

Multi-regional transmission model (former name: D-TIMES)

Energy Model to Make Evidence Based Decision Making
for Achieving Carbon Neutral Goal under Future Uncertainties

Deloitte Tohmatsu Consulting LLC
November 2022



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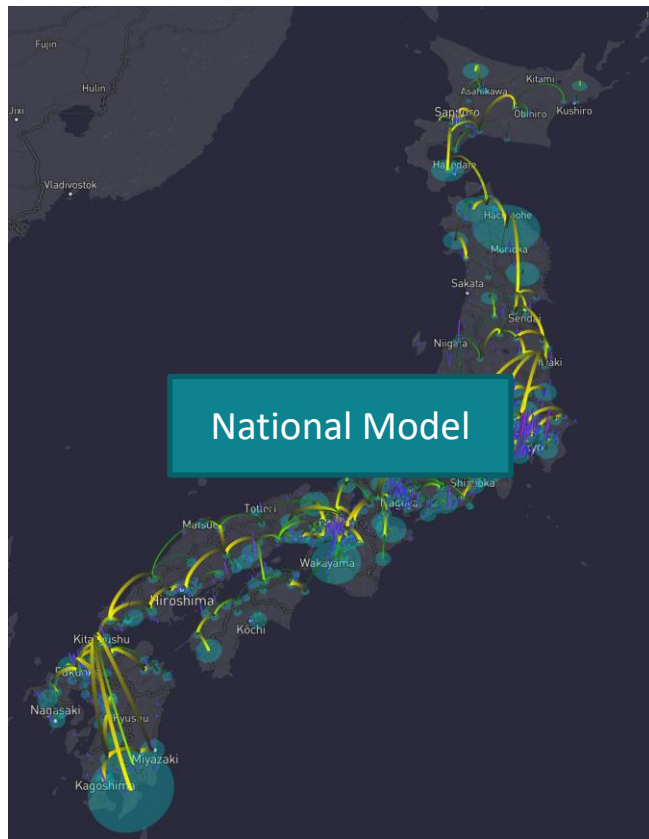
- I. Why Do We Build/Need the Simulation?
 - Challenges to Achieve Carbon Neutral Target
 - Shift to Renewable Based Energy System
 - Complex and Inter-connected Energy System

- II. What is the Multi-regional transmission model (former name: D-TIMES) ?
 - System Views
 - High Regional Resolution
 - Energy Infrastructure
 - Economic and Social Change

- III. Model Use Case
- IV. Global model
- V. Democratisation of Knowledge
- VI. Demo

Multi-regional transmission model (former name: D-TIMES) : National and Global Energy Model

National Model



Global Model



https://unsplash.com/ja/%E5%86%99%E7%9C%9F/vhSz50AaFAs?utm_source=unsplash&utm_medium=referral&utm_content=creditShareLink

I. Why do we need the simulation?

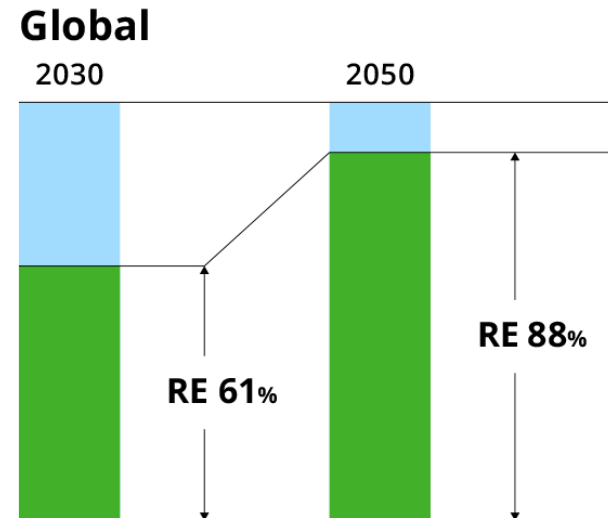


The **Paris Agreement** and
Nationally Determined Contribution (NDC)
Promote Energy Transition to
Realise Carbon Neutral Societies.

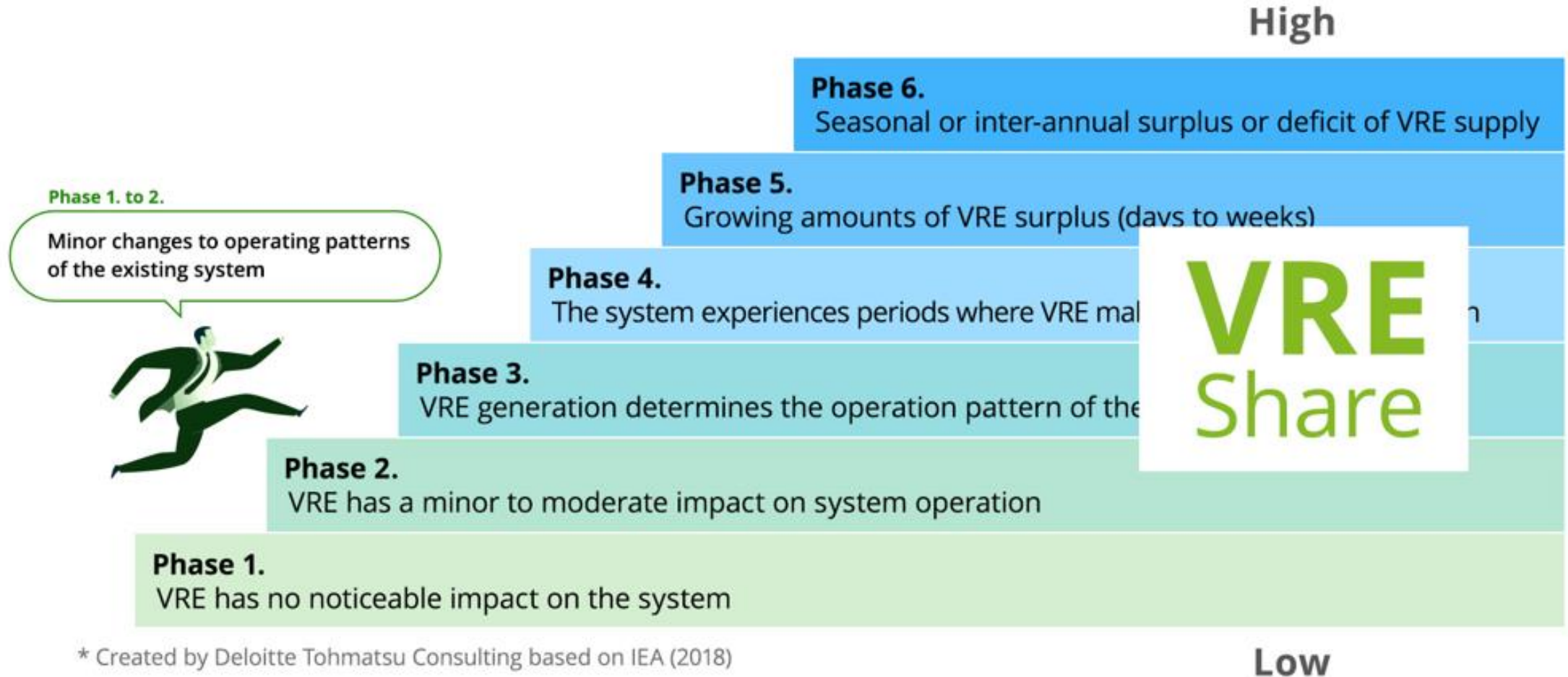
The **Paris Agreement** and Nationally Determined Contribution (NDC) Promote Energy Transition to Realise Carbon Neutral Societies.



The share of RE will be 61% in 2030 and 88% in 2050 (IEA, 2021)



The Different Phases of Energy Integration as VRE Share Increase

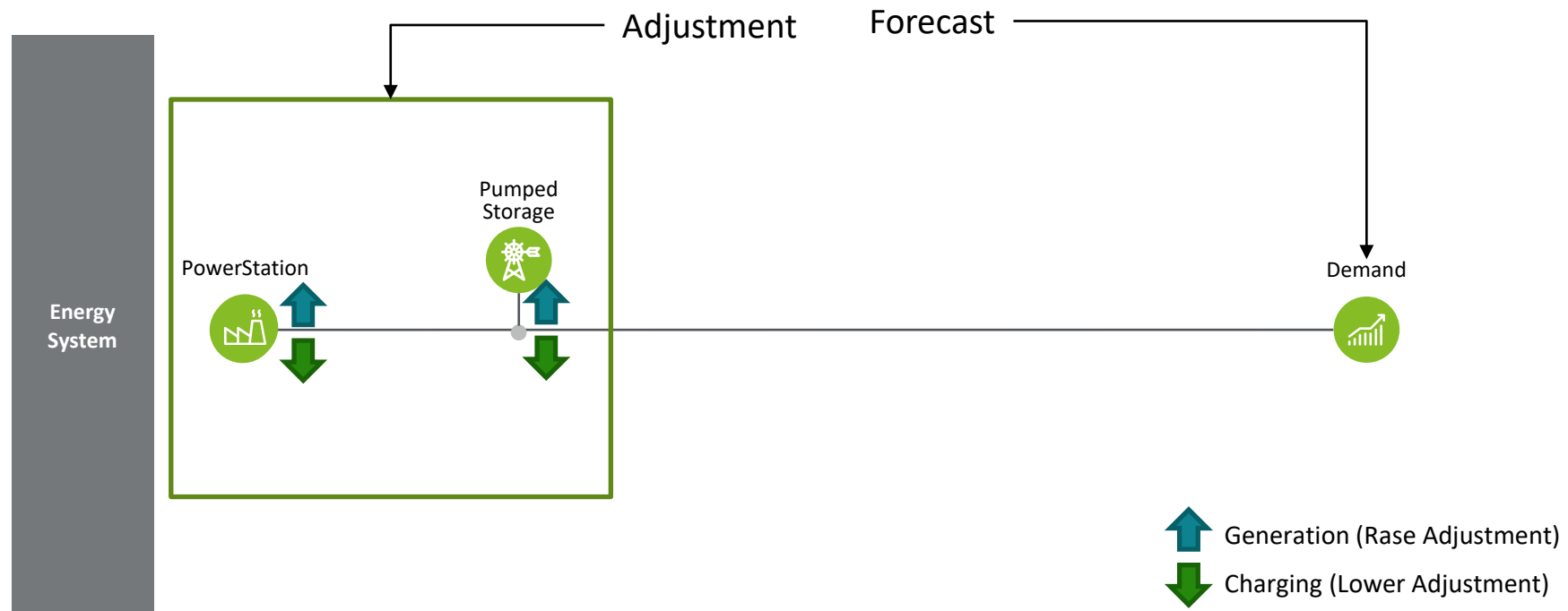


* Created by Deloitte Tohmatsu Consulting based on IEA (2018)

I. WHY DO WE BUILD/NEED THE SIMULATION?

Existing Energy System (e.g. Electricity)

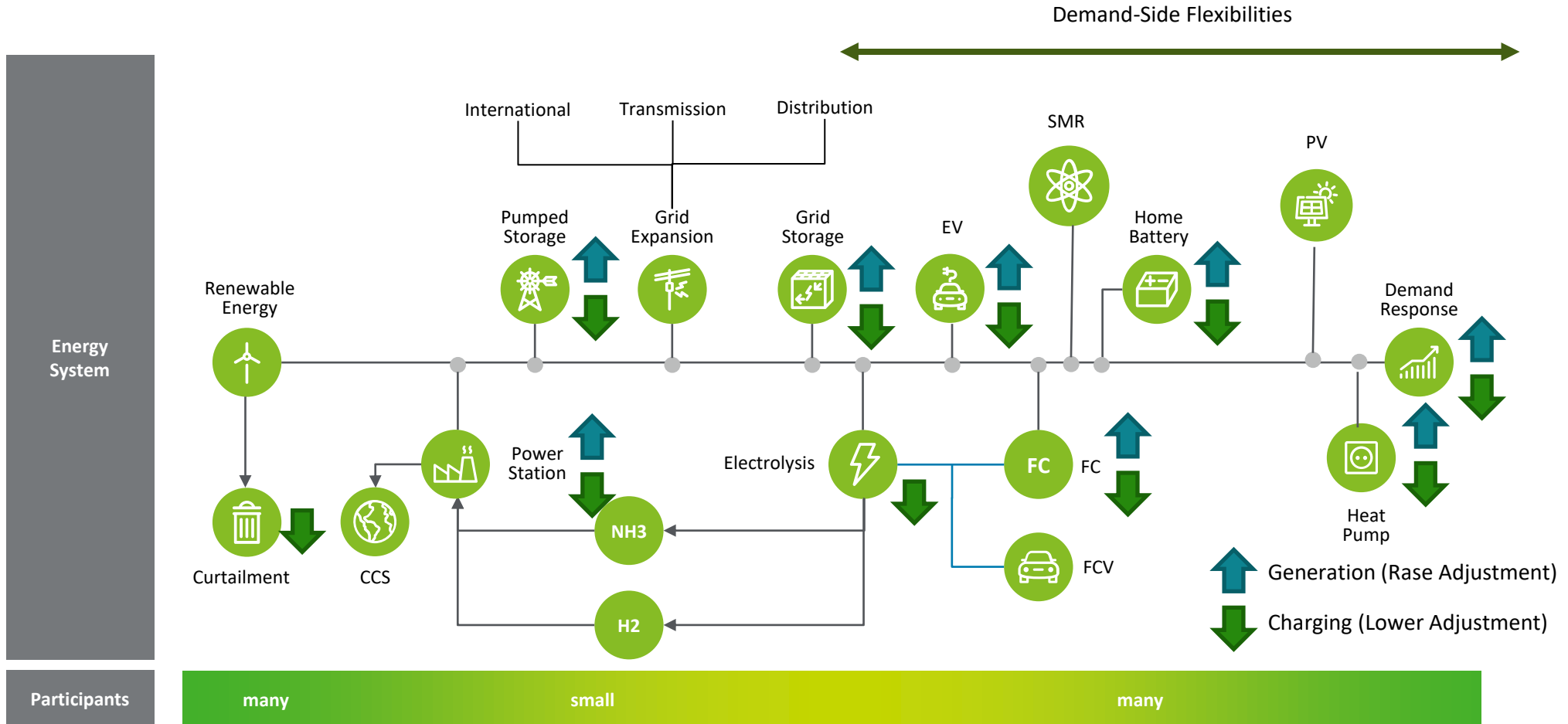
Conventional energy system is simple value-chain and supply adjustment-based.



I. WHY DO WE BUILD/NEED THE SIMULATION?

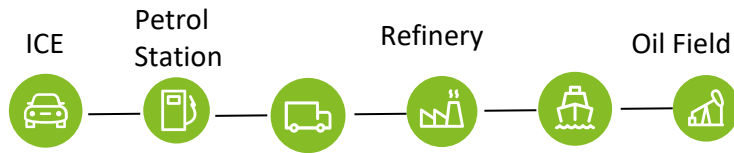
Carbon Neutral Era Energy System

Existing energy analysis methodology cannot use for business strategy and policy analysis, We need to build new tool which reflect 1) System View, 2) High Regional Resolution , 3) Energy Infrastructure and 4) Economic and Social Change.



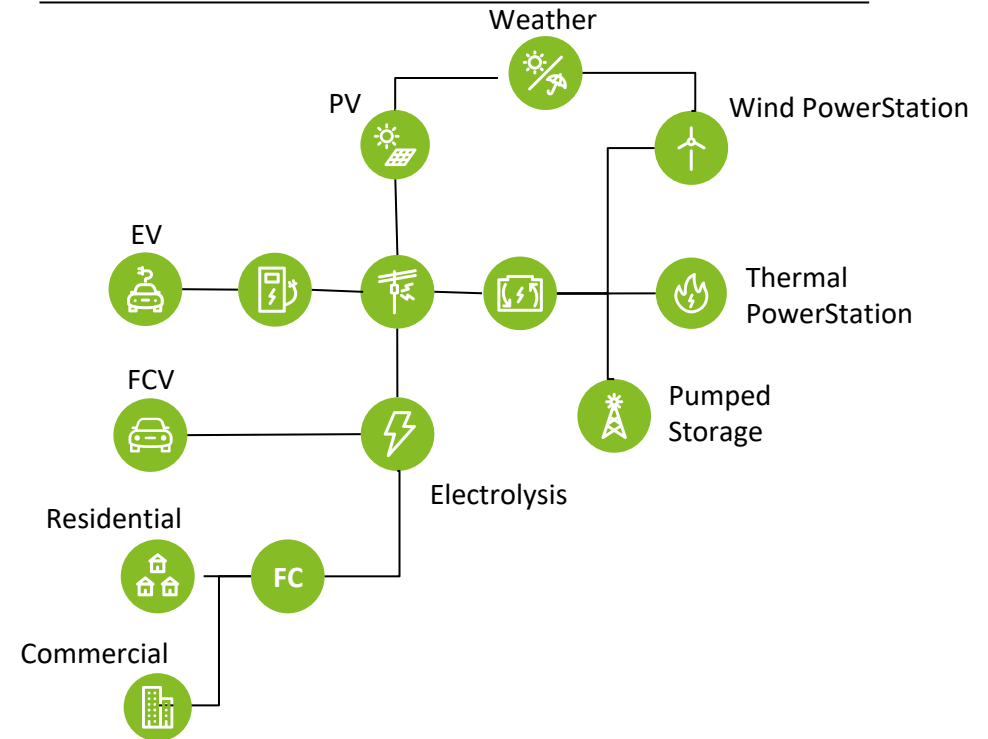
Vehicle become a part of energy system

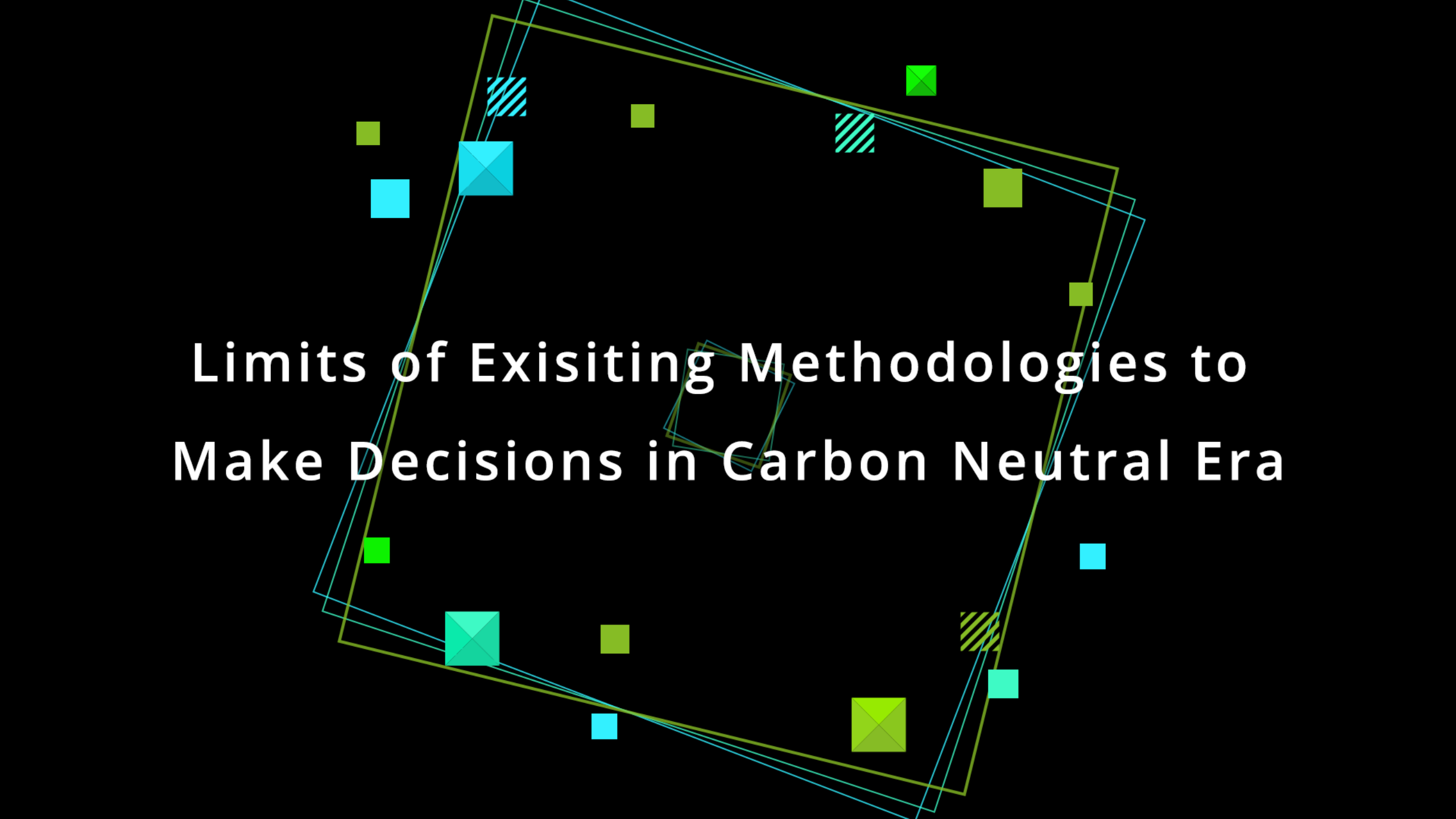
ICE* Value Chain (Sectoral View)



*ICE (Internal Combustion Engine)

EV Value Chain (System Views)



The background features a complex geometric design. It consists of several overlapping, irregular polygons outlined in thin, light-colored lines (cyan and lime green). Scattered throughout the composition are various colored squares: solid cyan, solid lime green, and squares with diagonal hatching in cyan and lime green. The overall aesthetic is modern and technical.

Limits of Existing Methodologies to Make Decisions in Carbon Neutral Era

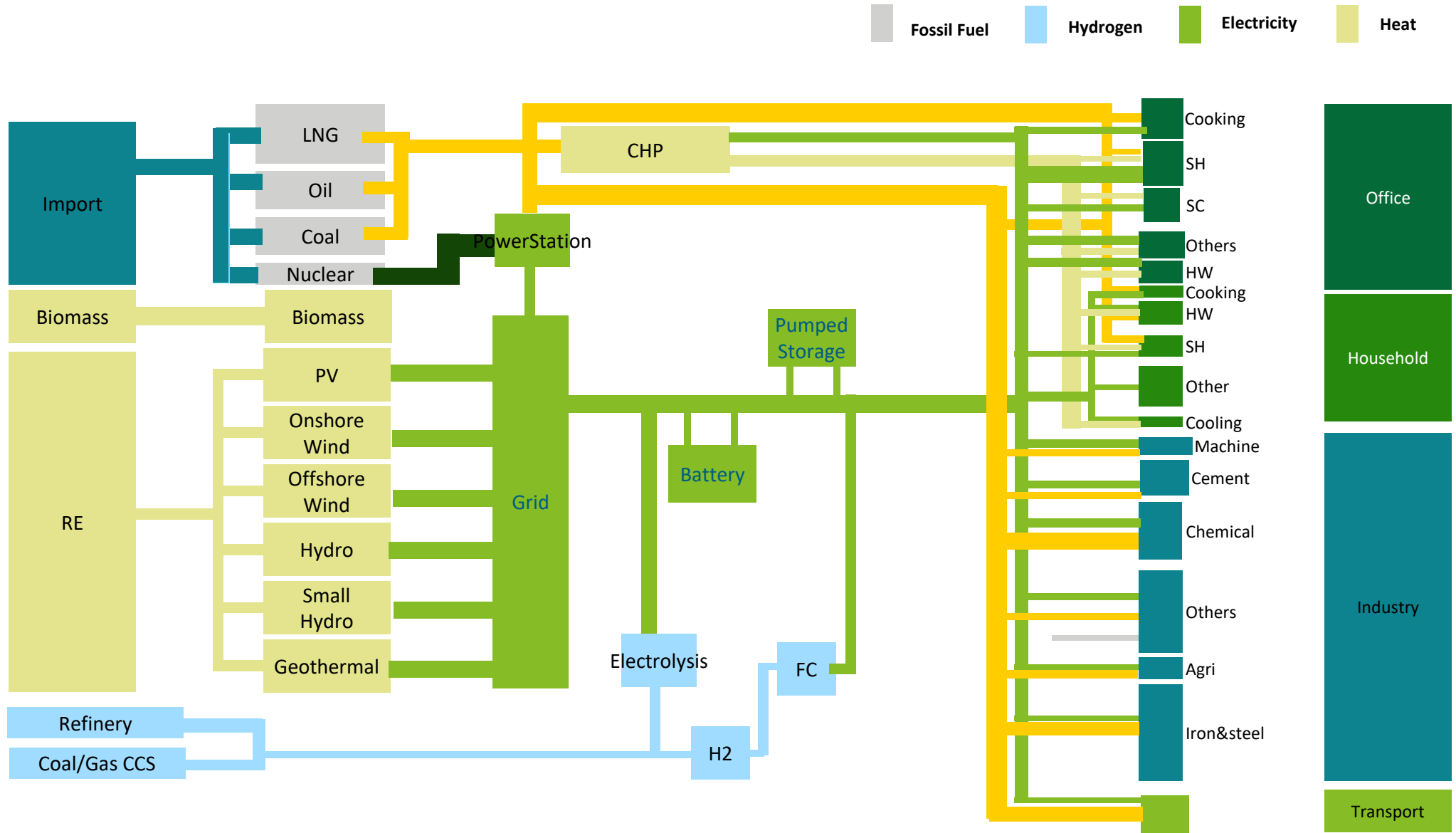
What is the Multi-regional transmission model (former name: D-TIMES)



Uniqueness of D-TIMES

(Deloitte Energy Simulations)

All Energy and Sectors are Modelled



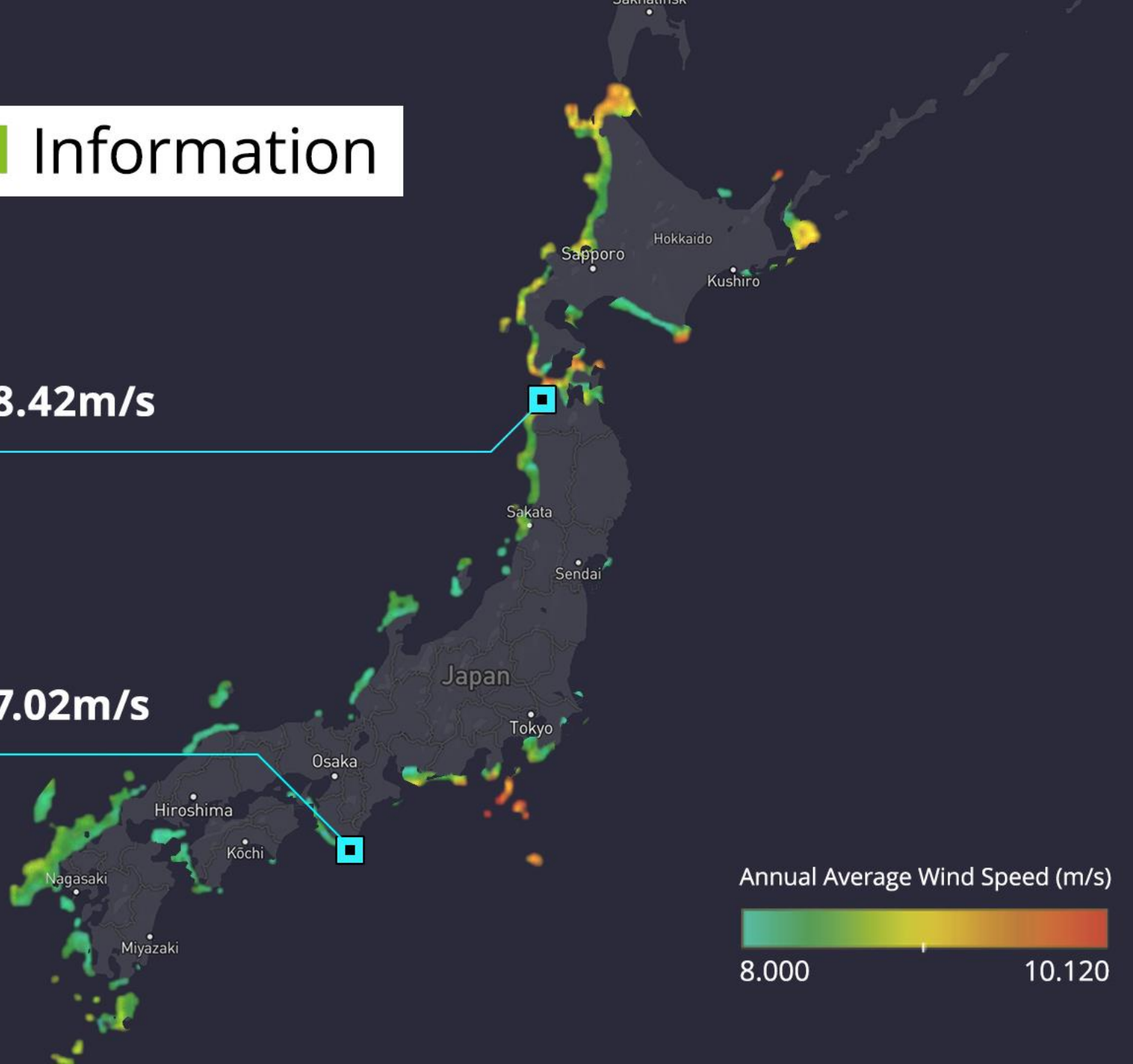
Detailed **Geological** Information on Renewables.

Average Wind Speed : **8.42m/s**

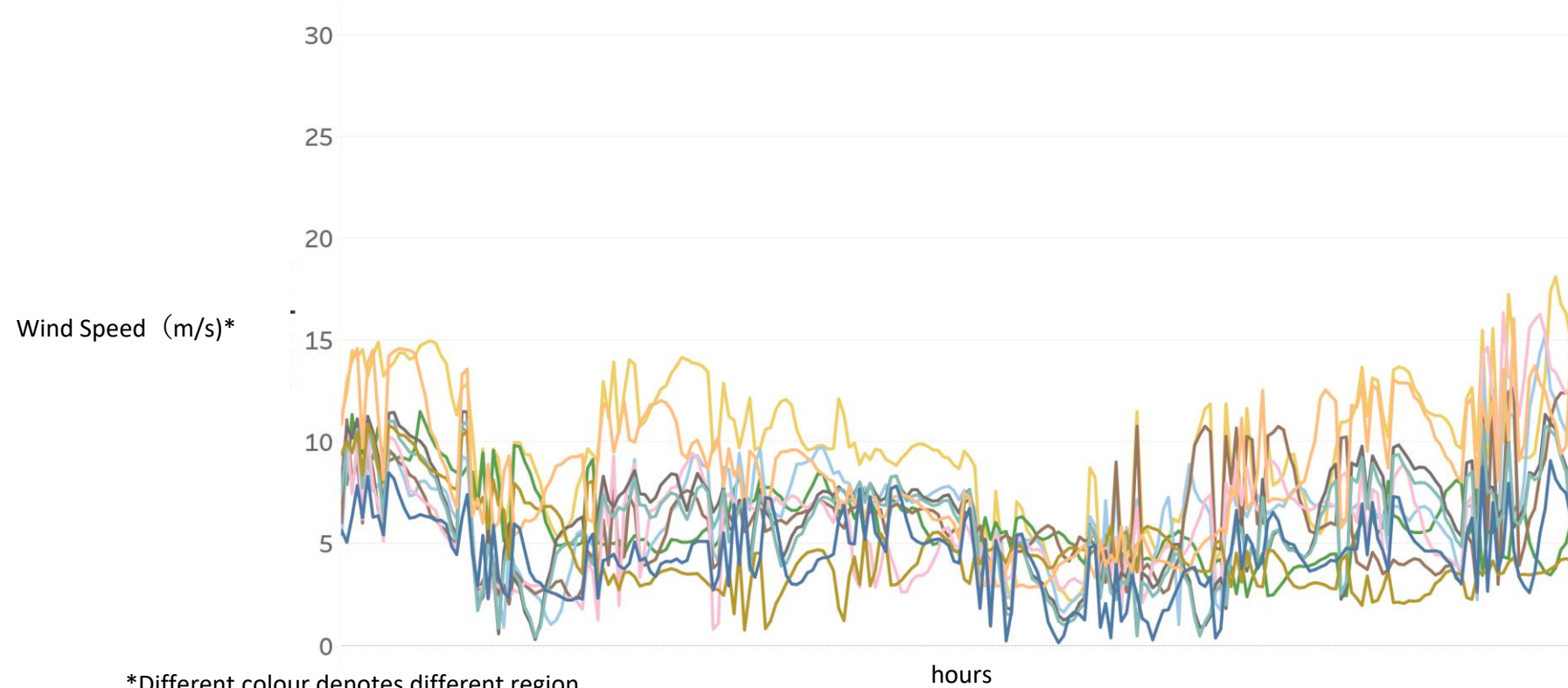
Sea Depth : **46m**

Average Wind Speed : **7.02m/s**

Sea Depth : **8m**



Wind Speed by Region

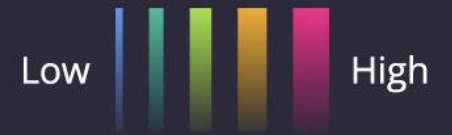


*Different colour denotes different region.

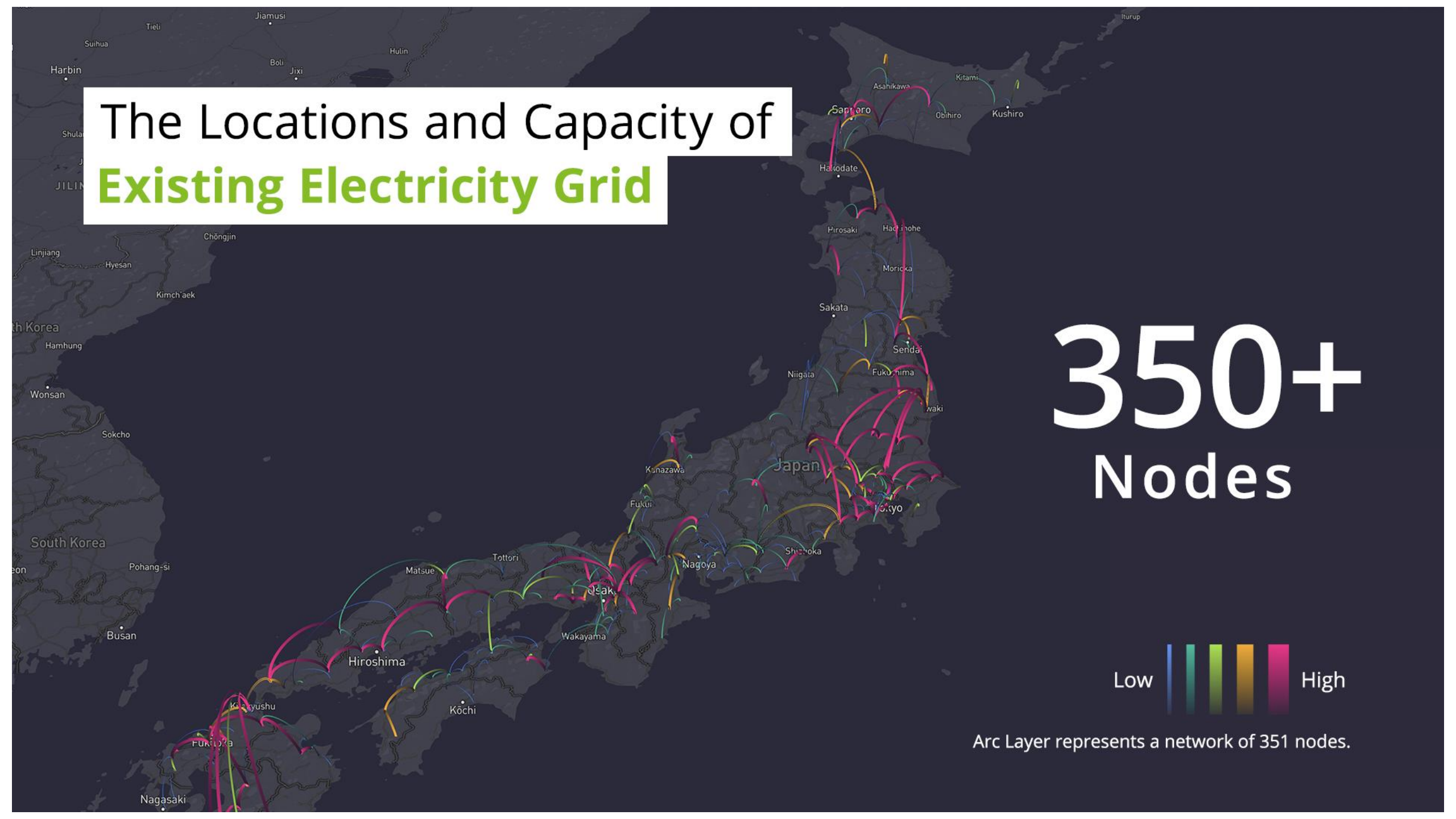
Source: <http://www.soda-pro.com/web-services/meteo-data/merra>

The Locations and Capacity of Existing Electricity Grid

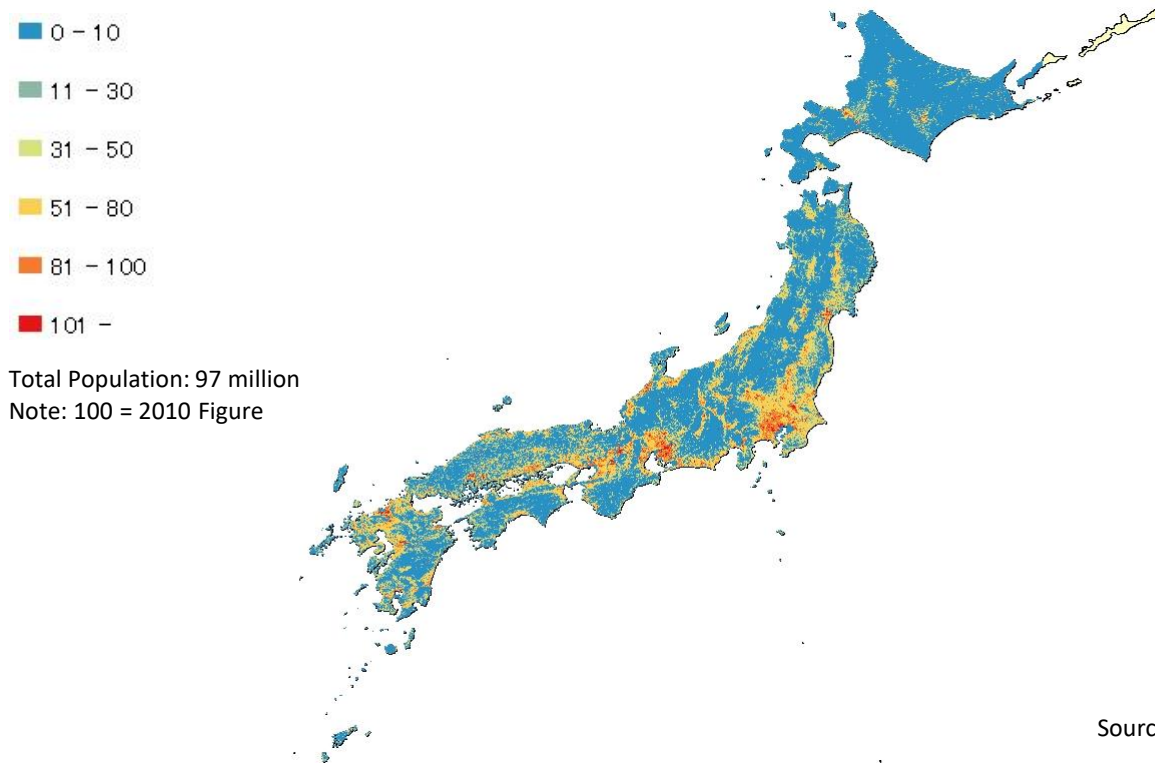
350+
Nodes



Arc Layer represents a network of 351 nodes.



Population Change towards 2050



Source: MLIT, <http://nlftp.mlit.go.jp/ksj/index.html>

Visualisation of Big/Complex Simulation Results

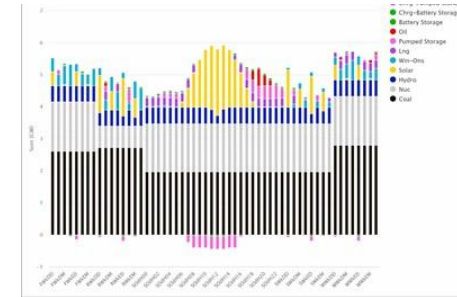
Human brains process visuals **60,000** times faster than they do text. (University of Minnesota)

Traditional Visualisation

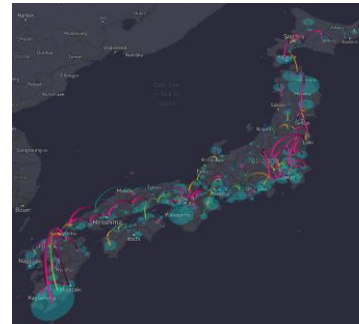


21st Century Visualisation

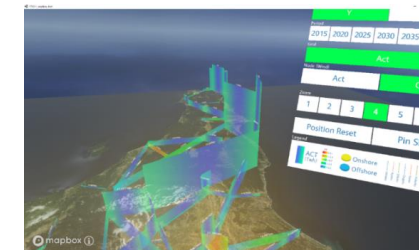
Motion Chart
Generation & Charging
by Time and Technology



WebGIS
Renewables by Node
Grid Utilisation Rate



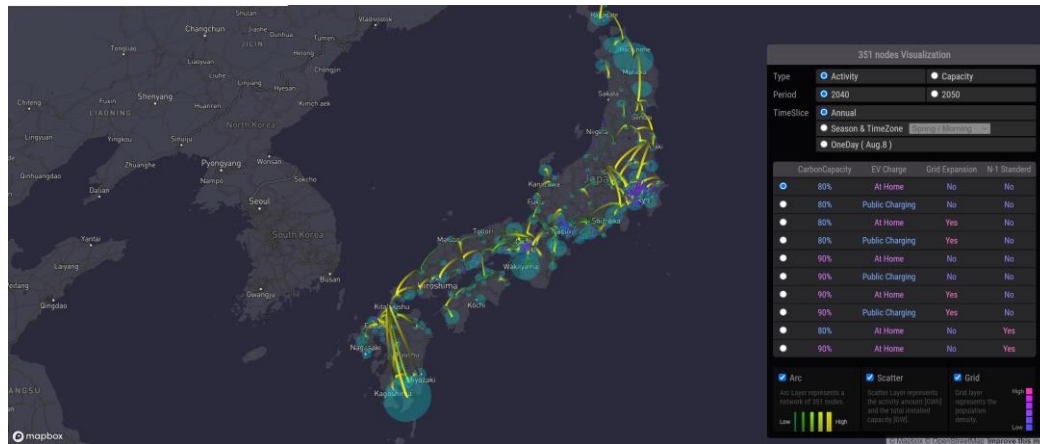
Immersive & Interactive
Electricity Flow between nodes
VRE* Capacity/Generation



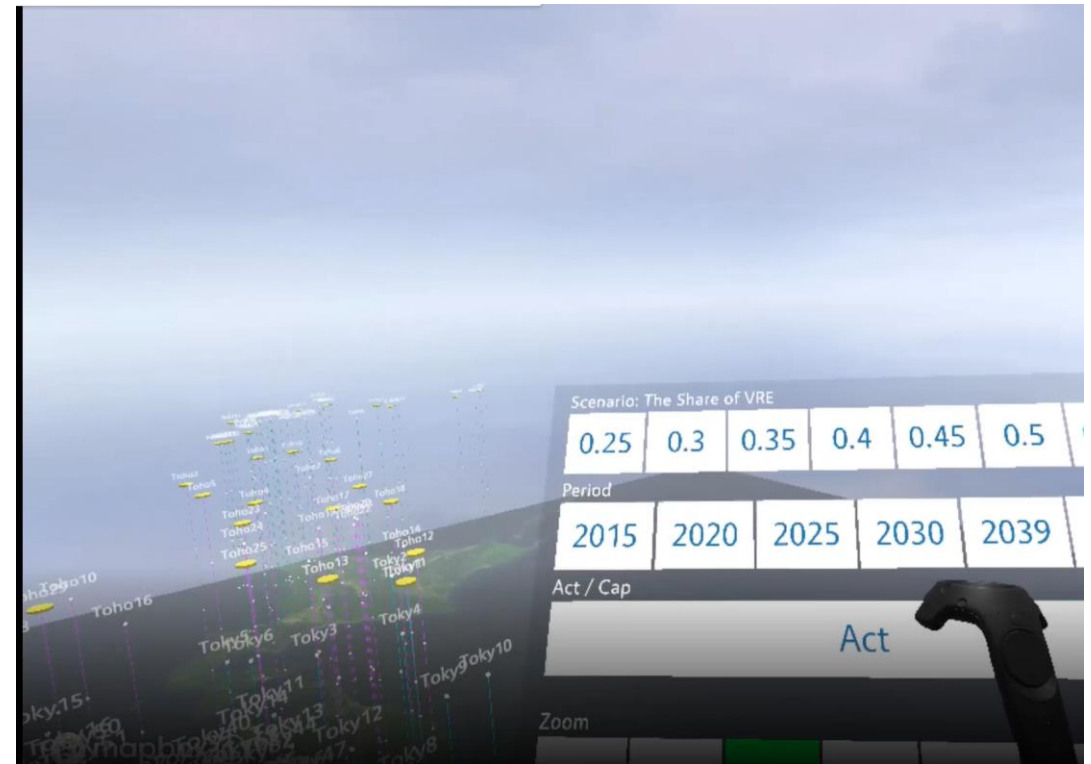
*VRE: Variable Renewable Energy

Visualised Simulation Results

Web GIS



Immersive VR



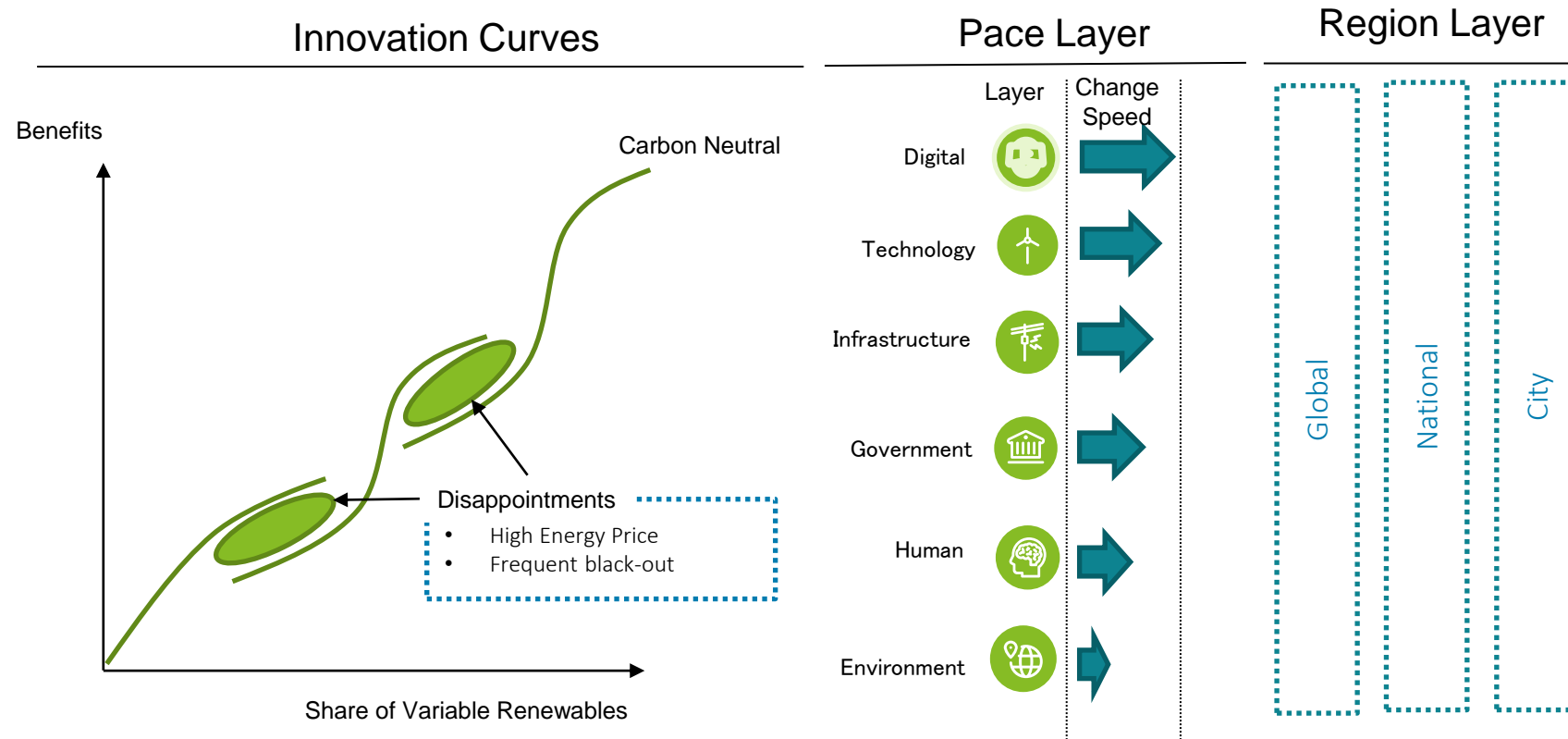
III. MODEL USE CASES

Energy System for

Realising De-carbonisation Society
under the Combinations of Uncertainties

TIMES Identifies Solutions to Achieve Carbon Neutral by Layer

TIMES are widely used by Government and Private Companies for a variety of Purposes, e.g. 1) Policy Making/Analysis, 2) Future Market Analysis, 3) Technology R&D, 4) Infrastructure Development Plan and 5) Mid-long Term Business Plan.





Market :

Future Optimised Energy System and
Market Size by Technology and Region



R&D :

How much target should be set to be employed in De-carbonisation market.



Energy Infrastructure and Global Energy Supply Chain



Policy Analysis

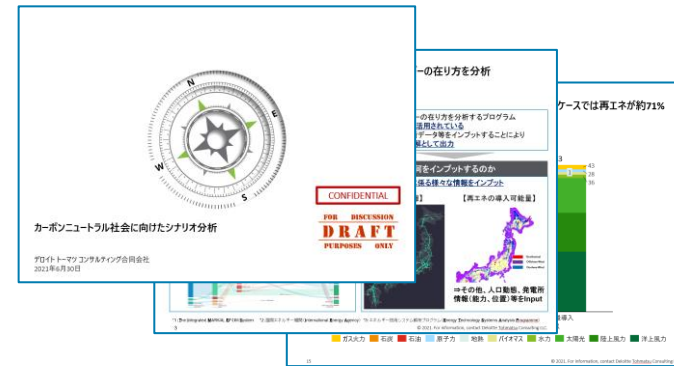
Contributions to EBPM*

DTC did a presentation at the METI's Sub-committee on Energy Basic Plan and insisted that electricity price increase sharply under current energy system to achieve carbon neutral target and energy system should have further flexibilities to minimise an integration cost to absorb the high share of renewables.

METI's Sub-committee on Energy Basic Plan



*EBPM (Evidence Based Policy Making)



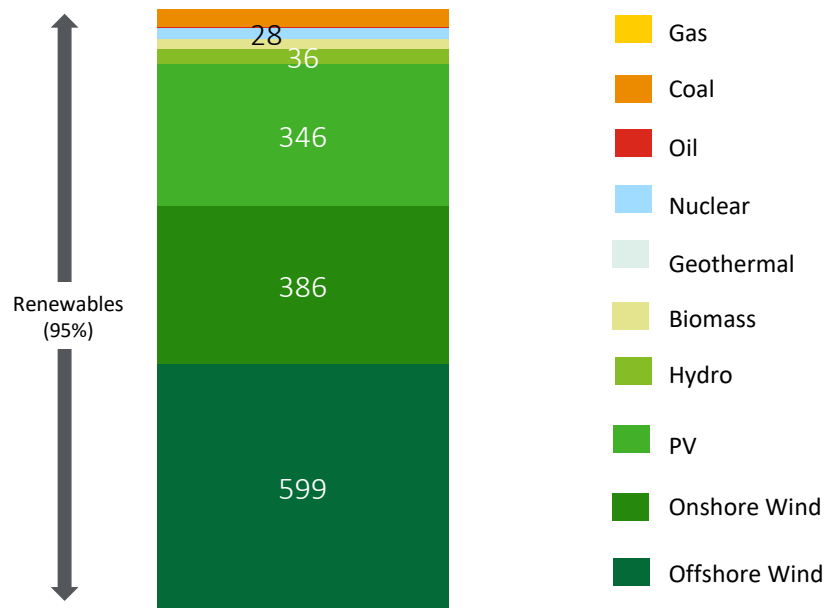
Nikkei, 30th June 2021

Decarbonization will increase power generation costs by 2 times in 2050, panel says, METI Councils

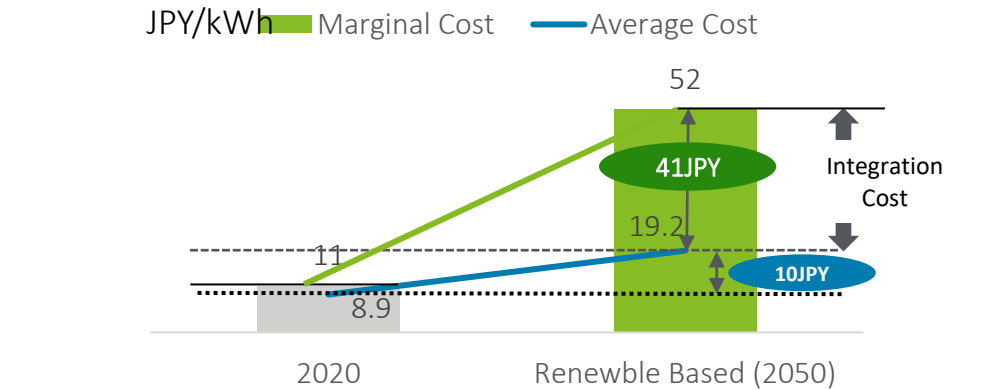
How to minimise integration costs

Electricity price will increase from 11JPY/kWh to 52JPY/kWh. To decrease an integration cost is a key factor to realise carbon neutral society towards 2050.

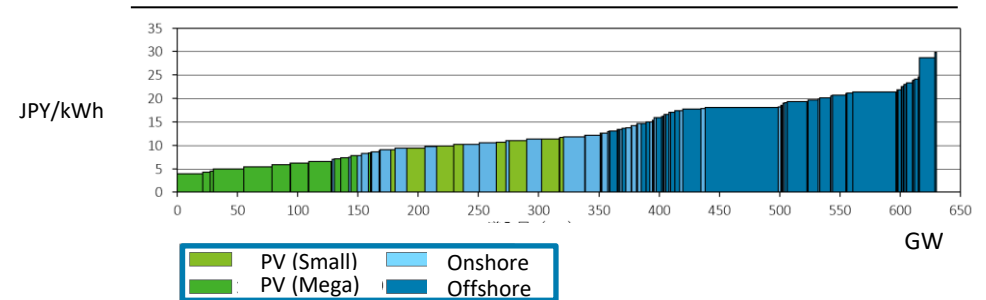
Electricity Generation in 2050



Marginal and Average Cost of Electricity



Merit-Order Curve



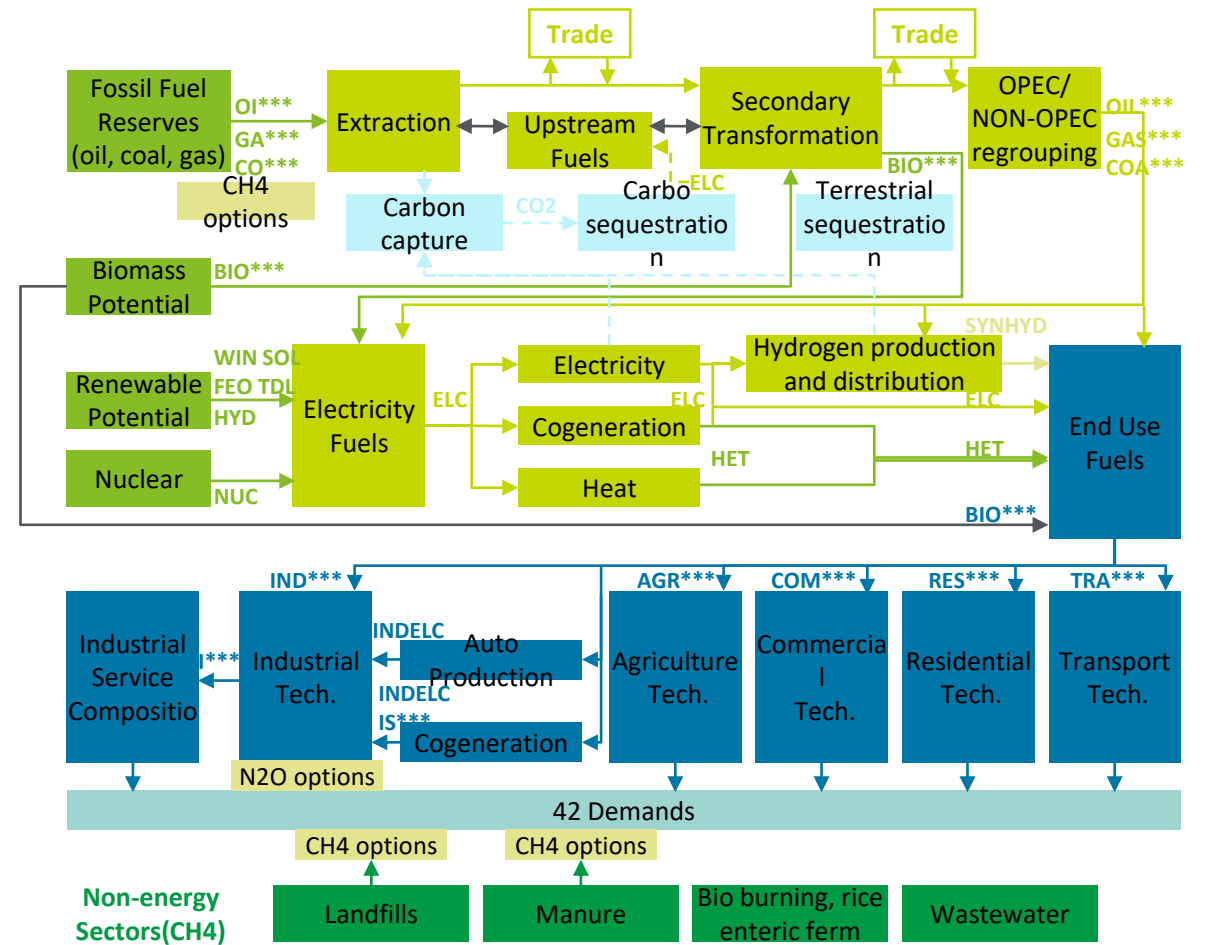
IV. Global model

Overview of Global Model

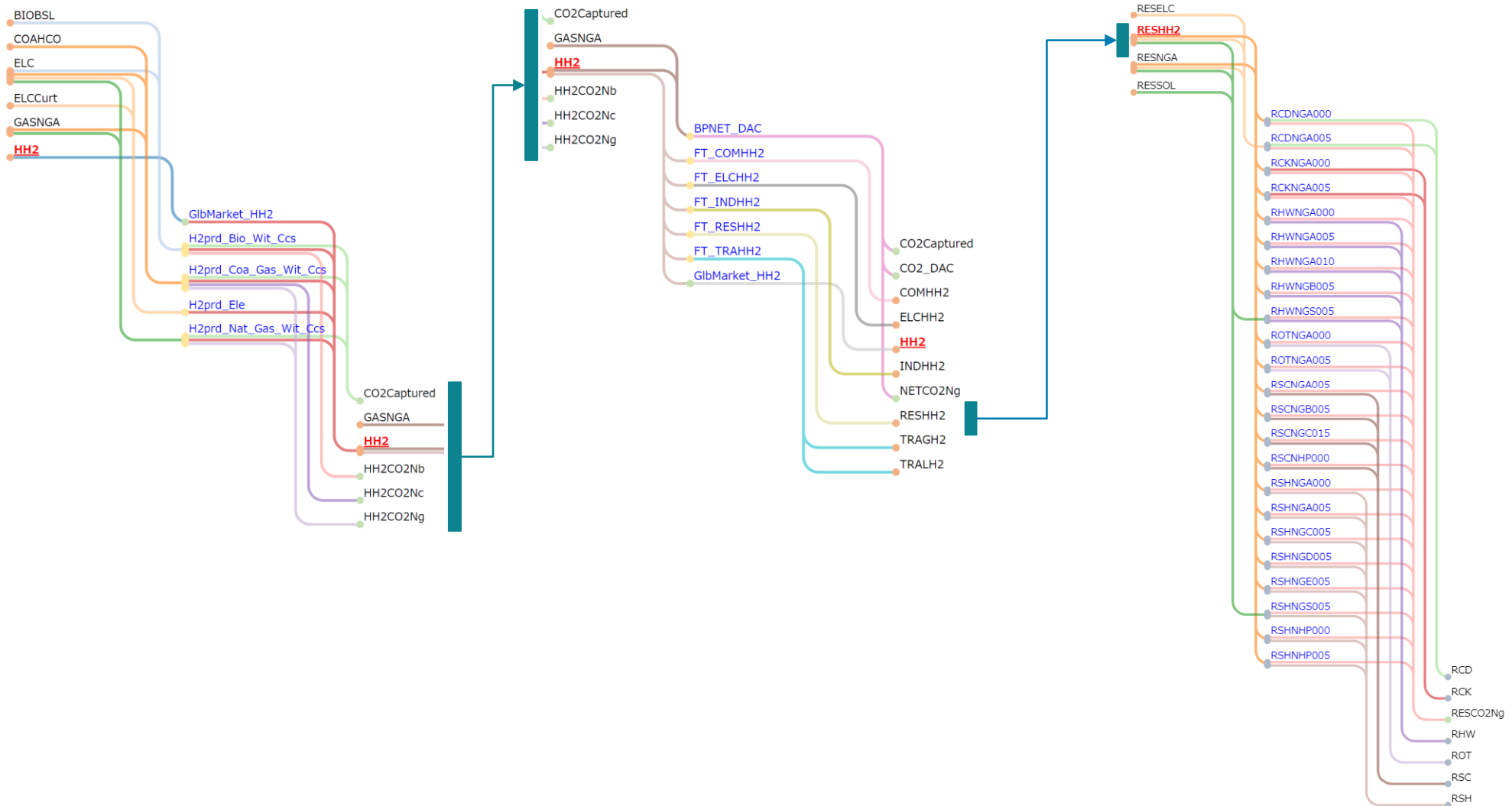
30 Countries/Regions

	Region/Country	Description		Region/Country	Description
1	Africa	Africa	16	Mexico	Mexico
2	Africa_North	North Africa	17	MidEast	Middle East
3	ArgenChil	Argentine and Chille	18	Russia	Russia
4	Asia_Cen	Central Asia	19	SaudiArabia	Saudi Arabia
5	Asia_Em	Emergrging Asia	20	UK	UK
6	AusNZ	Australia and NZ	21	USA	USA
7	Brazil	Brazil	22	Asia_Dev	Developed Asis
8	Canada	Canada	23	Eur_Em	Emerging Eurpe
9	China	China	24	Germany	Germany
10	EU26	EU26	25	Indonesia	Indonesia
11	Eur_Dev	Developed Eurpoe	26	Japan	Japan
12	France	Frace	27	Malaysia	Malaysia
13	GCCother	Gulf Countries	28	Qatar	Qatar
14	India	India	29	SouthKorea	South Korea
15	LatAm	Latin America	30	UAE	USA

Reference Energy System (RES)

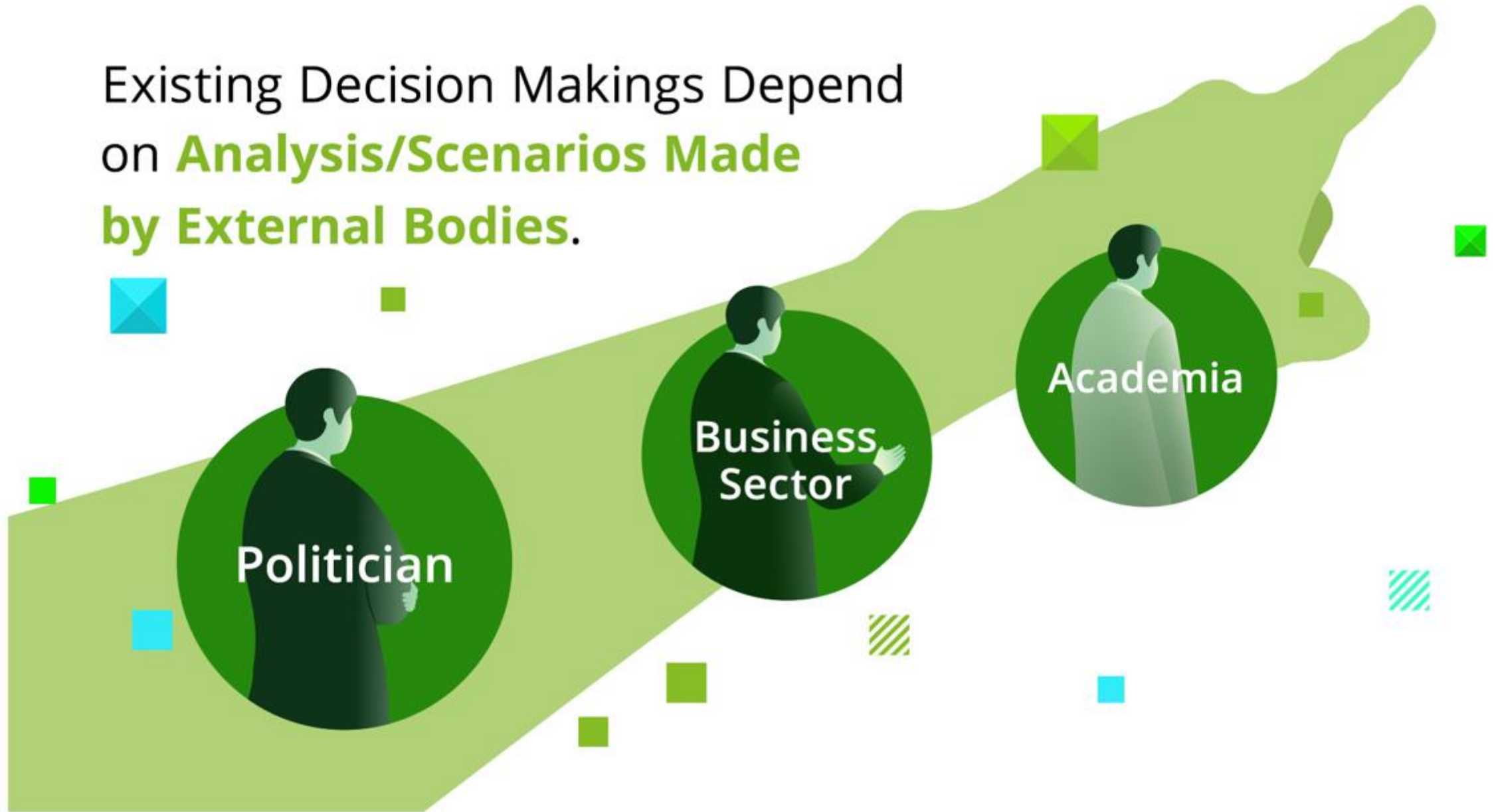


e.g. Hydrogen Network Diagram



IV. Democratisation of Knowledge

Existing Decision Makings Depend on **Analysis/Scenarios Made by External Bodies.**





U





H_2

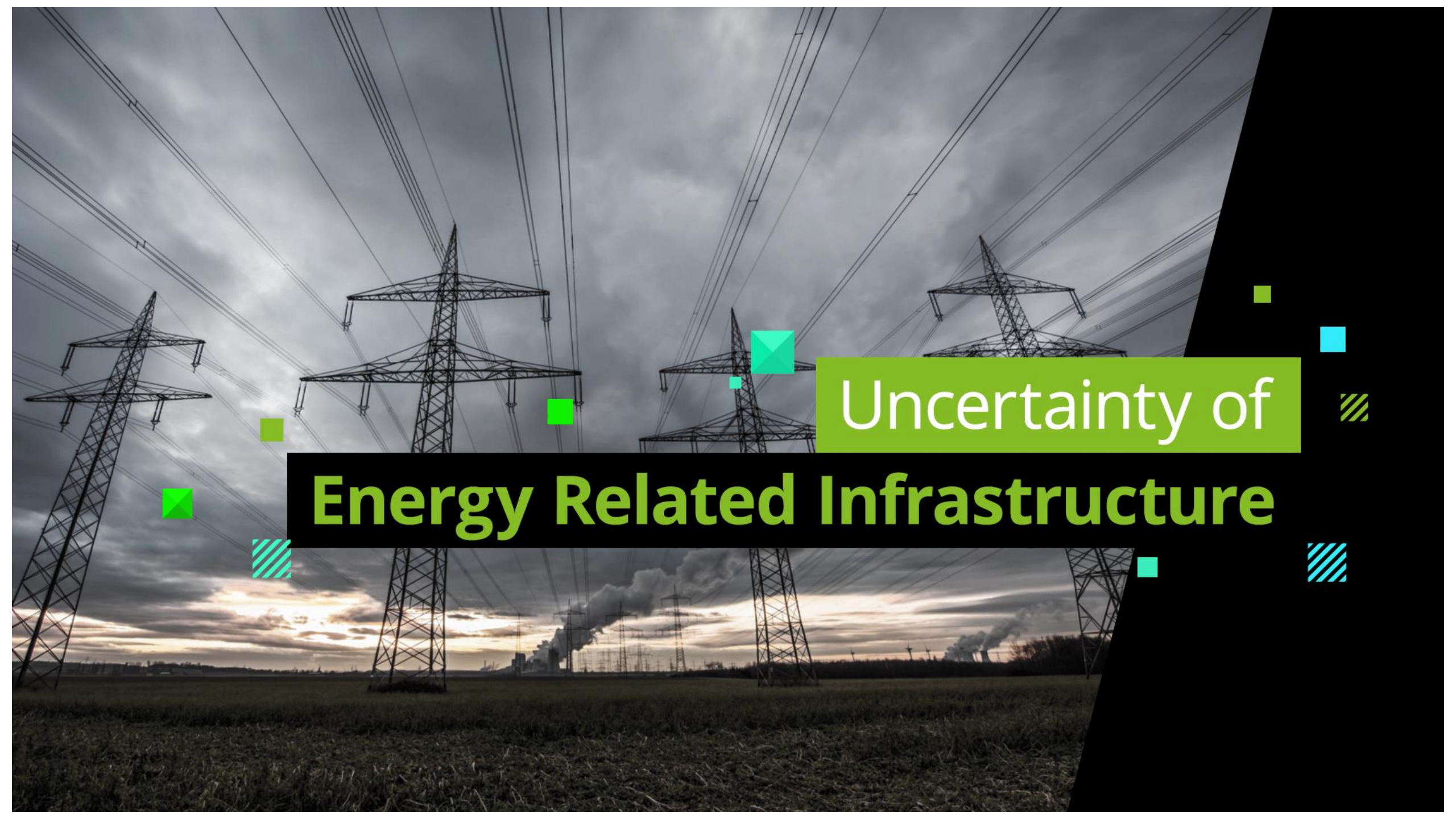
H_2

H_2

H_2

Uncertainty of

Technologies



Uncertainty of

Energy Related Infrastructure



System Thinking under

a Variety of Uncertainties

Web-based UI/UX

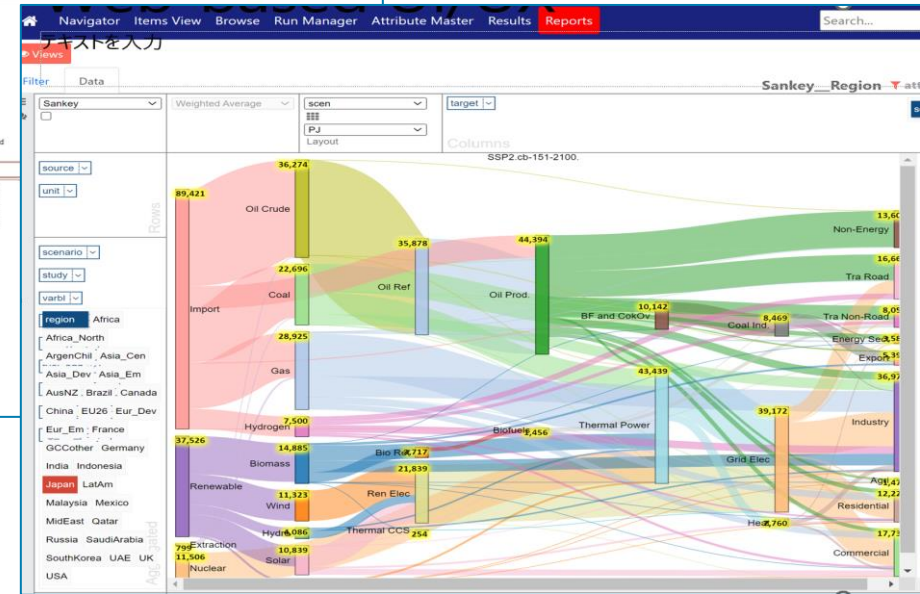
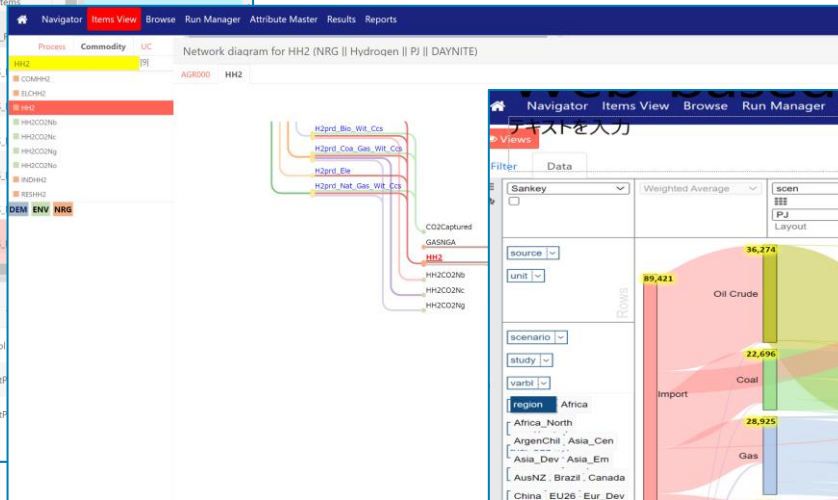
Simulation Settings/Run

Diagram

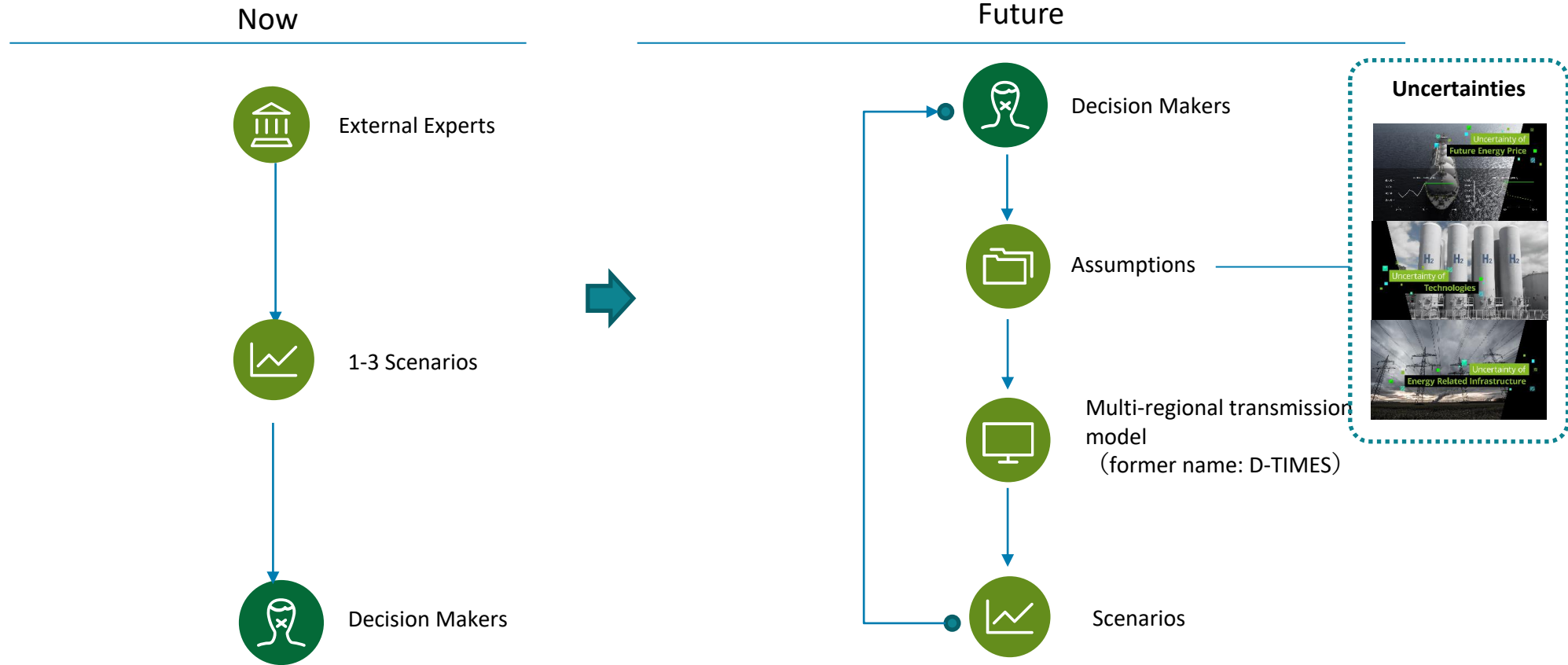
Results Visualisation

The screenshot shows the 'Run Manager' interface. It features a top navigation bar with 'Navigator', 'Items View', 'Browse', 'Run Manager', 'Attribute Master', 'Results', and 'Reports'. Below this, there are several panels: 'Scenario Groups' (18 / 18 Items), 'Region Groups' (31 / 31 Items), 'Parametric Groups' (4 sensi for TS48), and 'Property Groups' (DefaultProperties). A table at the bottom lists 'Manage Saved Cases' with columns for Case, Description, User, Source Times, Scenar..., Region..., Param..., and Proper....

Case	Description	User N...	Source Times	Scenar...	Region...	Param...	Proper...
TFRef	TIAM2022 set up	amitkanudia	GAMS_SrcTIMES.v...	Ref set - TS12	AllRegion		Save sol
TF	CO2	amitkanudia	GAMS_SrcTIMES.v...	Ref set - TS12	AllRegion	all_C- budgets_CC...	DefaultF
TFRef-icoe	icoe computation	amitkanudia	GAMS_SrcTIMES.v...	Ref set - TS12-icoe	AllRegion		DefaultF



Independent Evidence Based Decision Making





Democratisation of Knowledge

for Evidence-based Decision Making



VI. Demo

Sample Scenarios for Systems Analysis

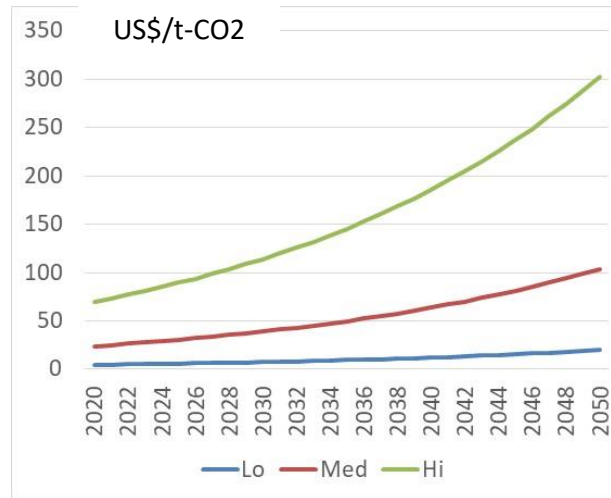
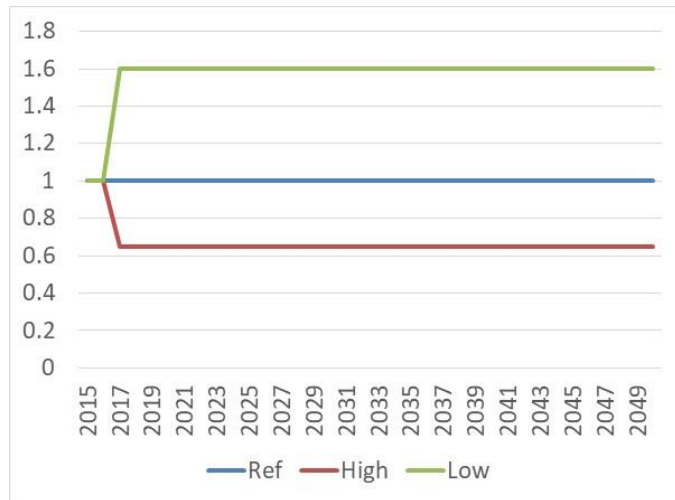
Gas Price
Ref
High
Low

×

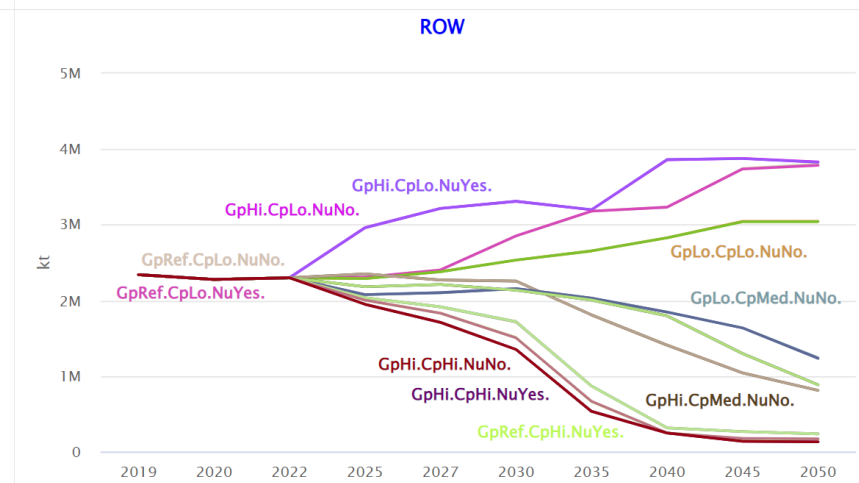
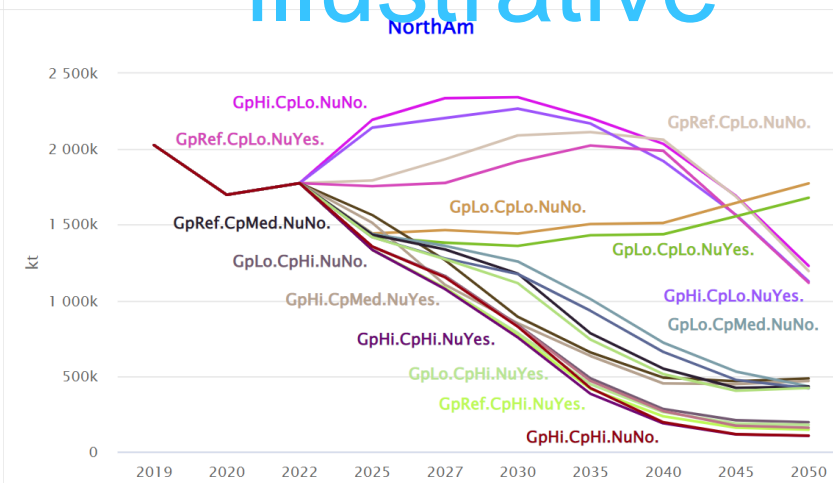
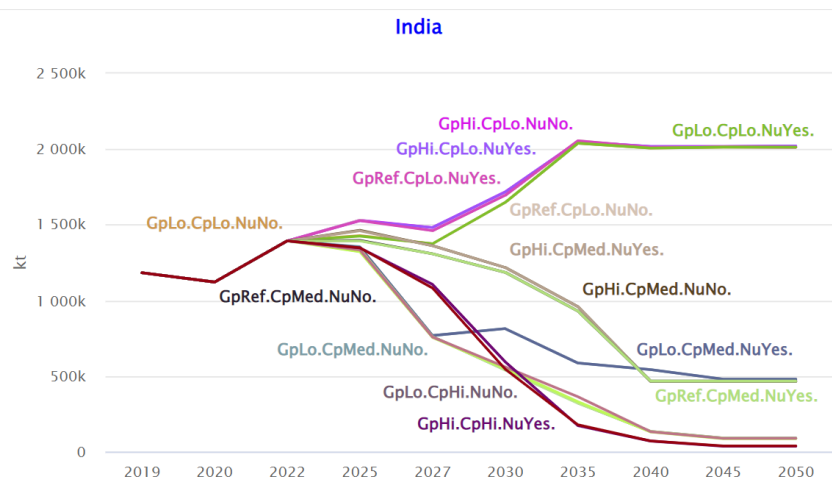
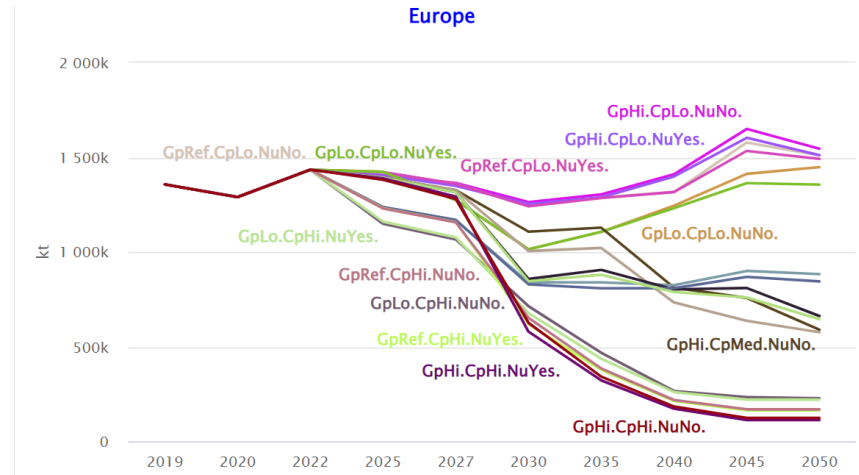
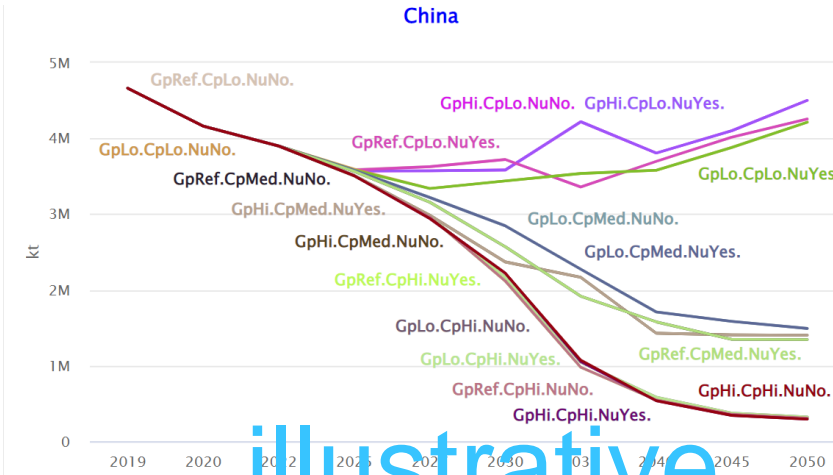
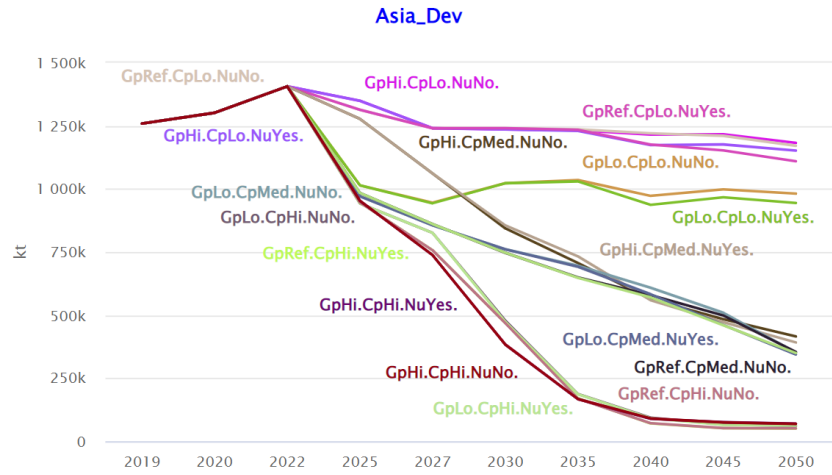
Carbon Price
Low
Mid
High

×

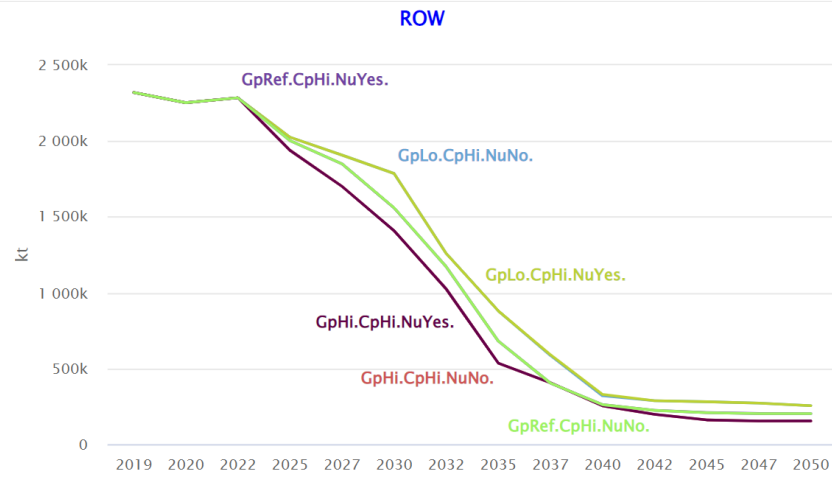
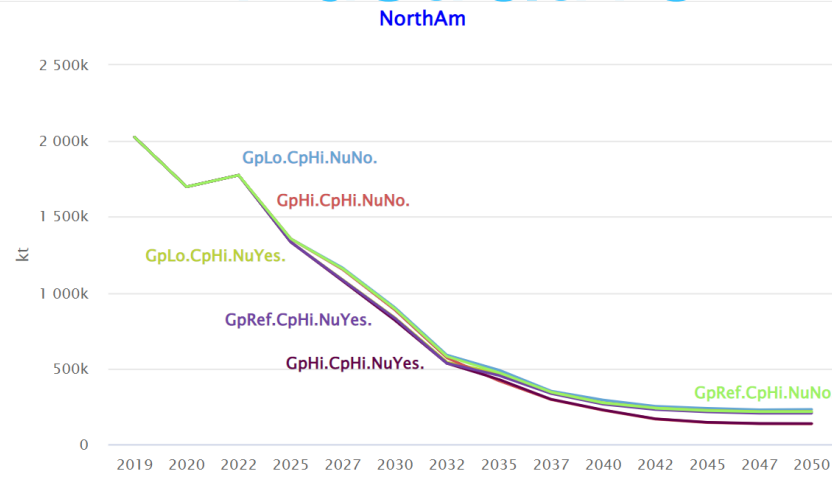
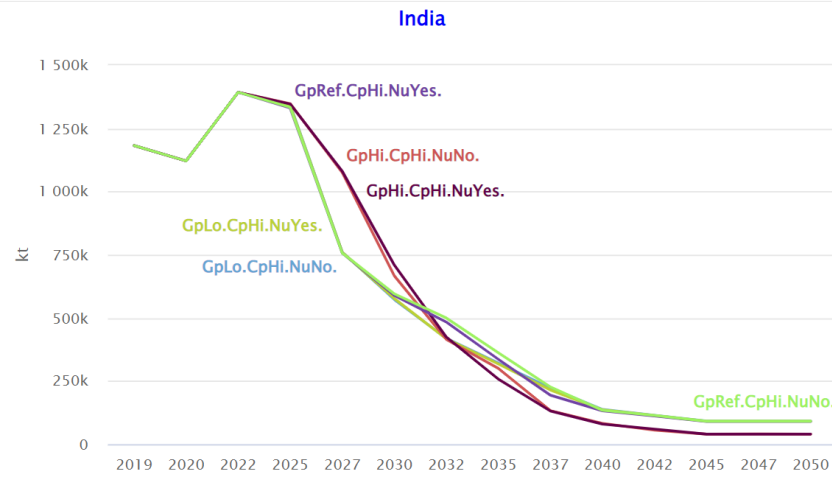
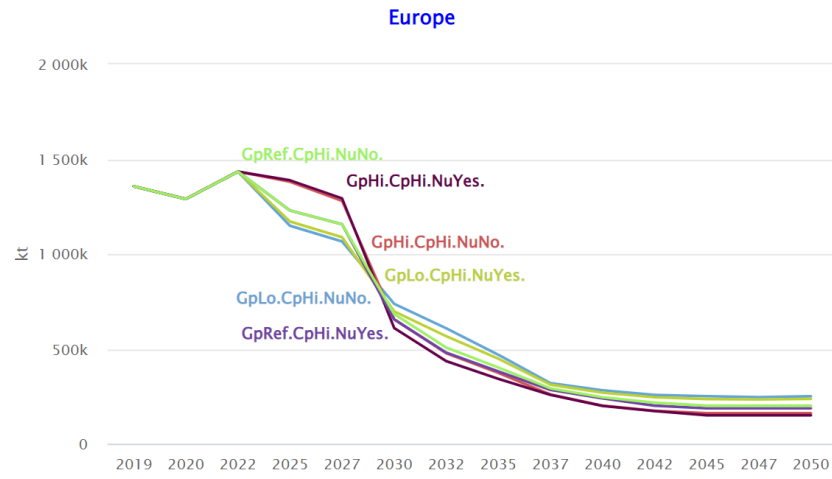
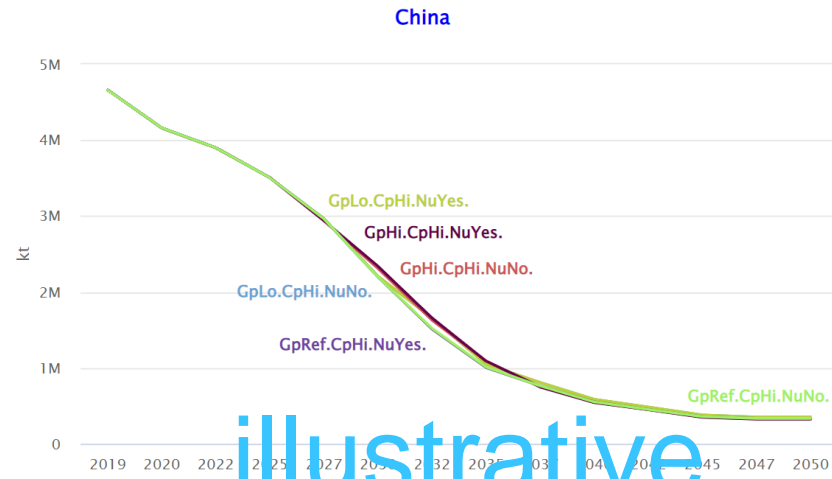
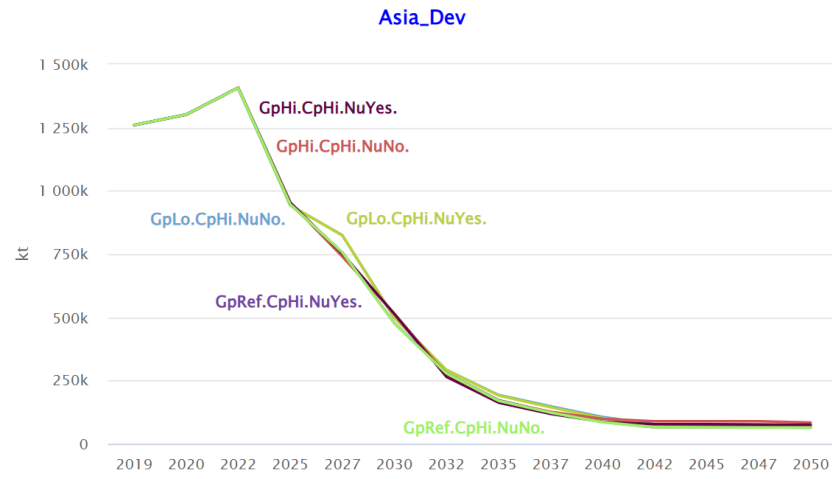
Newly Built Nuclear
Yes
No



Emissions by Region

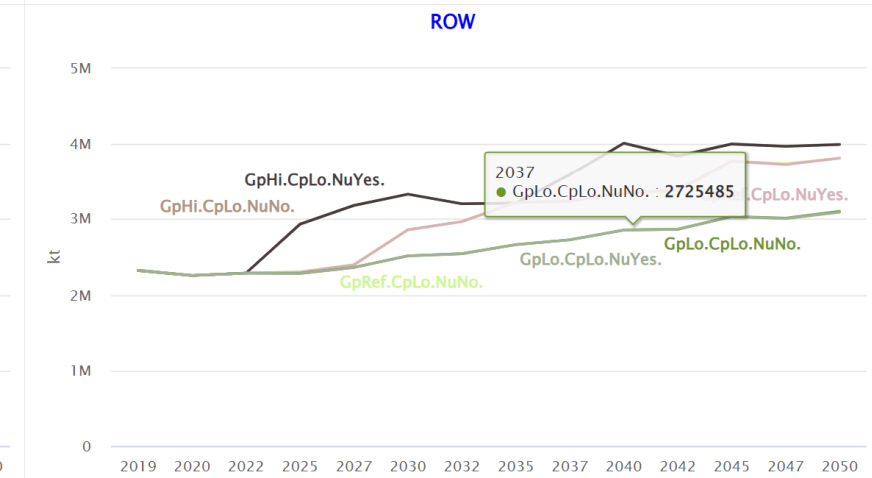
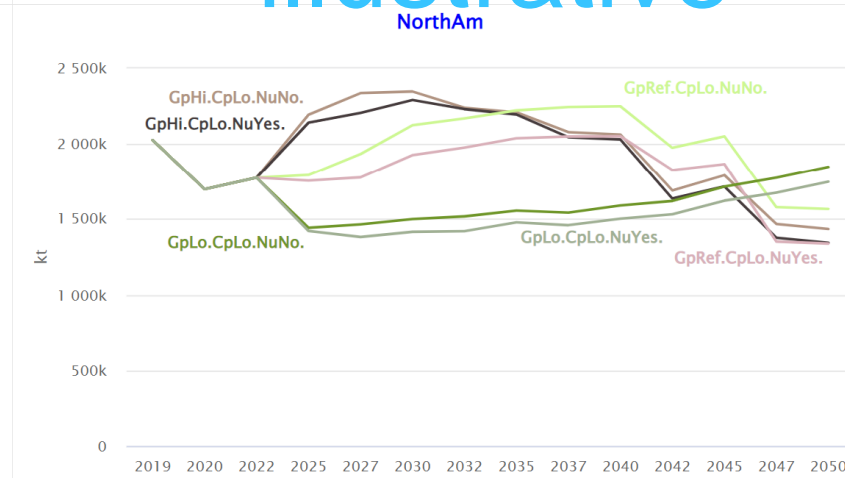
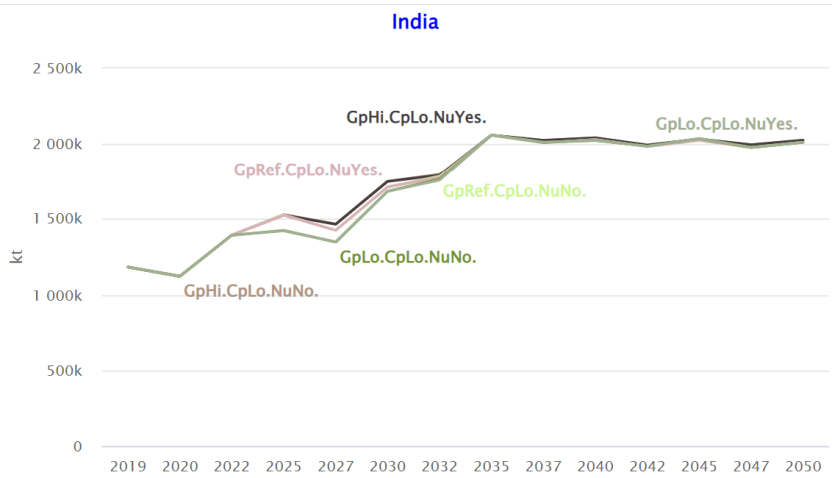
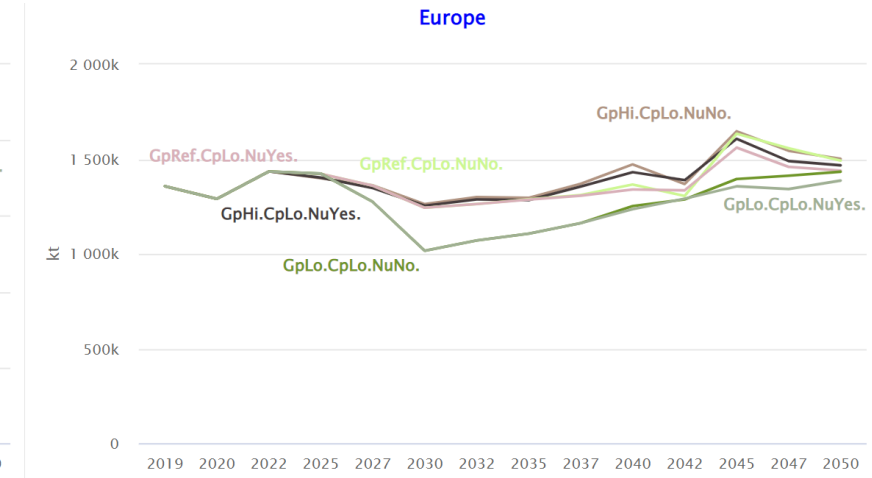
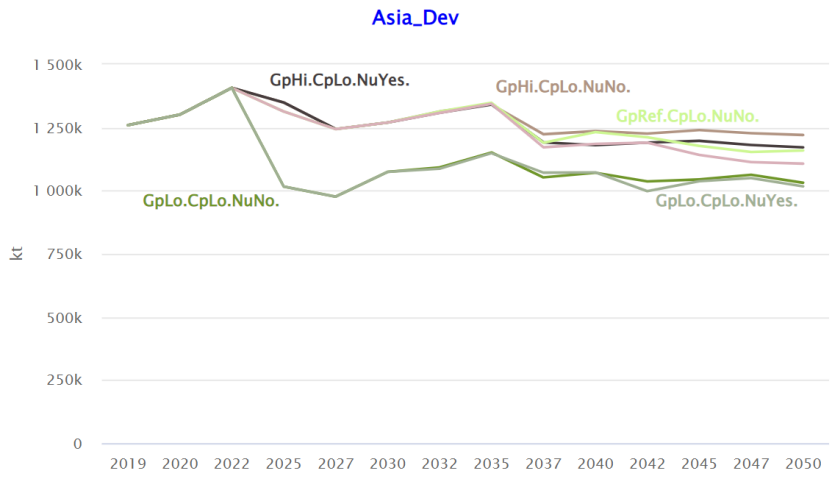


Emissions by Region under High Carbon Price



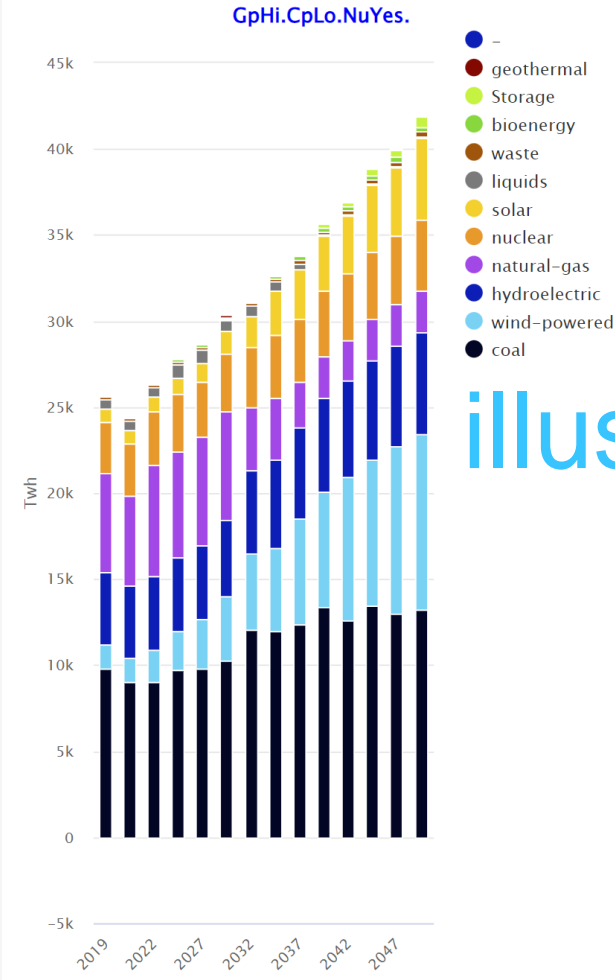
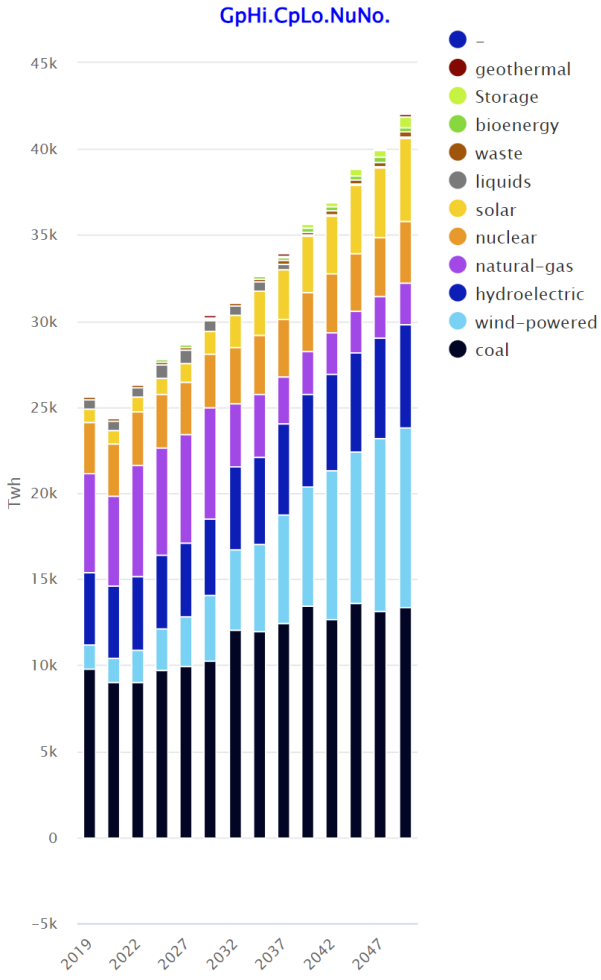
illustrative

Emissions by Region under Low Carbon Price

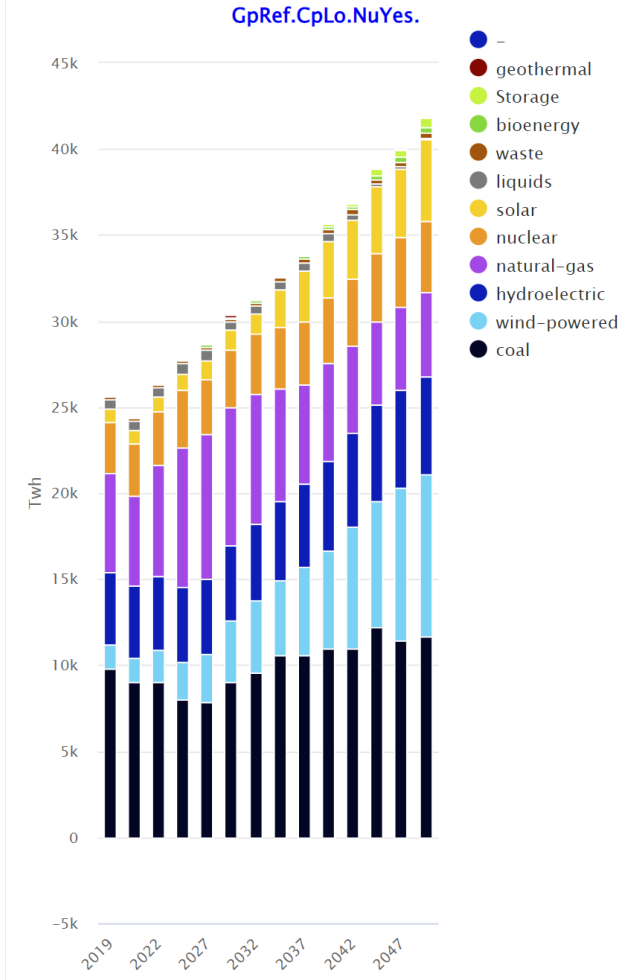
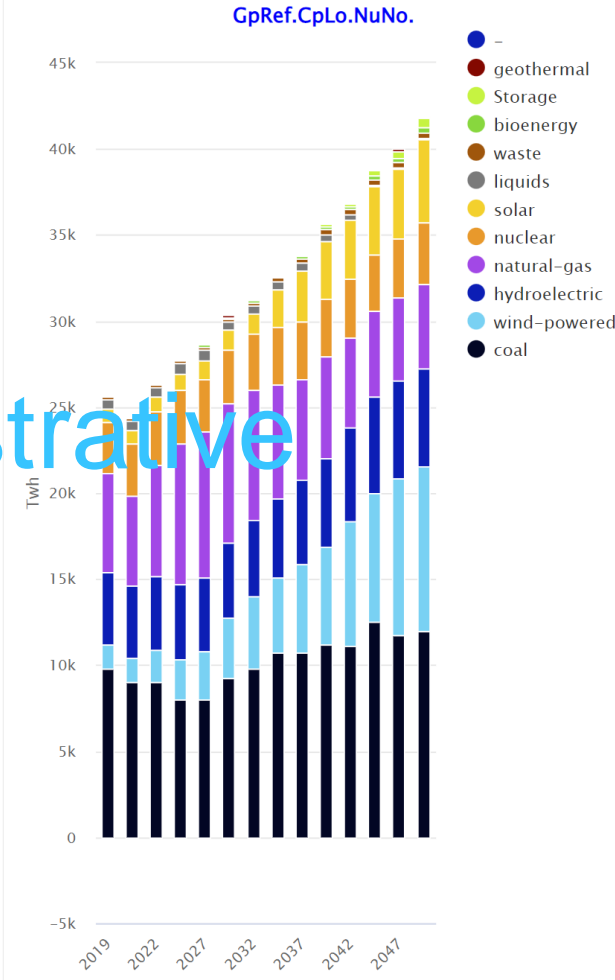


illustrative

Electricity Generation by Technology



illustrative



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