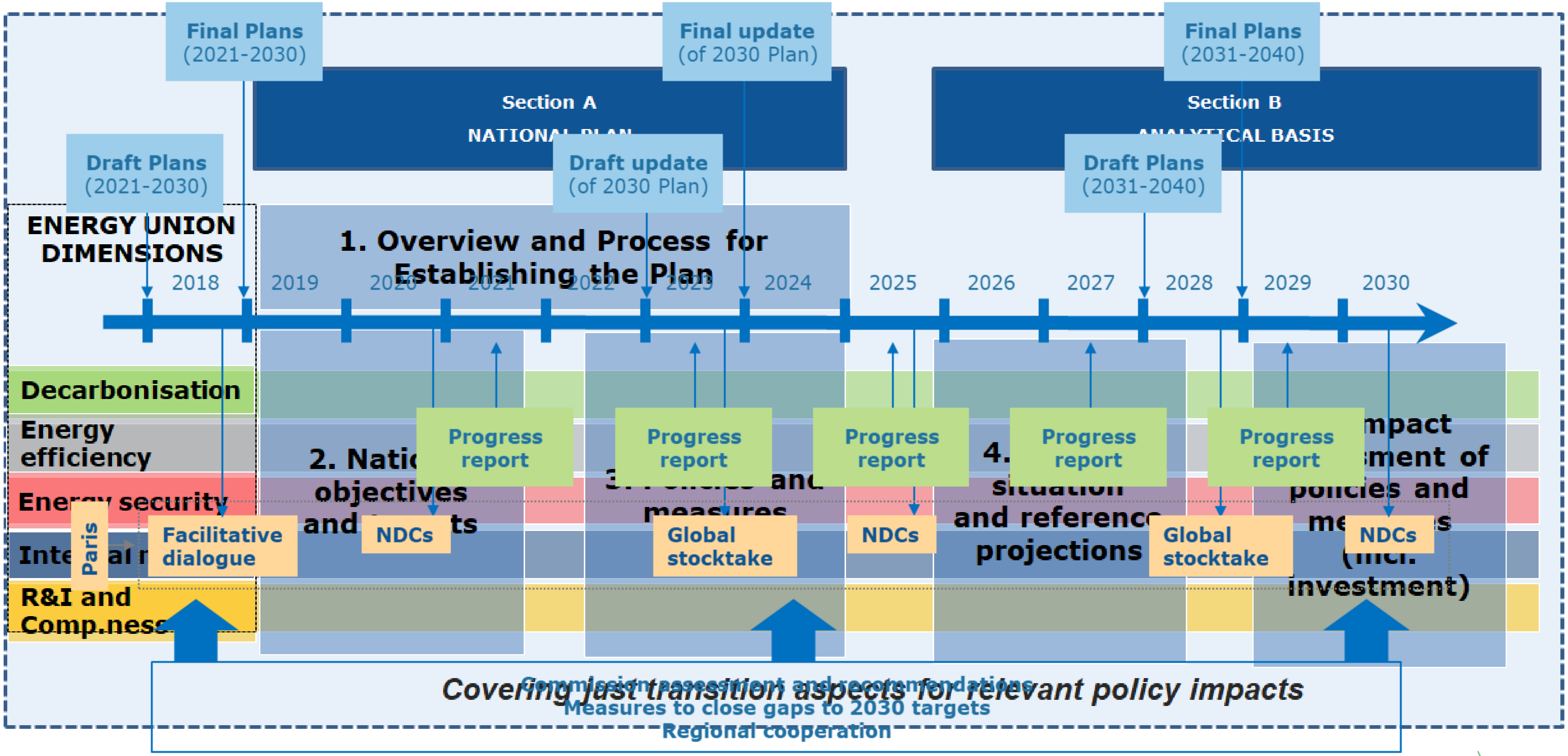
Model-based strategic analysis (EU-NECP)



Model-based strategic analysis (EU-NECP)

GENERAL FRAMEWORK FOR INTEGRATED NATIONAL ENERGY AND CLIMATE PLANS

SECTION A: NATIONAL PLAN

1. OVERVIEW AND PROCESS FOR ESTABLISHING THE PLAN
2. NATIONAL OBJECTIVES AND TARGETS
3. POLICIES AND MEASURES

SECTION B: ANALYTICAL BASIS

4. CURRENT SITUATION AND PROJECTIONS WITH EXISTING POLICIES AND MEASURES
5. *IMPACT ASSESSMENT OF PLANNED POLICIES AND MEASURES*

List of parameters and variables, NEB, key indicators

→ **WORKSHOP 3**

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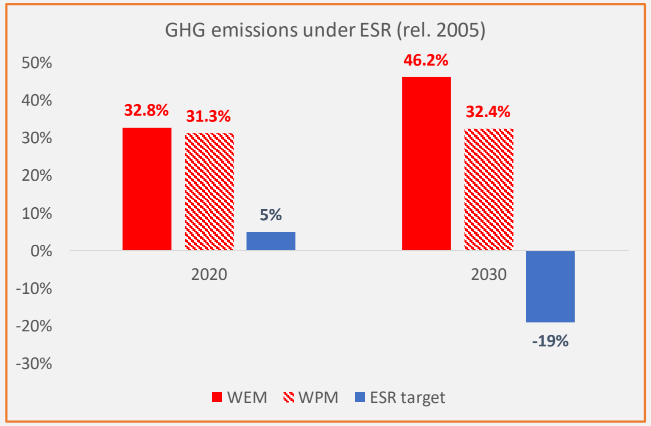
Model-based strategic analysis (EU-NECP)

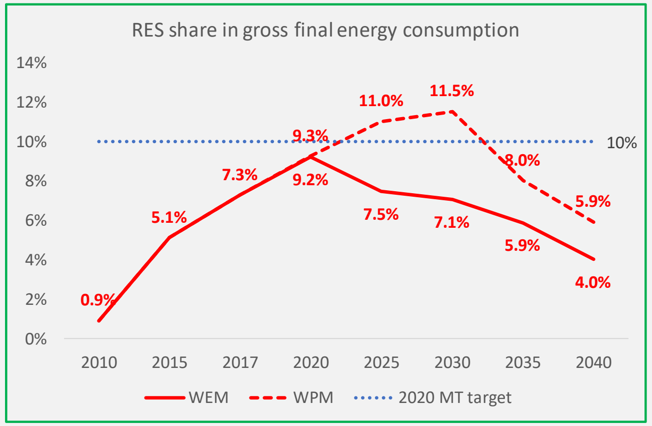
Sensitivity name

Central | EffSens | ElecSens

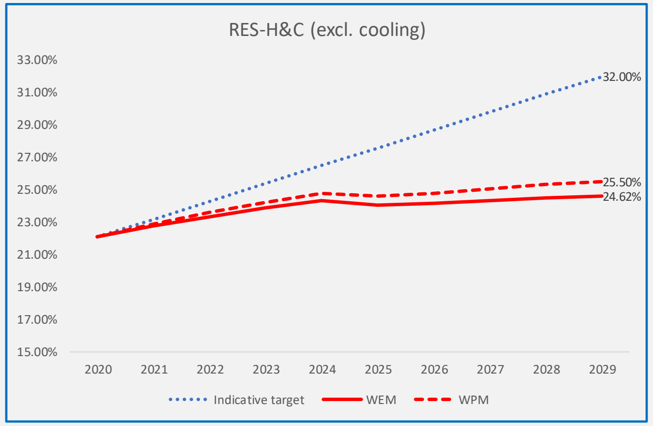
Decarbonisation



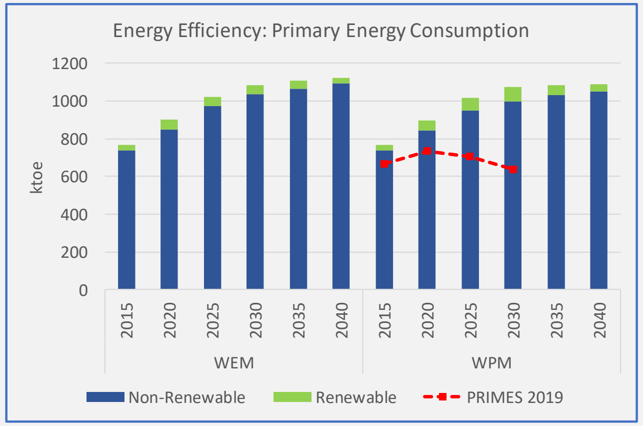
Renewable Energy Share



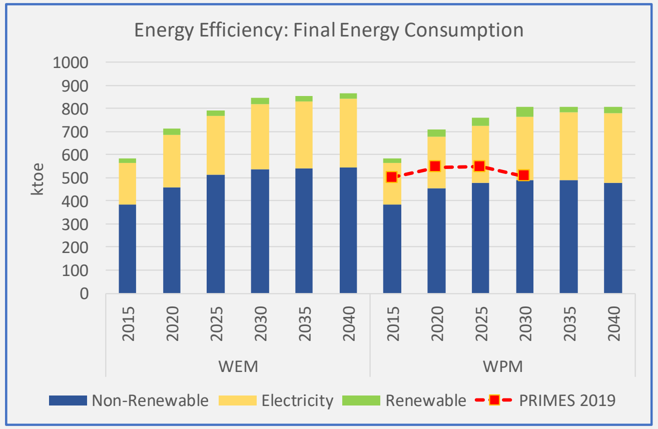
Renewable Heating



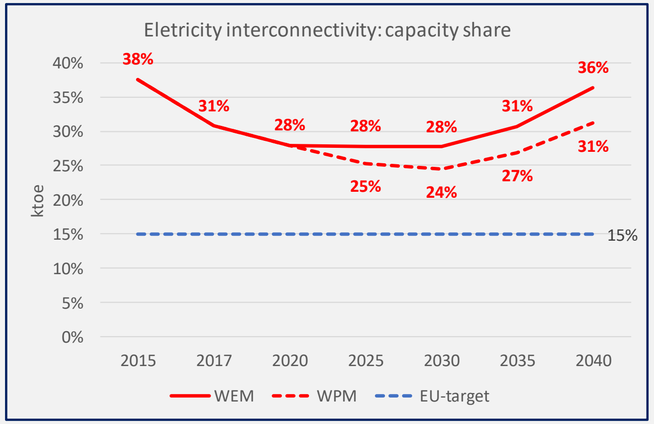
Energy Efficiency (1)



Energy Efficiency (2)



Electricity interconnectivity



https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en

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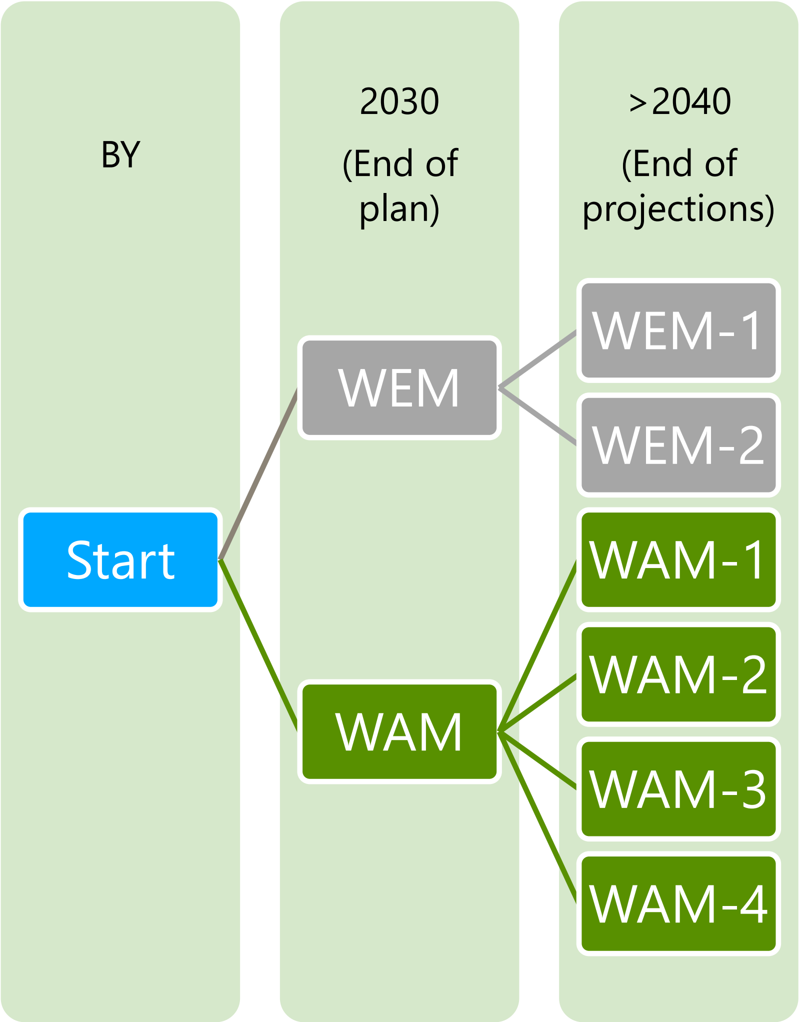
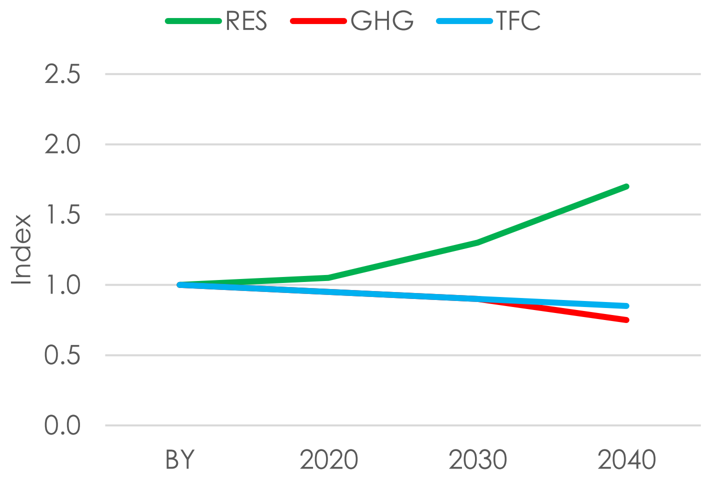
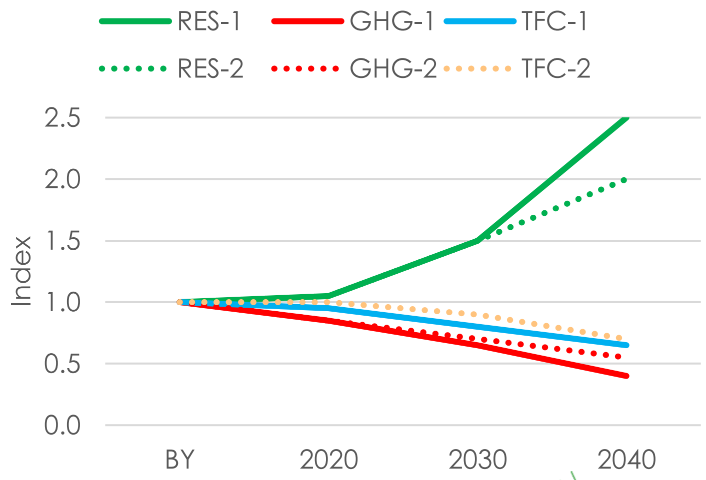
Model-based strategic analysis (EU-NECP)



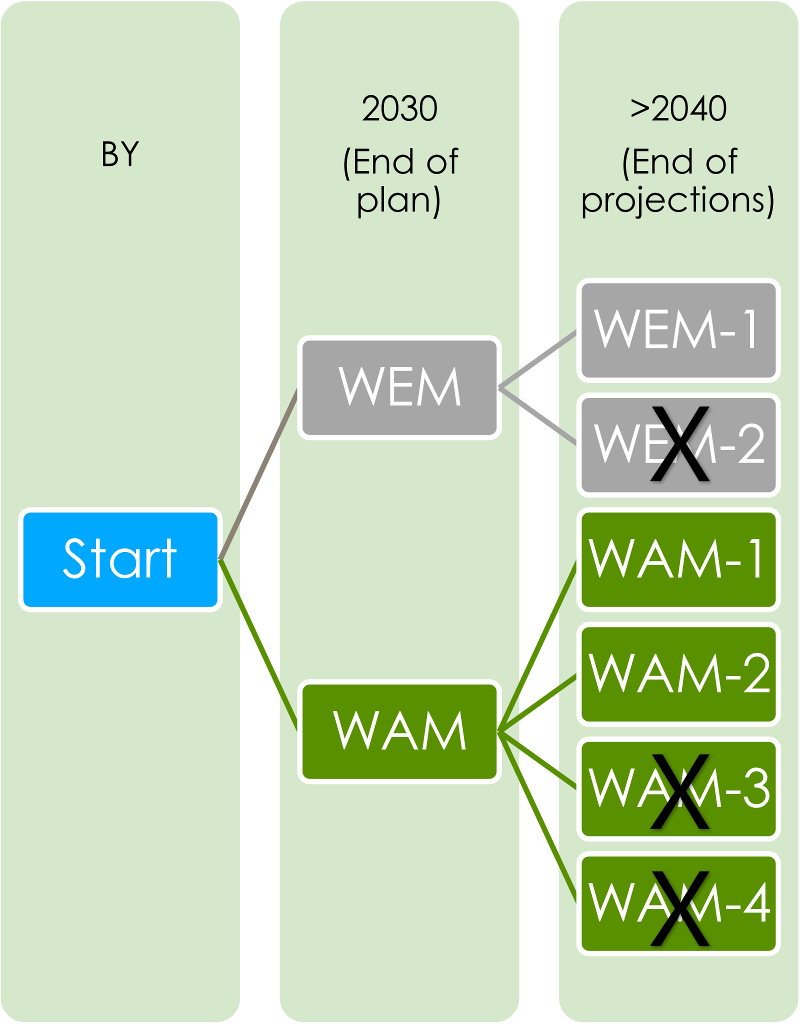
“Outlook” of the WEM to > 2040

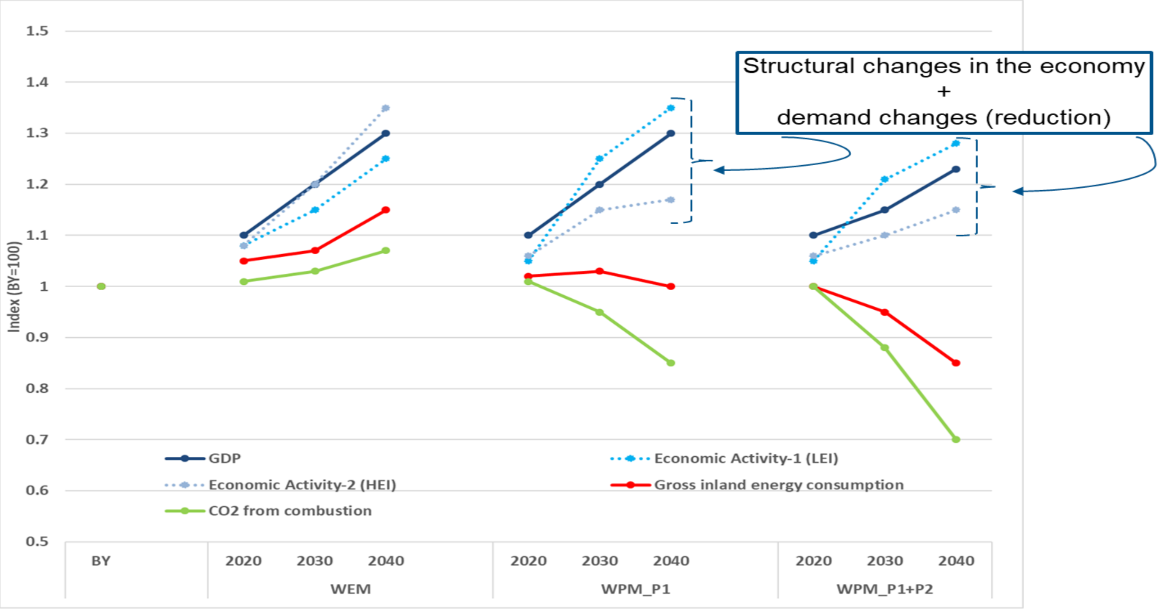


“Outlook” of the WAM to > 2040



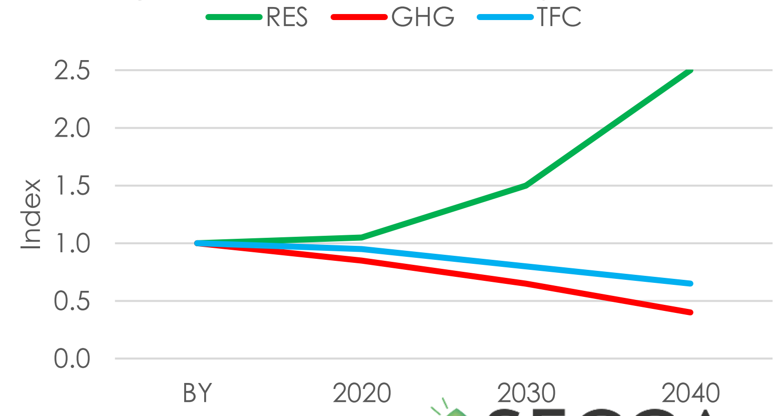
Model-based strategic analysis (EU-NECP)





Multiple explorations / Continuous parsing of the "exploratory tree" until a "robust" path is found.

"Robust outlook" of the WAM > 2040 (against multiple criteria)



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WB- Country Climate and Development Reports (CCDRs)

New core diagnostic reports that integrate climate change and development considerations. They will help countries prioritize the most impactful actions that can reduce greenhouse gas (GHG) emissions and boost adaptation, while delivering on broader development goals.

As public documents, CCDRs aim to inform governments, citizens, the private sector and development partners and enable engagements with the development and climate agenda.
CCDRs help attract funding and direct financing for high-impact climate action.

https://www.worldbank.org/en/publication/country-climate-development-reports

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Example – SECCA - KZ

Highlights

<u>Scope of the work</u>: Explore the role of coal in the energy system of Kazakhstan against the emission reduction ambitions.

Provide a test-bed for the development of additional/alternative assessments.

<u>Approach</u>: Analysis organised in a model-based "large strategic exercise" with 240 cases to investigate the "combined" impact of the following influencing factors: CO_2 prices, CCS potential, development of nuclear energy, support of coal-fired stations, costs of RES and H_2, contribution of emission offset options.

<u>Findings</u>: the role of coal differ "case by case" depending on the specific combination of factors. *Even under the most favourable conditions, the coal consumption in the medium-long term is hardly compatible with medium-deep emissions mitigation ambitions.*

<u>Material</u>: full spreadsheet-based dashboard (to navigate the 240 cases and the "key" outputs of each case).

<u>Model files</u>: hosted in a cloud-based platform for collaborative development and version control. Access can be granted to local experts and Institutions for further development (and use) in the framework of the SECCA project ("co-development"), and/or for independent utilisations.

<u>Next steps</u>: ideas, proposals and discussion

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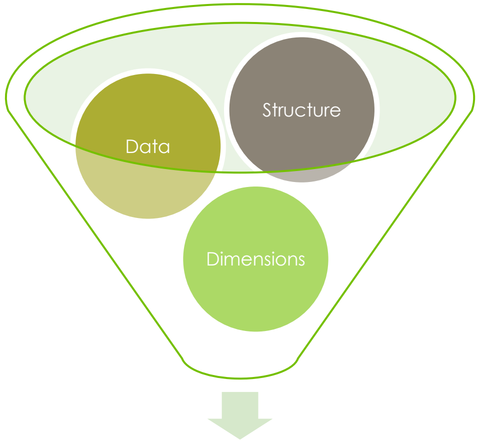
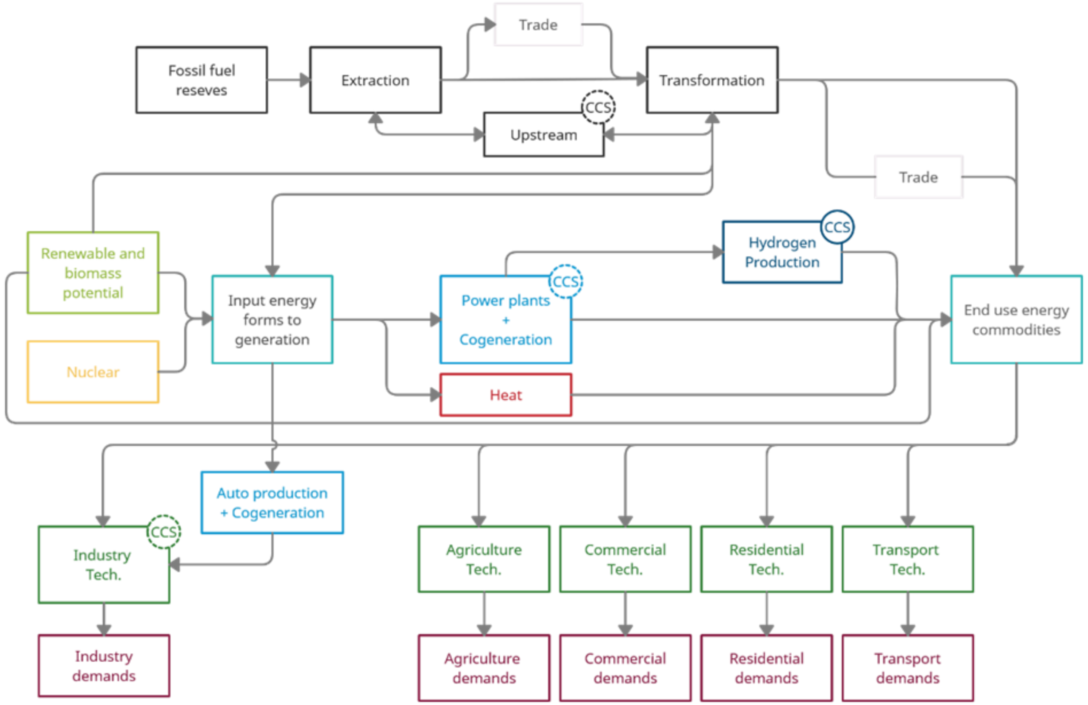
Scope of the work: interpretation

Integrated analysis: based on a holistic approach which addresses simultaneously as many perspectives or dimensions of the energy and climate dynamics as possible, and takes into account the cross-cutting nature and interactions between those dimensions.

Multiple explorations: learning by exploring / learning by comparing.
Energy scenarios serve as points of comparison to evaluate sensitivities and multiple outcomes.



Findings



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Approach: design of a large strategic exercise

5 - different CO2 prices (to mimic different emission reduction ambitions, from "no" to "decarbonisation") ---> Very Low / Low / Medium / High / Very High (EU decarbonisation)
3 - different assumptions on CCS (uncertainty covering the storage potential and the rate of capture) ---> No / Medium / Large
2 - different assumptions for nuclear ---> No / Yes (up to 12 GW in 2060)
2 - different assumption for IGCC (CAPEX and subsidy) ---> Default values / -25% CAPEX and subsidy covering the variable costs (excluding fuel)
2 - different cost of renewable techs and H2 techs (uncertainty for CAPEX) ---> Default / High (+33% CAPEX)
2 - different contribution of other offset options (DAC and natural) ---> Default / Low (-40% CAPEX)

240 Total number of cases

Combinatorial method to explore scenarios (by permutating and combining influencing factors)

CO2-1	1	6	11	16	21	26	31	36	41	46	51	56	61	66	71	76	81	86	91	96	101	106	111	116	121	126	131	136	141	146	151	156	161	166	171	176	181	186	191	196	201	206	211	216	221	226	231	236
CO2-2	2	7	12	17	22	27	32	37	42	47	52	57	62	67	72	77	82	87	92	97	102	107	112	117	122	127	132	137	142	147	152	157	162	167	172	177	182	187	192	197	202	207	212	217	222	227	232	237
CO2-3	3	8	13	18	23	28	33	38	43	48	53	58	63	68	73	78	83	88	93	98	103	108	113	118	123	128	133	138	143	148	153	158	163	168	173	178	183	188	193	198	203	208	213	218	223	228	233	238
CO2-4	4	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79	84	89	94	99	104	109	114	119	124	129	134	139	144	149	154	159	164	169	174	179	184	189	194	199	204	209	214	219	224	229	234	239
CO2-5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240

Example (12): Low CO2 price; Large CCS potential, no nuclear, no support for IGCC, default costs for RES and H2, default costs for CO2 offset technologies

Example (46): Very low CO2 price; NO CCS potential, YES nuclear, YES support for IGCC, default costs for RES and H2, default costs for CO2 offset technologies

Example (240): Very high CO2 price; Large CCS potential, YES nuclear, YES support for IGCC, High costs for RES and H2, Low costs for CO2 offset technologies

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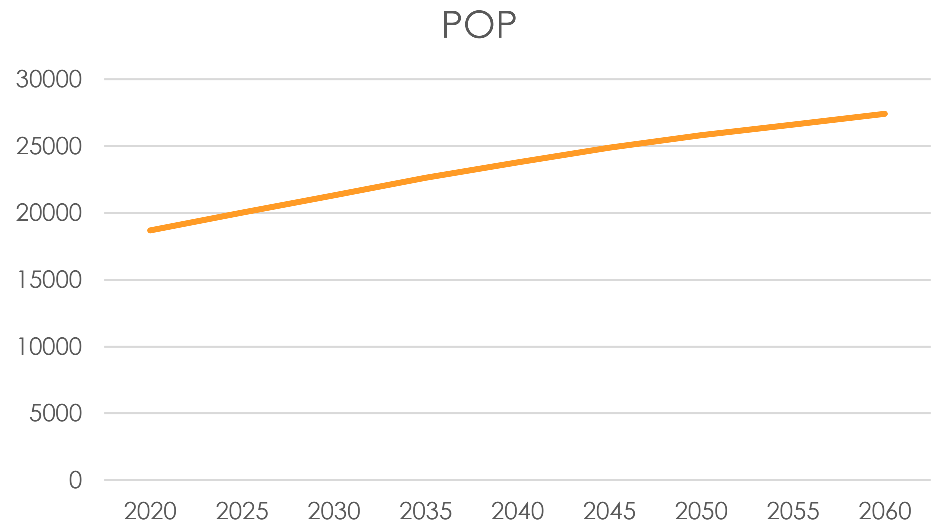
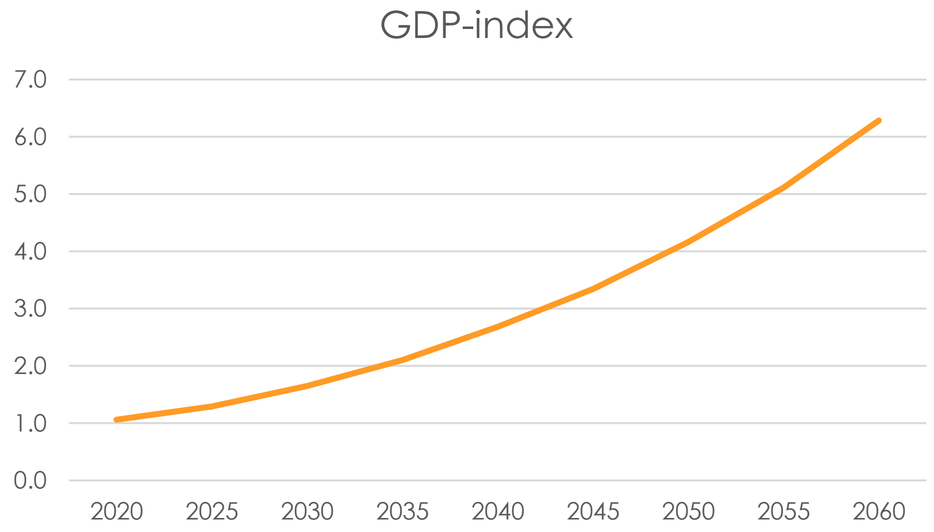
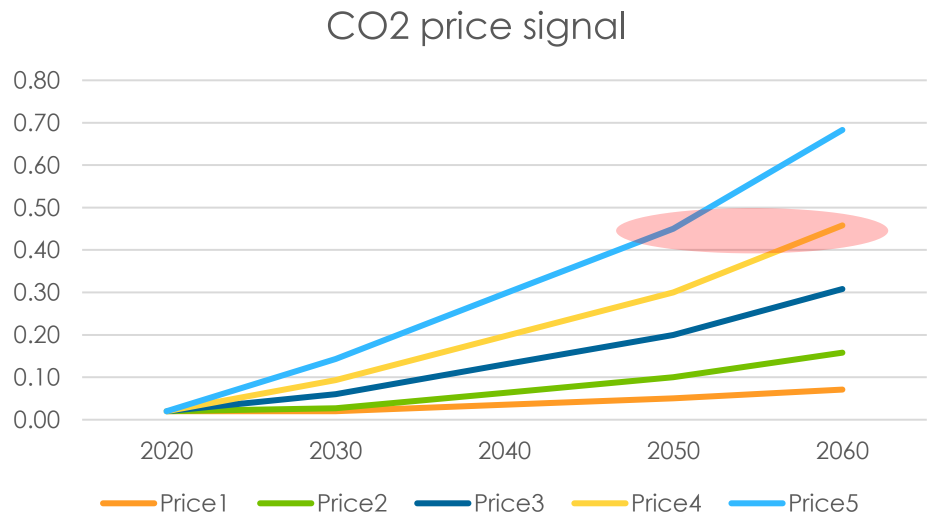
Approach: key drivers







˜450 $/t similar to the EU value (to reach the EU 2050 climate neutrality in the FF55 package analysis)

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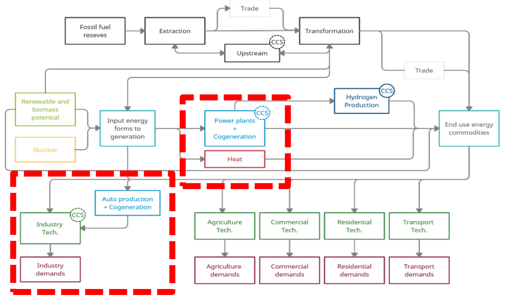
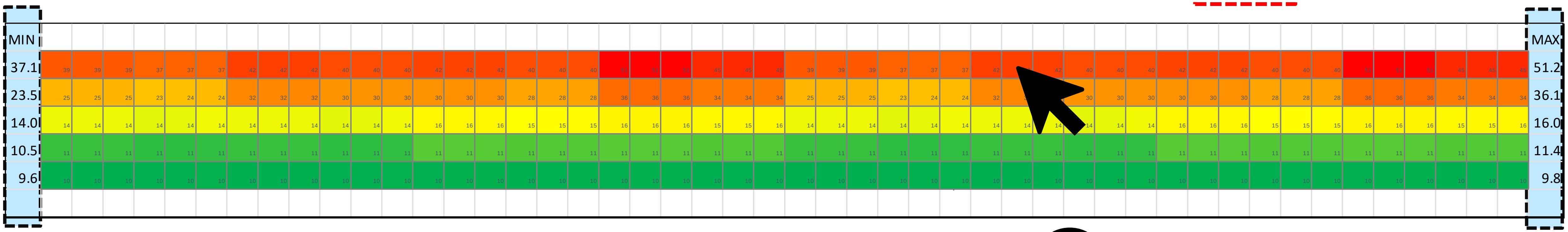
Findings (spreadsheet-based navigator)

KPI: Coal usage (in generation and industry) in the time horizon (2020-2060).
Expressed in terms of equivalent n. of years of 2020 consumption





Dark red cells: high number of years
Orange/Yellow cells: intermediate
Dark green cells: low number of years

A tooltip displays the description of the case when users point the corresponding cell.

Two click away from case specific results:
- Generation capacity
- Electricity generation
- Total emissions
- Final consumption
- System Costs (relative)

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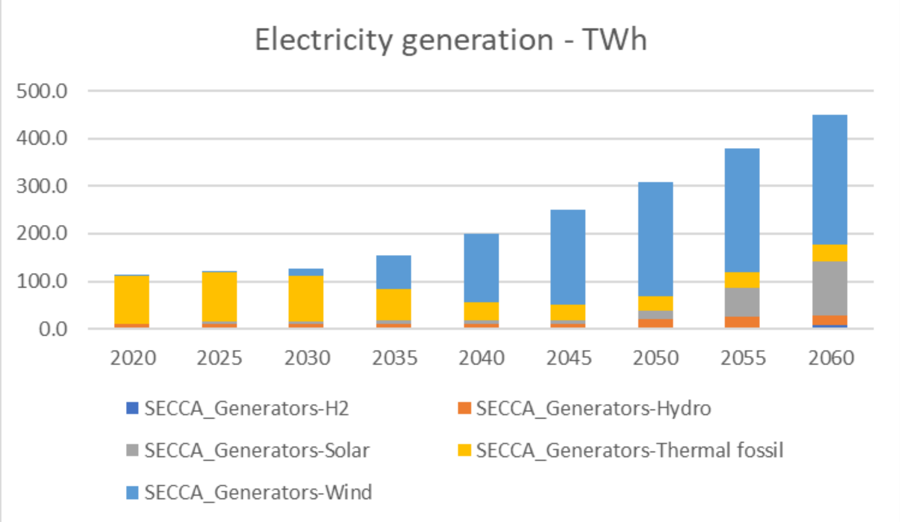
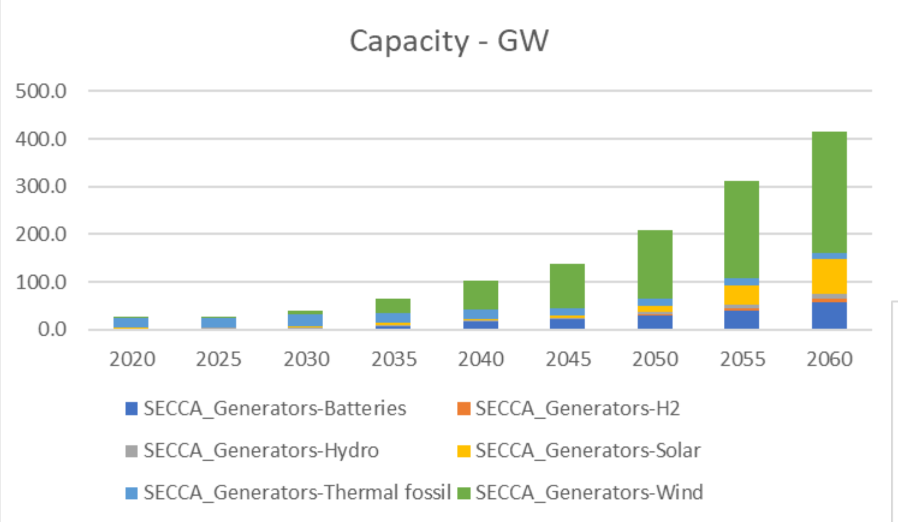
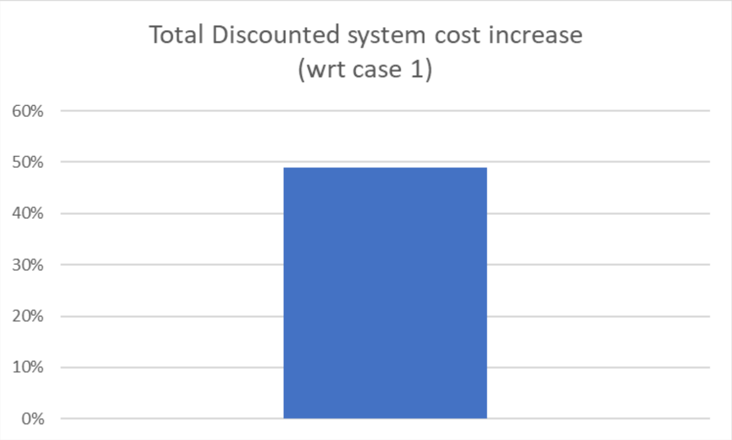
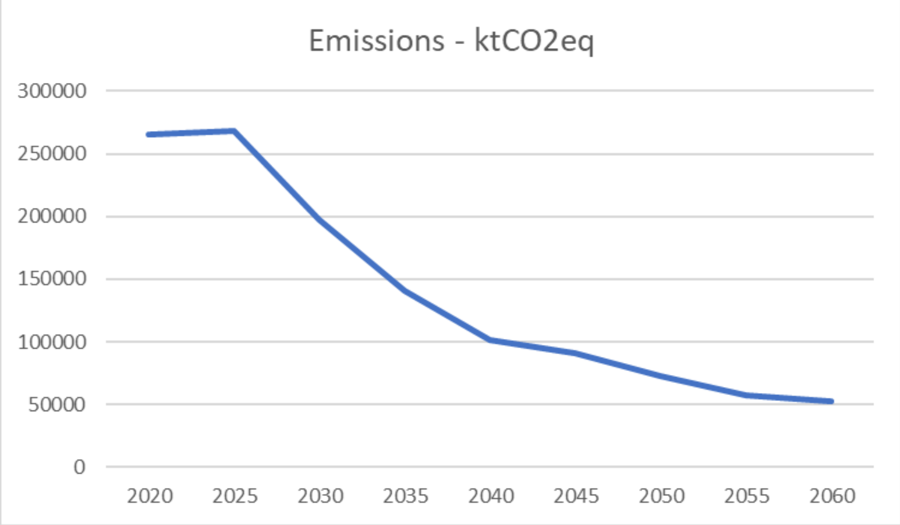
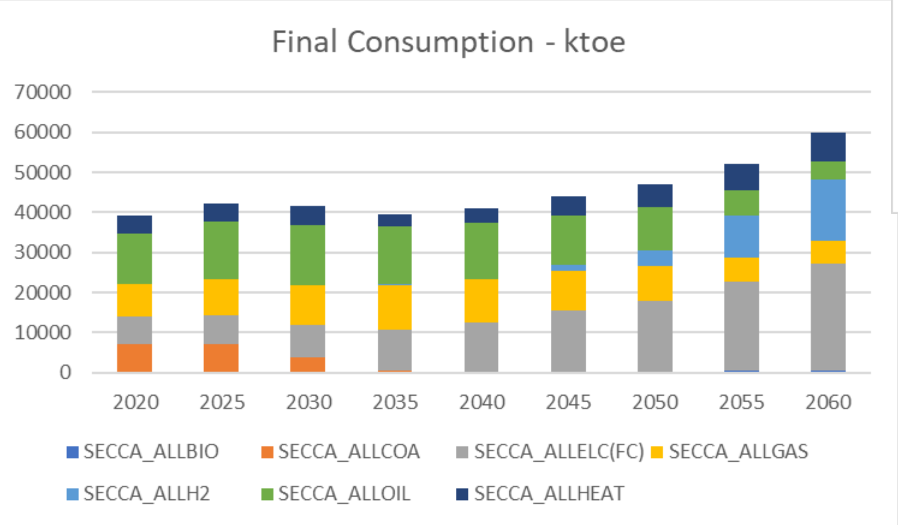
Findings (navigator) – Case X











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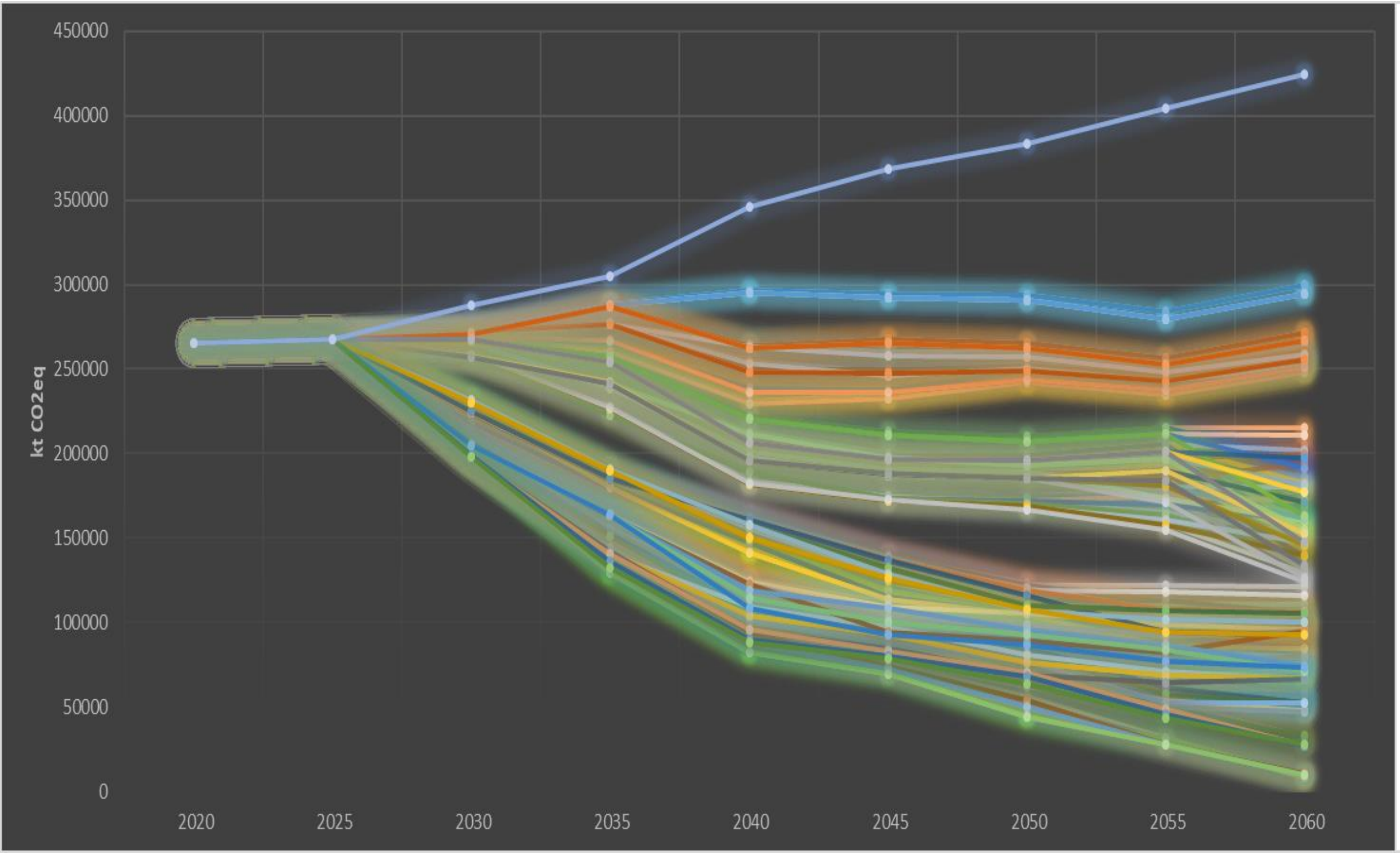
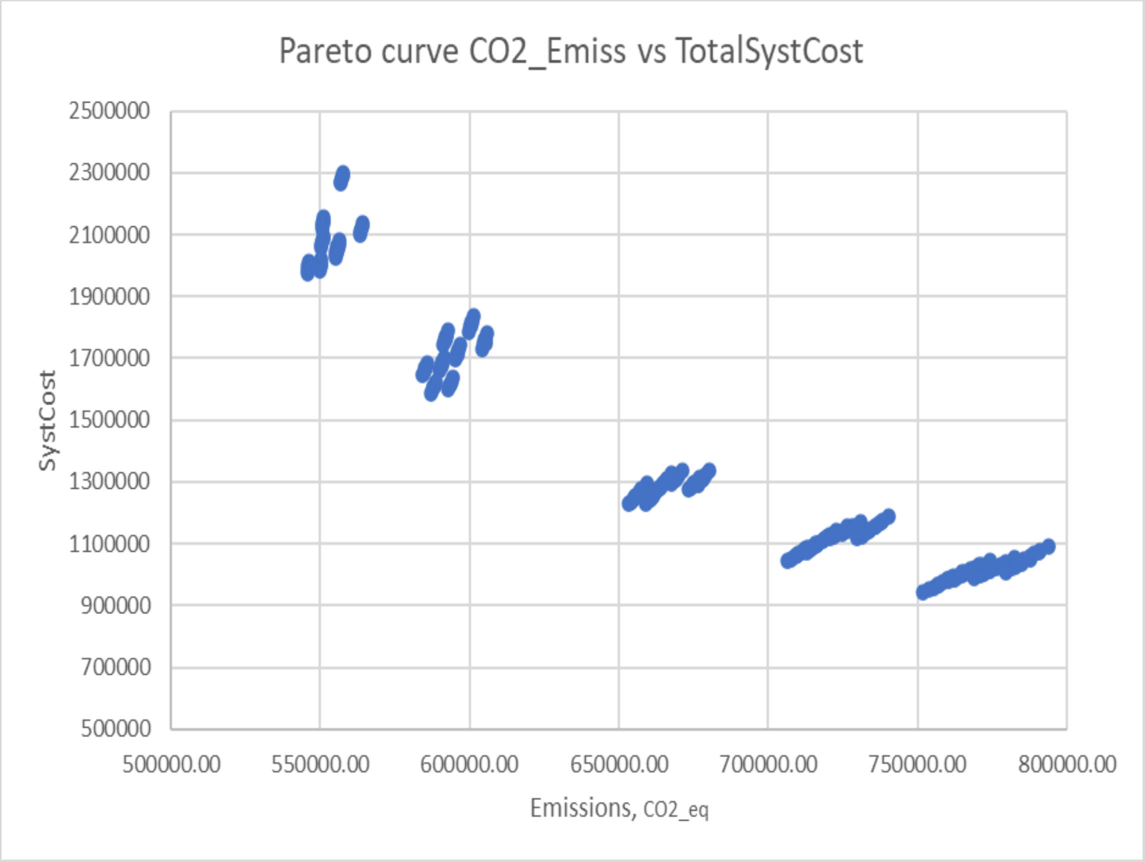
Findings (navigator) – Spectrum of emissions and tradeoffs





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Strategic insights

Under the undertaken exploration:

- Cumulative coal usage over the period (2020-2060) ranges between (around) 10 years and 51 years of 2020 equivalent consumption.

- None of the identified influencing factors makes a long-term utilisation of coal compatible with deep mitigation (nearly zero) trajectories.

- Even for mild mitigation targets (eg around -50% wrt to 2020), the annual (average) consumption of coal over the next 40 years is projected to be around 1/3 of today's values.

    - There is high risk of "stranded" assets (if new coal-based plants/facilities are built in the next years).

    - High risk of loss of competitiveness (to be further investigated)

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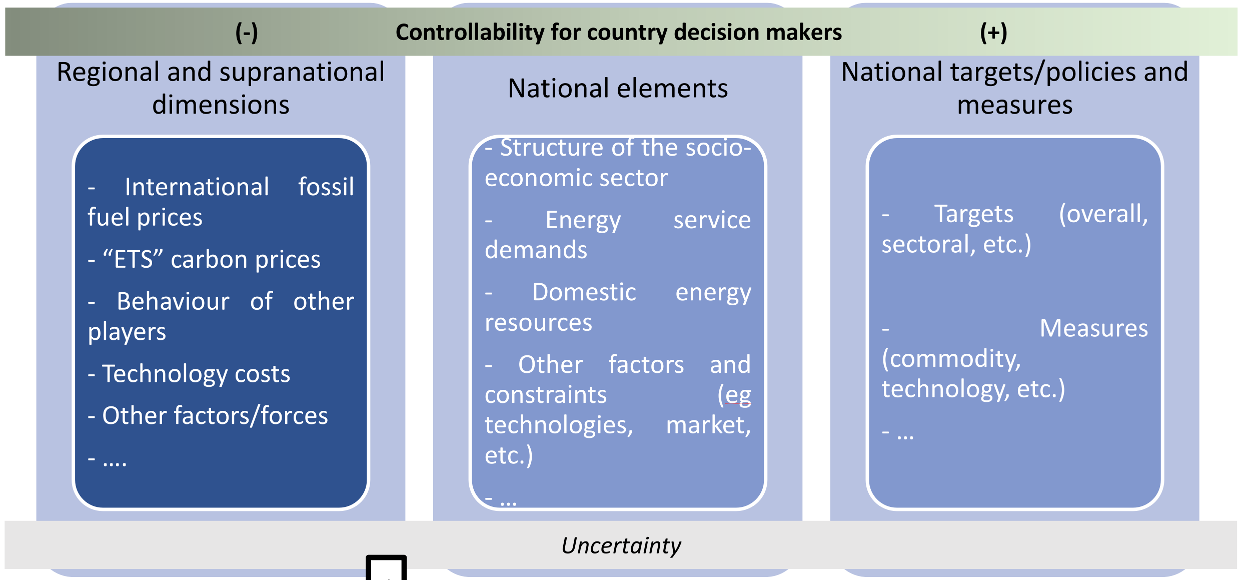
Limitations

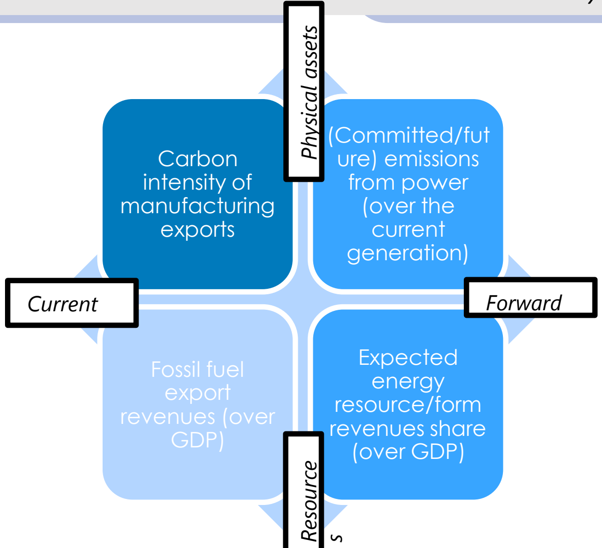
Base year data (households surveys, industry, transport, energy balance, …) and short-term decisions.

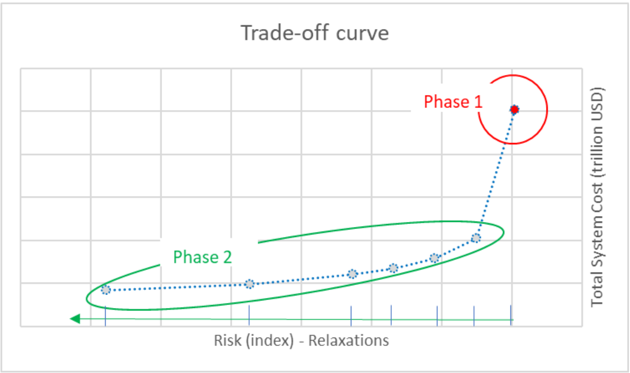
Scenario/Variant design (engagement and co-creation).



Alternative interpretations of the strategic question:

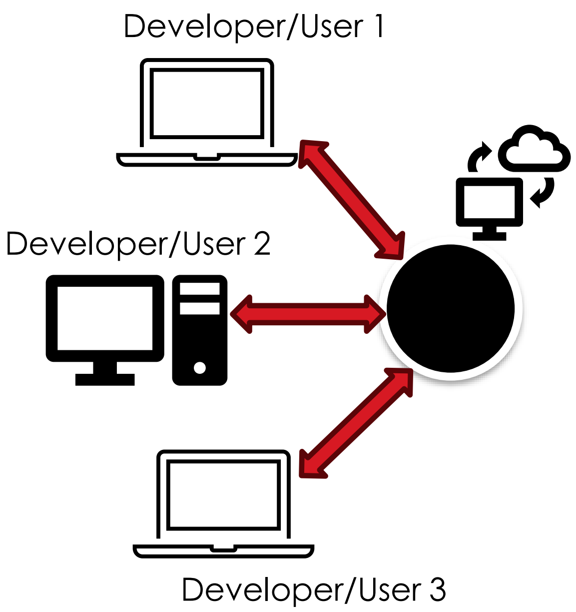
"mimic" the inclusion of an additional criterion (multi criteria analysis) in the strategic decision-making process, to define a mathematical expression that captures "risky configurations of energy mix".

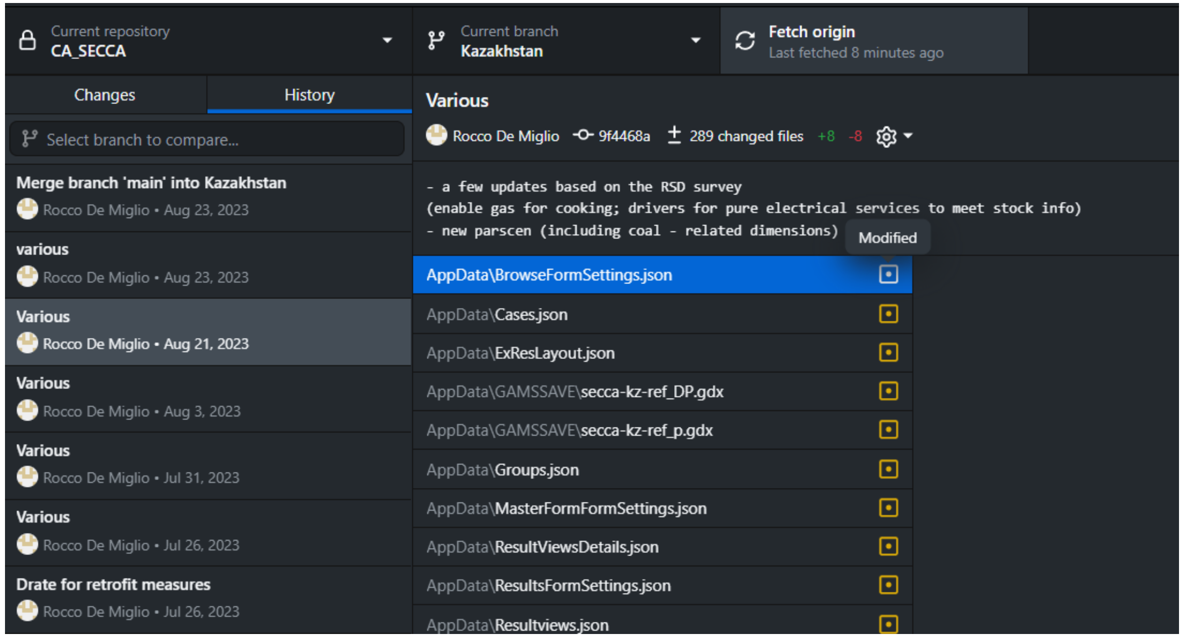




Author' elaboration, adjusted from World Bank. doi:10.1596/978-1-4648-1340-5

Collaboration and co-development

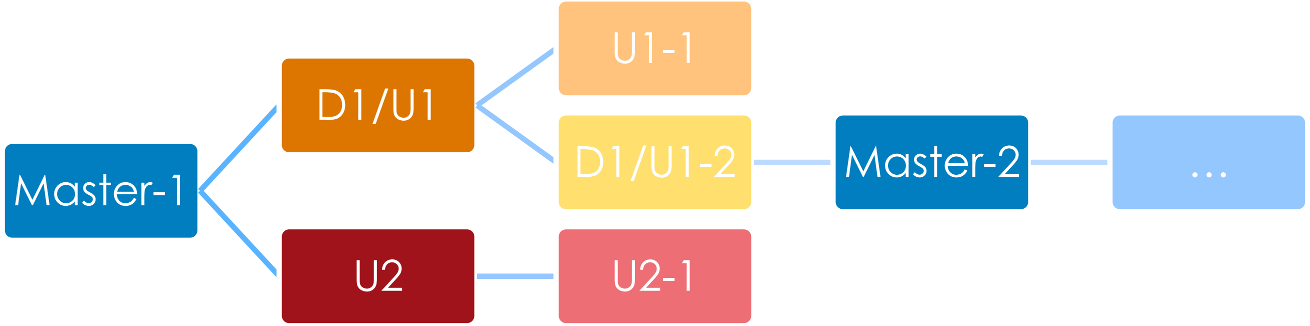




For hosting the model files and collaborating with the team.

Access can be granted to local Organisations (with previous modelling experience):
ERI
Zhasyl Damy
Astana IT
Nazarbayev University
...

A workflow example



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Energy Efficiency

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Defining Energy Efficiency Improvements - Indicators

Consume **LESS (-)** energy to provide **SAME (=)** service

Consume **SAME (=)** energy to provide **MORE (+)** service

Consume **LESS (-)** energy because of **CHANGE (≠)** in service

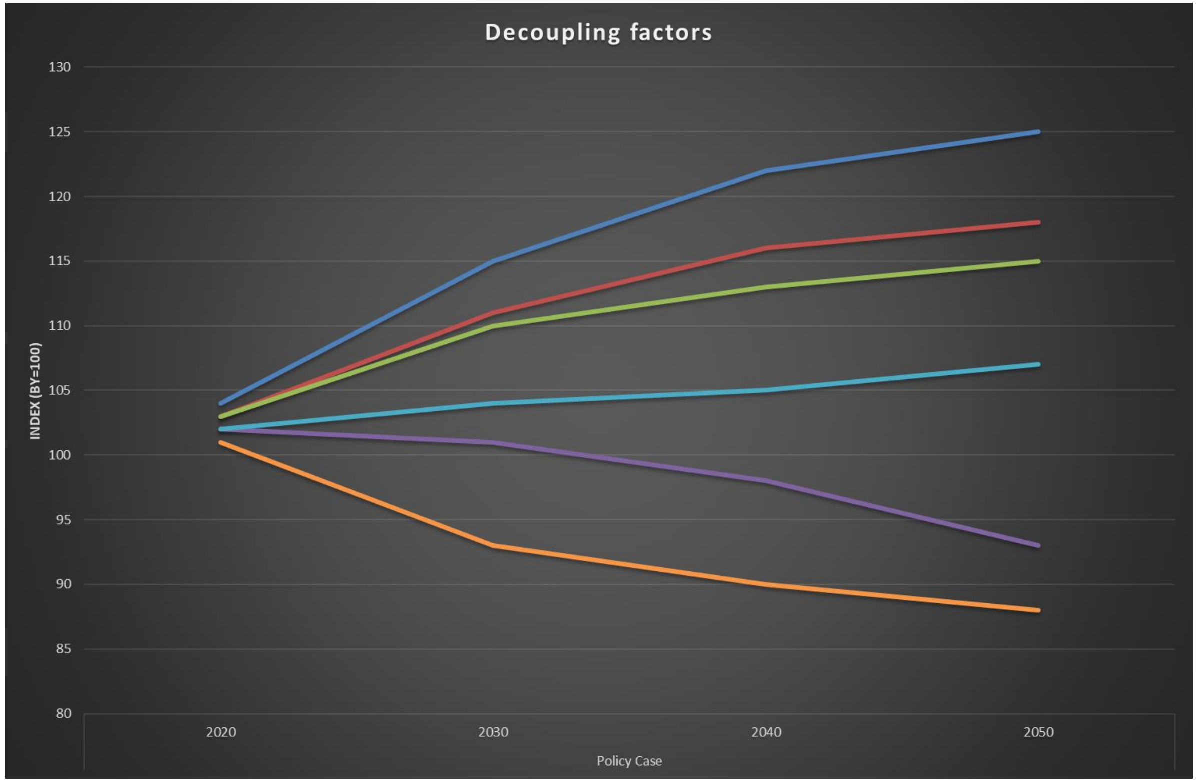
Consume **LESS (-)** energy and provide **LESS (-)** service

Are all the above energy efficiency improvements?

Generic energy efficiency indicator: $\frac{Energy\ Consumption\ (t)}{Activity\ (t)}$

Generic energy efficiency indicator: $Energy\ consumption\ (x,t)\ -\ Energy\ consumption\ (B,t)$

"Decoupling" is when two variables stop moving together:
- the correlation between them remains positive (relative)
- the correlation between them becomes zero, or negative (absolute)



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EE1st at the EU level

Article 2(18) of the Regulation on the Governance of the Energy Union and Climate Action

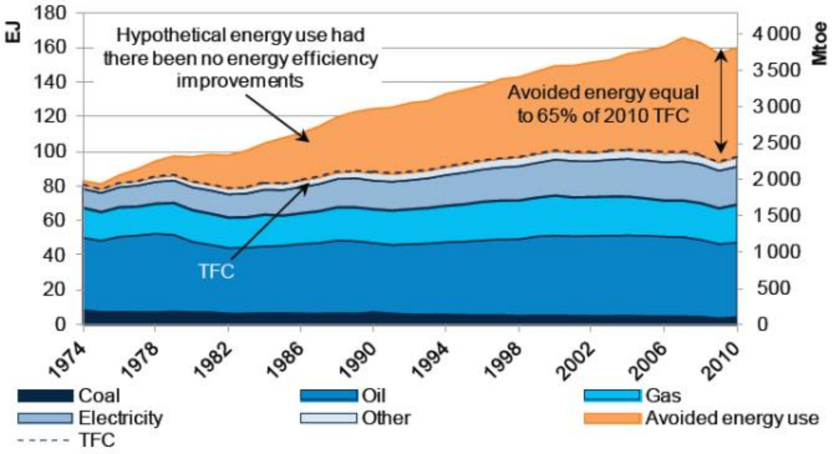
EE1st, as a horizontal "**guiding principle**" of the European climate and energy governance and beyond, should ensure, while taking full consideration of security of supply and market integration, that only the energy **needed** is produced and that investments in stranded assets are avoided in the pathway to achieve the climate goals.

Member States are required to take into account the principle in the integrated National Energy and Climate Plans (NECPs).

The principle aims to treat energy efficiency as the "**first fuel**", that is a source of energy in its own right
"save before you build/produce"

The EE1st principle implies adopting a holistic approach which takes into account the overall efficiency of the "integrated energy system" (holistic) and promotes the most efficient solutions for climate neutrality across the value chain (from energy production, network transport to final energy consumption) so that efficiencies are achieved both in primary and final energy consumption.

This includes giving **priority to "demand-side"** solutions whenever they are more cost-effective than investments in energy infrastructures.



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Overall energy efficiency target – Revision of the EED - EC

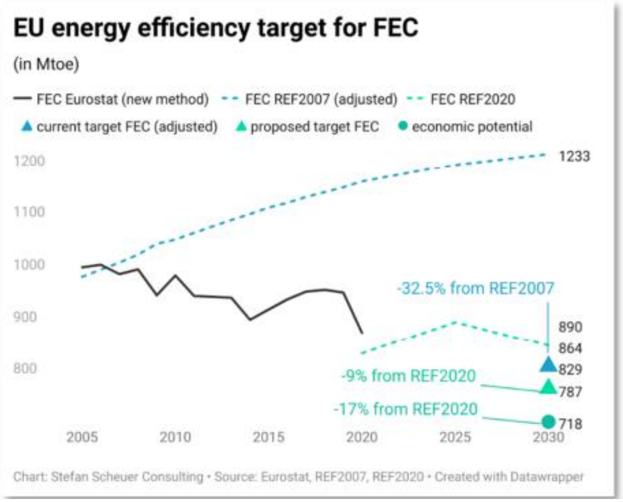
The EU has set ambitious energy efficiency targets for 2020 and 2030 to reduce **primary** and **final** energy consumption as part of its 2050 decarbonisation objectives.

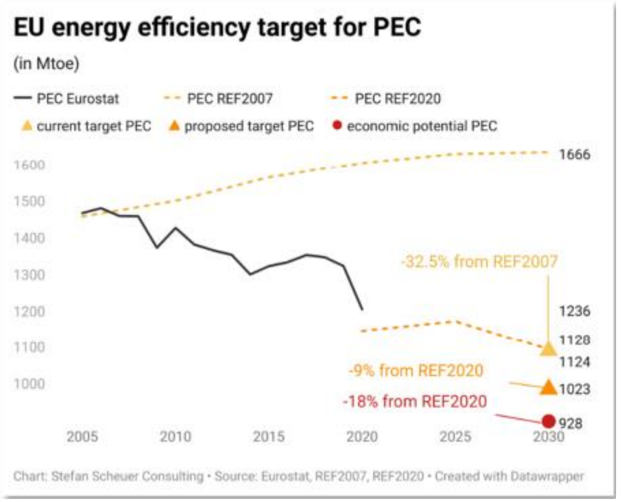
Initial (2018): headline EU energy efficiency target for 2030 of at least 32.5% (compared to projections of the expected energy use in 2030). 32.5% target translates into a final energy consumption of 956 Mtoe and/or primary energy consumption of 1273 Mtoe in the EU by 2030.

More recently (2022, in the context of the REPowerEU plan)

	Modelling analysis for the EED recast	New modelling analysis	
	Full Package Scenario 9%EE/40%RES	REPowerEU 13%EE/45%RES	REPowerEU 19%EE/45%RES
Energy consumption			
EU FEC target (wrt. REF2020 scenario)	**9%**	**13%**	**19%**
Final energy consumption (Mtoe)	787	751	701
EU PEC target (wrt. REF2020 scenario)	8%	10%	13%
Primary energy consumption (Mtoe)	1,033	1,006	979

Model-based analyses





Target values: "absolute numbers"

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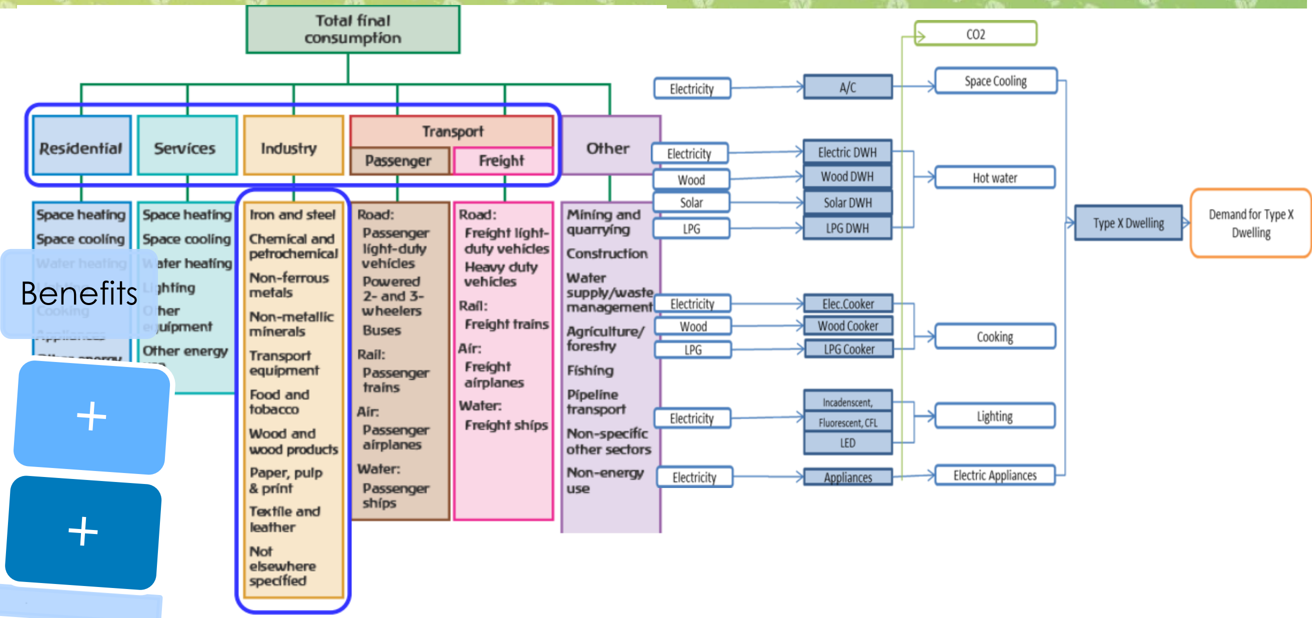
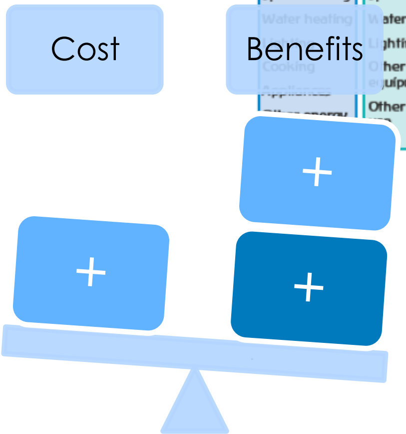
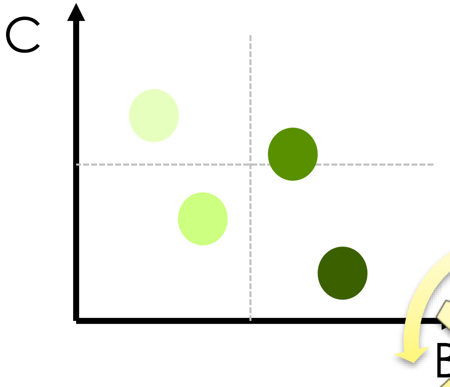
Understanding energy efficiency – Indicative steps

- Understand how energy is used across system/sectors
  Need end-use information beyond the energy balance

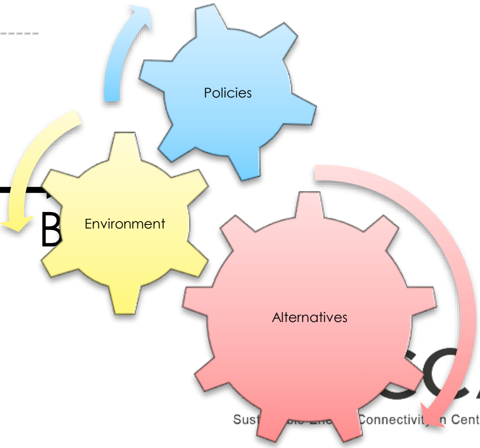




- Define evaluation methodology/rationale



- Information collection (statistics/surveys/metering/databases,..)
  Select and assess alternatives (technology explicitness is "key")



- Explore and project energy variables (EE "triggers" and other factors): modelling

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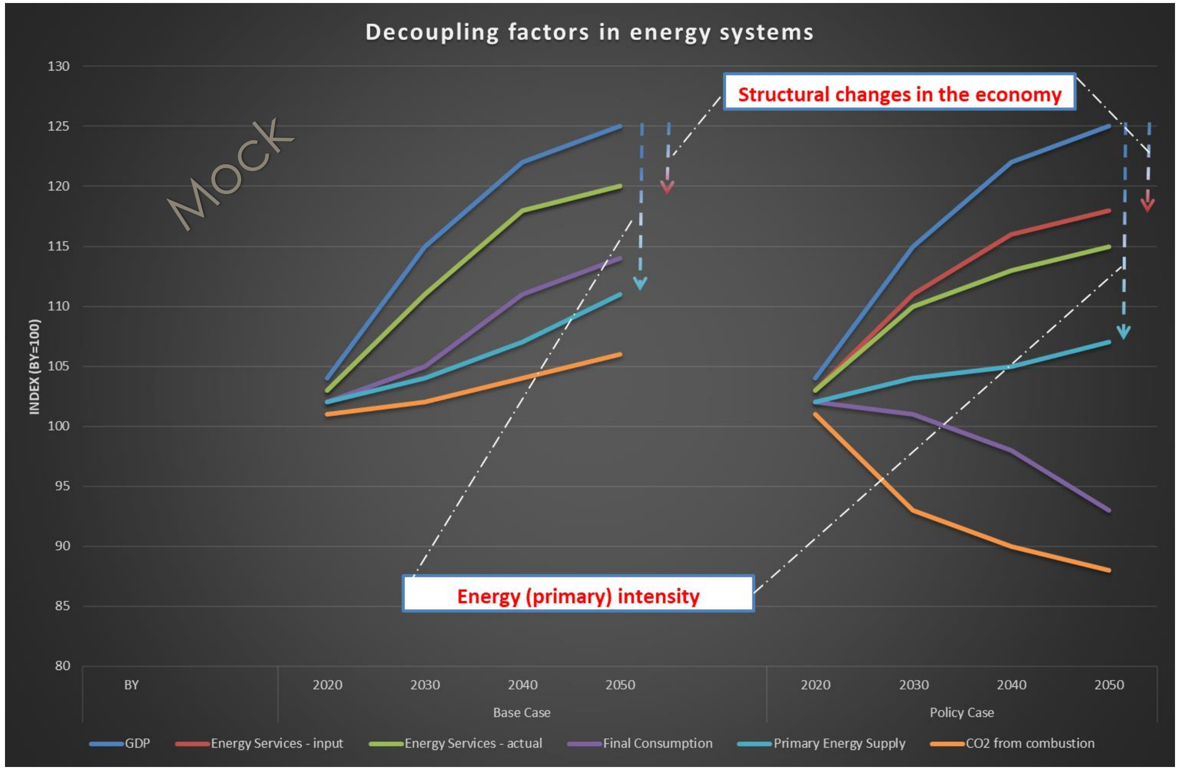
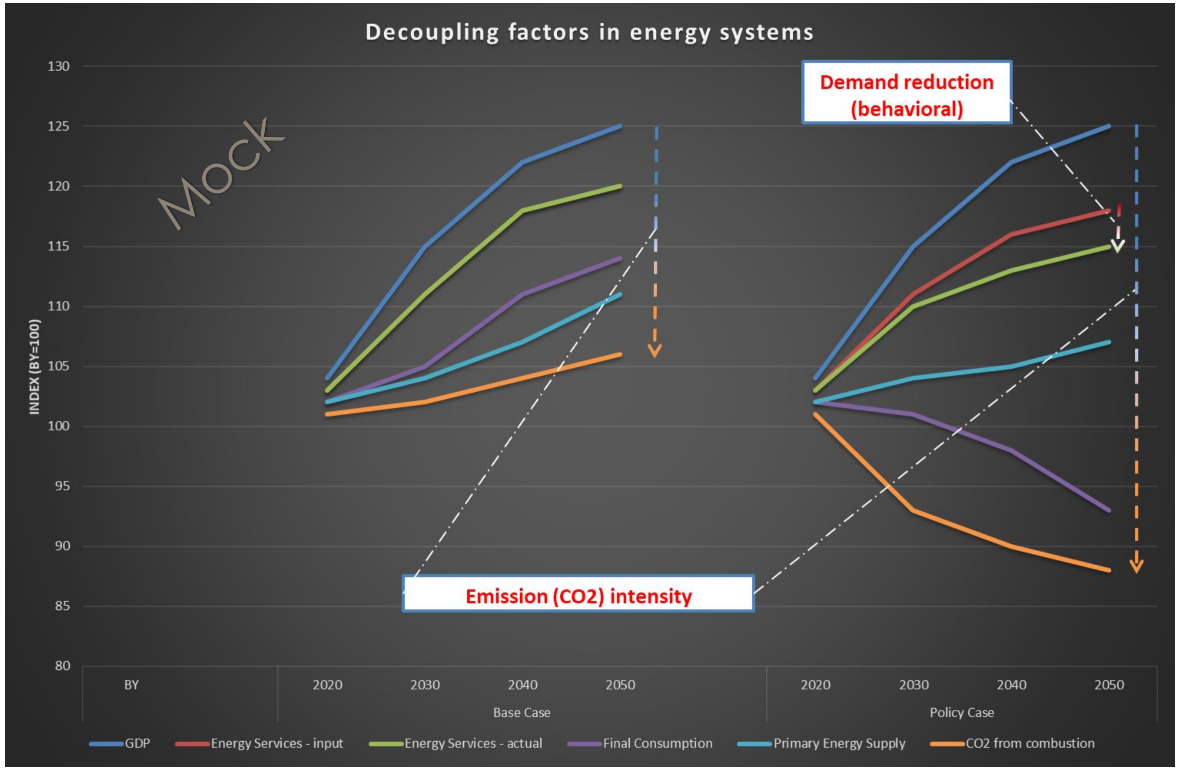
Unveiling and understanding energy efficiency indicators

The importance of disentangling “efficiency improvements” from “structural changes” of the economy and behavioural changes





Uzbekistan’s economy and population is expected to grow at high rates of over 4% and 1.5%, respectively, Unmet demand is an issue!

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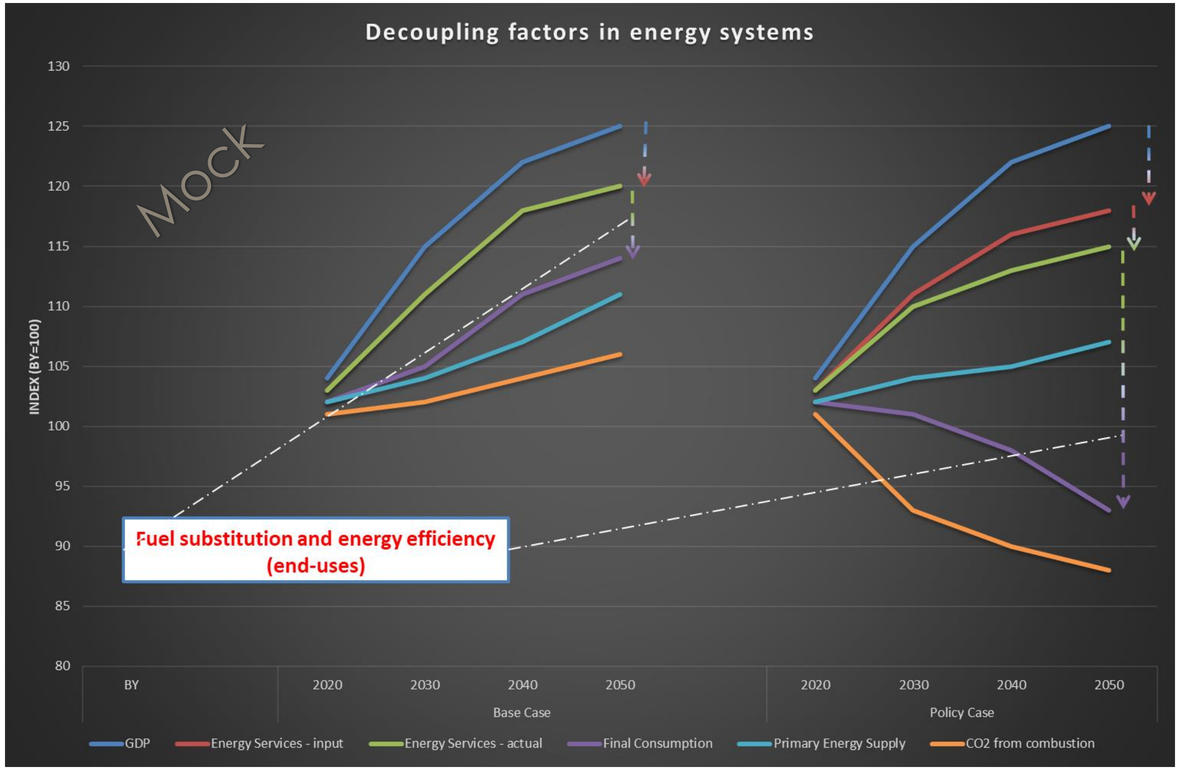
Unveiling and understanding energy efficiency indicators



Examples:

Final Energy per Inhabitant (toe/capita)	Energy use for Residential Space Heating (per sqm)	Energy Intensity Passenger Transport (per pass-km)
Final Energy per household (toe/household)	Energy use for Tertiary Space Heating (per sqm)	Energy Intensity Freights Transport (per t-km)
Final Energy per sectoral value added (toe/M$)	Energy use for Residential Lighting (per dwelling)	Energy use for Cement production (toe/t)
Electric vs bio-fuelled vehicles (over the chain)	Energy use for Public Lighting (per number)	Energy use for Iron&Steel production (toe/t)

Relative indicators need to be carefully interpreted!

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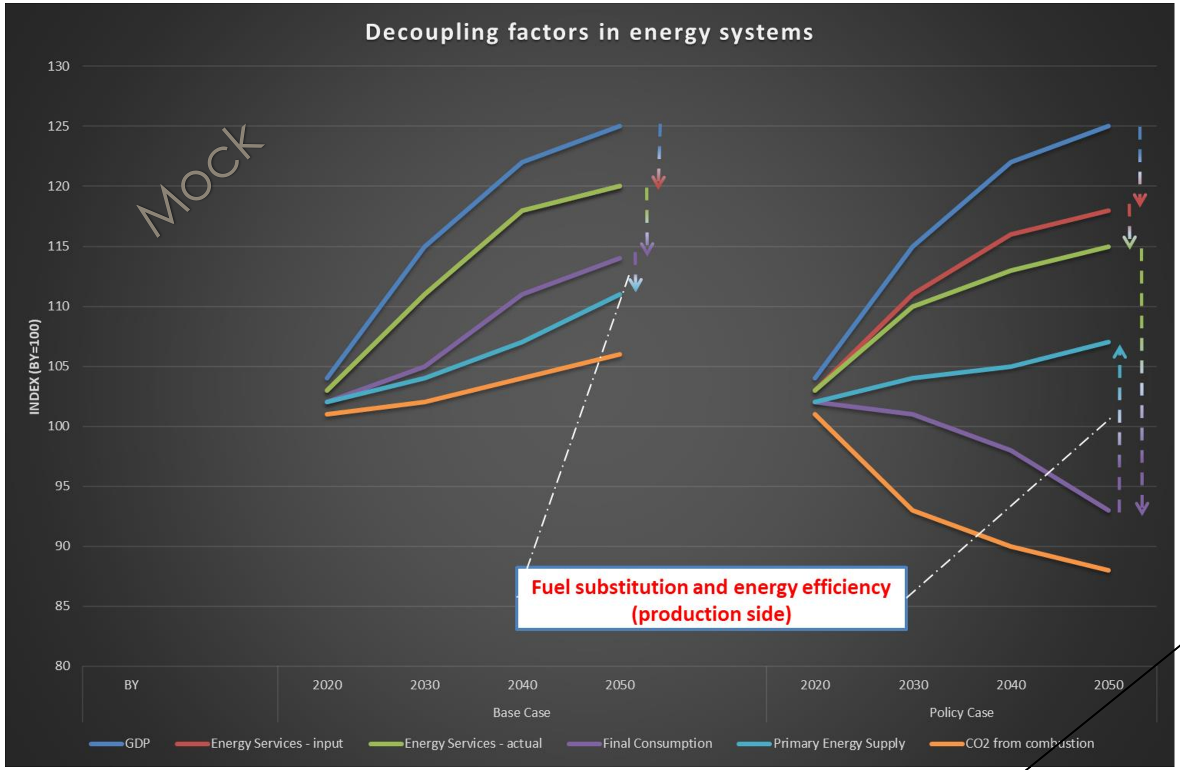
Unveiling and understanding energy efficiency indicators



1.4<UZ<1.55
KZ>1.65
EU (average): 1.35

Examples:

Primary Energy Supply per Inhabitant (toe/capita)	Efficiency of Thermal Electricity Generation	CO2 emissions from the power sector per unit of electricity produced (kgrCO2/kWh)
Primary Energy Intensity (toe/k$)	Electricity transmission and distribution efficiency	CO2 Emissions Intensity per unit of Primary Energy Supply (kg CO2 from Energy Sources / $ GDP)
Primary Energy over Final Energy (toe/toe) Best = 1	District Heat distribution efficiency	Per value added carbon intensity (kgCO2/$)
Electric vs bio-fuelled vehicles (over the chain)	Average Capacity Factor of Conventional Power Plants	H2 vs electricity in industry (over the chain)

Relative indicators need to be carefully interpreted!

Single indicators can be misleading!

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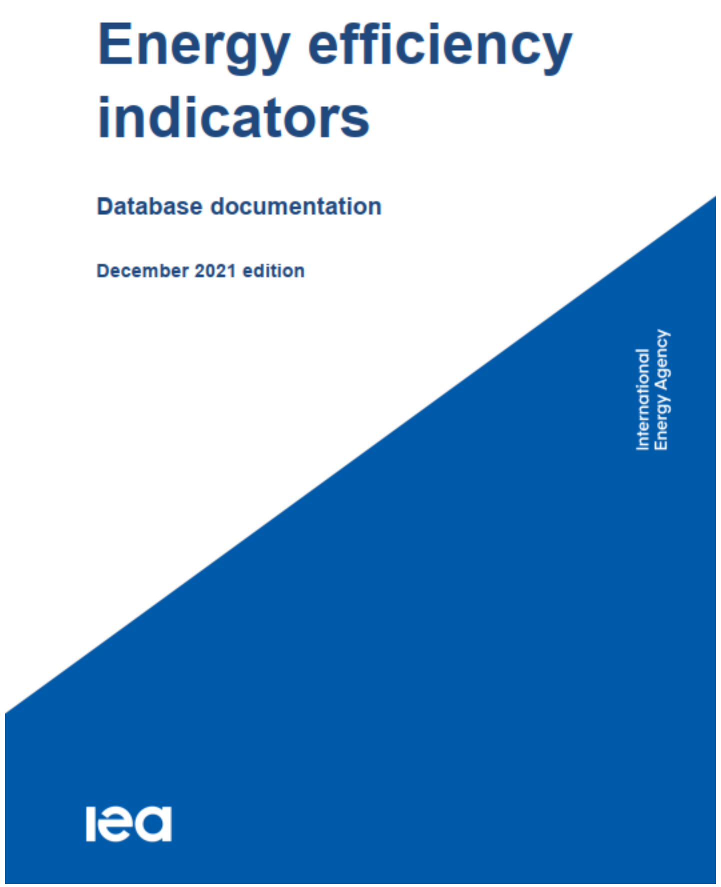
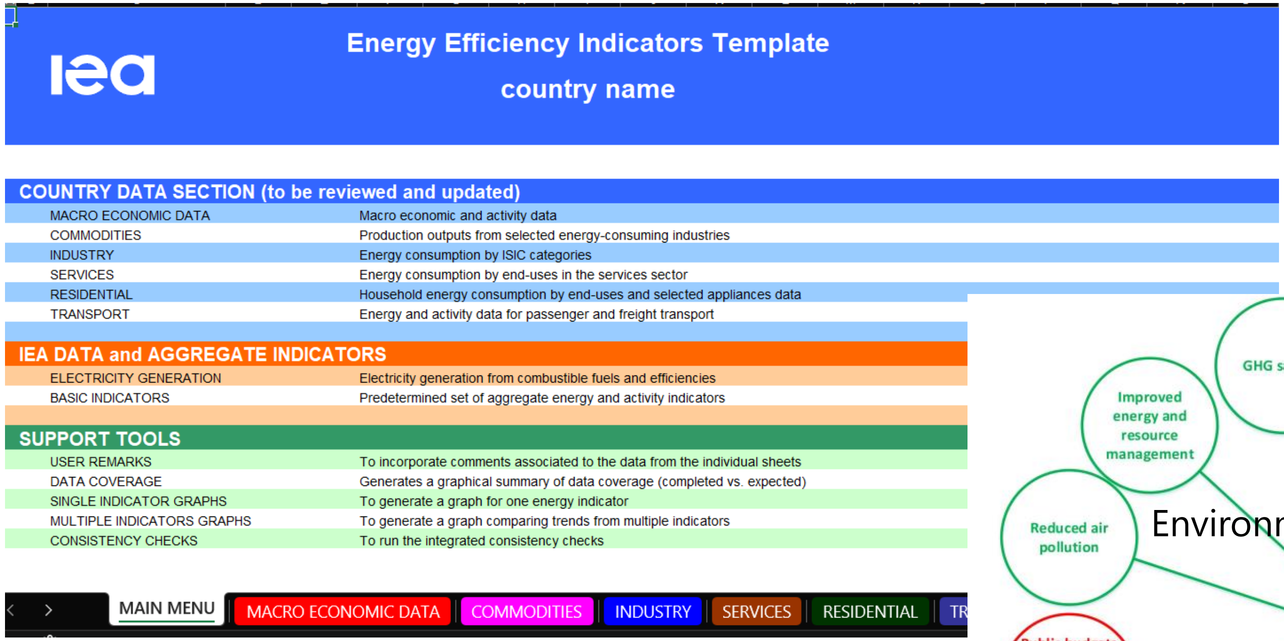
References



https://iea.blob.core.windows.net/assets/6d9daa77-45f0-41c9-978b-c23a3759b073/Efficiencyindicators_Documentation_December2021.pdf

https://www.iea.org/data-and-statistics/data-product/energy-efficiency-indicators

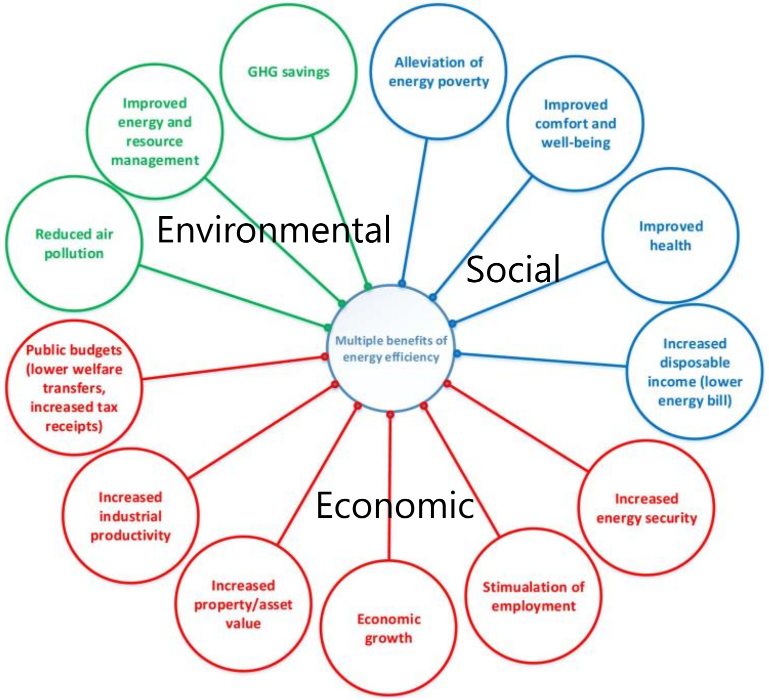


Energy Efficiency Indicators Template

country name

COUNTRY DATA SECTION (to be reviewed and updated)	
MACRO ECONOMIC DATA	Macro economic and activity data
COMMODITIES	Production outputs from selected energy-consuming industries
INDUSTRY	Energy consumption by ISIC categories
SERVICES	Energy consumption by end-uses in the services sector
RESIDENTIAL	Household energy consumption by end-uses and selected appliances data
TRANSPORT	Energy and activity data for passenger and freight transport
IEA DATA and AGGREGATE INDICATORS	
ELECTRICITY GENERATION	Electricity generation from combustible fuels and efficiencies
BASIC INDICATORS	Predetermined set of aggregate energy and activity indicators
SUPPORT TOOLS	
USER REMARKS	To incorporate comments associated to the data from the individual sheets
DATA COVERAGE	Generates a graphical summary of data coverage (completed vs. expected)
SINGLE INDICATOR GRAPHS	To generate a graph for one energy indicator
MULTIPLE INDICATORS GRAPHS	To generate a graph comparing trends from multiple indicators
CONSISTENCY CHECKS	To run the integrated consistency checks

MAIN MENU | MACRO ECONOMIC DATA | COMMODITIES | INDUSTRY | SERVICES | RESIDENTIAL | TR



Source: European Commission based on Odyssee-Mure

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Q&A

THANK YOU!

Eng. Rocco De Miglio
Energy systems modeller and analyst

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