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INTEGRATED ENERGY AND CLIMATE ANALYSES PHASE II

Tashkent, Uzbekistan

1-2 July 2025

REGIONAL WORKSHOP ON ELEMENTS OF COUNTRY ENERGY PLANNING

Rocco De Miglio

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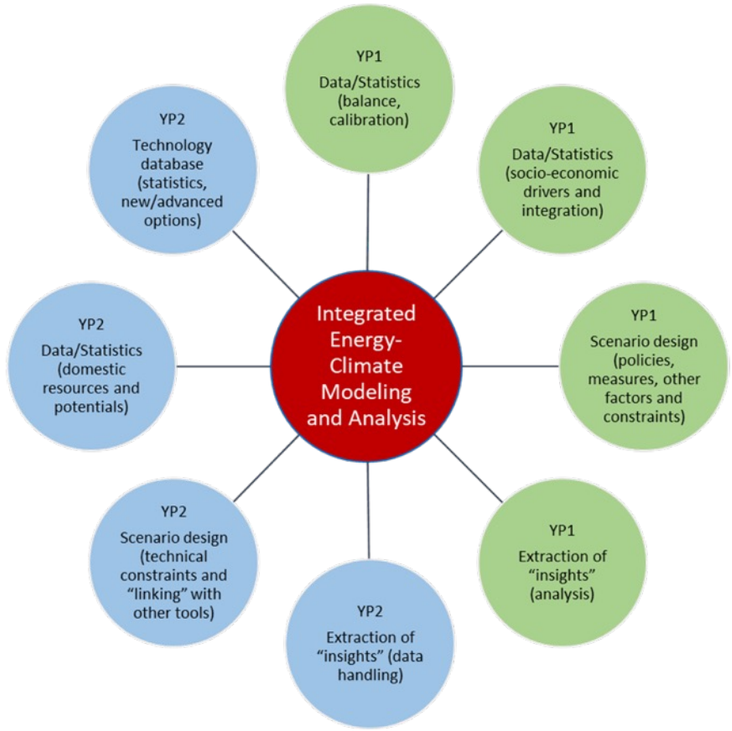
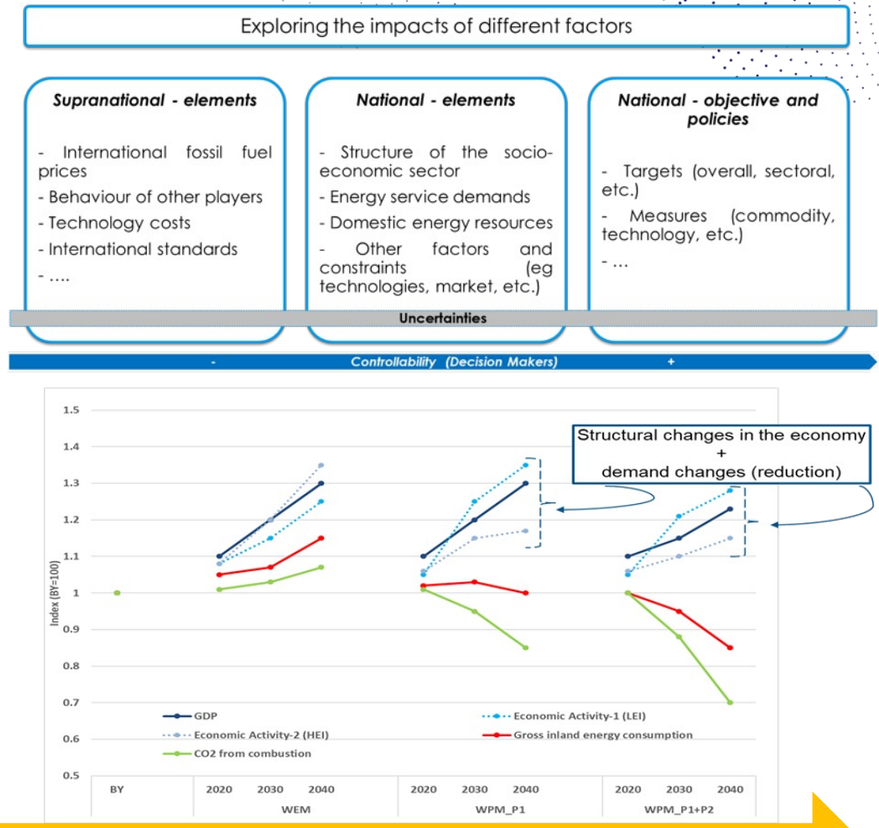
Phase I – Phase II



ALL

- Kazakhstan
- Kyrgyzstan
- Tajikistan
- Turkmenistan
- Uzbekistan



Phase I - Theory

Phase II - Application

While the first part focused on building a common understanding—covering harmonised terminology, key technical&methodological details, connectivity among country experts, and trainings—the second part will adopt a more targeted, country-specific and application-oriented approach.

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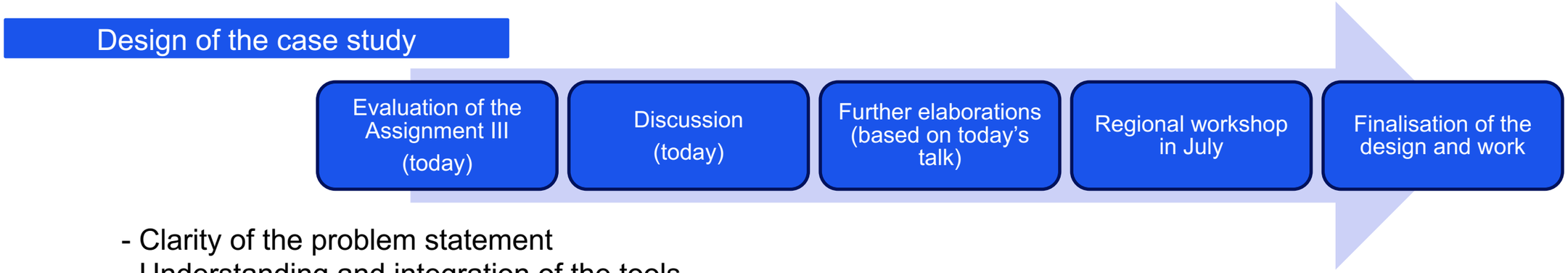
Phase II - Approach

The primary goal is to *strengthen local system-thinking and data-driven decision-making in the energy and climate sectors.*

Our approach focuses on applying and stress-testing acquired knowledge in real-case scenarios, followed by critical reflection and commentary.
We are not aiming to solve complex national-level challenges that require extensive expert analysis and resources. Instead, we aim to create opportunities for meaningful reflection using the tools and methods at our disposal.

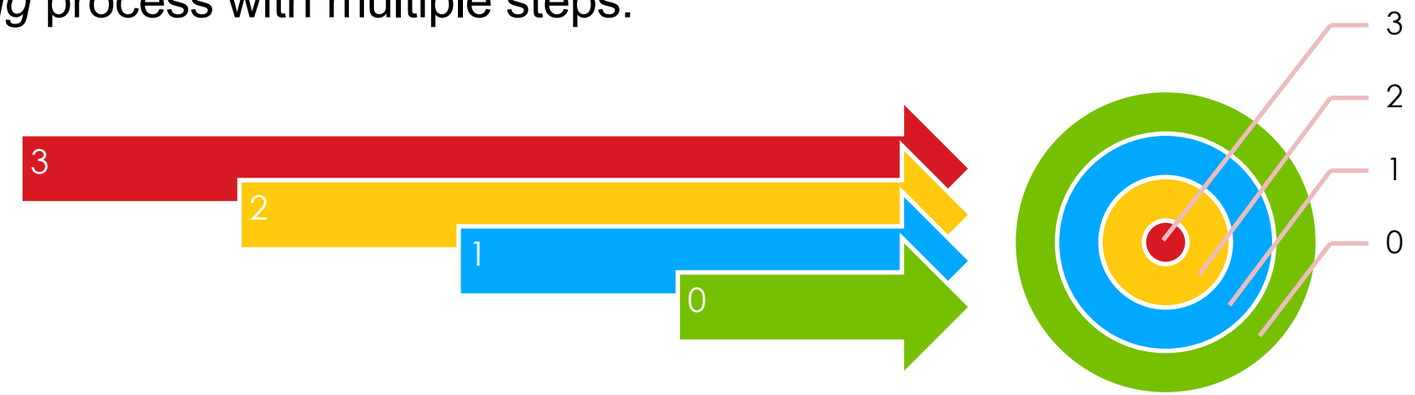
When designing the case study (scenario-based), it is important to maintain realistic expectations and focus on maximizing the benefits of the exercise, while remaining mindful of its limitations.



- Clarity of the problem statement
- Understanding and integration of the tools
- Soundness of the proposed methodology for next steps

Modelling in energy&climate 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 factors 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.

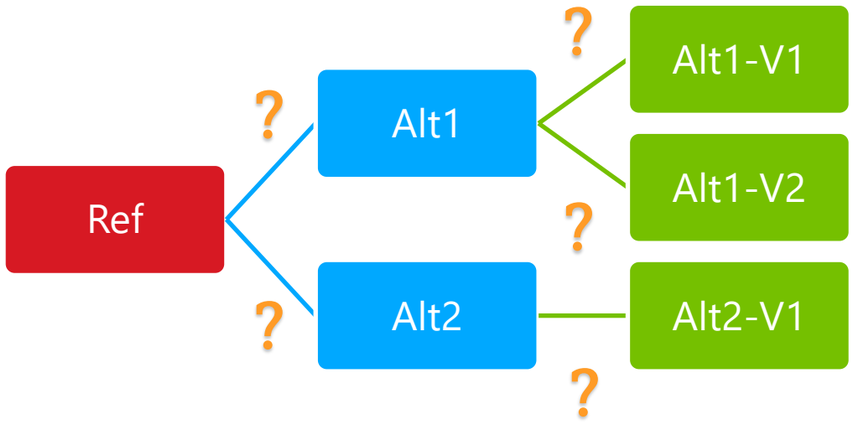
Model-based energy-climate scenarios - Map

Country unit	Tool(s) / scope and method
Kazakhstan	Energy system analysis – assessment of the contribution of RES (analysis of the potential and LCOE by "area") under different evolutions/scenarios of the country system. CONFIRMED!
Kyrgyzstan	Electricity projections and impact of pricing policies. Analysis of the electricity imbalance over time and possible mitigation actions. CONFIRMED!
Tajikistan	Electricity demand projections and energy savings actions. In-house tool for scenarios. CONFIRMED!
Turkmenistan	Efficiency improvements. projections and impact of targeted measures (lighting, etc.) under different scenarios. CONFIRMED!
Uzbekistan	Identification of targeted measures to reduce gas dependency. Scenario analysis of the space for substitution and the role of RES. CONFIRMED!

Model-based energy-climate scenarios - Map

Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
RES tool	E-calculator		E-calculator	E-calculator
ESM	RES tool	Ele demand projection tool	Out ot-model assessment	RES tool
Visuals	E-calculator (price responsive)			IA gas

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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Model-based energy-climate scenarios

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) +

Model-based energy-climate scenarios - 1

Modelling scenarios assumptions

	Trading of Electricity and Hydrogen	Trading of Fossil Fuels Between CA Countries and with Rest of World	Electricity Transmission Capacity
National Energy Self-sufficiency scenario	No		
Regional Connectivity Scenario	Yes (only between CA countries)	Yes	Limited by current and planned transmission grid
Full Connectivity Scenario	Yes (between CA countries and with rest of world)		
Unlimited Connectivity Scenario	Yes (between CA countries and with rest of world)		Unlimited

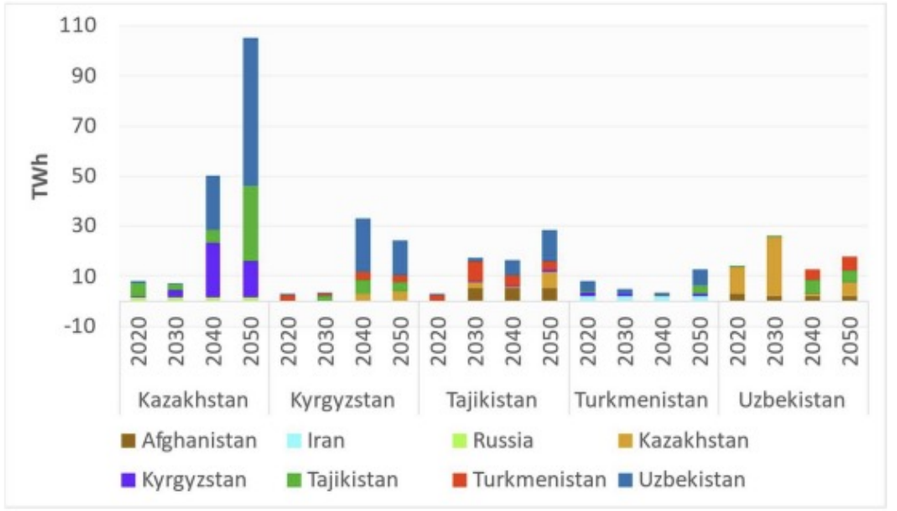
All the four scenarios are modelled based on:

- Ambitious decarbonization, including the implementation of unconditional NDCs and national clean energy p
- 2060 carbon neutrality in Kazakhstan;
- Adoption of national plans for hydropower development, agricultural expansion, and water efficiency;
- High impact of climate change (hot, dry future climate – SSP5-8.5)[16];
- Population projections from UN World Population Prospects;
- GDP projections from IMF (Turkmenistan), World Bank (all other countries);
- The price of CO2 is harmonized across all the countries, in order to avoid carbon leakage inside the region.

https://unece.org/sites/default/files/2025-03/Report.pdf

What knowledge or understanding does this provide?

Electricity exports to third countries and intra-regional (Unlimited Transmission Scenarios, exports from countries on x-axis to countries in legend), TWh



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Model-based energy-climate scenarios - 1

Modelling scenarios assumptions

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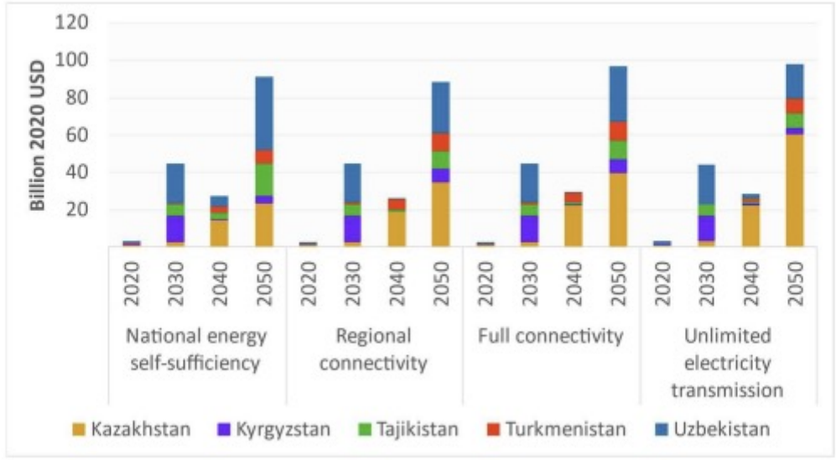
Investments needed in electricity sector[18] – scenario comparison



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Model-based energy-climate scenarios - 2

SCENARIOS		Integration dimension		
		National Optimization (N)	Trading Optimization (T)	Regional Optimization (R)
Decarb. dimension	Reference (R)	R – N	R – T	R - R
	Net-Zero (NZ)	NZ – N	NZ – T	NZ - R

The scenarios explore the impact of two relevant “policy” dimensions that can shape the future evolution of Central Asia’s power systems and the associated cross-border trades: the level of regional integration (three incremental degrees of integration are investigated) and the decarbonisation ambitions of the country power sectors

Decarbonization through Enhanced Regional Electricity Trade in Central Asia

WorldBank - Ongoing

What knowledge or understanding does this provide?

(eg different demand, rationale of the trades/directions, underlying assumptions/potentials. etc.)

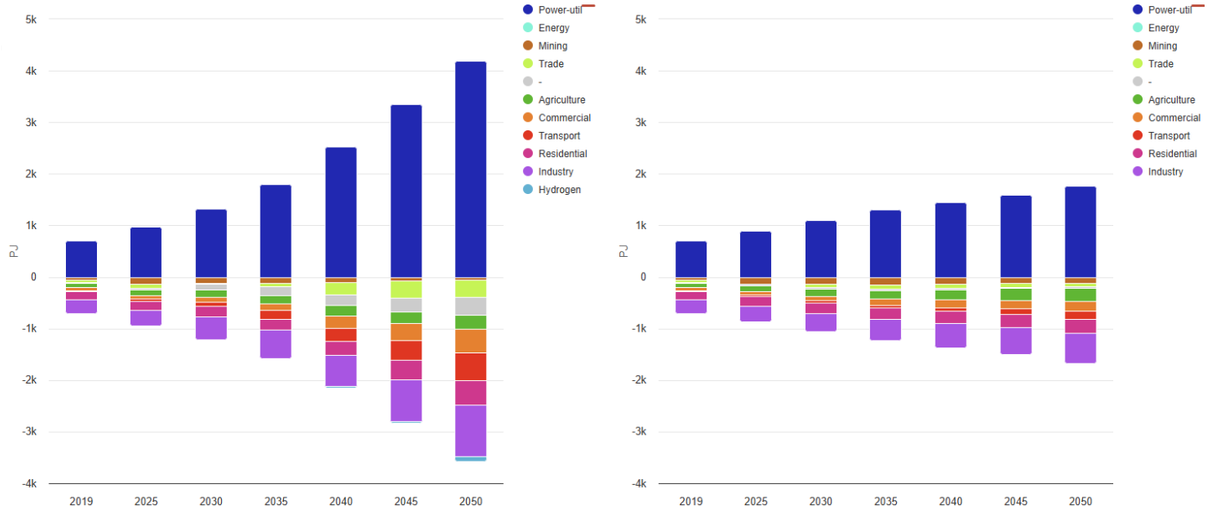
Model-based energy-climate scenarios - 3

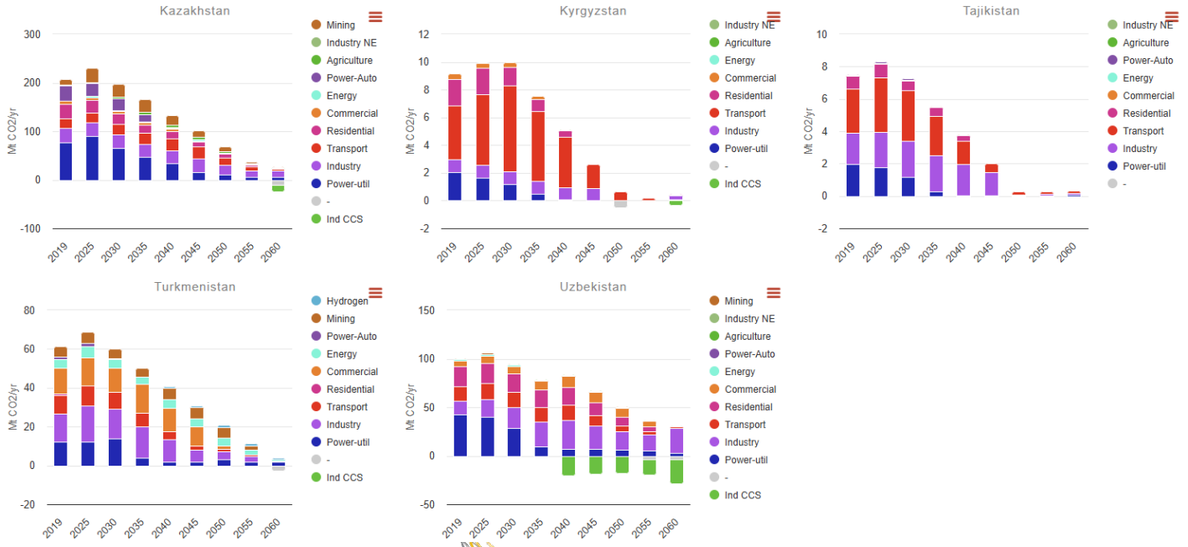
Carbon budget
CO2 storage potential
CO2 storage cost
Shared Socioeconomic Pathways Scenario Database (SSP) - https://iiasa.ac.at/models-tools-data/ssp
Gas subsidies
Wind costs
PPA
HPP Capacity factors
Gas pipelines (new)

What knowledge or understanding does this provide?

(how many scenarios? Etc.)

https://kinesys.readthedocs.io/en/latest/pages/introduction.html





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Model-based energy-climate scenarios - 4

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
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
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
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
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

CO2-1	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	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	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	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	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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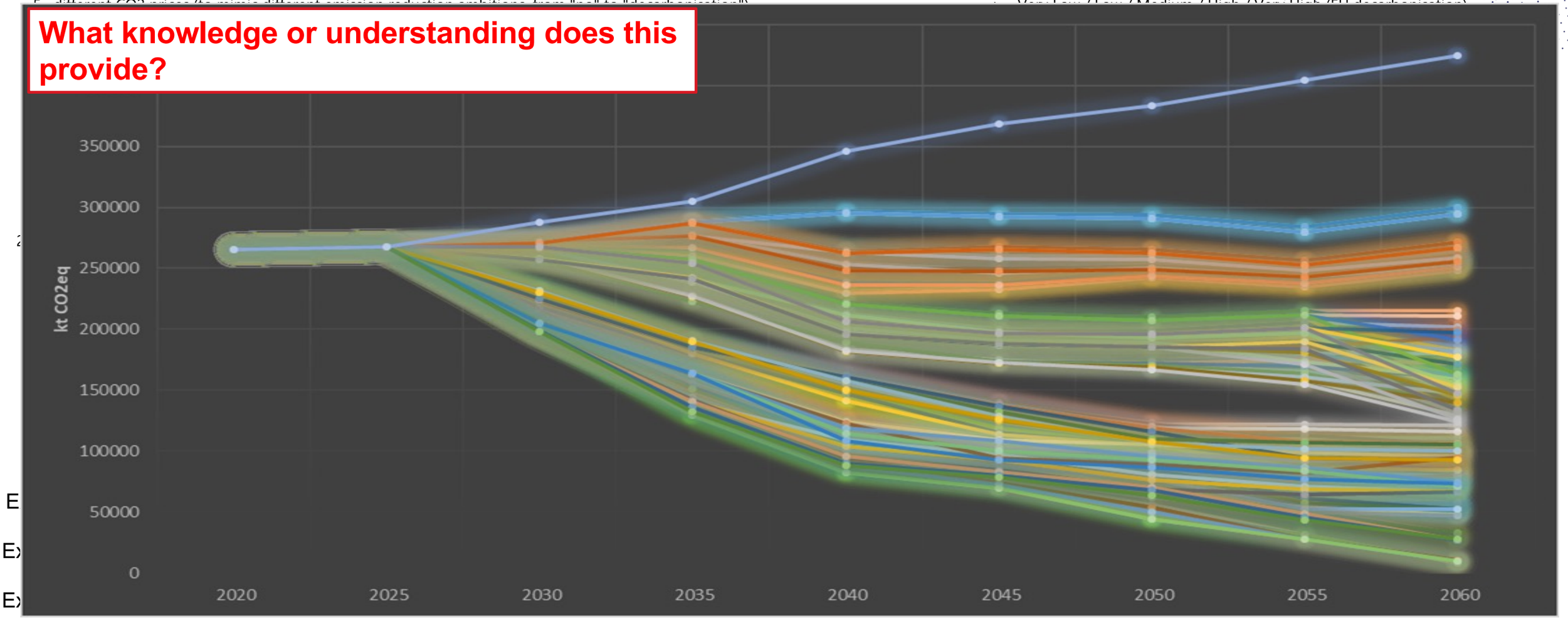
Model-based energy-climate scenarios - 4

What knowledge or understanding does this provide?



Model-based energy-climate scenarios - 4

Parametric Scenario Analysis is a risk management and strategic planning tool used to evaluate the impact of varying key parameters on outcomes in a model or system. It's especially common in finance, insurance, and strategic planning.

It involves systematically adjusting the input parameters of a model to observe how changes influence outputs. Unlike traditional scenario analysis that uses narrative-based assumptions (like "recession" or "boom"), parametric analysis is quantitative and structured.

Advantages:

- Provides a **quantitative view** of sensitivity.
- Can **highlight non-linearities** in the model/system.
- Useful for **regulatory stress testing**

Limitations:

- Can be **computationally intensive** if many parameters vary.
- ...

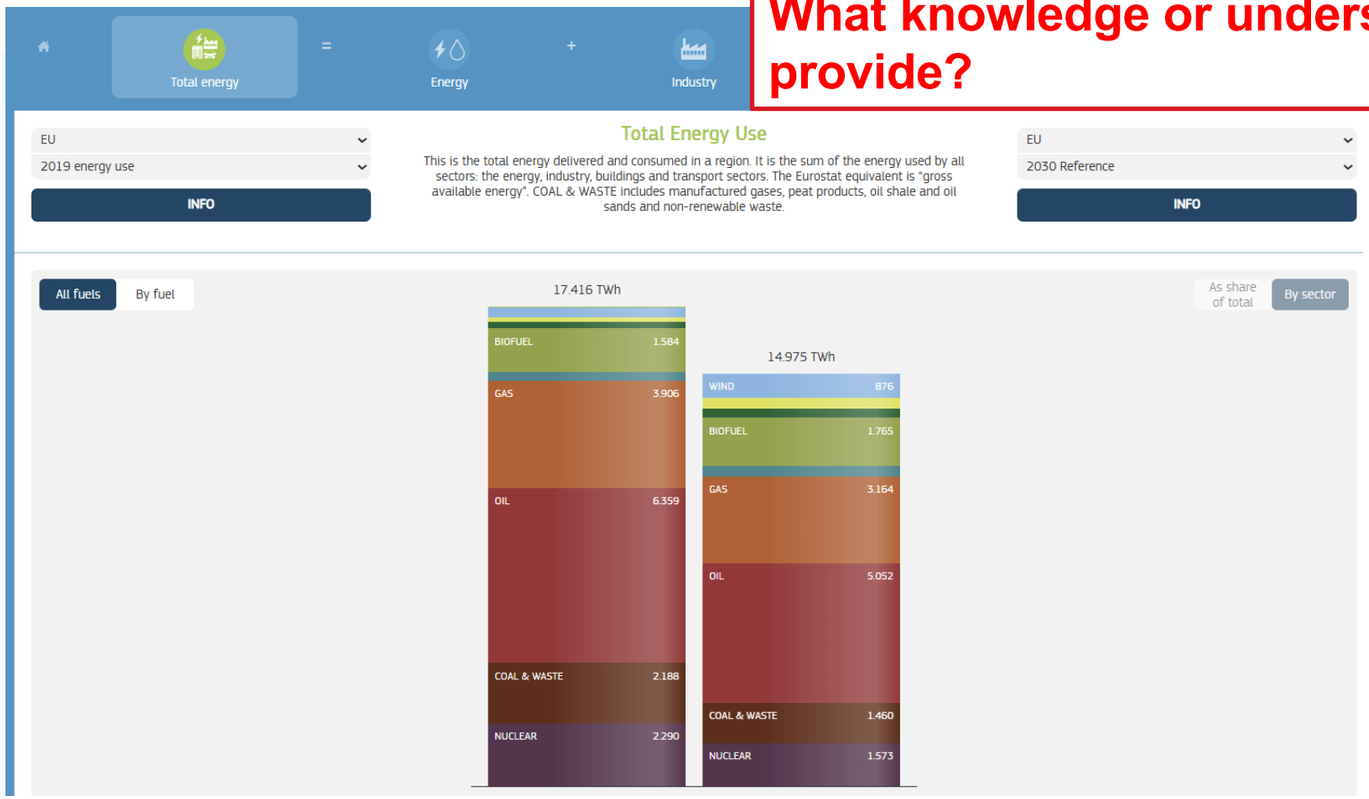
Combinatorial method to explore scenarios (by permutating and combining influencing factors)

Factors/Scenario	Scen1	Scen2	Scen3	Scen4
GHG targets (H/M/L)	L	M	M	H
Import (H,M,L)	M	M	M	
Measures in households (1,2,3)	1	1		3
Measures in industry (1,2,3)	1		1	3
Measures in transportation (1,2,3)		1	1	3
H2-related policies (1,2,3)	1	1	1	3
Others (H,M.L)	L	L	L	M

Illustrative example

Model-based energy-climate scenarios - 5

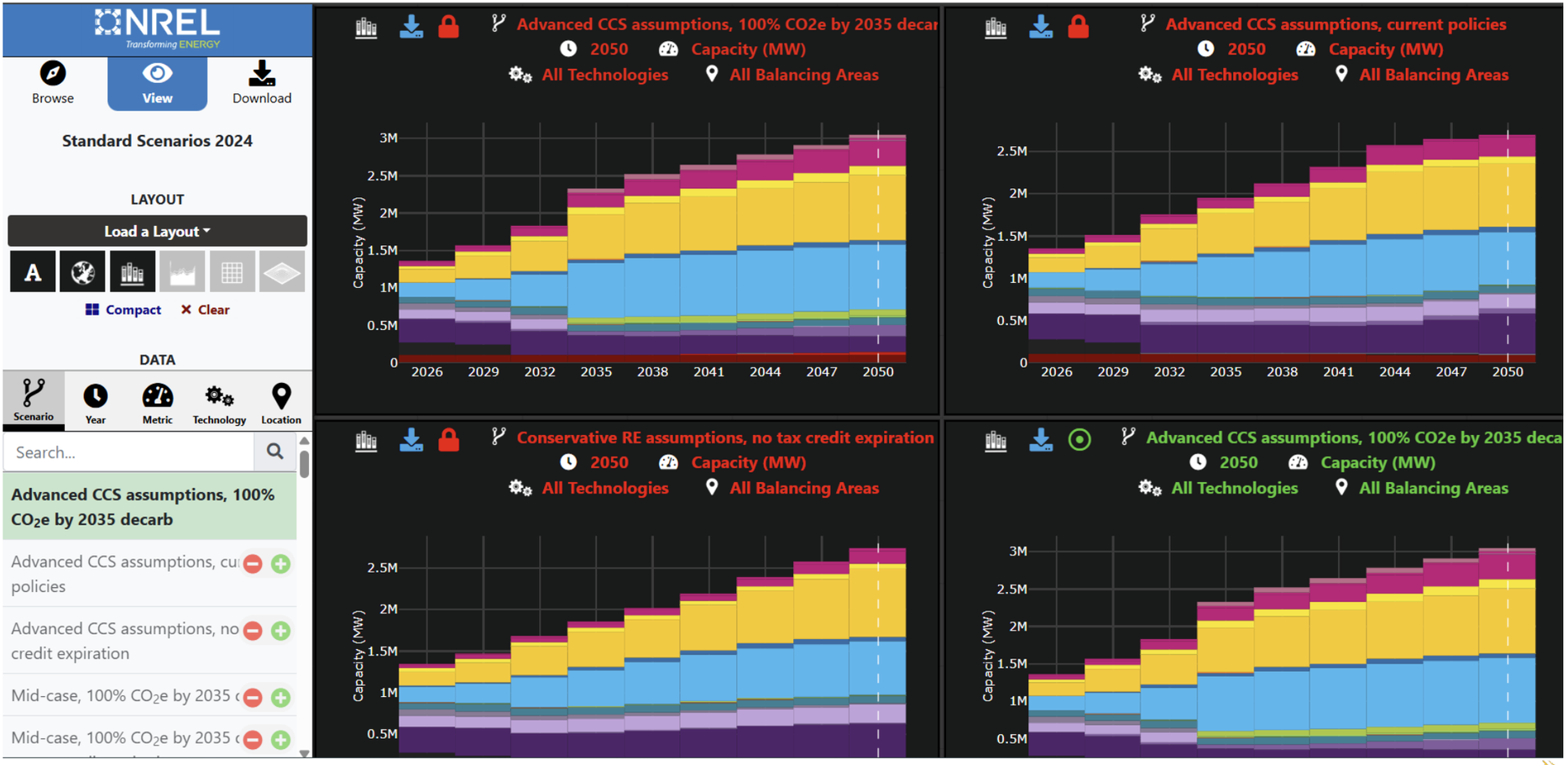
https://web.jrc.ec.europa.eu/visitors-centre-tools/energy_scenarios/



What knowledge or understanding does this provide?

Model-based energy-climate scenarios - 5

https://scenarioviewer.nrel.gov/?project=5573be35-16d1-4bc3-8c4d-38529c7bb640&mode=view&layout=Default



What knowledge or understanding does this provide?

THANK YOU!

Eng. Rocco De Miglio - Energy systems modeller and analyst

Discussion and Q&A

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