



Sharing session UI Energy Transition Model

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Sustainable Energy Systems and Policy Analysis,
Universitas Indonesia (SESP UI)

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Dr. Nadhilah Reyseliani

Lecturer
Chemical Engineering
Universitas Indonesia



Educational Background

- | Bachelor Degree in Chemical Engineering, Universitas Indonesia
- 2019** | Master Degree in Chemical Engineering, Universitas Indonesia
- 2023** | Doctoral Degree in Chemical Engineering, Universitas Indonesia

Professional Experiences

- 2021 - 2022** | Visiting scholar at Centre for Environmental Policy, Imperial College London
- 2022-2023** | Visiting scholar at Renewable and Appropriate Energy Laboratory, University of California, Berkeley
- 2023** | Graduate researcher at the Sustainable Energy Department of the Energy Technologies Area Division (ETA) of the Lawrence Berkeley National Laboratory (Berkeley Lab)
- 2023** | Affiliate at the Sustainable Energy Department of the Energy Technologies Area Division (ETA) of the Lawrence Berkeley National Laboratory (Berkeley Lab)
- 2023-2024** | Affiliate at the Sustainable Energy Department of the Energy Technologies Area Division (ETA) of the Lawrence Berkeley National Laboratory (Berkeley Lab)

Research Partners





Sustainable Energy Systems and Policy
Research Cluster
Universitas Indonesia

Sustainable Energy Systems and Policy Research Cluster (SESP UI)

SESP UI is an integrated research cluster on complex energy systems and policy analysis, trying to understand the environmental, economic and social impact of energy systems. The research approach is integrated and holistic by multi-dimension and multi-scale analysis of the field of study.



Conducts multi-disciplinary research in natural sciences, engineering, social science, and economics to develop sustainable energy systems by exploring the relationship between energy systems, economy, environment, and social factors to support the decision-making process for the government and the industry.



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Energy Systems Engineering
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Ahmad Syauqi, S.T., M.T.

Energy and AI
Department of Chemical Engineering



Research Topic and Current PhD Students



Natural Gas Systems and Policy



Low-carbon Energy Systems



Energy Security and Sustainability



Renewable Energy Systems



Multi-regional Energy Systems and Sectoral Analysis



Island Energy Systems



Smart Energy Systems and Circular Economy



Rizqi Ilma Nugroho

EV & Infrastructure



Osaliana Budiarto

CCS Hub



Reviana Revitasari

Green-Industry



Subhan Petrana

Island Power System



Erwan Hermawan

Waste-to-Energy



Galuh Setyo Anjani

Machine Learning for EV



Massita Ayu Cindy

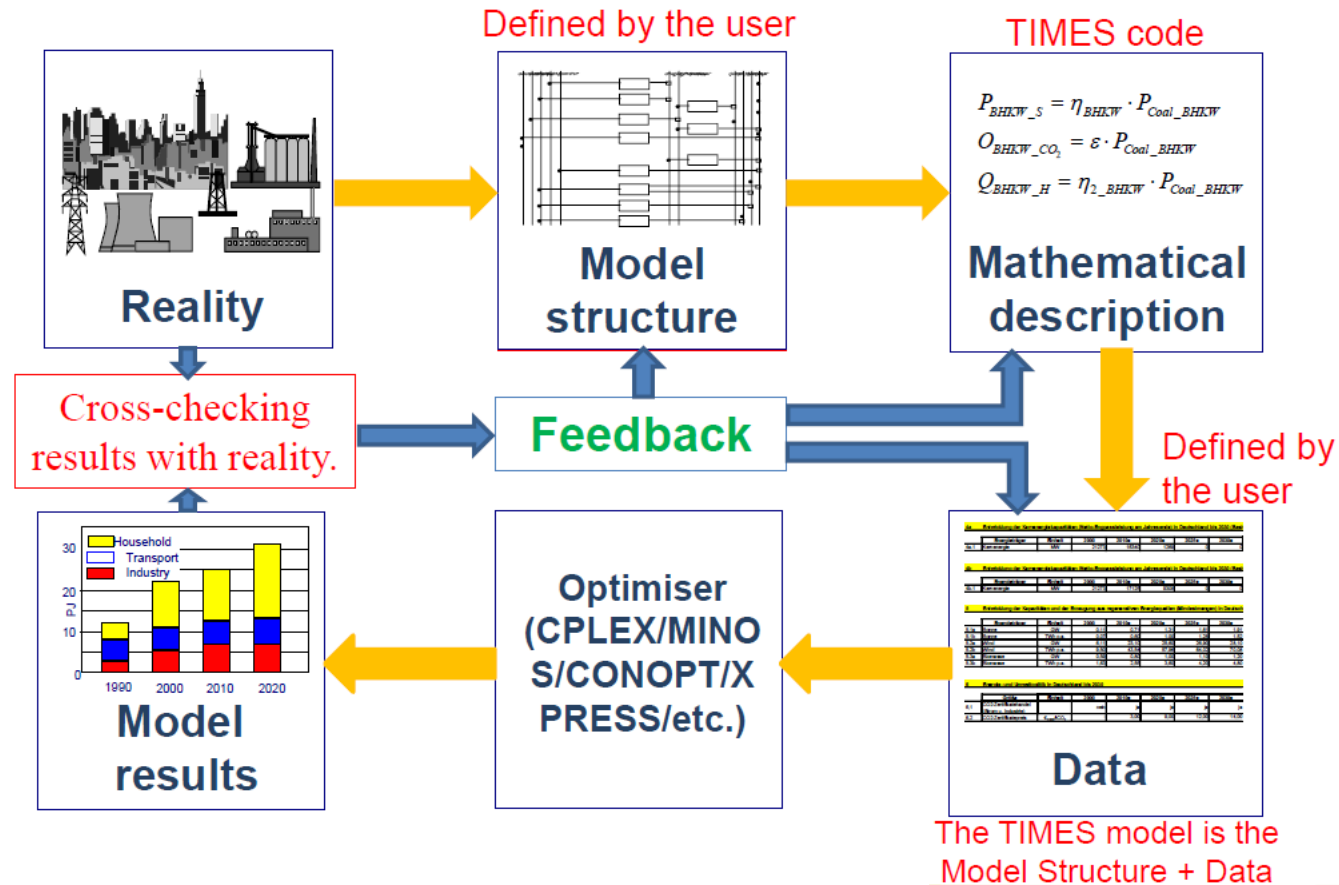
Natural Gas Market



Markus A. Gielbert

Deep Decarbonization

Energy System Model Concept Depicting Reality



Source: Gargiulo, M. (2019)

Deep Decarbonization Model and Policy Analysis: UI Energy Transition Model (UI ETM)

Process and energy system



Intensified process for green fuels and chemical
Carbon neutral and carbon negative (CCUS, CDR)



Energy system modeling

Integrated demand- and supply-side modelling for decarbonizing energy sectors covering power and fuel sectors .



Resources



Multi-regions-decarbonization strategy for supply-side sectors



Refinery



Energy storages



Power generations



Mid-stream infrastructures

Factors:

- Resource availability
- Operational/dispatch
- Cost
- Emission (LCA basis)



Bottom-up demand model for multi regional energy system development



Decarbonization strategy for demand-side sector considering the efficiency improvement, fuel switching, adoption rate, and technology conversion for building, transportation, and industrial sectors.

Policy analysis

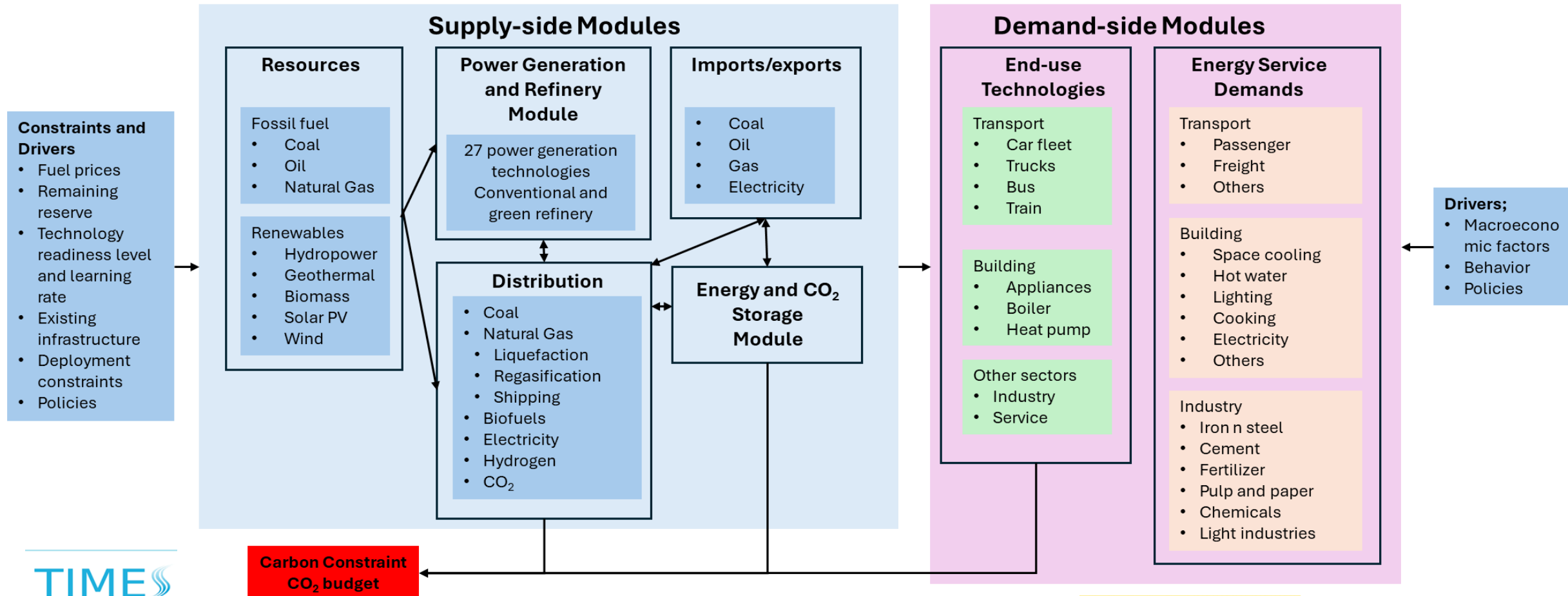


Policy scenarios

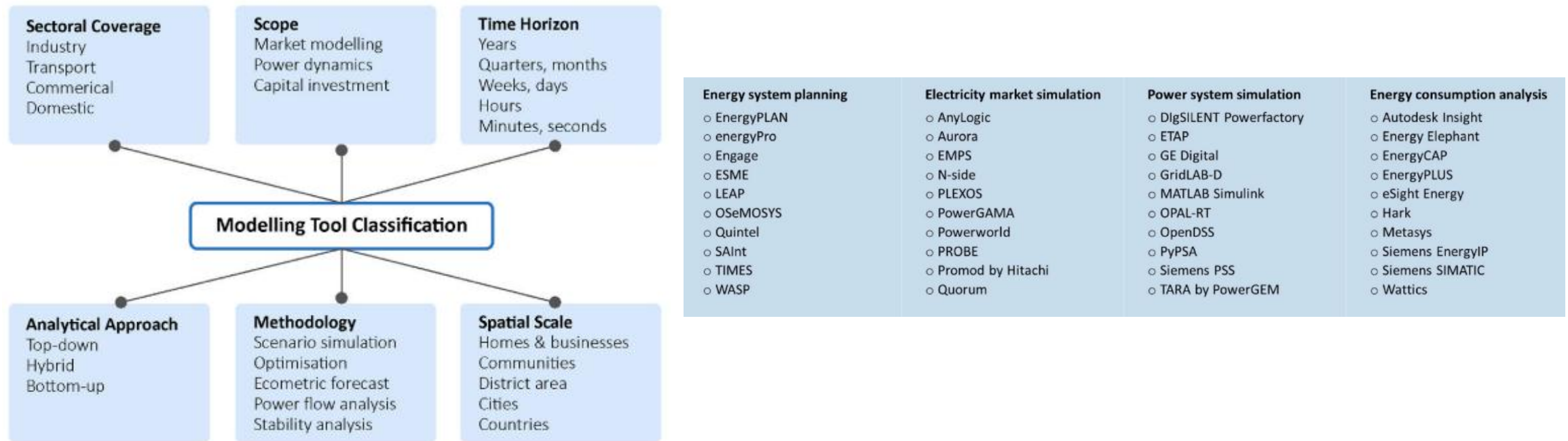
More information: <https://sesp.ui.ac.id/>



UI Energy Transition Model (UI ETM) Reference Energy System



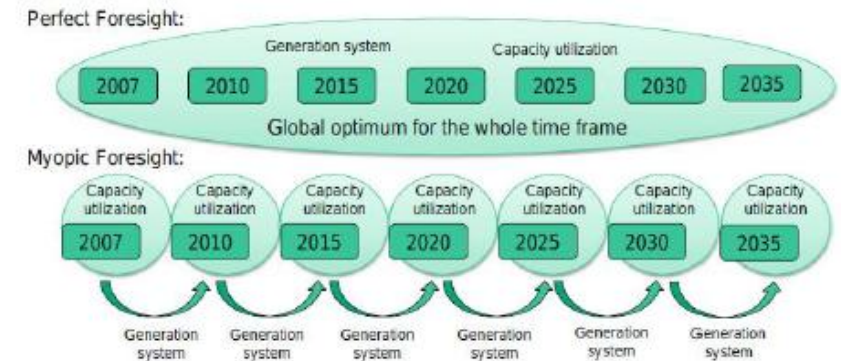
Positioning TIMES Model in Modelling Tool Classification



Source: Harrison Hampton, Aoife Foley. (2022) A review of current analytical methods, modelling tools and development frameworks applicable for future retail electricity market design. Energy. Volume 260. <https://doi.org/10.1016/j.energy.2022.124861>.

TIMES Model Generator

- TIMES is a model developed by IEA-ETSAP (www.ia-etsap.org) to build energy systems with in-depth analysis using two different but complementary systematic approaches, technical and economic approaches.
- The TIMES model covers the entire supply chain from the primary energy source to the demand-side sector.
- Two different yet complementary main approaches to the energy model:
 - Technical engineering approach
 - Economic approach
- TIMES reviews the energy system with partial equilibrium, perfect market, and perfect foresight approaches by dividing the range of years under review into several periods.



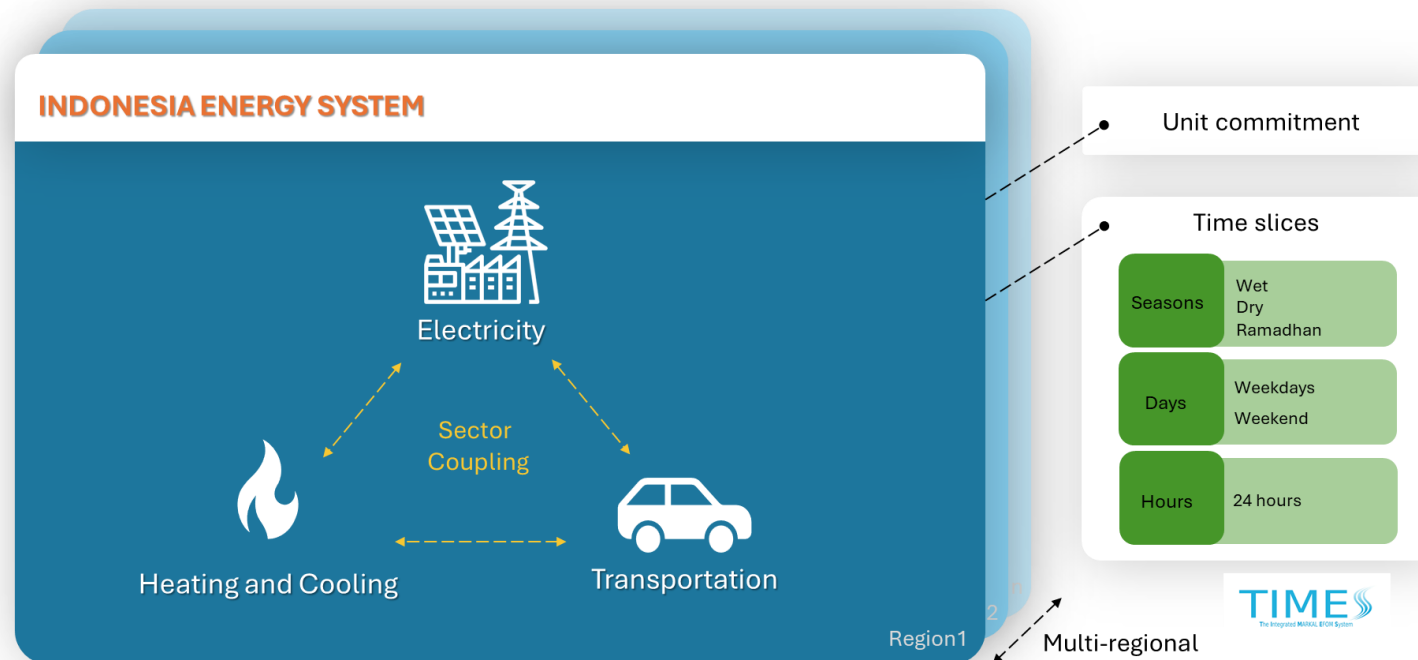
Source: Harrison Hampton, Aoife Foley. (2022) A review of current analytical methods, modelling tools and development frameworks applicable for future retail electricity market design. Energy. Volume 260. <https://doi.org/10.1016/j.energy.2022.124861>.

TIMES Model Generator

- **TIMES is a technology rich, bottom-up model generator**
 - Used linear-programming (LP) to produce a least-cost energy system;
 - Optimized according to a number of user constraints;
 - Over medium to long-term time horizons.
 - It is formulated in the GAMS language and solved via powerful optimizers.
- **The formulation of the LP problem consists of 3 types of entities:**
 - Decision variables: i.e. the unknowns, or endogenous quantities, to be determined by the optimization.
 - Objective function: expressing the criterion to be minimized or maximized, and
 - Constraints: equations or inequalities involving the decision variables that must be satisfied by the optimal solution.
- **Typical constraints:**
 - Energy service demands (this is the main driver and constraint)
 - Capacity, activity, growth rates, environmental targets, ...

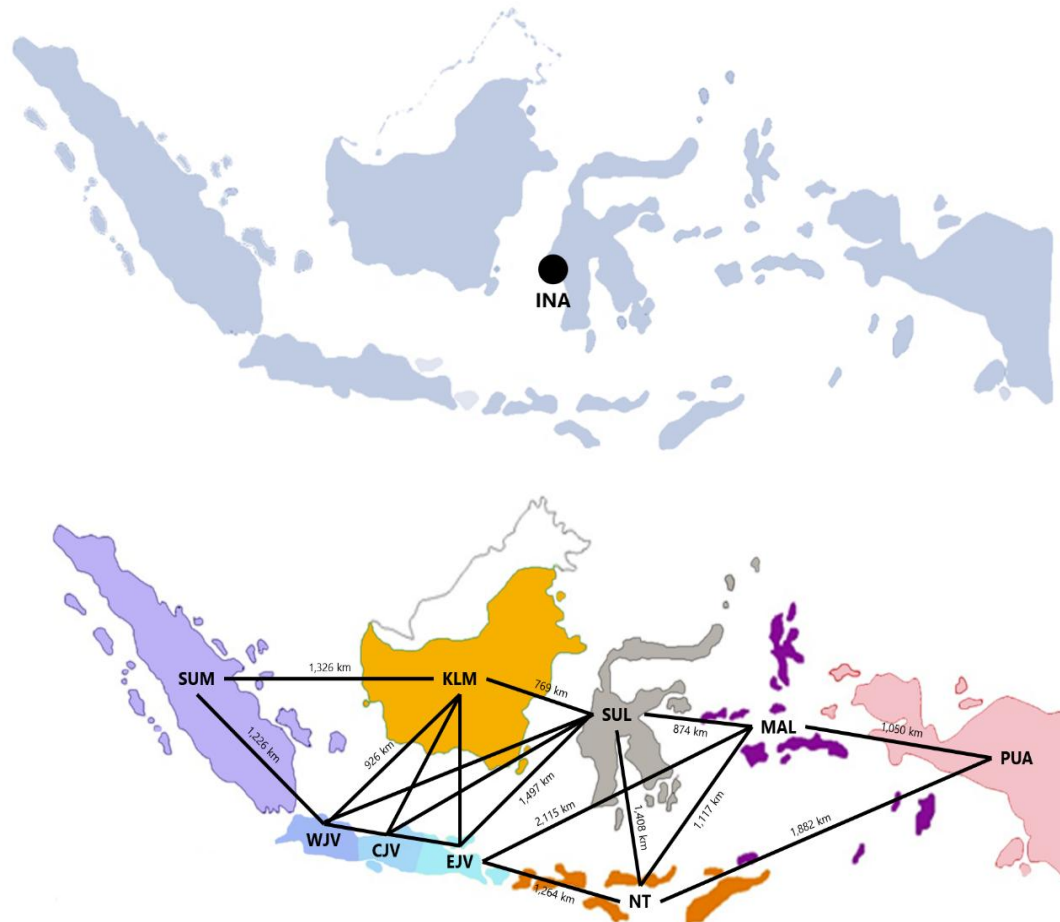
UI Energy Transition Model (UI ETM)

Sectoral and temporal approach



- A **multi-sectoral** modeling **approach** is needed to observe the integration between sectors and how emission constraints can be met simultaneously across sectors, enabling us to identify which sectors should be decarbonized first.
- A detailed temporal approach is necessary to demonstrate the role of energy storage and how the power system can adapt to variable renewable energy sources.

UI Energy Transition Model (UI ETM) Regional approach



As an archipelagic country with a mismatch between demand and infrastructure resources, Indonesia's energy system will be more complex, making a multi-regional approach essential.

UI Energy Transition Model (UI ETM) Constraints, Scenarios, and Policies

Constraints:

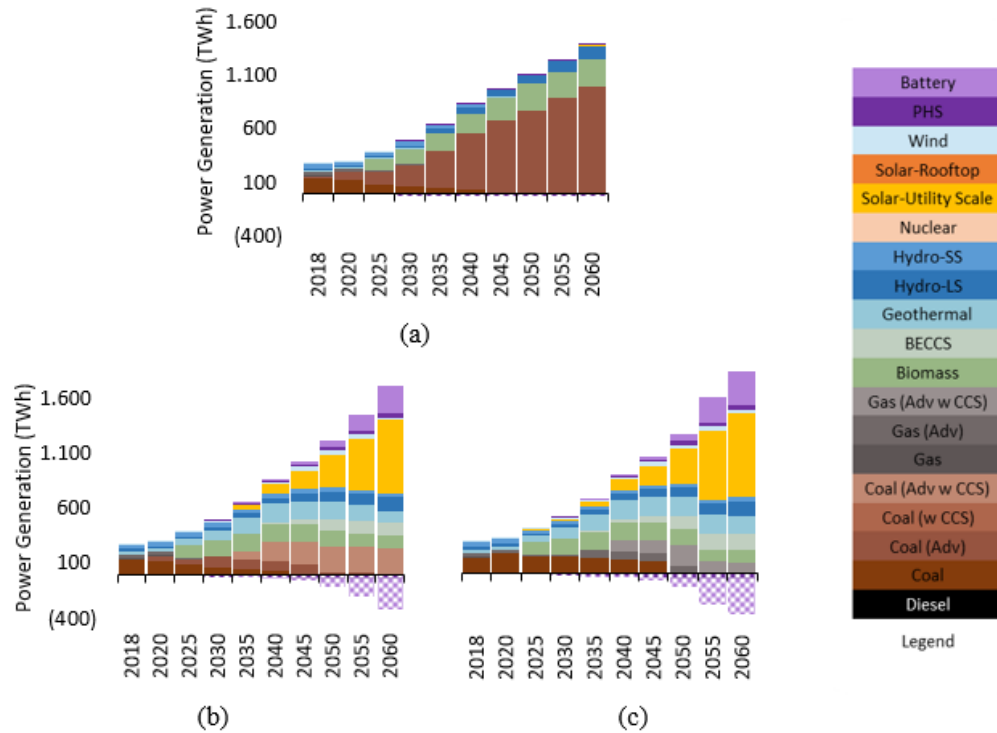
- Multi-regional resources
- Technology readiness level
- Adoption rate
- Technology learning rate
- Carbon budget or emission cap
- Renewable energies penetration

Scenarios and Policies:

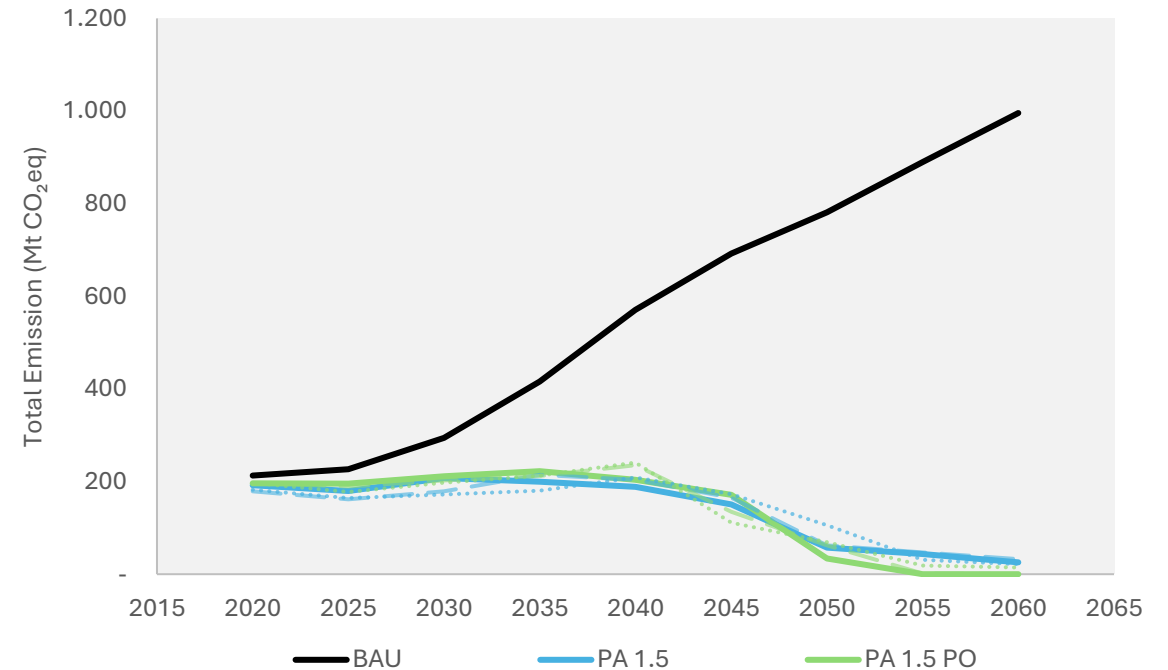
- KEN/RUPTL
- 100% RE
- Renewable auction
- Carbon tax
- Carbon cap
- Coal phase out
- Removal coal price cap
- Demand side: electric vehicle penetration

UI Energy Transition Model (UI ETM) Typical Results

Power Generation (a) BAU, (b) PA 1.5, (c) PA 1.5 PO

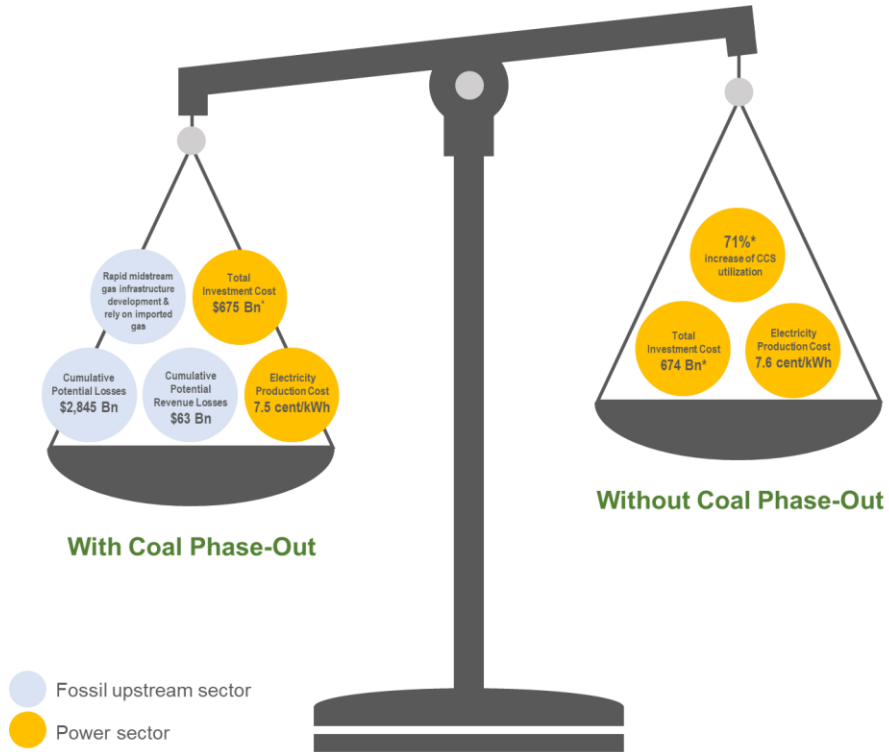


Emission Trajectories



Source: N. Reyseliani, Pratama, Y. W., Hidayatno, A., Mac Dowell, N., & Purwanto, W. W. (2024). POWER SECTOR DECARBONISATION IN DEVELOPING AND COAL-PRODUCING COUNTRIES: A CASE STUDY OF INDONESIA. *Journal of Cleaner Production*, 142202. doi:<https://doi.org/10.1016/j.jclepro.2024.142202>

UI Energy Transition Model (UI ETM) Typical Results



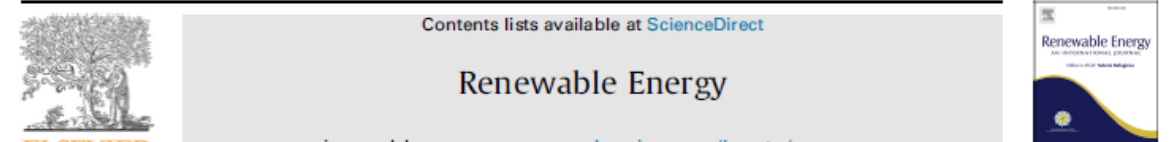
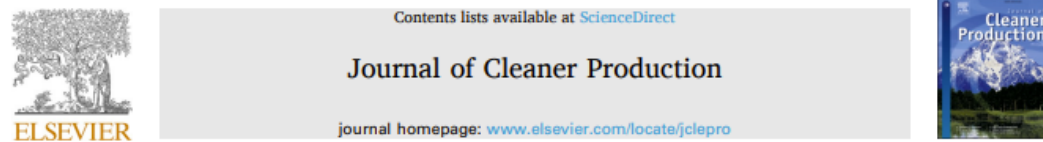
*under Low VRE scenario, power sector decarbonisation with coal phase-out plan will decrease the total investment by 24% and CCS utilization by 80%.

Source: N. Reyseliani, Pratama, Y. W., Hidayatno, A., Mac Dowell, N., & Purwanto, W. W. (2024). POWER SECTOR DECARBONISATION IN DEVELOPING AND COAL-PRODUCING COUNTRIES: A CASE STUDY OF INDONESIA. Journal of Cleaner Production, 142202. doi:<https://doi.org/10.1016/j.jclepro.2024.142202>

UI Energy Transition Model (UI ETM) Publications

Journal of Cleaner Production 454 (2024) 142202

Renewable Energy 176 (2021) 305–321



Power sector decarbonisation in developing and coal-producing countries: A case study of Indonesia

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Keywords:

Decarbonisation
Power sector
Coal phase-out
Developing country
Coal-producing country

ABSTRACT

Global efforts to transition away from coal within a decade encounter significant challenges, particularly in developing and coal-producing countries, e.g. Indonesia. Most current studies do not discuss the impact of coal phase-out on the upstream sector, which is important for coal-producing countries. This study aims to analyse Indonesia's power sector decarbonisation impact on the power and fossil upstream sectors. This analysis used VEDA-TIMES energy system optimisation using three scenarios: least-cost system (BAU), decarbonisation without coal phase-out (PA 1.5), and decarbonisation with coal phase-out (PA 1.5 PO). In all cases, decarbonisation will reduce the amount of coal used in energy systems. However, in a technology-agnostic transition, coal still constitutes 16% of total capacity in 2060. By this time, the coal-fired power generating assets have also transitioned to high efficiency, low emissions (HELE) technologies. CCS plays an important role in Indonesia's decarbonisation. A key implication of the coal phase-out scenario is the stranding of \$9 bn worth of existing assets and an increased role for renewable energy and imported natural gas in 2035–2050, posing a notable threat to gas security within the industrial sector. In addition, the potential loss due to untapped coal reserves is estimated at \$63 bn, while the cumulative net loss in the coal upstream sector amounts to \$799 bn (0.26% of Indonesia's GDP and 3.7% of the coal-producing GDRP). Nevertheless, the total investment and electricity production costs exhibit negligible differences in the rapid VRE expansion, but it will reduce total investment by 24% in the low VRE buildrate.

Pathway towards 100% renewable energy in Indonesia power system by 2050

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100% renewable energy
Variable renewable energy
Power system
Hourly operational profile
Energy storage

ABSTRACT

This study assesses Indonesia power system's transition pathway to reach 100% renewable energy in 2050. The pathway is determined based on least-cost optimisation in the TIMES model comparing 27 power plants and 3 energy storage technologies and using hourly demand and supply operational profile using 24-h time slices. From this study, it can be concluded that nuclear and solar PV utility-scale will play an essential role up to 16% and 70% of total electricity production, corresponding to 1396 TWh in 2050. The investment cost in 2050 is three times higher, and the emission is one-sixth lower than in Business as Usual, equal to 95 billion USD and 215 million tons of CO₂-eq. The RE mix based on current policy generates a higher CO₂ abatement cost, 120 USD/ton CO₂-eq in 2050. The optimistic demand projection will increase the coal by 82% in Business as Usual also nuclear and solar PV utility-scale of about 126% and 62% in 100% RE, respectively. The exclusion nuclear in power system increase the installed capacity of solar PV utility-scale and battery, increase land requirement by 78%–83%, increase the variability of supply from other power plants and batteries, and increase 9.7% of electricity production cost.

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UI Energy Transition Model (UI ETM) Publications

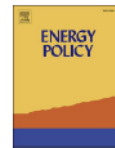
Energy Policy 169 (2022) 113184



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Implication of the Paris agreement target on Indonesia electricity sector transition to 2050 using TIMES model

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ARTICLE INFO

Keywords:
Electricity system planning
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Paris agreement
Net-zero emission
Policy
Indonesia

ABSTRACT

This study examines the transition of Indonesia's electricity system 2020–2050 to achieve Paris Agreement target using TIMES model. Three scenarios, including Reference Case, Current Policy, and Paris Agreement are reviewed. Reference case system will be 77% dominated by unabated coal power plant, and Current Policy will only reduce its share by 10% in 2050. Furthermore, the emissions from these scenarios are still half of estimated electricity emission in NDC due to different demand level between the policy target and current level indicating the ambition gap. Achieving well below 2°C long-term target, 50% of RE and 40% of IGCC-CCS in electricity production are needed. There will be 48% increase in investment compare to reference case and constant electricity production to current level. Uncertainty of carbon budget will not shift the emission peak or penetration of solar PV utility-scale, but will greatly affect the deployment time, as soon as 2030 or as later as 2040, and capacity of IGCC-CCS and the presence of BECCS up to 2050. Reform of Indonesia's electricity system needs to be carried out because of changes in technology and investment directions, the need to accelerate technological readiness, coupled with the current condition of market structure and electricity prices.

Cleaner Energy Systems 4 (2023) 100057



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Planning for the integration of renewable energy systems and productive zone in Remote Island: Case of Sebiria Island

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ARTICLE INFO

Keywords:
Sebiria Island
Hybrid mini-grid
VRE
Productive zone
Long-term planning

ABSTRACT

Sebiria Island is an Indonesian remote island that relies on its energy source mostly from diesel-generated electricity. The island's main economic activities include activities related to the coastal and fishery sectors. This research paper evaluates long-term planning of a mini-grid hybrid energy system from solar, wind, and diesel in island level based on technical and economic aspects. The mini-grid hybrid system is designed not only to meet the electricity demands of residential community, but also integrated with the development of productive zone to advance the local economy by enhancing the added value of local products and services. This study used TIMES model to obtain optimized energy system which will be used as an input for developing productive zone of the island. The optimization result is a portfolio of the energy system of Solar PV and wind turbine generators and Li-ion battery storage. The total investment cost of the energy system is USD 130,000. In order for the designed hybrid-mini grid to be financially feasible, a minimum of 25% of the grant is required. Innovative financing lies in a low-rate crowdfunding scheme. Most schemes productive activities are financially feasible and competitively priced in the market. Designed energy system model integrated with the productive zone generates a yearly net profit of USD 103,700 and create jobs for 51 islanders.

Key takeaways

1. Understanding how to use energy model tools can be challenging, but this is not the primary focus in energy system modeling. Your tools should simplify your work rather than complicate it!
2. Fundamentally, all energy model tools are similar; each has its strengths and weaknesses depending on specific needs.
3. Modelers must be creative in building models that accurately represent reality, incorporating interventions that are neither excessive nor compromise the scientific approach.
4. The most challenging stages in energy system modeling are data gathering, scenario development, and the dissemination of results.
5. The dissemination of the results presents numerous challenges, particularly in convincing stakeholders that our model is robust amid potential political interventions.

Modeling is often closer to art than science - like art it has to compromise and be selective on what aspects of reality to represent.

Sgouridis, S. (2022)

Thank You

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