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Policy Modelling in Indonesia: Gaps, Potential, and the Way Forward

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Executive Summary

Government policies demand an integrated approach that incorporates policy modeling, especially given the uncertainties in real-world conditions. The lack of a comprehensive approach may result in government failures or imbalances in economic sectors. In Indonesia, the state of policy is structured into government planning documents. The government also aspires to achieve a higher income country status and, at the same time, smooth energy transition with Indonesia's climate targets being comparable with other G20 countries. However, the methods to reach these goals often follow a top-down approach and have limited interlinks across different sectors or ministries.

Nonetheless, several studies indicate discrepancies between feasible actions and current targets, highlighting the need for clarity in modeling and communication. Policy modeling in Indonesia is both clustered and scattered. While there's consistency within the "families" of models, there's a gap between different "families," creating challenges in drawing comparative insights.

Therefore, there is an increased need for transparency and communication. Policy models need to be more transparent about their underlying assumptions and methodologies. This clarity would enable third-party replication and scrutiny, enhancing credibility and fostering accountability.

Many alternatives of policy modeling can be used, for instance, the platform developed by Sentient Hubs (Sentient Hubs can be accessed through its website on https://www.sentient-hubs.com). Serving as an integrated policy and impact modeling platform, Sentient Hubs could bridge the current modeling gaps. Its capability to integrate various models covering economic, social and environmental aspects, and providing customizable dashboards presenting a wide range of 'what if' scenarios, could enable stakeholders to gain deeper insights and holistic perspectives.

Achieving a comprehensive policy modeling framework in Indonesia requires collaborative efforts from various stakeholders. The use of unique new alternative platforms could play a pivotal role in bridging existing gaps, ensuring that policies are both transparent and actionable.

JEL Classification: C69, O21, Q56

Keywords
policy modelling — energy transition — Indonesia

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1. Background

Government policies should be crafted through an integrated framework that includes policy modeling.[1] Given the high degree of uncertainty in real-world conditions and the urgent nature of many policy issues, it is imperative to adopt a multi-dimensional approach. This should encompass project feasibility, cross-sectoral policy integration, and the balancing of diverse economic interests (Süsser et al., 2021). Failing to employ a holistic approach in policy modeling could lead to suboptimal outcomes, risking either government failure or imbalances favoring specific sectors (Singh & Chowdary, 2020).

While there is growing evidence of the importance of policy modeling globally, particularly in the realms of climate and energy policy, our understanding of its actual usage and extent in government decision-making remains limited. This is evident in the Indonesian context, where ambitious policy goals and targets are set, but the methodologies and strategies for achieving these remain nebulous. For example, a recent study by Resosudarmo et al. (2023) observes that Indonesia's commitments to energy transition targets appear challenging, partly due to inadequate policy modeling.

This policy brief aims to discuss the current state of policy modeling in Indonesia. We will begin by outlining the policymaking processes in Indonesia's key development planning documents and examine how these incorporate policy modeling. Additionally, we will explore the shortcomings in Indonesia's goal-setting, particularly concerning energy transition targets, and discuss the lack of a holistic approach across different ministries and stakeholders. Subsequently, we will address the existing gaps in the policy framework and suggest how alternative policy modeling tools, such as Sentient Hubs, can help fill these gaps. The ultimate goal is to present a more ideal approach to policymaking that ensures each policy has undergone thorough, holistic evaluation and stakeholder accommodation.

2. Existing Condition of Policy Modeling in Indonesia

In Indonesia, national level government development planning is structured into three sequential documents, each building upon the previous one in a more detailed manner. At the most general document is the long-term planning (Na-

[1] The definition of policy modeling used in this paper is drawn from Estrada (2011), who describes policy modeling as the application of quantitative or qualitative models and techniques to analytically evaluate the impact of past and future policies on society. Specifically, a policy is defined as a technical instrument introduced by policymakers to address particular issues that affect society either directly or indirectly, over various time frames.

tional Long Term Development Plan/RPJPN), covering 20 years and outlines both the current state of the nation affairs and the desired objectives the government aims to achieve within this period. Subsequently, the medium-term planning (National Medium-Term Development Plan/RPJM) spanning 5 years incorporates the President's vision, setting measurable targets along with the strategies for achieving them. Finally, the short-term plan (National Plan/RKP) focuses on annual objectives and details specific actions to be undertaken.[2]

In alignment with the pursuit of sustainable development, Indonesia's Government has outlined ambitious objectives in its latest long-term plan for 2025–2045. These goals include attaining a GDP per capita comparable to that of major developed nations and significantly reducing greenhouse gas emissions. This commitment was materialized through the creation of the Green Economy Index, introduced at the G20 Development Working Group Meeting in 2022. This index serves as a measurement tool, where it allows for systematic tracking of progress against both national benchmarks and global development standards. The Green Economy Index consists of 15 selected indicators that represent the three fundamental pillars of Sustainable Development: economic, social, and environmental. These indicators are evaluated annually and are displayed in both cobweb and line graphs for each pillar, allowing for a clear assessment of the relative performance of each pillar in any given year and facilitating a better understanding of the overall progress.

While sustainable development policies have been relatively recently integrated into the government's planning, some existing work had already been initiated through Bappenas' Low Carbon Development Initiative (LCDI). The LCDI aims to serve as a foundational framework for both medium- and long-term planning. This initiative identifies policies that simultaneously promote economic growth, reduce poverty, and achieve sectoral development targets while also helping Indonesia meet its climate goals and, at the same time, preserve and improve its natural resources.

The LCDI has released several thematic reports; however, two economy-wide modeling exercises are particularly noteworthy. The first, titled "Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia" (hereafter referred to as "LCDI 2019"), was released in 2019 (Bappenas, 2019). It explores policy scenarios for achieving conditional and unconditional Nationally Determined Contribution (NDC) targets from 2020 to 2050, and at the same time help Indonesia to achieve high-income status by 2045.

A follow-up report in 2021, titled "A Green Economy for a Net Zero Future: How Indonesia can build back better after COVID-19 with the Low Carbon Development Initiative (LCDI)" (hereafter referred to as "LCDI 2021") explores strategies to align post-COVID-19 recovery with climate and sustainable goals, specifically achieving net-zero emissions (NZE). The report evaluates several scenarios to achieve NZE in 2045, 2050, and 2060 (Bappenas, 2021).

Both reports use an integrated assessment model specific to Indonesia called Bappenas IV2045 with technocratic processes to identify policy options and their impacts. In addition to modeling how measures reduce emissions, they also identify impact on GDP per capita and employment. Additionally, LCDI 2019 also utilized two spatial models: SpaDyn and GLOBIOM-Indonesia. The overarching message of both reports is consistent: green economic transformations with ambitious climate targets are not only feasible but also crucial for sustained economic growth.

The Ministry of Environment and Forestry (MoEF, 2011) has also conducted modeling to support Indonesia's climate commitment following the Paris Agreement. Indonesia's climate commitments originated with the 2011 National Action Plan for Reducing Greenhouse Gas Emissions (*Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca*/RAN-GRK). This plan aimed for a 26% reduction in greenhouse gas (GHG) emissions relative to business-as-usual (BAU) levels under Indonesia's own effort by 2020, or 41% reduction with international support.

In alignment with the Paris Agreement, Indonesia submitted its first NDC in 2016. The country pledged to unconditionally reduce its GHG by 29% compared to Business as Usual (BAU) levels by 2030, and by 41% with international assistance. The 2021 Updated NDC maintained the same percentage targets but introduced updates related to the baseline scenario. Further revisions were made in 2022 when Indonesia submitted an Enhanced NDC. The new commitment adjusts the unconditional reduction target to 31.89% and the conditional reduction target to 43.20%.

Indonesia has also submitted its "Long-Term Strategy for Low Carbon and Climate Resilience 2050" (LTS-LCCR 2050). This strategy explores various scenarios based on Indonesia's commitment to meet unconditional and conditional climate targets by 2050. Indonesia aims to peak its GHG emissions by 2030 in the most ambitious scenario. The plan involves broad emissions reduction and aims to transform the Forestry and Other Land Uses (FOLU) sector into a net carbon sink (United Nations Framework Convention on Climate Change/UNFCCC, 2021). If successful, this would set Indonesia on a course to achieve net-zero emissions by 2060, possibly even sooner.

The planning relies heavily on a set of analytical models: The AFOLU dashboard for agriculture and land use, AIM-EndUSe and the AIM-ExSS focus on energy modeling, and the Asia Pacific Integrated Model/Computable General Equilibrium (AIM/CGE)-Indonesia evaluates the economic and environmental impacts. Notably, beginning with the upcoming second NDC, the long-term planning outlined in LTS-LCCR 2050 will be integrated with the medium-term planning of future NDCs.

Most of the emissions reduction targets in plans set forth by Bappenas' and the MoEF's come from the energy sector. Indonesia's long-term goals for the energy sector are outlined in two key documents. First, a council of seven ministries formulated the 2014 National Energy Policy (*Kebijakan Energi Nasional*/KEN). This foundational document is further detailed in the National General Energy Planning (*Rencana Umum Energi Nasional*/RUEN) released in 2017, which covers the period from 2015 to 2050 (Asian Development Bank/ADB, 2020). The RUEN utilizes the Long-range Energy Alternatives Planning (LEAP) System model to fore-

[2] At the regional level, provincial and district (*Kabupaten/Kota*) governments also have their own development planning documents, similar to those at the national level.

cast energy needs and supplies. It also identifies potential policy scenarios that align with the KEN.

Second, the Ministry of Energy and Mineral Resources (MoEMR, 2019) has specified these long-term plans in the National Electricity General Plan (*Rencana Umum Kelistrikan Nasional*/RUKN), which covers the year 2019 to 2038 (with plans for 2023 to 2060 currently being drafted) (PT. PLN (Persero), 2021). The RUKN obtains its results and targets based on the least cost investment and dispatch of the electricity sector using the Balmorel software, based on top-down and bottom-up demand forecasts.

Lastly, these long-term and medium-term plans are embedded in investment plans by the state-owned electricity company PLN in the Electricity Provision General Plan (*Rencana Umum Penyediaan Tenaga Listrik*/RUPTL), covering the period 2021 to 2030. The RUPTL takes its cues from the base assumptions, projections, and policies outlined in RUKN, using them to further consolidate demand forecasting and infrastructure planning.

Table 1 recaps the latest versions of the modeling exercises based on the documents, relevant appendixes, and other public information.

3. Issues in the Government Targets

Indonesia's climate targets, as outlined in its Enhanced NDC and Net Zero Emissions (NZE) 2060 target in LTS-LCCR 2050, are comparable to other developing economies in the G20. According to Climate Action Tracker, Indonesia's NDC is rated "highly insufficient", a classification it shares with China, India, and Saudi Arabia (Climate Action Tracker, 2023). Meanwhile, Brazil, India, and South Africa also have net-zero targets set for between 2050 and 2070, although these targets are not yet legally binding (Climate Transparency, 2021). Understanding how Indonesia's climate targets compare to its G20 peers is vital for benchmarking progress and identifying areas for improvement. However, the current 'highly insufficient' rating indicates that there is substantial work to be done to align Indonesia's actions with global climate goals.

Some government and non-government modeling suggest that Indonesia could do more. For instance, a report from the World Resource Institute (Wijaya et al., 2017) posits that if Indonesia were to implement existing policy measures, it could achieve a 29% reduction in greenhouse gas emissions from the baseline by 2030, thereby exceeding its unconditional commitment. Moreover, by adopting strengthened measures, the reduction could reach as high as 41%. Meanwhile, the LCDI 2021 document suggests that Indonesia could achieve NZE as early as 2045.

Nonetheless, meeting even the existing targets remains a question. For example, emission reductions from the energy sector are crucial to meet the net-zero emissions target by 2060. However, Resosudarmo et al. (2023) argued that despite ambitious energy transition targets and initiatives, the energy sector still faces persistent issues such as lack of capital and knowledge, low institutional quality, rigidity in conducting policy reforms, and regulatory uncertainty. They concluded that while Indonesia could make significant progress, the probability of achieving the 2060 NZE target remains low.

This divergence in viewpoints highlights a significant contradiction: why do some models suggest that Indonesia could aim for more ambitious targets, while other assessments question the feasibility of meeting even the existing ones? This discrepancy could be attributed to the way in which these models construct scenarios, make assumptions, and are communicated.

Government models in Indonesia often cross-reference targets and documents from various ministries to ensure coherence and continuity. For instance, the moderate and high scenarios in Bappenas' LCDI 2019 report are constructed around the unconditional and conditional pledges in the Nationally Determined Contribution (NDC) modelled by the Ministry of Environment and Forestry (MoEF). Further, Bappenas shapes its policy scenarios through technical consultations that take into account targets set by other government bodies.

One advantage of this approach is that it fosters consistency across different plans and reports. For example, the Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050) and the NDC can be more easily aligned if they share a common set of assumptions and targets. This commonality also makes it easier to compare the results of different modelling exercises.

However, there's a downside: errors or faulty assumptions in one model can cascade into others. For instance, if the NDC assumptions are flawed, these errors may propagate into the LTS-LCCR 2050 and other related plans. BOX 1 provides an example of this, discussing how over-projection of energy demand led to an unnecessary build-up of coal-fired power plant capacity in Indonesia.

Table 1. Summary of Target Documents

Document	Institution	Status	Scope		Mentioned utilized model
			Sector	Temporal	
LCDI 2019	Bappenas	Published	Energy, Waste, IPPU, Agriculture, FOLU	2020-2045	IV2045, SpaDyn and GLOBIOM-Indonesia
LCDI 2021		Published		2020-2060	IV2045
Enhanced NDC (2022)	MoEF	Submitted to UNFCCC		2010-2030	AFOLU dashboard, AIM-EndUSe & AIM-ExSS, AIM/CGE-Indonesia
LTS-LCCR (2021)		Submitted to UNFCCC		2010-2050	
RUEN (2017)	NEC	As Presidential Rule	Energy	2015-2050	LEAP
RUKN (2023)	MoEMR	Published draft	Electricity	2023-2060	Simple-E, LEAP, Balmorel
RUPTL (2021)	PLN	As MoEMR Decision	Electricity	2021-2030	WASP, ABB e7, Energy Exemplar Plexos, Simple-E

Source; Authors' compilation

Box 1: Roseate Economic Projection and Excessive CFPP Investment

Economic growth is used as one of the bases for creating RUEN (Rencana Umum Energi Nasional or National Energy General Plan). Hence, an over-projection of economic growth leads to an over-projection of energy and electricity demand. Moreover, the use of outdated data in RUEN which was created in 2017 based on data collected up until 2015, results in forecast errors (IESR, 2020). During 2015–2018, on average the economy grew 1.6% lower than RUEN's projection, highlighting a notable deviation from the initial expectations (IESR, 2020). Given Indonesia's abundant reserves of both coal and renewable resources, the energy diversification strategy focuses on optimizing the utilization of these resources (IESR, 2019). This over-projection results in renewables being less competitive than their potential. This over-projection also causes the projected demand for coal-fired power plants to become excessively large. This leads to over-investment in coal-fired power plants, especially in the Java-Bali region (IESR, 2019).

Creating a range of scenarios in government modeling could be beneficial for both feasibility and ambition. These scenarios could span from foundational assumptions to those that explore the boundaries of what is possible. For example, a more 'basic' scenario could be one that aligns with the International Energy Agency (IEA) as seen in Indonesia's National Electricity General Plan (RUKN). This would use the IEA's assumptions about economic and population growth specific to Indonesia, thereby allowing for greater comparability with IEA's global energy modeling.

More ambitious scenarios could aim to stretch the limits of what is currently feasible. An example is the 'LCDI Plus' scenario found in Bappenas' LCDI 2019 report. This scenario envisions reducing emissions by as much as 75% relative to the baseline by 2045, while still achieving an additional 0.25 percentage points of annual GDP growth between 2019 and 2045. To do this, the scenario proposes ambitious strategies such as completely halting further deforestation and increasing the share of renewable energy to 60% by 2045, up from the current 19.1%.

However, implementing such ambitious measures would require technical and institutional capabilities that Indonesia currently lacks. Therefore, these initiatives are modeled to start only after 2024. Adopting such a diverse range of scenarios in future modeling exercises could help balance the scales between what is currently feasible and what could be ambitious yet achievable goals.

Evaluating the underlying assumptions and methodologies of climate models is challenging, primarily because this 'under-the-hood' information is often not publicly disclosed. While many planning and modeling documents do discuss these issues to some extent—often in appendices that list key assumptions—greater transparency is needed. For example, Climate Transparency's 2021 review of Indonesia's First NDC pointed out that it could benefit from more details. These could include the temporal pathway of emission reductions, the role of the land sector, and how specific policies might contribute to cutting emissions. These gaps persist even in the Updated NDC.

This lack of thoroughness and transparency could have implications for accountability. When models are transparent, third parties can replicate and scrutinize their results, enhancing credibility and public trust. For instance, the level of detail in the 2016 National General Energy Planning (RUEN) enabled the Institute for Essential Services Reform (IESR), a non-governmental organization, to replicate and expand upon its findings (IESR, 2017). However, the replicability of other modeling work, particularly those employing proprietary models, remains uncertain.

Some climate modelling exercises do include sensitivity analyses, which help to examine how different parameters and policy scenarios could impact the outcomes. For instance, the LCDI 2019 report includes a high-carbon scenario alongside a moderate scenario focused on green economy policies. Interestingly, the moderate LCDI scenario projects a GDP that is 1.22 times the baseline by 2045, compared to only 1.12 times in the high-carbon scenario. This suggests that it's not merely higher investments that drive economic growth, but the integration of green economy policies as well.

However, the depth of these sensitivity analyses could be improved. While many reports identify key sectors and policies, there is room for more granular examination. For example, could the models isolate the impact of specific policy levers within each broader scenario? WRI's 2017 report did model multiple policy scenarios, but it could go a step further by quantifying the contribution of each individual policy—such as a forest moratorium or peat restoration—toward achieving emission reductions (Wijaya et al., 2017). This kind of detailed disaggregation could provide insights into the feasibility and robustness of the modeled policy scenarios, and also help to determine if the models are placing appropriate emphasis on the policies to achieve their targets.

Clear communication of results and policy implications is crucial for effective climate action. While some documents like the 2016 RUEN, as formalized in Presidential Regulation No. 22/2017 (Republic of Indonesia, 2017), are limited by legal formatting requirements, others like the LCDI 2021 report have the flexibility to be more explicit. However, even with this flexibility, many reports fall short of offering transparent details. For example, Indonesia's Updated NDC refers to the 'enhancement' or 'expansion' of mitigation actions for the energy sector without specifying the degree to which these actions will be scaled up. This leaves room for interpretation and limits accountability. Another case in point is the LTS-LCCR 2050 report, which provides an in-depth breakdown of total and sectoral emissions for 2050 but omits specific data for the agriculture and FOLU sectors. Interestingly, this data is not confidential and could be calculated from existing charts, raising questions about why it was not directly communicated.

The lack of clarity in modeling exercises hinders understanding and makes it difficult to compare different studies, even when their scopes are similar. For instance, ambiguities between the LTS-LCCR 2050 and the LCDI 2021 impair our ability to contrast their findings. While it's acceptable for different models to yield diverse results, the reasons behind such differences should be openly discussed. This is vital, especially when one policy document serves as a basis for another. For example, the RUEN, which outlines broader energy sector goals, feeds into the more specialized RUKN for electricity planning, influencing investment plans in the RUPTL. Given this interconnectedness, it's crucial to understand how newer, more ambitious renewable targets in the 2023 RUKN can align with the still-in-force 2016 RUEN. Additionally, when national targets like those in the RUEN are disaggregated into regional objectives, there should be transparency on how these regional targets collectively align with the national vision.

4. What is the Gap in the Current Policy Modeling in Indonesia?

Environmental modeling in Indonesia is clustered but also scattered between clusters. This modeling framework can be classified as "families" of models, where these models are handled by the same ministries/institutions. They would use similar modeling platforms and have good comparability and continuity. For example, the NDCs and LTS-LCCR 2050 were modeled by the MoEF and the LCDI models by Bappenas.

However, they are also scattered in the sense that to what extent models between "families" can be compared with one another. Even when they share a sectoral and temporal scope, like LCDI 2021 versus LTS-LCCR 2050. Within families of models, there might be some lags. For instance, if the draft 2023 RUKN aims to incorporate a greater share of renewables in the electricity sector, this progressive change may not be reflected in the NDCs if they continue to rely on projections from the 2016 RUEN, which is still the most up-to-date planning document for the broader energy sector.

Several enhancements can be considered to improve the connection and transparency among different models while preserving their granularity. One significant step could be creating a 'library of scenarios' that compiles both baseline projections and policy scenarios. Drawing inspiration from the use of Representative Concentration Pathways and Shared Socioeconomic Pathways in Integrated Assessment Models (IAMs), such a library could standardize translatable pathways across different modeling frameworks (Hausfather, 2018). Doing so would allow modelers to transparently demonstrate how their models yield varied outputs even when utilizing similar input parameters and baseline scenarios.

Furthermore, the library could house a variety of policy scenarios, which may be adaptable to other models. For example, one could test the Net Zero Emissions (NZE) policy scenarios from the LCDI 2021 report using the frameworks in LTS-LCCR 2050, thereby evaluating the consistency of targets across different models. If the library is made publicly accessible, especially to non-governmental modelers, it will facilitate the calibration of independent models, thereby enriching the policy dialogue and increasing accountability.

Another crucial improvement involves enhancing both ownership and understanding of environmental models. In this context, 'ownership' means effectively communicating model outcomes to relevant government agencies and regional administrations. It also entails the capability for cross-ministry comparisons, like juxtaposing Bappenas' LCDI model with the Ministry of Environment and Forestry's LTS-LCCR model. However, such efforts may encounter obstacles, including the availability of skilled personnel—particularly when proprietary models and private consultants are involved—and data availability limitations. A feasible workaround could be the development of simplified, high-level models that encapsulate the core mechanisms of the original models. This could be achieved through interactive dashboards that offer accessibility at the expense of some granularity. An iterative, exploratory approach is advisable, where initial insights are gleaned from these accessible models, and more in-depth analyses are performed using complex models when required.

Improving the presentation of environmental models should prioritize enhanced transparency in several areas, including policy scenarios, model construction, data sources, and assumptions used. Clear communication is vital and could involve the side-by-side comparison of scenarios using structured tables, similar to the approach used in LCDI 2021. These comparisons could be vertical, examining how the sub-components in the Regional Energy Demand Outlook (RUED) contribute to the National Energy General

Plan (RUEN), and horizontal, comparing models with similar scopes, such as LTS-LCCR and LCDI. Future iterations could include contributions from private modeling entities like the Institute for Essential Services Reform (IESR).

Moreover, robust sensitivity analyses should be carried out to account for various scenarios and probabilistic elements, especially in comprehensive reports like those presented in LCDI. It's crucial to acknowledge that certain official documents, such as presidential decrees, may be constrained in their ability to communicate complex modeling results. Given these limitations, creating a separate platform for improved communication should be considered. Lastly, to foster replicability, technical appendices, and attachments, including data spreadsheets, should be made readily available to streamline subsequent modeling efforts.

5. Mediating the Current Gap Through Alternative Modeling

As an integrated policy and impact modeling platform, Sentient Hubs could play a role in overcoming existing shortcoming in Indonesia's policymaking scene. Sentient Hubs serves as a platform facilitating the integration of financial, infrastructure, and scientific models, thereby enabling comprehensive planning and impact assessments encompassing economic, environmental, and social dimensions.

Sentient Hubs' nature as a "glue for models" allows it to improve the comparability of scenarios. Given the relevant permissions/access, currently employed open-source and/or proprietary models can be manually on-boarded into the secure Sentient Hubs environment to allow for automated integrated execution. Regardless of the models' nature or data source, these can be adapted to the daisy-chain model of inputs and outputs in Sentient Hubs' environment. This could facilitate comparisons between different "families" of models covering similar scopes, such as the IV2045 used Bappenas with the AIM models used by the MoEF. Fixing scenarios and assumptions, users can compare outputs of different models side-by-side, benchmarking performance of different models under different scenarios or conditions. Additionally, users can also average or weigh the results of several models.

Sentient Hubs also enables models of different levels to be integrated; for example, one might be interested in how energy-transition targets modeled by LEAP could have implications on employment and value-added, which might require an integration with a computable general equilibrium model of the economy. Integrating models could help policymakers review the bigger picture and see how targets and planning in one sector affect targets and planning in other sectors.

Furthermore, users are given freedom to customize dashboard and visualization tools, empowering themselves to gain insights into their specific problem inquiries. In addition, Sentient Hubs employs a federated modeling approach, permitting users from diverse entities to collaborate within their respective domains without necessitating visibility or access to other portions of the model from different stakeholders. This feature could prove to be valuable in facilitating a more holistic perspective for higher order clients without causing friction over data sharing and autonomy concerns among stakeholders of various nature. For instance, when 3 major mining companies conduct their own highly sensitive groundwater modeling on the same aquifer/environment, they are able to do internal modelling and publish within the Sentient Hubs environment so that Government authorities/regulators to see and respond to the impacts. Upon approval by each stakeholder, this "gate" can be opened or closed with data sharing and timing fully configurable.

6. Possible shortcomings?

It's important to note, that regardless of the availability of new tools, methods and platforms, human factors can hamper outcomes - particularly where trade-offs across departments and between stakeholders become apparent and quantifiable. The premise of integrated policy modelling inherently requires trust and willingness to collaborate across sometimes competing individual interests for the betterment of society and environment as a whole. The emergence of federated modelling environments may allow tensions between departmental or provincial autonomy, and the need for over-arching executive governance across domains and portfolios, to be balanced, if not resolved.

7. Conclusion

The article underscores the indispensable role of holistic policy modeling in Indonesia, emphasizing the importance of adopting a comprehensive and integrated approach to address the complexities and uncertainties inherent in policy formulation and implementation. This approach is not merely a bureaucratic requirement but is central to realizing the ambitious developmental and environmental targets that Indonesia has set for itself. The fragmented and sometimes discordant nature of the current policy modeling landscape reveals significant gaps. Models often operate in isolation, without a standardized framework, leading to inconsistencies in projections and potential policy misalignments.

Box 2: Application of Sentient Hubs in Energy Mix

One example of Sentient Hubs' holistic planning and impact modeling is its Energy Mix Simulator, with a mock-up for the United States shown in Figure 1. Users can review how changes in assumptions or scenarios impact the power system through a user-friendly interface. For example, policymakers can test proposed electricity prices or carbon prices and quickly get results for relevant information about the power grid, such as the possible power generation mix, the generation model over the day, and voltage profiles (to see potential outages). With relevant permissions, users can utilize the same models used in target and planning documents. Yet users can also leverage Sentient Hubs' linkage to other open-source and proprietary models to answer ancillary questions that could have not been addressed in isolation.

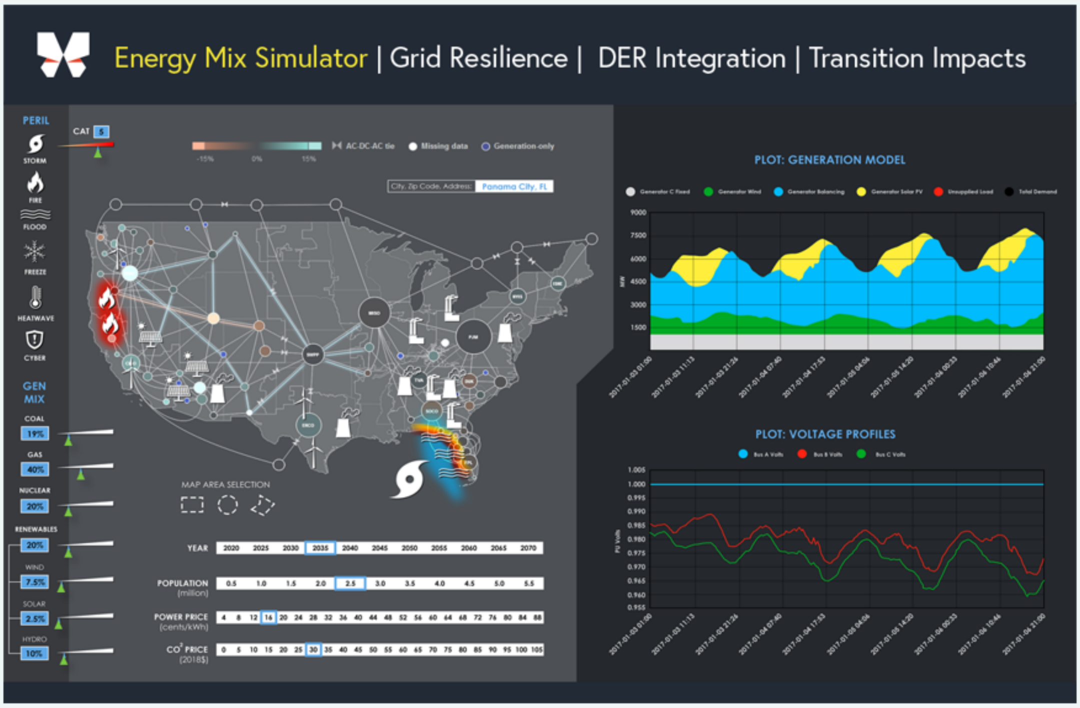

Figure 1. Energy Mix Simulator, United States Mock-Up
Source: Sentient Hubs

Compounded with Sentient Hubs' disaster, weather, and climate models, users could also review how resilient the system is to disasters, such as forest fires, floods, or cyberattacks. Such analysis is critical because climate change is not only a matter of increasing average temperatures but also more frequent extreme weather events. This affects power demand, generation, and transmission (IEA, 2021). Since the energy mix simulator allows users to map power infrastructure, it would allow users to analyze these issues through a spatial lens. Consequently, the energy mix simulator could also derive results for micro-level planning, such as siting decisions for grid infrastructure or procurement plans for power storage facilities.

Although it cannot be fixed using one platform, Sentient Hubs and other types of platforms can offer a promising solution to these challenges. By serving as an integrative hub, Sentient Hubs can assimilate diverse modeling frameworks, allowing for cross-comparisons, enhancing transparency, and promoting a more collaborative policy-making environment. Such platforms can pave the way for a more harmonized approach, ensuring that policy decisions are rooted in robust, comprehensive, and transparent modeling processes. Furthermore, their capacity to bridge the gap between different "families" of models empowers stakeholders with a clearer understanding of the intricacies involved, fostering more informed decision-making.

In the final analysis, the success of policy modeling in Indonesia hinges on the collaborative spirit of stakeholders, the adoption of advanced platforms, and an unwavering commitment to transparency and clarity. As Indonesia navigates the challenges of sustainable development, energy transition, and environmental conservation, a cohesive policy modeling framework will be paramount. Harnessing the potential of platforms like Sentient Hubs, coupled with a unified approach from all stakeholders, can ensure that Indonesia's policy aspirations translate into tangible, impactful actions.

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