Carbon lock-in in Southeast Asia

Assessing the Persistence of Non-Renewable Sources of Energy in the Philippines, Indonesia, and Viet Nam

A master thesis

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Supervisor: Pascale Combes Motel

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Declaration of Authorship

I, Hannah Guinto, declare that this thesis entitled **"**Carbon lock-in in Southeast Asia: Assessing the Persistence of Non-Renewable Sources of Energy in the Philippines, Indonesia, and Viet Nam**"** is my original work completed under the supervision of Professor Pascale Combes Motel. All publications that were consulted or quoted are cited in the main text and references.

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Zásady pro vypracování

Southeast Asia has immense potential in sustainable energy sources, and the need to leverage renewable energy is underpinned by increasing energy demand and international commitments to cleaner energy. The region’s renewable energy deployment, however, is riddled with various challenges. This paper argues that Southeast Asia suffers from carbon lock-in, which occurs when fossil fuel-based technologies, markets, and institutions co-evolve and become structurally linked, making the energy transition inert. The research aims to answer two key questions: (1) What are the factors that contribute to carbon lock-in in selected Southeast Asian countries and (2) What are the available policies and mechanisms that can overcome carbon lock-in?

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Abstract

Southeast Asia is endowed with immense potential in sustainable energy sources, and the need to leverage renewable energy is underpinned by increasing energy demand and climate commitments. The region's energy transition, however, is riddled with various challenges. This paper argues that Southeast Asia suffers from carbon lock-in, which occurs when fossil fuel technologies, markets, and institutions co-evolve and become structurally linked, making the energy transition inert. The research focuses on three Southeast Asian countries driving the expansion of fossil-fuel production in the region: Indonesia, the Philippines, and Viet Nam. Using Trencher et al.'s socio-technical framework on carbon lock-in (2020), the paper answers two key questions: (1) What are the sources of carbon lock-in in Indonesia, the Philippines, and Viet Nam and (2) What are the available opportunities that can rupture carbon lock-in? A scoping review was conducted using 183 publications comprised of journal papers, practice-based reports, news articles, and government documents. Using content analysis, the scoping review produced 31 sources of carbon lock-in ranging from material factors, human actors, non-material factors, and exogenous factors; and 21 key opportunities for a low-carbon pathway for Indonesia, the Philippines, and Viet Nam.

Keywords: Carbon Lock-in, Energy Transition, Path Dependency, Southeast Asia

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List of Abbreviations

IPV	Indonesia, the Philippines, Viet Nam
ASEAN	Association of Southeast Asian Nations
ADB	Asian Development Bank
NDC	Nationally Determined Contributions
GHG	Greenhouse Gases
RE	Renewable energy
VRE	Variable renewable energy
MTOE	Million tonnes of oil equivalent
MTCO2e	Metric tonnes of CO2 equivalent
GW	Gigawatt
MW	Megawatt
GwH	Gigawatt hour
KwH	Kilowatt hour
LCOE	Levelized cost of electricity
LNG	Liquified natural gas
CCS	Carbon Capture Storage
IPP	Independent Power Producers
PPA	Power Purchase Agreement

1 Introduction

The need to leverage Southeast Asia's immense potential in sustainable energy resources is underpinned by two reasons. First, despite the economic challenges brought by the pandemic, the region is still expected to be one of the fastest-growing in terms of energy demand. The region's energy demand is expected to increase by 60% by 2040 while its economy more than doubles its size and its urban population increases by 120 million (IEA, 2021). The question is whether the region can keep up with energy demand and which energy sources, technologies, and policies the region will pursue. The second rationale pertains to international commitments: the Association of Southeast Nations (ASEAN) aims for a renewable energy share of 23% in energy supply and 35% in installed capacity by 2025 (ACE, 2021).

The region's energy transition, however, is challenged by energy sector fragmentation, infrastructure capacity, lack of financing for renewables, inept regulatory frameworks, among others. This thesis argues that these challenges are symptomatic of the region's pervasive carbon lock-in which largely inhibits a smoother transition to sustainable energy.

Carbon lock-in is a multi-sectoral issue where a combination of forces perpetuates carbon-intensive infrastructure in a society, causing a resistance to the deployment of less carbon-intensive sources of energy. It hinders the competitiveness and innovation of low-carbon alternatives because of mutually reinforcing physical, economic, institutional, and social constraints that have co-evolved throughout history (Erickson et al., 2015; Seto et al., 2016). Past decisions and events that favored carbon-emitting activities have thus created a robust system composed of actors, institutions, and rules that serve to maintain a high-carbon path.

Despite the variation in energy regimes in Southeast Asia, carbon lock-in poses a threat to all countries' commitments to cleaner energy. In terms of assets alone, 87.7% of Southeast Asia's current fossil fuel generation is incompatible with the carbon budget aligned with the 1.5°C warming threshold (Caldecott et al., 2018).

This thesis aims to investigate the factors driving carbon lock-in for three countries in Southeast Asia: Indonesia, the Philippines, and Viet Nam, which from this point are referred to as “IPV”. These countries are consistently within the top five emitters in the region (The World Bank, 2022). The focus on IPV is primarily motivated by the fact that they are driving the expansion of the region’s fleet of coal-fired plants equivalent to 91 gigawatts (Global Energy Monitor, 2022). Interestingly, while adding more coal plants, the Asian Development Bank (ADB) has formalized an ambitious plan to retire 50% of IPV’s coal fleet within the next fifteen years, equivalent to 30 gigawatts and approximately 200 megatons of CO_2 emissions per year (ADB, 2021b).

The literature on carbon lock-in in the region has so far been limited and fragmented. Publications that specifically discuss carbon lock-in in Southeast Asia focus on coal infrastructure and power purchase agreements as evidence for carbon lock-in (Caldecott et al., 2018; Isaad, 2021), while relevant research on institutional, behavioral, and dynamics of political economy have not been written under the lens of carbon lock-in, but through other theoretical frameworks (L. L. Delina, 2021; Dorband et al., 2020; Ialnazov & Keeley, 2020; Marquardt, 2015). This research complements existing literature by providing a comprehensive analysis of carbon lock-in in Southeast Asia through a socio-economic and technical framework. This applied framework, based on Trencher et al.’s study of the persistence of coal in Japan (2020), distinguishes four sources of carbon lock-in: *material factors*, which include physical assets, *human actors,* which include key stakeholders, *non-material factors*, which involve institutional and behavioral aspects, and finally *exogenous factors*, which are macro-level conditions.

This thesis answers the following questions:

- What are the sources of the persistence of fossil fuel-based energy in Indonesia, the Philippines, and Viet Nam?
- What are the opportunities to overcome carbon lock-in?

These questions will focus on power generation, where coal and gas have significant shares in IPV. By identifying sources of carbon lock-in for these countries, the thesis analyzes and uncovers interlinkages which create pathways generating carbon lock-in. Once an exhaustive carbon lock-in picture is mapped for each country, possible opportunities to rupture carbon lock-in are further identified.

The research relies on secondary sources for a qualitative analysis of carbon lock-in in IPV. A scoping review is conducted using government documents, practice-based reports, academic journals, and news articles. Guided by the socio-technical framework on carbon lock-in, a set of themes are coded and analyzed. By consolidating material, non-material, human, and exogenous factors that were previously scattered across the academic and discursive ether, this work provides a more comprehensive illustration of carbon lock-in for the region than previous scholarship.

The thesis is structured as follows: the energy sectors of IPV are discussed to contextualize the prevalence of carbon lock-in in Chapter 2. Chapter 3 discusses the research methodology through a review of related literature on existing measurements of carbon lock-in and the chosen framework by Trencher et al. (2020). Results and discussions are presented in Chapter 4, limitations are discussed in chapter 5, and conclusions and policy implications are discussed in Chapter 6.

2 The Energy Landscapes in Indonesia, the Philippines, and Viet Nam

This chapter explores whether IPV can manage and reconcile energy demand, economic growth targets, and climate commitments at the same time. An overview of economic and demographic indicators related to energy demand and security is discussed (2.1), followed by climate and energy commitments and policies (2.2), domestic power markets (2.3), renewable energy potential (2.4), and lastly an outlook on carbon lock-in for 2030 and beyond (2.5).

Figure 1. Map of IPV

Source: (MapChart, 2022)

2.1 Energy Demand and Energy Security in IPV

Demographic and macroeconomic factors are significant determinants for energy demand for IPV, where economic growth has yet to be decoupled from electricity demand (Isaad, 2021; Kurniawan et al., 2020). IPV have had steadily growing energy consumption rates in the last thirty years similar to GDP growth trends as seen in figures 2 and 3.

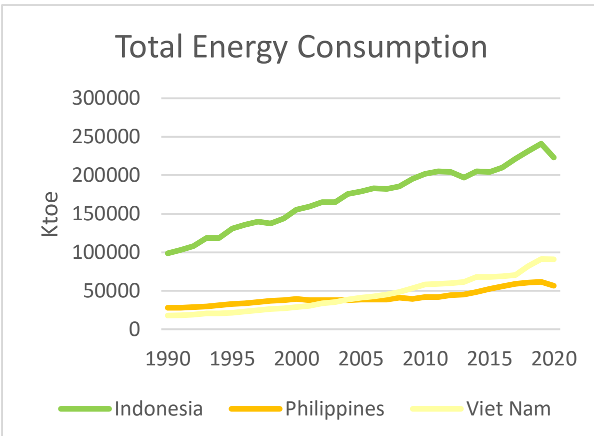

Figure 2. Total Energy Consumption of IPV

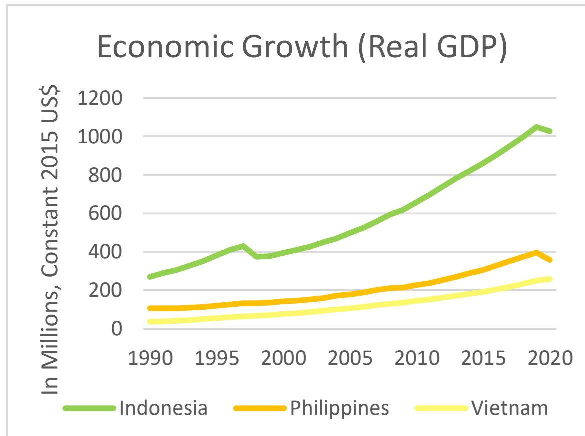

Figure 3. Economic growth (Real GDP) of IPV

Sources: (Enerdata, 2022; World Bank, 2021)

Table 1 summarizes important drivers of energy consumption. The most influential factors involve population, labor, economic growth, urbanization growth, industrialization, trade openness, and foreign direct investments (FDI) (S. Chen et al., 2019; Khuong et al., 2019; S. Li et al., 2021; W. Li et al., 2019; X. Liu & Bae, 2018; Ozturk & Acaravci, 2013; Sandu et al., 2019; Shahbaz et al., 2013; Waheed et al., 2019; Q. Wang et al., 2020; S. S. Wang et al., 2011; Zaharia et al., 2019). Trade, industry, and FDIs contribute significant shares to all three economies. Similar studies on IPV show that an increase in these indicators, along with urbanization, economic growth, and population growth, tend to increase GHG emissions (Baek, 2016; Budhi Utomo & Widodo, 2019; Guzel & Okumus, 2020; Nasir et al., 2019; Sandu et al., 2019; Y. Wang et al., 2016).

Indonesia is a net energy exporter, with coal comprising 11.2% of total energy export value as the principal export (ADB, 2020). The country is self-sufficient in energy due to its resource abundance. Domestic fossil fuels currently make up 83% of its power generation mix. For the

Philippines, fossil fuels account for almost 80% of the power generation mix. Coal is a major energy source with an annual growth of 8.7% in the energy supply since 1990 and is projected to maintain its largest share in total energy supply at 38.4% by 2050 (Olvido & Morales, 2021). Viet Nam's energy consumption has grown by 9% annually in the last two decades, and energy demand is expected to increase by 8% annually until 2030 to keep up with the economy (Fitch Solutions, 2021).

The three lower middle-income countries have promising economic outlooks in the medium term, with forecasts at above 5% for Indonesia and Viet Nam (OECD, 2021b; World Bank, 2022) and 7-9% for the Philippines (Morales & Lema, 2022). IPV aim to graduate to upper middle-income status with aggressive plans for economic development centered around infrastructure, transportation, and industrialization. Energy demand is expected to almost triple to 548.8 MTOE from 192 MTOE in 2020 for Indonesia (National Energy Council, 2019); triple in 2050 to 116.1 MTOE from 36.3 MTOE in 2019 for the Philippines (DOE, 2020; Olvido & Morales, 2021); and quadruple from 78.9 MTOE in 2017 to 293.1 MTOE in 2050 for Viet Nam (Minh, 2021).

The increases in energy consumption over the next few decades, coupled with the dominance of fossil fuels present a significant challenge for IPV: a widening gap between supply and demand. This threatens energy security and affordability. In fact, it is estimated that by 2030, both the Philippines and Viet Nam will be net importers of fossil fuels to meet energy demand (Shi & Yao, 2022).

Table 1. Energy and Macroeconomic Indicators

Indicator	World	LMIC[1]	ASEAN	Indonesia	Philippines	Viet Nam
Population (2020)	7.9 B	3.33 B	673.65 M	273.52 M	109.58 M	97.34 M
Urban population (2020)	55.26%	42.4%	52.26%	56.6%	47.4%	37.3%
Working age population (2020/2021)	65.2%	64.6%	67.7%	71%	64.4%	68.9%
GDP (Current US$) (2020)	84.75 B (Ave)	23.77 B (Ave)	274.02B (Ave)	1,058.42 B	361.39 B	271.16 B
GDP per capita (Current US$) (2020)	10,916	2,217	11,123	12,072.7	8,389.8	2,785
GDP Growth Rate (2020/21)	-3.3 (2020)	-3.4 (2020)	0.6	3.69	5.6	2.58
FDI (GDP%) (2020)	1.4	1.9	5.82	1.8	1.8	5.8
Trade (GDP%) (2020)	51.6	46.6	113	33.2	58.2	208.3
Industry (GDP%) (2020)	26	27.7	35.62	38.3	28.4	33.7
Power generation mix (2020)	Fossil fuels: 58% • Coal: 35% • Gas: 23% Renewables: 29% • Nuclear: 10%	-	Fossil fuels: 73.9% • Coal: 31.1% • Gas: 35.8% • Oil: 6.8% Renewables: 26.1% • Hydro: 19.7% • Others: 6.4%	Fossil fuels: 83% • Coal: 60% • Gas and oil: 23% Renewables: 17% • Bioenergy: 7.3% • Hydro: 5.1% • Geothermal: 3.74% • Solar and wind: 0.68%	Fossil fuels: 78.8% • Coal: 57.2% • Gas and oil: 21.6% Renewables: 21:2% • Geothermal: 10.5% • Hydro: 7.1% • Biomass, solar, wind: 3.5%	Fossil fuels: 49% • Coal: 34% • Gas and oil: 15% Renewables: 51% • Hydro: 26% • Solar: 24% • Wind and bioenergy: 2%
Final energy consumption (2019/2020)	9938 MTOE	-	375 MTOE (2017)	163.58 MTOE	36.3 MTOE	92 MTOE
RE% in final energy	11.5%	-	26.1%	20.86%	23.22%	23.49%

[1] Lower Middle Income

consumption (2018)						
Energy independence (2019/2020)	-	-	-	100%	53%	66.5%
Installed capacity (2020)	7,180.6 GW	-	285.089 GW	71 GW	26.25 GW	56 GW
Electricity consumption per capita (KwH) (2019)	3,081	-	-	1,084	810	1,471
Energy demand growth until 2030	1.7%	-	4.4%	4.4%	5.8%	8%
Access to electricity (2019)	90.5%	89.8%	93.3%	98.9%	95.6%	99.4%
CO2 emissions per capita[2] (2018)	4.5	1.7	4.39	2.18	1.33	2.70

Sources: (DOE, 2020, 2021a; International Trade Administration, 2020; IRENA, 2021; Manila Bulletin, 2021; UNFCCC Secretariat, 2021; World Bank, 2021)

2.2 Climate and Energy Policies

This section presents an overview of the policy environment governing sustainable energy development for IPV. Climate targets are first discussed, which are overall insufficient to aid climate mitigation in line with the Paris Agreement. Section 2.6 further explores how these unambitious commitments are unlikely to be reached.

Indonesia has an emissions reduction target of 29% unconditionally using domestic resources, and up to 41% conditional to international assistance from 2020 to 2030 (Republic of Indonesia, 2021). Moreover, they aim to reach net-zero emissions by 2060. The Philippine Government on the other hand is targeting GHG emissions reductions by 75% by 2030; however only 72.29% is conditional to international support. Viet Nam aims to reduce its GHG emissions unconditionally by 9% by 2030, which can be raised to 27% conditional to international support. Viet Nam also announced a target of net zero emissions for 2050. The

[2] In metric tons

climate commitments of IPV have been deemed either critically or highly insufficient, based on comparisons between the targets and modelled feasible domestic pathways. The targets reflect minimal to no climate action and are incompatible with the Paris Agreement's temperature limit of 1.5°C above pre-industrial levels (Climate Action Tracker, 2022).

A summary of climate policies relevant to sustainable energy is shown in Table 2. These are classified within the typology of environmental policies, namely (1) market-based instruments and (2) command-and-control regulations. For Indonesia, the emphasis of its RE policies is on geothermal energy, solar photovoltaics (PV), biomass, and hydropower. For the Philippines, geothermal, hydropower, and biofuels are prioritized. In Viet Nam's case, policies are strongly oriented towards solar and wind sources.

Table 2. Climate and Energy-Related Policies in IPV.

		Indonesia	**Philippines**	**Viet Nam**
Market based instruments				
Subsidies	Tax incentives	Available	Available	Available
	Feed-in tariffs	Available	Discontinued	Available
	Preferential financing	Available	Available	Available
	Credit guarantees	Not available	Available	Available
Taxes	Reduction or removal of high carbon taxes and subsidies	Existing subsidies for kerosene, diesel, LPG, and coal-fired electricity	Not available	Existing subsidies for coal-fired electricity
	Differentiated pricing	Electricity pricing still cheaper for fossil fuels	Not applicable	Electricity pricing still cheaper for fossil fuels
	Emissions Tax	Planned for 2022	Not available	Planned for 2022
Trading Systems	Energy efficiency and renewable energy target-based cap and trade	Planned for 2022	Not available	Not applicable
	Emissions based cap and trade	Not applicable	Not available	Planned for 2028
	Baseline and credit	Planned for 2022	Not available	Not applicable
Other mechanisms	Net metering	Discontinued	Available	Discontinued
	Auctions for RE power	Available	Available	Planned after 2023

Command and Control instruments				
	Biofuels Mandate	Available	Available	Available
	Renewable Portfolio Standards	Not available	Available	Available

Market-based instruments, which incentivize producers and consumers to voluntarily adopt RE technologies, are further classified into subsidies, taxes, and trading systems. All countries provide tax incentives and preferential financing from state banks for RE development. Credit guarantees for RE technology providers in the Philippines are available through the LGUGC, a private company catering to projects involved in public-private partnerships, while credit guarantees in Viet Nam are given by the state's Vietnam Environmental Protection Fund (IISD, 2020; UNIDO, 2018).

In terms of taxes, fossil fuel subsidies in Indonesia and Viet Nam exist, while the Philippines has removed fossil fuel subsidies since IPPs have passed on their production costs to consumers. At present, Indonesia still provides subsidies for kerosene, diesel, LPG, and coal-fired electricity. These include subsidies from the state-owned PLN, which has a domestic market obligation to purchase coal at market rates while selling electricity at prices below these rates. Fossil fuel subsidies have been reduced throughout the years, yet they remain at 9% of the annual state budget on average since 2015, and it continues to outweigh climate-related expenditures (Mafira, 2021). Similarly, Viet Nam has existing subsidies for coal amounting to at least $270 million in 2020 (Climate Transparency, 2020b).

Both Indonesia and Viet Nam plan to roll out domestic carbon markets within the decade, starting with a carbon tax within 2022. Indonesia's carbon market is planned to be a baseline-and-credit system which sets benchmarks for different categories of coal-fired plants, instead of a traditional cap-and-trade system. The Indonesian government also plans to have an energy efficiency-based cap, putting pressure on corporations with the highest energy intensities. For Viet Nam, an emissions-based cap-and-trade program will be followed and is planned for full operation by 2028.

Net metering schemes and competitive auctions are also important market-based mechanisms to incentivize RE users and developers. Net metering, which incentivizes solar users to sell unused solar power to main grids, is only available in the Philippines. Auctions for RE projects are at place in Indonesia and the Philippines, while Viet Nam plans to pursue auctions after 2023 (Urakami, 2020).

Command and control instruments, on the other hand, are regulations set by governments which domestic entities must abide. There are two key command and control instruments in IPV: biofuels mandates and renewable portfolio standards (RPS). RPS requires RE production must increase at a certain level. Biofuels mandates are at place in all three countries, while RPS is present in all but Indonesia.

While the right policies do exist to support the development of sustainable energy in IPV, the support mechanisms and implementation are fraught with challenges. For example, feed-in tariffs are now seen as less promising for RE development in IPV. The most recent FIT in Indonesia has been designed to undermine RE development by capping the purchase price at 85% of the local electricity production cost by PLN, the state-owned company known to prioritize coal (Hamdi, 2019). Similarly, the net metering scheme was discontinued in Indonesia as it provided an awkward arrangement for producers: users of rooftop solar will not be able to sell their excess electricity back to the grid because PLN supposedly cannot pay for this by law. Instead, the excess electricity becomes a credit which will net-off electricity use from PLN. This translates to a lack of transparency on the financial benefits for rooftop solar users. In fact, investments in solar would only provide a return in 23 years for users with minimal output (Hamdi, 2019).

In the Philippines, the FIT has been discontinued since 2019 for three reasons. First, since investment costs are shouldered by end-users, electricity prices soared and aggravated consumers. Second, since the FIT was implemented in 2012, the share of RE in the power generation mix decreased while the share of coal continued to increase. Third, the FIT implementation incurred a net cost in monetary terms after accounting for total benefits (Yap & Lagac, 2020). In Viet Nam, while the FIT was first deemed a driver for RE uptake, there is evidence of unbalanced development of solar power projects in the country due to the policy, with the FIT being too low in many regions. This is because the FIT is derived from the global average levelized cost of electricity (LCOE) of solar power instead of the domestic LCOE (Le et al., 2022).

The biofuels mandates of IPV have been unsuccessful, as the biofuels targets are largely unmet due to lack of investments in biofuel production, feedstock supply, volatile oil prices, and insufficient government support in general (Acda, 2022; Kharina et al., 2016; U.S. Grains Council, 2018). Differentiated pricing is also a major barrier for RE, as fossil fuel-fired electricity is still cheaper in Indonesia and Viet Nam. In Indonesia, this is largely due to the cap for purchasing electricity from RE at 85% the electricity production cost of PLN.

2.3 Power Markets in Indonesia, The Philippines, and Viet Nam

The power markets of IPV are illustrated in Table 3. Indonesia has a highly regulated power market. Perusahaan Listrik Negara (PLN), a state-owned utility company, handles majority of generation, transmission, and distribution. Viet Nam also follows a regulated market, although to a lesser degree compared to Indonesia. The state-owned Viet Nam Electricity (EVN) holds a large share of generation assets with 46.3% installed capacity, while the rest are controlled by private investors (Isaad, 2021). Other state-owned enterprises (SOEs) like Viet Nam Oil and Gas Group (PVN) and Viet Nam National Coal Mineral Industries (Vinacomin) are among the largest Independent Power Producers (IPPs) in the country. Transmission is also under state authority through the National Power Transmission Corporation.

The Philippines on the other hand has the most fragmented and deregulated energy sector. Most state-owned generation assets have been privatized, with only transmission controlled by the government. In pursuit of more competitive prices, wholesale electricity spot markets were established in the Philippines and Viet Nam in 2006 and 2019 respectively. However, both electricity markets only control a small share of power generation, with most of the generated power still procured through power purchase agreements (Ibid).

Table 3. IPV Power Markets

	Indonesia	**Philippines**	**Viet Nam**
Number of powerplants	5,000+	208	73
Installed capacity	71 GW	26.25 GW	56 GW
Generation	State-owned PLN (only 16% of generation through IPPs)	All assets owned by independent power producers.	46.3% owned by state-owned EVN; the rest by independent power producers
Transmission	State-owned PLN	State-owned Transco	State-owned National Power Transmission Corporation (NPTC)
Grid operations	State-owned PLN	National Grid Corporation (private)	
Distribution	State-owned PLN	Private distribution utilities and electric co-operatives	Five EVN subsidiaries
Coal Importation	Does not import its energy supply.	Has some sporadic coal reserves; imports 75% of its coal from Indonesia.	Imports around 53% of its coal from Indonesia, Australia, and Russia.
Electricity pricing	Highly regulated and set by the government	Largely determined by market forces/ international prices of coal and diesel	Highly regulated and set by the government
Average power tariffs (US c/KwH)	8.1	14.9	9.8
Competitive markets	No competitive markets.	Presence of a wholesale market, but traded electricity is very limited.	Presence of a wholesale market, but traded electricity is very limited.

Sources: (ABS-CBN, 2021; Enerdata, 2022; International Trade Administration, 2020; Isaad, 2021)

2.4 Renewable Energy Potential

As seen in Table 4, IPV have large untapped RE potential which could address both energy security and GHG emission reduction targets. The Indonesian government's priorities for the energy sector are contradictory, as although it includes environmental sustainability in its strategy, maximum use of domestic energy resources, particularly coal, is emphasized. The National Electricity Plan (Ibid) aims to have a long-term goal of 28% RE, 25% gas, 47% coal, and 0.1% oil for electricity utilization beyond 2025. While the target share of clean energy would be a steady improvement, coal dependence continues to prevail in the medium term. The incremental increase in the renewables target is considerably scant, given that the country has vast amounts of RE sources. The country has the largest geothermal potential in the world at 28.5 GW, or 40% of the global reserve (Kurniawan et al., 2020). Other renewable sources have considerable potential as well with hydropower at 94 GW, solar at 200 GW, wind at 61 GW, and biomass at 33 GW (ADB, 2020).

The Philippines will also continue to largely depend on coal despite its abundant RE resources. Demand for renewables is projected to have a minimal growth of 0.5% per year, while coal will still be the dominant source of energy for power generation through 2050 (Olvido & Morales, 2021). Geothermal energy presents at least 4,000 megawatts of untapped potential. Wind resources have a potential of 196,200 GWh per year, while untapped potential for hydropower and biomass are 13,097 and 4,450 megawatts respectively (IRENA, 2017).

Similarly, coal will continue to play a prominent role to meet energy demand in Viet Nam, accounting for 31.4% of installed generation capacity for 2030. Gas-fired power will also account for 22.4% in the same year. Among IPV, Viet Nam is a leader in RE with hydro and solar making up 50% of the country's generation mix in 2020. In terms of solar alone, 2020 saw a doubling of installation capacity within just eight months, and the growth of rooftop solar was at 6,000% in just two years (Energy Tracker Asia, 2020). The most recent proposal of the national power development plan, however, signals the government's priority of coal with a target increase of installed capacity by 3 GW by 2030 and 10 GW by 2035, sacrificing 8 GW of renewables (Tachev, 2021).

Table 4. Untapped renewable energy potential in IPV.

RE Potential	Indonesia	Philippines	Viet Nam
Geothermal	28.5 GW	4000 MW	340 MW
Hydropower	94.3 GW	13,097 MW	7,200 MW
Solar	207.8 GW	5.1 $kWh/m^2/day$	13,000 MW
Wind	61 GW	76,600 MW	27,750 MW
Biomass/bioenergy, waste	33 GW	4,450 MW	2,820 MW
Ocean energy	17.9 GW	170 GW	550-850 MW

Sources: (ADB, 2018, 2021a; Aruna K. Wanniachchi et al., 2016; IRENA, 2017; Kusuma, 2018; Lee et al., 2020; Quirapas & Taeihagh, 2021)

2.5 Prospects of Carbon Lock-in for IPV

Significantly reducing emissions from the power sectors of IPV is crucial in achieving climate targets. Their power sectors have the highest contributions to energy-related emissions at 40%, 51%, and 49% respectively (Climate Transparency, 2020b, 2020a; IESR, 2020).

As members of the ASEAN, all three have reaffirmed their commitments to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The Asian Development Bank's early coal retirement program, apart from IPV's own initiatives, is expected to aid in achieving their targets. However, they have ongoing and planned investments for expanding their coal-fired plant fleet equivalent to 91.16 GW, which will double the entire ASEAN's existing coal generation capacity (95 GW), as illustrated in figure 4 (Global Energy Monitor, 2022). If all planned fossil fuel plants are built, the CO2 emissions from the region's power sector will increase by 72% from 2020 to 2030, and its long term committed emissions will double (X. Chen & Mauzerall, 2021). Furthermore, the future generation from fossil fuels combined with RE will surpass IPV's electricity demand before 2030. Future fossil fuel plants will hence be become stranded or underutilized, as well as hinder the deployment of RE (Ibid.).

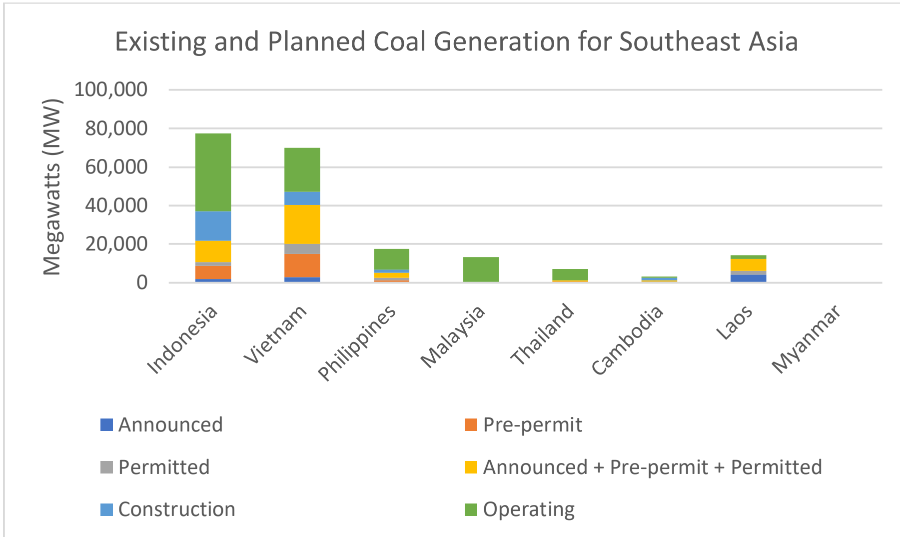

Figure 4. Existing and Planned Coal Generation for Southeast Asia (MW)

Source: (Global Energy Monitor, 2022)

Carbon lock-in will clearly be worse off for IPV within the decade due to its ongoing investments in coal plants. Figure 5 illustrates that 90% of both existing and planned power plants of IPV are incompatible with the carbon budget threshold for a 1.5°C increase in global temperatures[3].

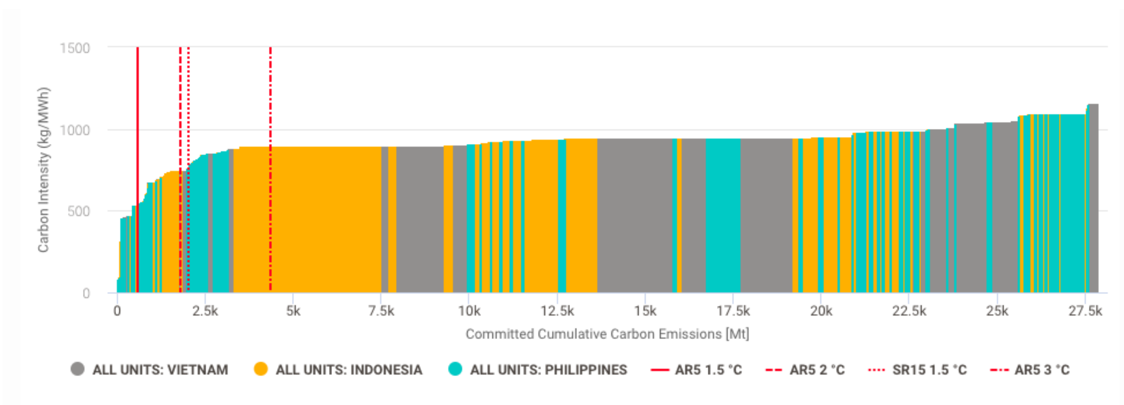

Figure 5. Carbon Lock-in Curves for IPV

[3] Assets to the left of the budget lines are considered compatible with a budget allocation for a specific warming scenario, while those to the left are incompatible.

The ADB's aim to retire coal plants equivalent to 30 GW in IPV will be undermined by their coal pipelines for this decade. The planned coal units will more than offset the reduced CO2 emissions from the ADB program. There is also a risk that the energy transition mechanism would merely direct cash flows to powerplants already near retirement (Isaad, 2021).

IPV are unlikely to meet their targets for emissions reduction and renewable energy with their current plans and policies (Overland et al., 2021). The ASEAN power sector must reach carbon neutrality by 2050 to comply with a below 2°C scenario, and the three countries' fossil fuel pipelines set them up for failure. For Indonesia to reach its climate commitments, coal power generation must decrease to 5-10% of the generation mix by 2030 and reach zero by 2040 (Climate Action Tracker, 2020). This accounts for only 17 GW of coal generating capacity—an unlikely achievement given that Indonesia's current pipeline equals 77 GW for coal generation (Global Energy Monitor, 2022). While Viet Nam announced a carbon neutrality target by 2050, its current policies and plans are deemed critically insufficient to meet climate targets consistent with the Paris agreement (Climate Action Tracker, 2021). Meanwhile, the Philippines has yet to announce a carbon neutrality goal, and estimations of its GHG emissions resulting from current policies indicate that the Philippines will fall short of its NDC targets (Kuramochi et al., 2021).

This chapter endeavored to illustrate the energy landscapes in IPV, particularly its macroeconomic contexts, policies, its sources of energy, and domestic power markets. Despite their differences, their energy trajectories remain the same: a heavy reliance on fossil fuels until 2050 pressured by the need to sustain economic growth and maintain energy security, while their capacity to exploit their RE resources is highly constrained. Given this trilemma, the underlying causes for the persistence of fossil fuels for the top emitters in Southeast Asia merit a deeper investigation. The next chapter discusses how carbon lock-in will be examined in IPV.

3 Research Methodology

The extent of carbon lock-in can be measured in various methods. First, existing approaches to measure and explain carbon lock-in are summarized (3.1), and the chosen socio-technical framework for this thesis is discussed (3.2).

3.1 Measuring Carbon Lock-In

Table 5 shows an overview of quantitative approaches to measure carbon lock-in from a review of related literature. Meanwhile, table 6 summarizes the key typologies that categorize sources of carbon lock-in from literature using mixed methods. This section presents the most extensive review of related literature on carbon lock-in measurements so far.

Carbon lock-in occurs when fossil fuel-based technologies, markets, and institutions co-evolve and become structurally linked. This leads to a persistent carbon-emitting path for energy systems despite the availability of cleaner technologies. Carbon lock-in can be measured through different aspects: through material factors (e.g. how capital stock make it harder to pursue an energy transition due to financial commitments), through institutional and technological factors (e.g. how employment in fossil fuel sectors, policies propping up fossil fuel production, and the market share of fossil fuel technology indicate an entrenched system in favor of fossil fuels), as well as behavioral factors (e.g. how human patterns of consumption, transportation, and other actions become inflexible norms, indicating a lock-in effect for carbon intensive systems).

Table 5. Quantitative Approaches to Measure Carbon Lock-in

Quantitative Approaches	Description	Key literature
Shadow Prices and Marginal Abatement Cost Curves (MACC)	A MACC illustrates the cost of emissions abatement for varying amounts of emission reduction. Estimating the MACCs requires the shadow price or the cost of CO2 reduction and covariates such as GDP, labor, capital, energy consumption, industrial composition, urban concentration, and vehicle ownership. Fossil fuel assets increase the cost of transforming carbon-intensive economies. The higher the cost, the more severe the lock-in effect.	(Chignell & Gross, 2013; Du et al., 2015; J.-Y. Liu & Feng, 2018; Maradan & Vassiliev, 2005; Unruh, 2000; Zhou et al., 2014)
Carbon Lock-in Curves (CLICs)	CLICs combine committed cumulative carbon emissions (CCCEs), which are the emissions an asset will produce over its remaining lifetime, and MACCs. The CCCE is plotted for each asset ordered by either by plant efficiency, marginal cost, or plant age. Carbon budgets are plotted as vertical lines. Assets to the left of the carbon budget line are compatible with the budget, while those to the right are not. The share of assets incompatible with a carbon budget is used to indicate the severity of carbon lock-in.	Caldecott et al., 2018
Committed Carbon Dioxide Emissions (CCE)	CCEs are estimated based on their generation capacity, plant lifetimes, the mean capacity factor[4] and emissions factor[5] of generators. CCCEs are indicative of carbon lock-in as fossil fuel plants lock-in CO2 emissions because of long lifetimes.	(X. Chen et al., 2021; X. Chen & Mauzerall, 2021; Davis & Socolow, 2014; Tong et al., 2019)
Installed capacity, Equipment lifetime, Age of Existing Infrastructure Stock Inertia, Capital Costs Intensity	Installed capacity, capital stock age, equipment lifetime, and capital costs can be used as stand-alone indicators to show the extent of carbon lock-in. The more installed capacity in fossil fuels, the higher the carbon price, and the more severe the carbon lock-in effect. Meanwhile, the younger the high carbon fleet, the lower the probability to retire these assets in the immediate term.	(CTI, 2018b; Fisch-Romito et al., 2021; Gielen et al., 2019; IRENA, 2017; Kefford et al., 2018)
Stranded Assets	This is defined as the premature retirement, retrofitting, or under-utilization of assets with reference to a potential capital profit and its lifetime. An asset is stranded if a low carbon alternative is opted for, implying an escape from	(CTI, 2018b; Fisch-Romito et al., 2021; Gielen et al.,

[4] MWh electricity generated per MW capacity

[5] kg CO_2 per MWh

	carbon lock-in. Stranded assets can either be stranded investments or profits. With increased stranded asset risk, the higher the pressure to fulfill assets' operations, the higher the severity of carbon lock-in.	2019; IRENA, 2017; Kefford et al., 2018)
Elasticity related to capital cost variables	Elasticities related to capital stock variables illustrate the contributions of capital stock to CO2 emissions. Carbon lock-in stemming from capital stock is supported by correlations between emissions from coal capital and economic growth, emissions and material stock, and emissions and industrial agglomeration.	(Avner et al., 2014; Lin et al., 2017; Steckel et al., 2015; Zhang et al., 2018)
Employment	The distribution of employment in high carbon sectors and low carbon sectors offers insight on the level of entrenchment in a high-carbon system. The hypothesis is that when there is a bigger share of employment in high carbon sectors, there is less capacity, skills, and knowledge for low carbon development.	(Bjornaavold & Van Passel, 2017; Erickson et al., 2015)
Technology Scale	This refers to the market share of high or low carbon technology to indicate the extent of dependency on fossil fuels. Carbon lock-in is evident in economies with larger market share of fossil fuel technologies through network effects among industries and actors, as well as sunk-in investments.	(Erickson et al., 2015; Skoczkowski et al., 2018)
Directed technical change	To study the response of different technologies to environmental policies, this model uses two sectors--clean or dirty, depending on its use of fossil fuels or clean energy. A final good is produced by combining the inputs produced by the two sectors, one of which uses dirty technology and leads to environmental degradation. Variables for this production function may fall under labor, capital, and energy. If there is evidence of technical change in favor of fossil fuels (e.g. carbon capture), this hampers the deployment of RE, thus contributing to carbon lock-in.	(Acemoglu et al., 2009; Van der Meijden & Smulders, 2017; Yao & Zhang, 2021)
Quantified indicator system for: • Material lock-in • Technological lock-in • Institutional lock-in • Behavioral lock-in	A measurement indicator system is used based on Seto et al.'s (2016) typology of carbon lock-in. Each category used the following indicators: • Material: value added of industry to GDP, ratio of investment in high-tech industry to investment in fixed assets, ratio of depreciation of assets to GDP, carbon emission intensity of assets • Technological: energy intensity, carbon emission intensity, transaction value in the market • Institutional: R&D expenditure, employees, environmental treatment investment, ratio of investment in fossil fuels to investment in energy • Behavioral: family size, per capita GDP, passenger kilometers, private automobile ownership	(Niu & Liu, 2021)

The typologies presented in Table 6 are based on mixed methods. Material lock-in is measured through aforementioned quantitative approaches, while other types of lock-in such as behavioral and institutional are assessed using qualitative approaches such as semi-structured interviews and thematic analyses.

Table 6. Typologies of Carbon Lock-in Sources

Typologies from mixed methods	Description	Key Literature
• Infrastructural and Technological • Institutional • Behavioral	Infrastructural and technological sources of carbon lock-in are measured through indicators mentioned above: stranded assets, sunk-in capital costs, installed capacity, CCEs, etc. Institutional factors cover policies, actors, networks among energy actors all in favor of fossil fuels. Behavioral factors involve individual and social behaviors that require carbon intensive assets.	(Hernandez et al., 2021; Janipour et al., 2020; Niu & Liu, 2021; Seto et al., 2016)
• Material/Equipment • CO2 emissions • Financial • Techno-institutional	Material factors are measured by equipment lifetime. CO2 emissions are CCEs. The financial barrier for rupturing carbon lock-in is taken as the carbon price, which is equal to the existing cost of high carbon technology. Techno-institutional barriers can be measured by multiple indicators: production capacity of fossil fuel based energy, R&D investment for fossil fuels, political contributions, voting-age employment generation for the technology, technology-specific consumer habits, or technology market share.	(Erickson et al., 2015)
• Material • Human actors • Non-material • Exogenous	Material factors involve the readiness and compatibility of technologies and infrastructure, and the financial value. Human actors involve networks, vested interests, and power balances. Non-material factors involve formal and informal institutions, knowledge and competencies, and microeconomic factors. Exogenous factors are the broader societal, geographical, and environmental conditions that affect the systems that enable carbon lock-in.	(Susskind et al., 2020; Trencher et al., 2020)

Carbon lock-in develops over time because fossil fuels are not just tangible objects. Rather, these nonrenewable sources of energy have multiple functions: first, as a resource, to be extracted, second, as a fuel to be burned, and lastly as a social object. Surrounding these fossil fuels are the "*technologies, and systems in its generation, combustion, and distribution, as well as the political, economic, and social power that animates these systems*" (L. L. Delina, 2021). Fossil fuels thus create socio-technical systems that emerge from its use in society.

To capture the socio-technical systems created by fossil fuels in IPV, a socio-technical framework for this thesis is utilized. The discussion below further explores the factors of carbon lock-in guided by the typology by Trencher et al. (2020). The framework categorizes sources of carbon lock-in as (i) material, (ii) human actors, (iii) non-material, and (iv) exogenous. While preceding literature consider the first three (material, human, and non-material) in their varied typologies (Erickson et al., 2015; Seto et al., 2016; Unruh, 2000), this particular framework includes exogenous factors, which are macro-level conditions outside energy regimes, to paint a deeper and more comprehensive picture of carbon lock-in. To date, Trencher et al.'s framework is the most exhaustive categorization of carbon lock-in sources.

3.1.1 Material factors

Material factors involve technologies, assets, and infrastructure that influence the ability of actors and institutions to adopt alternative technologies or dispose assets. All hitherto literature has highlighted material factors as primary sources of carbon lock-in (L. L. Delina, 2021; Erickson et al., 2015; Fisch-Romito et al., 2021; Seto et al., 2016; Susskind et al., 2020). These are investments in long-lasting built infrastructure such as pipelines, refineries, gas stations, street layouts, transportation, and buildings inhibiting efforts to reduce energy intensity (Seto et al., 2016). Long lead times, large investments, and sunk costs are the mechanisms in which the investment choices perpetuate carbon lock-in. Incompatibility and low levels of technologies for cleaner energy, as well as the widespread adoption of high carbon technology are a significant hindrance escaping lock-in (Janipour et al., 2020). Literature on directed technical change provides insight on carbon lock-in in the lens of technology adoption. Acemoglu et al. (2009) argue that the market size effect encourages innovation toward the technology with the larger market share. If the fossil fuel industry makes up majority of the share of the market, then dirty innovation will prevail. This is the case in developing economies where advanced technologies for fossil fuel production are more easily available than cleaner alternatives during the early stages of economic development—R&D end up focusing on fossil fuels to increase competitiveness in the immediate term, as was the case of China (Yao & Zhang, 2021).

The carbon price is a useful measurement, as the decision to retire an asset is based on the competitiveness of alternatives. Erickson et al. (2015) emphasize financial barriers, which they measure as the levelized cost of the low carbon technology equal to the marginal cost, or the fuel cost of the existing high carbon technology. Quantification of stranded assets and marginal abatement costs are also helpful in illustrating the financial costs of transitioning to low carbon alternatives.

3.1.2 Human Actors

Human actors include actor compositions and power balances, networks, and vested interests involved in maintaining and changing socio-economic systems. This category tackles how actors exercise their power and agency to maintain or change a carbon-intensive system. Economic, social, and political actors seek to reinforce the status quo that favors their interests (Seto et al., 2016). This can be measured through indicators such as political campaign contributions or voting age employment generation for each technology (Erickson et al., 2015).

3.1.3 Non-material Factors

While human actors are more about power and agency, non-material factors explain the formal and informal tools, mechanisms, and dynamics at work in energy regimes that are directly influenced or created by human actors. The typology sets the two apart based on these distinctions.

This category has multiple subdimensions. First, it includes ***formal institutions***, which are codified rules such as contracts, roadmaps, and policies. ***Informal institutions*** are narratives, behaviors, and worldviews that shape peoples' routines which involve energy-intensive assets. Using private vehicles instead of commuting is an example of a carbon intensive behavior on the individual level, while practices like travel, heating and cooling buildings, and normalized diets are examples of carbon-intensive behaviors developed through social structures. Moreover, social structures include the narratives created by various actors in the imaginaries they create to sustain their vested interests (L. L. Delina, 2021).

The third subdimension of non-material factors is ***knowledge and competencies***, which refers to the intellectual capital relevant to high or low carbon technologies (Trencher et al., 2020). Lastly, ***micro-economic factors*** affect the behavior of and constrain market actors to pursue the production of alternative sources of energy, e.g. the higher investment risks in RE development prevent developers from expanding.

3.1.4 Exogenous Factors

Exogenous factors are the broader macroeconomic, societal, geographical, technological, and environmental conditions that enable carbon lock-in (Trencher et al., 2020). For example, rapid economic growth coupled with a rising population and increasing urbanization increases the pressure for fast and cheap fuel, often times coal, to meet growing energy demand. On the other hand, exogenous factors can rupture a carbon dependent path by creating momentary pressures, instability, or crises. For example, the volatile fluctuations of coal prices due to crises like war or a pandemic can drive the shift to RE adoption from domestic resources to ensure energy security. These exogenous shocks are windows of political opportunities trigger the adoption of low carbon alternatives, facilitated by government measures to sustain this shift, like R&D, subsidies, or tax provisions.

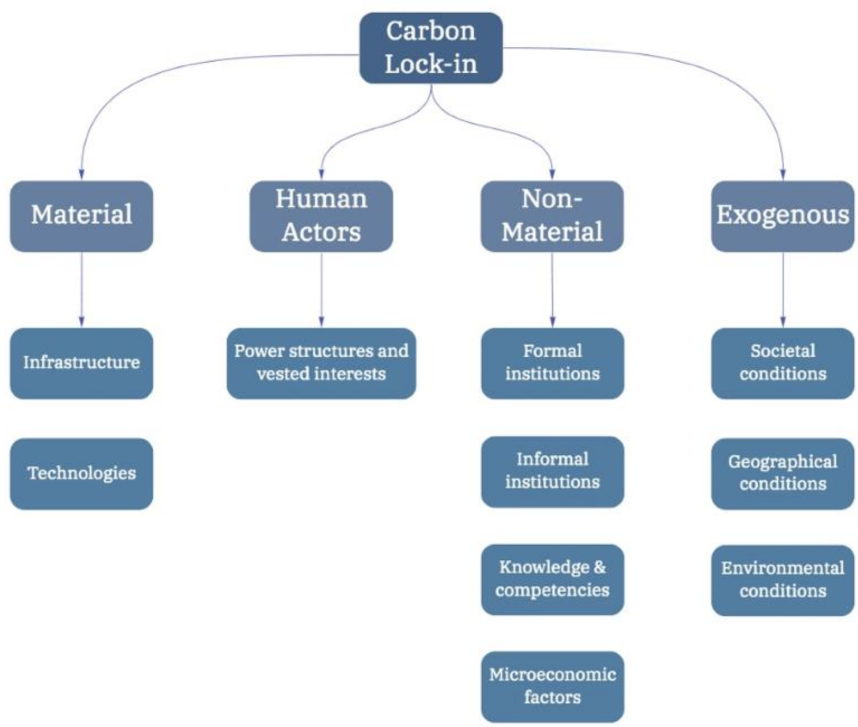

Figure 6. Trencher et al.'s socio-technical framework for carbon lock-in

3.2 Scoping Review Methodology

Content analysis from an extensive scoping review was conducted to identify sources of carbon lock-in and discover opportunities to "unlock" the persistence of carbon-emitting pathways. Figure 5 depicts the overview of the scoping review and Table 7 illustrates the distribution of sources used for the research. A total of 197 publications were sampled from the rounds of scoping using the keywords listed in Figure 9. Out of these publications, 183 publications were coded. With the amount of publications used for the thematic analysis, this thesis is thus far the most comprehensive study of carbon lock-in in Indonesia, the Philippines, and Viet Nam.

Table 7. Sampled Literature

Publications		Scope	
Total	183	Indonesia, Philippines, Viet Nam	42
Snowballed	48	Indonesia	41
Journals	63	Philippines	46
Reports	57	Viet Nam	41
News articles	47	Indonesia, Philippines	8
Government documents	16	Indonesia, Viet Nam	5

2015 was the chosen benchmark for publication year to account for the fast-changing trends in technology development, market trends, and developments since the Paris agreement in 2015. First, keywords from existing carbon lock-in literature were identified and used in search engines mentioned in Figure 9. From here, publications were extracted and filtered based on whether carbon lock-in sources were heavily discussed, focused on IPV, and used latest information on energy markets. Coding was done manually by inputting the relevant results of each publication into excel sheets to uncover common themes. A second round of sampling was done using relevant keywords from the first round of content analysis. This round is complemented by backwards snowballing through key literature from the first batch of sampled publications. When a publication discusses a source of carbon lock-in for IPV and heavily refers to similar sources, these sources are extracted, read, and coded. A final thematic analysis was conducted from the code sheets.

Table 16 in the appendix summarizes the themes coded through the scoping review. The thematic coding process was inductive. Documents were read and any relevant excerpts were inputted in the coding sheet and assigned a theme. These themes were categorized under the socio-technical framework for carbon lock-in: material, human actors, formal institutions, informal institutions, microeconomic factors, knowledge and competencies, and finally exogenous factors. For example, this excerpt from a paper discussing the dynamics of key stakeholders in the Philippines is categorized under human actors, with the theme industry lobbying: "Another fossil-fuel energy developer highlighted that private message groups between other incumbent developers and government officials allowed for near instantaneous spread of confidential information" (Altomonte, 2021). Excerpts from news articles and government documents that claim IPV has the "right" to develop and use fossil fuels to power economic growth are categorized under informal institutions, with the theme pro-fossil fuel narratives. Papers that discuss the market entry barriers for renewables or the ease of doing business for fossil fuel producers are placed under microeconomic factors, with the theme disproportionate market rules. Sources that mention the power supply crises that triggered the lock-in of fossil fuels through long term guaranteed contracts are useful for exogenous factors and formal institutions, and so on and so forth.

In conjunction with coding the sources of carbon lock-in, the same literature was used to code opportunities to rupture carbon lock-in. Relevant excerpts that answered the question "what are the potential opportunities available that may rupture carbon lock-in?" were extracted and assigned themes. For example, sources that mentioned that traditional financiers of coal in IPV like Japan and South Korea are pulling back their coal investments due to international pressure are parked under "declining availability of finance for fossil fuel projects." Studies that analyzed the projected demand of energy for IPV and presented pathways to reach a 100% renewable electricity system are categorized under "renewable energy potential." The entire set of themes for opportunities are presented in table 17 in the annex.

Figure 7. Scoping Review Methodology

Types of publications:
Peer-reviewed journal articles, government roadmaps, reports from research institutes and multilateral institutions, news articles, conference papers

Publication year:
From 2015 onwards

Search engines:
Scopus, JSTOR, Google Scholar, Google, ResearchGate, EBSCO

Method:
(1) Identification of keywords from literature review on carbon lock-in
(2) Use of keywords to identify publications from search engines
(3) Screening of publications
(4) First round of coding and production of evidence database
(5) Use of keywords from first round of coding and snowballing from first sample of sources to acquire more relevant publications
(6) Second round of screening of publications
(7) Second round of coding
(8) Content and thematic analysis

Keywords:

First round	*Second round*
Coal	Committed carbon emissions
Carbon Lock-in	Stranded assets
Fossil fuel	Coal reporting
Coal phase-out	Coal imaginary
Coal mining	Coal incumbents
Path dependency	Renewables market barriers
Energy transition	Low carbon pathways
Southeast Asia	Southeast Asia
Indonesia	Indonesia
Philippines	Philippines
Viet Nam	Viet Nam

4 Results and Discussions

This chapter is structured in two parts. Section 4.1 discusses the sources of carbon lock-in uncovered from the scoping review: material factors (4.1.1), human actors (4.1.2), nonmaterial factors (4.1.3), and exogenous factors (4.1.4). Section 4.2 tackles the opportunities identified from the content analysis, which are further sorted as tools or levers.

4.1 Sources of Carbon Lock-in

Table 8 presents a total of 31 distinct sources of carbon lock-in were identified across the material, human, non-material, and exogenous dimensions.

Table 8. Sources of Carbon Lock-in in IPV

		Indonesia	Philippines	Viet Nam
Material		Sunk-in capital in assets		
		Young coal fleets		
		Fossil fuel pipeline		
		Inadequate infrastructure and technology for RE		
Human Actors		Industry lobbying	Industry lobbying	Industry lobbying
		Power imbalances	Power imbalances	Power imbalances
		Conflicts of interest		Conflicts of interest
Non-material	Formal institutions	Supportive fossil fuel policies and subsidies	Supportive fossil fuel policies and subsidies	Supportive fossil fuel policies and subsidies
		Deterring policies for RE	Deterring policies for RE	Deterring policies for RE
		Long term power purchase agreements	Long term power purchase agreements	Long term power purchase agreements
		Poor fiscal sustainability of energy institutions		Poor fiscal sustainability of energy institutions
	Informal institutions	Fossil fuel narratives	Fossil fuel narratives	Fossil fuel narratives
		Institutional norms	Institutional norms	Institutional norms
		Perceptions on RE	Colonial legacy	Perceptions on RE
		Narrow climate protection narrative		Government legitimacy
		Colonial legacy		
		Government legitimacy		
	Micro-economic factors	Disproportionate market rules		
		Unbankability of renewable energy		
		Profits from fossil fuel production		
		Lack of finance for RE		
		Domestic and external financing for fossil fuels		
	Knowledge and Competencies	Weak institutional capacity		
		Lack of skills for RE technologies		
		Lack of research and data		
Exogenous		Fossil fuel reserves	Fossil fuel reserves	Fossil fuel reserves
		Geopolitical Influences	Geopolitical Influences	Geopolitical Influences
		Geographic barriers for RE	Geographic barriers for RE	Geographic barriers for RE
		High public and industrial demand for fossil fuels	High public and industrial demand for fossil fuels	High public and industrial demand for fossil fuels
			Power supply crises	Insufficient public awareness of RE

4.1.1 Material sources of carbon lock-in

There are four sources of material factors contributing to carbon lock-in in IPV: (1) sunk-in capital in assets, (2) the young age of coal fleets, (3) fossil fuel infrastructure pipelines, and (4) inadequate infrastructure and technology for RE.

The *investments* made in the production of fossil fuels present a huge barrier to the energy transition. For Indonesia, the energy transition could risk losses from $34.7 billion in 30 GW worth of existing coal fired power plants (CFFP) (CTI, 2018a) to 118.06 billion in coal mining (Mumbunan & Sari, 2016). In the Philippines, stranded assets are estimated at $13.11 billion for some plants equivalent to merely 41.3 MW (CTI, 2018c) and $20.8 billion for some 10 GW of its current pipeline, all of which are expected to be stranded (Ahmed & Logarta, 2017). The large expansion of coal infrastructure to meet energy demand in the Philippines is even more egregious considering the government's decades-burden with stranded assets in the energy sector. When the power market was liberalized in 2001, the government's obligations from stranded assets were at $23.14 billion; half of this value is still within the government's liabilities today (Ibid.). In the case of Viet Nam, renewables are expected to out-compete today's existing and planned coal-fired generation in Viet Nam by 2030, risking $11.7 billion in stranded assets for some 18 MW of existing coal capacity (Gray et al., 2018).

Fossil fuel generation is also likely to persist due to the *young age* of IPV's coal fleet. More than 60% of IPV's CFFPs are less than 10 years old (Demoral et al., 2022; IESR, 2020). To comply with the Paris Agreement's 2°C scenario, the average ages at forced retirements of IPV's plants would be 17, 16, and 14 respectively (Gray et al., 2018). Considering the average 40-year lifetimes of coal plants, sunk-in capital in assets will involve both foregone profits and financial liabilities that are unfulfilled due to an energy transition. This is exacerbated by the three countries' *pipelines* for coal projects equivalent to 91 GW, which will more than double the entire ASEAN region's generation capacity for coal (figure 4).

Lastly, the *inadequacy of infrastructure and technologies for renewable energy* integration is a major technical barrier to establishing a more robust industry chain for renewables. The power systems in IPV are based on a traditional centralized model, with low levels of regional interconnection of grids, making them unable to integrate variable renewable energy sources

(VRE) at a large scale. In all three countries the intermittent nature and low load factors also limit the effectiveness of renewables with huge energy losses (Ali et al., 2021).

For example, due to the under-capacity of transmission grids, Viet Nam is still reluctant to issue more policies to promote wind power (Nam Do et al., 2021). Rooftop solar users in Viet Nam have expressed their difficulties from curtailment after connecting to the grid, thus not being able to recuperate their investments (Urakami, 2020). If more than 10-20% RE was accommodated in the national grid, transmission and supply could be destabilized (Dorband et al., 2020). In the Philippines, issues of supply and demand of power have been attributed to curtailment and grid congestion. Because of the lack of interconnection capacity between regions, prices of the wholesale electricity spot market (WESM) have been decoupled (ADB, 2018).

4.1.2 Human actors

The power structures, vested interests, and relationships of the actors which maintain a carbon-intensive system in IPV are heavily discussed in literature that tackle the political economies surrounding fossil fuels. In all three countries, the fossil fuel industry has an entrenched influence in political decisions. This is categorized as *industry lobbying* in table 8. Regulatory capture is evidenced in revolving doors and *conflicts of interest* in both the fossil fuel industry and government, as well as the supportive policies for coal and gas.

The influence of the coal sector extends beyond governments to the regional level with the ASEAN itself. The World Coal Association is an established partner of the ASEAN, and their collaboration has resulted in the ASEAN explicitly promoting the construction of new coal plants, and establishing an ASEAN Forum on Coal (AFOC) and a periodic “coal award” to encourage the use of coal. In the last seven years, the ASEAN has been promoting high efficiency, low emissions (HELE) coal power and carbon capture and storage (CCS), as well as easing the access to financing for these technologies while continuing to paint coal as playing a “crucial role in providing reliable and affordable energy in the ASEAN region well into the future” (ACE, 2015, 2017, 2021; ACE & World Coal Association, 2021). The ASEAN’s energy cooperation strategy includes enhancing the image of coal through the promotion of clean coal technologies as a key pillar (ACE, 2015). ASEAN countries have thus pledged to exchange knowledge and technical capacity to deploy low-emission coal technology and look into the development of CCS (Wright et al., 2017).

In Indonesia, *industry lobbying* is evidenced by the aggressive efforts to grow coal demand by multiple actors: the utility companies, local governments, and the national government. The country's state-owned energy utility, PLN, which sustains its operations mainly by its coal assets, is known to consistently resist policies that support RE. In 2016, PLN refused to comply with the biofuels mandate, citing the possible damage to generators (Asmarina & Munthe, 2016). PLN has also repeatedly gone against directives to buy more renewable-sourced electricity for the national grid (Kurniawan et al., 2020), once putting $783 million worth of hydropower projects on hold (Ayuningtas, 2016).

Similarly, Viet Nam's state-owned EVN, which controls majority of the electricity generation and solely handles distribution, has used its strong *lobbying* power to resist the shift to renewables (Ialnazov & Keeley, 2020). Further, EVN's close personal ties with the energy industry account for regulatory biases towards fossil fuel-based generation. EVN is credited as the biggest barrier to Viet Nam's energy sector reform (Dorband et al., 2020).

Meanwhile in the Philippines, *industry lobbying* is exercised by powerful oligarchs that control various industries in the economy apart from energy. Since the liberalization of the power market in the early 2000s, the largest family-run conglomerates have grabbed up power contracts and bought coal mines (Jaeger et al., 2017; Saculsan & Mori, 2020). These include the Consunjis (David M. Consunji Corporation), who own coal mines and powerplants across Luzon and are exploring coal in Mindanao. San Miguel Corporation and the Ayalas have similar stakes, with the latter being the most prominent backer of coal with at least $3.48 billion in coal projects through its banking arm (L. L. Delina, 2021). Fossil fuel energy developers in the Philippines bypass several government processes for coal generation by way of phone calls with authorities in the Department of Energy (DOE). Private message groups between developers and government officials also exist, which allows for private teams to act on any confidential issue and discuss with the government before public announcements (Altomonte, 2021).

The pervasiveness of industry lobbying in the energy sectors is made possible by the *power imbalances* among actors in favor of fossil fuels and those that promote cleaner sources of energy. Holding both roles as the single buyer and single seller of electricity, PLN has significant political power, and is thus able to keep the primacy of coal uncontested. The Ministry of Energy and Mineral Resources (MEMR) has a legal basis to oversee all of PLN's decisions, however in reality its influence is minimal to the state-owned utility (Hamdi, 2019). The Ministry of Environment and Forestry also has no say over PLN's decisions (Ordonez, 2021). PLN's monopoly has therefore inhibited the confidence of potential investors in renewables, in fear of projects being thwarted by PLN (Ayuningtas, 2016; The ASEAN Post, 2020). The same is true for Viet Nam's EVN, which holds significant political leverage. The state-owned utility has a strong influence in both the Ministry of Industry and Trade (MOIT) and the independent Institute of Energy; hence both institutions are hesitant to issue policies that curb fossil fuels and be at odds with EVN's interests (Heger, 2017).

Power imbalances skewed towards proponents of fossil fuels is also evident in the limited role of public discourse, the constraints on freedom of speech, and the limited influence and the fragmentation of clean energy proponents in IPV (Healy & Marchand, 2019). The proclamations by both President Widodo (Widya Yudha et al., 2018) and President Duterte (L. L. Delina, 2021) on coal's necessity for Indonesia and the Philippines' development illustrate the high-level support for fossil fuel-based energy. The repression of public opposition against fossil fuels in IPV is also common. In Viet Nam, for example, when an NGO obtained a copy of the Power Development Planning VIII (PDP8) that was different to a previous version—one that emphasized opposition to renewables by the Ministry of Industry and Trade, the NGO's executive director was arrested after exposing its implications (Brown, 2022). In Indonesia and the Philippines, many protesters against mining and coal projects are continually jailed, stalked, and harassed by the police, as well as tagged as terrorists or rebels (Aspinwall, 2020; Civicus Monitor, 2021).

The entrenched bias towards coal can also be explained by *conflicts of interest.* In Indonesia, conflicts of interest are evident in the public sector through the following: PLN's operations, campaign donations, and officials with financial stakes in the energy and mining business. PLN has a mandate to supply electricity to the public, however its coal-supportive decisions are owed to the fact that the utility owns half the country's coal-based supply (Sayne, 2020).

Political patronage has evolved throughout the decades in favor of coal incumbents in Indonesia. The coal industry heavily funds local election campaigns (Atteridge et al., 2018) and various functionaries from different levels of government—political parties, subnational offices, to ministries—have financial stakes, if not direct ownership in coal and mining operations in Indonesia. For example, in South Kalimantan, one of the largest coal producing provinces, mine bosses are heavily involved in elections either through financial contributions to campaigns, or as candidates themselves (Herman & As'ad, 2019). Many known magnates in coal mining have held high-level positions in the Indonesian government, one of which is Luhut Binsar Pandjaitan, founder of a group of companies in energy and mining, and has held four minister positions, and was also the chief of staff to President Widodo. Similarly, one of the biggest political personalities, Aburizal Bakrie, a Minister in the previous administration and chairman of the Golkar party, has a majority stake in one of Indonesia's largest coal enterprises (Ordonez, 2021).

In Viet Nam's case, *conflicts of interest* are prevalent in state-owned enterprises that maintain a revolving door for senior employees, specifically in the Ministry of Industry and Trade, EVN, and Vinacomin (Dorband et al., 2020). Actors in both the regulating and regulated entities thus become entangled and propagate shared interests relevant to the continued pursuit of fossil fuels. A source of personal revenue for these actors come from the procurement of coal. EVN or the state's coal extraction and import arm, Vinacomin, reportedly imports coal at lower prices, higher exchange rates, or lower quantities than what is documented (Ibid.).

4.1.3 Non-material sources of carbon lock-in

4.1.3.1 Formal institutions

Preferential treatment for coal production and electricity generation exists in the form of *supportive fossil fuel policies and subsidies,* as summarized in table 9. In Indonesia, fossil fuel subsidies are a huge burden to the national budget, reaching $17.5 billion in 2017, or almost 2% of GDP (REN21 et al., 2020). Notably, 88% of Indonesian government's financing support in 2020 for energy was allocated to fossil fuel-intensive state enterprises (Surmanio, 2021). Viet Nam's subsidies for fossil fuels also represent significant budget expenditures, approximately $260 million 0.2% of its GDP in the same year, resulting in coal prices that are 30% lower than import prices (Dorband et al., 2020).

Another example is the enabling legal framework for fossil fuel extraction and production, for which these activities are seen as value-adding to IPV economies (Cornot-Gandolphe, 2017; NEDA, 2017; Vu, 2021; Widya Yudha et al., 2018). For example, the 2009 Law on Mineral and Coal Mining saw the uncontrolled rise in coal mining, production, and exports after licensing was made easier and obligations were mandated for domestic mineral smelters (Atteridge et al., 2018). The Philippine Energy Plan on the other hand stipulates the aggressive pursuit of awarding new contracts and discovery of new gas and oil fields and coal mines, as well as the importation of liquified natural gas at 349 billion standard cubic feet by 2022 (DOE, 2021b).

These are further supported by unambitious energy targets in national roadmaps that prioritize fossil fuels (DOE, 2021b; MEMR, 2019; MOIT, 2021). Moreover, technology-neutral policies in the Philippines and Viet Nam have allowed fossil fuel technologies to remain dominant due to cost-effectiveness (Healy & Marchand, 2019).

Table 9. Supportive fossil fuel policies and subsidies

	Indonesia	Philippines	Viet Nam
Tariff and price controls in favor of fossil fuel-based electricity	✓	✗	✓
Tax incentives and direct subsidies for fossil fuels	✓	✓	✓
Laws, directives, roadmaps prioritizing fossil fuel production	✓ Coal mining, production, exports	✓ Oil, coal, gas exploration, production	✓ Coal and gas extraction and production
Technology-neutral policies	✗	✓	✓

The large state investments in fossil fuels in Indonesia and Viet Nam have ultimately led to create a separate source of lock-in, which reinforces the same fossil fuel policies that give its cause: the *poor fiscal sustainability of energy institutions*. Credit-constrained state-owned enterprises, fossil fuel subsidies, and public debt block a decarbonization pathway for Indonesia and Viet Nam. Electricity tariffs do not enable PLN to recover costs, resulting in PLN relying on state capital injections (ADB, 2020). To aid PLN, the government enforces a domestic market obligation for coal, wherein coal must be sold to PLN at a maximum rate of $70 per ton. Still, PLN is in a financial straitjacket that does not allow for reforms so easily (Hamdi & Adhiguna, 2021). With PLN solely supplying electricity, this in turn feeds the cycle of coal production and consumption.

For Viet Nam, as much as 95% of its capital expenditures is financed by debt, and its electricity tariffs are insufficient to cover expenses (World Bank Group, 2018). Due to the increase in energy demand, Viet Nam is confronted with tariffs that are too low to provide incentives for cleaner energy, but not high enough to recover costs. Both EVN and Vinacomin rely on government capital, with financing support of around $3–4 billion for EVN and $1.5 billion for Vinacomin (Dorband et al., 2020).

While policies relevant for fossil fuels are advantageous, the *policies for renewable energy remain deterring*. The specific issues found in the scoping review are outlined in Table 10.

Table 10. RE Policy Issues in IPV

	Indonesia	Philippines	Viet Nam
Unbankable PPA terms	✓	✓	✓
Insufficient or lack of government financing mechanisms (Viability gap funding (VGF), concessional loans)	✓	✓	✓
Unviable tariff schemes for electricity purchase	✓	✓	✓
Uncertain, ad-hoc, and constantly changing RE regulations	✓	✓	✓
Highly complex bureaucratic procedures for RE	✓	✓	✓
Taxation on RE production	✓	✗	✗

IPV governments provide zero commercial finance offtake and viability guarantees for renewable projects (ADB, 2020). In Indonesia, people pay costs for solar PV out of pocket at around $2,700, or an average salary of five years (Setyawati, 2021). This is made worse by high local RE content requirements, which burden developers since the quality and capacity of local RE manufacturing are inferior. The lack of other financial support mechanisms such as VGF and soft concessional loans from the government for RE projects further discourage investors.

The Philippines ultimately gives no guarantees for renewable electricity since discontinuing the FIT. Meanwhile the FIT schemes in Indonesia and Viet Nam are disincentivizing where the maximum ceiling tariffs for renewables are capped below the cost of producing fossil fuel-based electricity (REN21 et al., 2020). The fixed FITs in Viet Nam do not account for inflation and exchange rate risk, as well as the varying costs of electricity production in different regions (Urakami, 2020). This has ultimately led to underdeveloped solar PV in the areas in the north, and out of control development in areas in the south, which make for a highly unstable solar PV market (Le et al., 2022). These FITs are also issued on an ad-hoc basis, where new rates are implemented before there is sufficient time to measure the impact of the previous one (Pratiwi & Jeurges, 2020). This leaves renewable developers insecure in between the expiration of a FIT and a issuance of a new one. Similarly, constantly changing regulations in the Philippines and Viet Nam present the biggest challenge for renewable developers

(Hamdi, 2019). Renewable developers also struggle with highly bureaucratic procedures in IPV, specifically with permits and land acquisition. Furthermore, RE sources such as biomass is subject to taxation in Indonesia, whereas coal is not (IESR, 2021).

Lastly, one well known lock-in factor common among IPV is *long-term power purchase agreements (PPAs)* that are valid for 25 years or more. PPAs for fossil fuels usually stipulate "take or pay" clauses (Fuentes & Chapman, 2020; Kurniawan et al., 2020) which guarantee existing and future fossil fuel plants will be paid to operate for the next decades. Fossil fuel investors are thus protected if plants perform below expectations through grid overcapacity or drops in plant utilization rates. The risk of stranded assets is therefore a burden to governments and taxpayers who may be required to pay billions of dollars in the future for unneeded plants.

4.1.3.2 Informal institutions

The following discusses the norms, traditions, routines, values, and cognitive schemes that influence how actors maintain or change a carbon intensive system. One uncovered theme from the scoping review is established *institutional norms*. These *institutional norms* among IPV, which enable the persistence of fossil fuels, are:

- silo mentalities in energy institutions;
- reliance on known technologies and resources, most often coal and natural gas;
- subsequently, skepticism on new energy sources;
- reliance on established contract models, specifically those long term and bilateral in nature; and
- a narrow scope of investment risk analyses, which typically excludes climate risks (e.g. stranded assets).

Silo mentalities, which explain the lack of coordination within the national governments, as well as between national and local offices, have led to inconsistencies in plans to mitigate climate change. Overall, robust and coordinated efforts to prioritize the energy sector at the forefront of achieving climate targets remain yet to be seen (ADB, 2020; Khuong et al., 2019; Urakami, 2020).

Among energy institutions in IPV, coal is perceived as stable and well-known. In Viet Nam, both the Ministry of Industry and Trade and the Ministry of Natural Resources and Environment have explicitly stated their preference for coal as the solution to electricity supply issues (Dorband et al., 2020). Another example is how the Energy Regulatory Commission (ERC) operates in the Philippines. In procuring services and PPAs, they prioritize legal and case precedents instead of new incentive regulatory structures, which crowd out new forms of contracts that prevent the lock-in effect (ADB, 2020). Furthermore, embedded routines and mindsets extend to investors. Assessing investment risks has historically excluded climate-related risks, including stranded assets, in investor decision-making within the ASEAN (Johnson et al., 2021). Short-term investors have an investment cycle of five to ten years, hence they ignore longer-term climate related risks despite the 20-40 year lifespan of the assets they invest in.

Relatedly, the cognitive framing of the Communist Party of Viet Nam's legitimacy is an indirect factor of carbon lock-in. The power sector is structured as a monopoly. This stems from the Communist Party's prerogative to provide all basic needs in affordable prices for citizens. With no competition, state institutions choose to maximize its assets, which are largely coal-fired. The reliance on coal to keep prices low is also a determinant for energy policy in Indonesian politics, where electricity tariffs are kept low during elections (Baek, 2016).

In terms of fossil fuel narratives, Table 11 lists the various frames that support the primacy of coal uncovered from this scoping review. These were mainly found in government roadmaps for energy, news articles, reports from research institutions like the ASEAN Centre for Energy, as well as journal articles which made use of semi-structured interviews of relevant actors in energy institutions.

Table 11. Fossil fuel narratives of IPV

Cost	Coal is inexpensive and fair to consumers
Industrialization	Coal is essential for industries and supports national development
Growth	Coal powers growth and recovery
Domestic production	The country is endowed with coal and natural gas, which provides profits and jobs
Reliability	The production of coal is known and is a dependable source in times of supply issues and power crises
Cleanliness and Transition Fuels	Through technological advancements, coal can be clean; Natural gas and clean coal will be the bridge to RE
Energy security	We need to utilize our domestic fossil fuel reserves to be self-sufficient

Notably, a majority of media outlets in Indonesia consistently portray coal positively as the superior energy source. In the lens of climate change, coal is framed as a clean source with applications of new technologies like CCs or ultra-supercritical boilers (Hoang, 2020).

Perceptions against sustainable sources of energy are also an important factor inhibiting the energy transition. Public resistance to wind power in Viet Nam is attributed to aesthetic reasons (Nam Do et al., 2021). Nuclear power development plans in Viet Nam were also shelved partly due to its unpopularity stemming from Japan's Fukushima disaster (Brown, 2022). Some hydropower and geothermal projects have encountered local opposition in Indonesia and Viet Nam because these are perceived as damaging to the environment (Pratiwi & Jeurges, 2020), and because local communities find no benefits being shared with them from these projects (Hasan & Wahjosoedibo, 2018). In Indonesia, the government employs a specific *framing of climate protection* which exempts the energy sector's responsibility in reducing emissions. Despite the government's awareness of the energy sector's major contributions to emissions, climate action is confined as a land-use and forestry issue (Ordonez, 2021).

Lastly, carbon intensive systems in place in Indonesia and the Philippines are products of their colonial past. The formation of extractive industries in general are *colonial legacies*: the rapid industrialization of its colonizers, the Netherlands and the United States, required more energy sources and sought to exploit coal-rich areas in Indonesia and the Philippines. These extractive industries then boomed, impacting power and wealth among relevant institutions until today. The vested interests surrounding coal mining and fossil fuel production have sustained oligarchies led by elites, which have hitherto historically shaped the economic and political forces in both countries (Camba, 2015; L. L. Delina, 2021; Guild, 2019).

4.1.3.3 Microeconomic Factors

This section elaborates on the economic dynamics that hamper the ability of players to opt for low carbon sources of energy that are not directly explained by material sources of lock-in. First, the unbankability of RE projects due to high upfront costs, as well as the high risks and lack of guarantees[6] provide very little incentive for developers to enter the renewables market in IPV. These issues are a result of the weak enabling policy environment in IPV as discussed in section 4.1.3.4.

Next, there are a number of *disproportionate market rules* that prop up the fossil fuel industry and hinder RE development due to high market entry barriers. Indonesia's PLN is mandated to purchase renewable power at higher prices compared to coal power, along with a 25% domestic market obligation to protect the coal fleet from rising international prices (Isaad, 2021; Setyawati, 2021). Without subsidies for renewables, most companies within the power supply chain are not motivated to make any investment, even PLN (H. Wang et al., 2021). Furthermore, since 78% of Indonesia's installed capacity are owned by PLN, the state-owned company is also in direct competition with other IPPs for market share (Guild, 2019). The limited market opportunities make it harder for renewables companies to scale up. For example, solar manufacturers sell their panels in Indonesia for a significant premium compared to Chinese counterparts. Solar projects are thus constrained to less attractive units ranging merely between 5-15 MW (Hamdi, 2019). Renewables developers are further burdened by PLN's high local content requirements for solar PV and the unclear and irregular schedules of procurement and auctions of renewables projects (IESR, 2021).

[6] see "deterring policies for renewable energy" under the category formal institutions for elaboration

In the Philippines, fossil fuel investors are protected from price fluctuations through the pass-through cost mechanism, where end-users shoulder fuel cost adjustments (CTI, 2018b). While the same pass-through mechanism was blamed for the discontinuation of the FIT, it still applies for conventional fossil fuels. Furthermore, investments in the fossil fuel industry are motivated by the shorter baseload capacity requirement compared to that of renewables (DOE, 2021b).

In Viet Nam, RE investors face risks from the irregular regulations on renewables, risks from plant capacity utilization, off-taker risk, or the willingness of EVN to absorb and pay for generated power, and convertibility risk, or the ease of converting and repatriating earnings (UNDP, 2018). On the other hand, coal projects benefit from contracts that are completely underwritten by the government. Coal is further protected as prices are capped 10% below international market prices (Isaad, 2021). Grid operators are not obligated to buy electricity from renewable sources that allow for cost recovery (Nguyen-Trinh & Rizopoulos, 2022). Energy auctions are also biased towards fossil fuels, as the bid chosen must have the lowest levelized cost of electricity as mandated by the Ministry of Finance. The government however does not make the tender competitive, and chooses from mostly unsolicited bids, which are often fossil fuels (Dorband et al., 2020). Manufacturers for RE are thus small and the overall supporting industry for RE is underdeveloped (Das, 2020).

Another disproportionate market norm in favor of fossil fuels in IPV is investors' need to bankroll huge amounts of funds quickly. Investors that hold large portfolios are under pressure to find projects large enough to absorb capital and which they have considerable experience in. This leads to a continued preference for large fossil fuel projects instead of small renewable projects (Johnson et al., 2021).

The *lack of finance* further exacerbates the difficulties faced by renewables developers in IPV. RE projects are capital intensive and there is limited access to finance from both government and commercial banks. Fiscal constraints in IPV make the governments reluctant to increase tariffs for electricity produced from renewables (OECD, 2021a). Low financial maturity in the case of Viet Nam is a major hindrance; its financial sector is considered the most underdeveloped among its neighbors—a big reason RE developers struggle to get projects off the ground (World Bank Group, 2018).

Financing for fossil fuel production, however, is easy to access. Domestic banks play a huge part in supporting coal generation in the three countries. At least $12 billion was provided by 15 Philippine domestic banks for coal companies (Fuentes & Chapman, 2020). External financing from state-owned financial institutions in Japan, South Korea, and China, as well as private banks from the US, UK, Singapore, Hong Kong, Malaysia, and the Netherlands, plays a heavy hand in coal-fired power projects. China is the biggest financier—providing $13.4 billion Indonesia from 2000 to 2016 and $7 billion to Viet Nam from 2009 to 2019 for coal production (Gallagher et al., 2021; Tritto, 2021). Multilateral banks are also responsible for injecting capital in coal—the Philippines has received $254-$563 million from the World Bank for coal expansion (Inclusive Development International, 2022).

Lastly, both the state and the private sector *profit from fossil fuel production*. Revenue from land rents and production royalties provide steady streams of revenue for both national and local governments in IPV (Atteridge et al., 2018; Cornot-Gandolphe, 2017; DOE, 2021b). Indonesia's coal mining is a key economic industry, exporting about 80% of its production. In the Philippines, coal producers profit heavily from their entitlement of fuel cost adjustments being indexed to consumers, as this empowers IPPs to manipulate prices by easily citing issues ranging from supply to maintenance (ADB, 2018; Business World, 2021).

4.1.3.4 Knowledge and Competencies

One common factor inhibiting renewable energy in IPV is weak institutional capacity, which manifests in many aspects, summarized in Table 12.

Table 12. Weak institutional capacities of IPV

	Indonesia	Philippines	Viet Nam
Poor project implementation	✓	✓	✓
Lack of coordination	✓	✓	✓
Delays in decision making	✓	✓	✓
Lack of public consultations on RE projects	✓	✓	✓
Unreliable dispute resolution for contracts	✗	✗	✓
Lack of long-term planning	✓	✓	✓

Poor project implementation is a major concern in Viet Nam, where the deployment of solar installations has been rushed and uneven in the country (Le et al., 2022). In some areas where demand is low, the enthusiasm to increase renewable applications has led to transmission overloads of up to 360%, leaving huge excesses of power (Viet Nam News, 2019). In the Philippines, development partners are discouraged with their experience in solar projects as operations have become unsustainable due to weak institutional capacity, leading to several projects being junked (Pratiwi & Jeurges, 2020). Moreover, delays in decision making occur in project approvals, land acquisition, logistics, inter-connection, and arbitration. The unreliable dispute resolution for contracts has reduced investor confidence in Viet Nam, where issues like risk allocation in agreements are a precarious topic in negotiations between the government and investors (World Bank Group, 2018).

A lack of coordination, especially between national and local offices has led to inconsistent and weakly implemented climate targets in IPV. Climate strategies are generally detached from electricity sector planning due to insufficient collaboration between line ministries (Dorband et al., 2020; Fuentes & Chapman, 2020). While there are national targets, there is none at the local level, with confusion in translating national objectives into local plans (Khuong et al., 2019). Furthermore, there is a lack of public consultation for power sector strategies and policies in general, which hinder RE projects from coming to fruition. In IPV, local communities reject hydropower dams and geothermal energy due to scarce information (Pratiwi & Jeurges, 2020).

IPV also suffer from *a lack of qualified human resources with the proper know-how and skills in RE systems and technologies*. Even skills in energy economics and energy analysis are insufficient among key actors in the power sector in the Philippines (ADB, 2018). In Viet Nam, the government is struggling to procure PPP projects partly because there is limited technical capacity to fulfill the feasibility study requirement (World Bank Group, 2018).

The insufficient expertise also affects the ability to effectively assess the availability of domestic RE sources and measure the success of RE policies. IPV thus struggle with a *lack of reliable research and data* necessary to implement RE projects. This involves available locations, land use, electricity supply, infrastructure capabilities, renewable potential, and so on (L. L. Delina, 2021; Urakami, 2020).

4.1.4 Exogenous sources of carbon lock-in

All three countries are endowed with *coal and natural gas reserves* (table 13), which reduces the incentive to diversify their energy mixes. Indonesia is the richest among the three, and has one of the largest coal reserves in the world with a reserves to production ratio of about 70 years (Cornot-Gandolphe, 2017).

Table 13. Coal and natural gas reserves of IPV

	Indonesia	**Philippines**	**Viet Nam**
Coal	39.9 billion tons	2.4 billion metric tons	10.5 billion metric tons
Natural gas	1.3 trillion cubic meters	98.54 billion cubic meters	30 billion cubic meters

Sources: (ADB, 2018; Cornot-Gandolphe, 2017; DOE, 2021b; IESR, 2021; Nguyen, 2014)

Geopolitical influences are also an exogenous source of carbon lock-in for IPV. Traditional partners like the U.S., U.K., Japan, and South Korea have been instrumental in building and sustaining the fossil fuel industry by financing coal projects and their extractive industries in general. The United States, which has remained a valued ally of its former colony, the Philippines, is already seeking to lock-in future demand for natural gas by providing large imports of LNG to replace the Philippines' declining indigenous reserves. The Philippine government welcomes this despite the volatility of LNG prices, the higher costs of LNG, and the availability of cheaper, cleaner domestic energy sources (Reynolds, 2021). The current plan by the Philippine Department of Energy seeks to import LNG that will triple the current installed capacity of the country (DOE, 2021b).

The changing geopolitical dynamics in the region resulting from the rise of China has also largely contributed to carbon lock-in. Since the launch of the Belt and Road Initiative, IPV saw a sharp increase in investments in coal projects supported by China (Estrada, 2018; Sands, 2019; Tritto, 2021). IPV's strengthened alliances with China and its domestic implications on coal are partly attributed to IPV's decreased interest in multilateralism, as well as constrained diplomatic leverage in climate and energy (Healy & Marchand, 2019).

High public demand for fossil fuels is another factor, considering the macroeconomic conditions in IPV, where the power sector has to keep up with demands from economic growth, industrialization, urbanization, and population growth. Relatedly, the *limited fiscal space* in their national accounts due to debt obligations and general deficits have hindered the states' investments in new, riskier, yet more sustainable sources of energy (OECD, 2021a).

Furthermore, there are certain *geographic barriers* that prevent RE development in IPV. The variable output from large-scale renewable generation is easier to accommodate in bigger grids and the archipelagic nature of the IPV's geography makes interconnection among the grids difficult. Many geothermal resources are in Indonesia are found in forest areas, a lot of which are conservation areas where mining operations are prohibited (Hasan & Wahjosoedibo, 2018). In Viet Nam, geothermal prospects are found in remote locations. Finding staff to work in these areas has proven to be difficult. Furthermore, hydropower projects in Viet Nam are expected to cause major changes in river hydrology, negatively impacting fisheries and floodplains in the coasts (Pratiwi & Jeurges, 2020).

In the Philippines, *power supply crises* have contributed to carbon lock-in. In response to the global oil crisis in 1973 the Electric Power Crisis Act was enacted, which is responsible for the expansion of privately owned coal power stations (ADB, 2018). When the country experienced heavy power shortages in the 1990s, the government prioritized energy security through coal and mandated the take-or-pay clauses in PPAs. At least 40 long-term contracts were signed in 1994 to secure coal power (Saculsan & Mori, 2020). Lastly, the sampled literature have emphasized the *insufficient public awareness on renewable energy* in Viet Nam. There is a general lack of understanding of RE's economic and environmental benefits and the disadvantages of fossil fuels (Dung, 2019; Urakami, 2020).

4.2 Opportunities to Rupture Carbon Lock-in

In uncovering the developments and policies aiding the energy transition in IPV, the scoping review generated various opportunities, categorized as "tools" and "levers" (table 14). Tools are specific instruments such as financing, policies, or resources. These could be climate finance instruments, policies, or renewable energy resources that IPV may take advantage of to rupture a carbon-intensive pathway. Levers, on the other hand, are exogenous circumstances or externalities resulting from high carbon systems that strategically bolster tools for IPV, creating windows of political opportunities to escape carbon lock-in.

Table 14. Opportunities to Escape Carbon Lock-in

	Indonesia	Philippines	Viet Nam
Tools	Renewable energy potential	Renewable energy potential	Renewable energy potential
	Carbon market development	Carbon market development	Carbon market development
	Electric Vehicle (EV) Deployment	Electric Vehicle (EV) Deployment	Liberalization of the electricity retail market
	Increased external financing for sustainable energy	Energy efficiency policies	Competitive auctions for RE
		Green jobs policy	Commitment of central leadership
		Nuclear program	Increased external financing for sustainable energy
		Increased external financing for sustainable energy	
		Local government bans on coal	
		Decarbonization initiatives of the private sector	
Levers	Declining availability of external finance for fossil fuels	Declining availability of external finance for fossil fuels	Declining availability of external finance for fossil fuels
	Coal price volatility	Coal price volatility	Coal price volatility
	Cost competitiveness of RE	Cost competitiveness of RE	Cost competitiveness of RE

Growing global renewables market	Growing global renewables market	Growing global renewables market
Public awareness and resistance to fossil fuels	Public awareness and resistance to fossil fuels	Public awareness and resistance to fossil fuels
Negative externalities of fossil fuels	Negative externalities of fossil fuels	Negative externalities of fossil fuels
Conflicts between coal miners and communities	Depletion of fossil fuel reserves	Depletion of fossil fuel reserves
Shrinking international market for coal		

The review reveals that IPV power sectors can be supported entirely by domestic RE sources (L. Delina, 2021; Langer et al., 2021; The Solutions Project, 2022). In fact, modelling work has demonstrated the technical and economic feasibility for IPV to use RE sources to support all energy services: electricity, transportation, heating and cooling, industry, agriculture, forestry, and fishing (Jacobson et al., 2019). Table 15 shows the projected energy mixes fully supplied with RE sources for 2050, taking into account projected demand.

Table 15 Energy services by % supply in a 100% RE scenario for IPV

	Indonesia	Philippines	Viet Nam
Residential rooftop solar	13.1	13	21.6
Commercial & government rooftop solar	29.1	28.8	14.1
Solar plants	15.3	15.1	25.2
Concentrating solar plants	4.7	4.3	4.6
Onshore wind	15.8	7.7	0.7
Offshore wind	15.3	15.1	25.2
Wave devices	0.9	0.6	0.6
Geothermal	4.4	11.2	0
Hydroelectric	1.3	4	8.1
Tidal Turbines	0	0.3	0

Compiled by: (The Solutions Project, 2022)

The emerging climate-related policies are also promising opportunities that may encourage divestments from fossil fuels and a more developed renewables market. There are two key promising policies in Indonesia: the carbon tax and an aggressive development of an electric vehicle (EV) market. At present, Indonesia's carbon market is undergoing a pilot voluntary stage with 32 CFPPs signed up for pilot carbon trading (IESR, 2021). Potential gains from an effective carbon tax are expected to counteract large energy subsidies (Nurdianto & Resosudarmo, 2016). The Indonesian government's plan for an EV market on the other hand is ambitious. By 2030, it plans to be an EV hub in Asia with 51% new installed capacity and 15 million EVs. PLN has already opened for commercial and public investments for the domestic EV industry (Bong et al., 2022). At present, there is no clear decision on the primary fuel for the use of planned EVs, however the state is aware that the use of RE to fuel the massive deployment of EVs will further encourage a sustainable shift in the power sector and reduce emissions more effectively (Antara News Agency, 2022).

In the Philippines, key policies and plans involve its new RE market rules, massive EV adoption, fossil fuel subsidy reforms, intensified energy efficiency policies, the Green Jobs Act, and the nuclear program. Its new market rules include auctions for renewables, as well as a carve-out clause allowing utilities to curtail coal-fired power in favor of buying cheaper renewable power (Fuentes & Chapman, 2020). The country's EV adoption has been a priority, with public transport modernization being fast tracked (REN21 et al., 2020). Its fossil fuel subsidy reforms meanwhile have been successful—reform revenues were directed to cash transfers for vulnerable households and to energy-intensive firms for energy efficiency measures (Rentschler & Bazilian, 2017). Its 500% increase in fossil fuel taxes has also been instrumental in weakening the competitiveness of coal power (CTI, 2018c).

The Philippines is one of the few countries in the region to address skill requirements, workers' rights, and inclusive growth in the Green Jobs Act to aid the energy transition. To further support the coal phase out, the nuclear program has been reopened after being mothballed for 35 years, with prospective investors already in place. The country also has promising initiatives from institutions outside of the central government: the rising number of coal bans among local governments and the extensive decarbonization plans of big conglomerates. Large private sector groups involved in various industries like Ayala and SM have acknowledged the economic opportunities in energy efficiency and sustainability, knowing that RE will outcompete fossil fuels soon, and announced net zero goals.

For Viet Nam, promising policies for RE development include its shift from the FIT to renewable power auctions, a direct power purchase agreement scheme for renewable developers, and its compulsory carbon market program. The success in ramping up RE installed capacity is expected to sustain or increase the 50% utilization of RE in the power mix with the competitive auctions and the direct PPA scheme, which will enable RE companies to directly sell electricity to private off-takers for the first time (Thompson et al., 2022). This step towards liberalizing retail power could weaken the monopoly of coal in the power sector owing to EVN's large coal assets. Notably, while they do have to contend with resistance from actors within the line ministries and EVN, Viet Nam's central leadership remains committed to climate change mitigation policies—a unique instrument of political will among IPV.

One shared opportunity between IPV is the increased financing for sustainable energy projects. The access to facilities from multilaterals like the World Bank and ADB's such as the Early Transition Mechanism, as well as from bilateral partners like Japan's Asia Energy Transition Initiative provide the needed international support for IPV's energy transitions (Nhede, 2021).

These opportunities exist at critical junctures, namely the volatile prices of coal, the fast approaching cost competitiveness of RE, the declining availability of external finance for fossil fuels from Japan, South Korea, and China, the depletion of fossil fuel reserves in the Philippines and Viet Nam, as well as the shrinking international coal market in the case of Indonesia.

IPV's coal pipelines with secured financing stand at 75%, 45%, and 38% respectively, putting into question whether there will be sufficient capital to implement all of the planned capacity for new coal (Isaad, 2021). In terms of RE competitiveness, solar PV alone is expected to outcompete new and existing coal by 2029 for Indonesia, and 2030 for the Philippines and Viet Nam (Orozco et al., 2022). While the international market for coal is becoming more crowded, IPV may also take advantage of the growing global renewables market. In fact, Singapore's demand for sustainable power imports has already influenced solar PV development in Indonesia (IESR, 2021).

Lastly, the increasing public awareness in and activism against the negative externalities impacting communities and the general population of IPV are powerful levers. The destructive effects of coal has resulted in thousands of health casualties in IPV. These include lung, cardiovascular and skin diseases from the exposure to air, soil, and water pollution from coal. Coal plants also negatively impact the livelihoods of those in fisheries and agriculture. In Indonesia, coal mining has led to conflict and displacement among local communities (Atteridge et al., 2018). Just last year, a citizen lawsuit decided that the government is failing to address air pollution in Jakarta, resulting in an order for the Ministry of Environment and Forestry to conduct an emissions inventory (Suarez, 2021). In the Philippines, local residents have been successful in preventing the construction of several coal plants, as well as influencing local policy, resulting in bans of new coal in at least 11 provinces (Alvarez, 2021). There are similar events in Viet Nam, where concerns about air pollution, wastewater, and ash and slag discharge from coal plants have mobilized public resistance and pressured the cancellation of various coal plants in the south (Dorband et al., 2020).

5 Conclusions and Policy Implications

This study aimed to answer why Indonesia, the Philippines, and Viet Nam find it difficult to transition to less carbon-intensive energy systems. The underlying assumption is that IPV resist large-scale systemic changes because they are trapped in dynamics that depend on carbon-intensive processes. This is evident in their unambitious yet still unattainable climate commitments, as well their heavy reliance on fossil fuels in their power sectors, which contribute significantly at 40-51% in their total emissions. Using the lens of socio-technical lock-in, the comprehensive analysis uncovered a wide array of economic, socio-political, behavioral, and exogenous factors that cause carbon lock-in for IPV.

Results show that material causes of carbon lock-in are sunk-in capital in fossil fuel assets, the young age of coal fleets, and large fossil fuel pipelines, all of which could risk stranded assets worth $60 billion dollars at the very least if IPV were to pursue an energy transition to meet climate goals. The inadequate infrastructure and technology for renewable energy is also a major material barrier. For key actors, there is heavy evidence of industry lobbying from the fossil fuel industry, conflicts of interest within institutions responsible for energy policy, and power imbalances between proponents of fossil fuels over clean energy. These material factors, the vested interests, and power structures of key actors thus shape the formal institutions that prop up fossil fuels in IPV's power sectors. These include supportive fossil fuel policies and subsidies, inadequate policies for RE, and risk-free, long term power purchase agreements for coal-fired power producers which ensure financial returns. The poor fiscal sustainability of energy institutions stemming from these formal institutions in Indonesia and Viet Nam further exacerbate the dependency on rents from fossil fuel production.

In terms of informal institutions, findings show that there are strong narratives in favor of fossil fuels among the media, political actors, and the fossil fuel industry. Institutional norms such as the reliance on known technologies, contracts, and risk assessments, as well as perceptions against renewable energy such as the dangers of RE projects to local communities, the exclusion of energy in the framing of climate protection, the protection of the incumbent government's legitimacy in providing cheap and accessible electricity, as well as the colonial legacy of the extractive industries all contribute to pro-fossil fuel imaginaries in IPV.

Microeconomic factors include disproportionate market rules, specifically the substantial market risks faced by RE companies, the unbankability of RE projects, rents made by both the state and the private sector in fossil fuel production, the lack of or inaccessible finance for RE, and the ease of access to financing for fossil fuels. Sources of lock-in stemming from knowledge and competencies are also recurrent. These include weak institutional capacity, human resources with insufficient skills for RE deployment, and a general lack of research and data to fulfill and sustain RE projects.

Exogenous factors, on the other hand, include the endowments of fossil fuel reserves, geopolitical influences from traditional and new allies which pressure IPV to build more fossil fuel infrastructure, and geographic barriers in producing and delivering renewable-powered electricity. The high public and industrial demand for fossil fuels, owing to economic growth and demographic changes, as well as the fiscal constraints inhibiting RE investments are also exogenous sources contributing to carbon lock-in. The Philippines has also had several power supply crises leading to the entrenchment of fossil fuel production, while Viet Nam contends with insufficient public awareness on the necessity and benefits of renewable energy.

All sources of carbon lock-in are mutually reinforcing. Fossil fuel reserves incentivize conglomerates and state-owned enterprises to mine coal and extract natural gas, create supporting infrastructure, establish its production as a baseload supply for a public utility and address growing energy demand, enrich both producers and political actors, sustain a supportive policy environment through political alliances and a pro-fossil fuel imaginary through discourse, incentivize research and development and human resources to stick to fossil fuel expertise, and so on.

However, there are multiple opportunities that have the potential to rupture carbon lock-in for IPV. A complete shift to RE sources to fuel IPV's power sectors and all other energy services, from transportation to agriculture, is technically and economically feasible. There is increased international financing for sustainable energy projects as well from existing multilateral and bilateral partners. There are emerging policies and plans that support a sustainable energy transition, such as carbon pricing and taxation, improved renewables market rules in Viet Nam, a mass manufacture and adoption of electric vehicles in Indonesia and the Philippines, as well as energy efficiency policies, nuclear development, green jobs provisions, and local coal bans in the Philippines. The continued commitment of senior officials in the Communist Party to climate change mitigation sustains Viet Nam's progress to meet renewable energy goals, while the ambitious decarbonization initiatives of the biggest conglomerates in the Philippines could be a major catalyst in overcoming carbon lock-in.

Proponents in favor of renewables and government leaders must take advantage of these opportunities in the context of identified levers, or exogenous windows of political opportunity. These include the declining availability of international finance for fossil fuels, the volatility of coal prices, the cost competitiveness of RE within the decade, the shrinking international market for coal, the growing global renewables market, the depletion of fossil fuel reserves, as well as the growing public awareness and anger stemming from the conflicts and negative externalities resulting from fossil fuel production.

The opportunities so far are focused on the country level. This stems from the weakness of the ASEAN to implement regional policies. ASEAN, as an organization, excels no more than in research and as a platform for dialogue, as members still highly value their sovereignty (Kliem, 2018). However, the energy transition entails effects of scale that could be leveraged from regional cooperation. Thus, a policy implication can be attributed to going beyond national policies and initiatives to achieve climate targets with respect to energy.

Limitations of the study stem from the chosen scope. The research could benefit from assessing the rest of the ASEAN countries for a comprehensive regional perspective. The thesis focused on the production and use of coal and natural gas in the power sector, and did not discuss diesel-generators for remote islands or petroleum products in the transport sector. While the study aimed to identify as many sources of carbon lock-in and opportunities to escape lock-in as possible, it cannot be guaranteed that all available literature was retrieved. Perhaps either due to inaccessibility or human error, some relevant data may not have been included. For example, in reviewing the general literature on carbon lock-in extending beyond IPV, several studies have pointed to the importance of behavioral sources of lock-in, which are the everyday routines of individuals and the broader culture that perpetuate the demand of fossil fuels—e.g. travel, consumption, home sizes, product preferences. While behavioral norms in investment and political decisions were uncovered in key institutions, there were no studies found on carbon lock-in effects of unsustainable behavioral patterns.

Nonetheless, the scoping review generated an extensive amount of themes. The relevance of this comprehensive mapping of carbon lock-in sources is that it illustrates the complexity and interconnectedness of factors and dynamics which resist the shift to low carbon alternatives. A general implication is that addressing one or a limited set of factors will not suffice. Carbon lock-in is a wicked problem— IPV systems operate in positive feedback loops centered on fossil fuels, making any single attempt at divergence immensely difficult. Yet, there are available and emerging opportunities that may potentially lead IPV to break free from carbon lock-in and create a divergent path that increasingly relies on sustainable sources of energy.

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7 Appendix

Table 16. Themes for Sources of Carbon Lock-in in IPV

Category	Themes from coding	Umbrella themes
Material	Sunk-in capital in assets	Sunk-in capital in assets
	Young coal fleets	Young coal fleets
	Fossil fuel pipeline	Fossil fuel pipeline
	Lack of infrastructure and technology for RE	Inadequate infrastructure and technology for RE
	Grid difficulties with RE integration	
Human Actors	Industry lobbying	Industry lobbying
	Vested interests	Conflicts of interest
	Corruption	
	Actor composition in political setups	
	Political will in favor of coal	Power imbalances
	High-level support for coal	
	Repression of anti-coal activists	
	Limited influence of clean energy sector	
Formal institutions	Financing policies	Supportive fossil fuel policies and subsidies
	Fossil fuel subsidies	
	Supportive fossil fuel policies	
	Lack of financing policies for RE	Deterring policies for RE
	Unambitious energy plans	
	Bureaucratic permitting and land acquisition process	
	Unbankable terms of power purchase agreements	
	Irregular and ad-hoc policies	
	Unviable tariff schemes for electricity purchase	
	Taxation on RE production	
	Long term power purchase agreements	Long term power purchase agreements
	Poor fiscal sustainability of energy institutions	Poor fiscal sustainability of energy institutions
Informal institutions	Coal as cheapest energy source	Fossil fuel narratives
	Industrialization	
	Fossil fuels to power growth	
	Support of domestic production	
	Reliability of fossil fuels	
	Cleanliness and Transition Fuels	
	Fossil fuel use for energy security	
	Hard to break institutional norms	Institutional norms

		Colonial legacy Legitimacy of incumbent government
	Perceptions on RE	Perceptions on RE
	Public resistance against RE projects	
	Narrow scope on climate protection	Climate protection narrative
	Colonial legacy	Colonial legacy
	Legitimacy of incumbent government	Legitimacy of incumbent government
Microeconomic factors	Disproportionate market rules	Disproportionate market rules
	High costs of RE	Unbankability of renewable energy
	High investment risks of RE	
	Coal and gas profits	Profits from fossil fuel production
	Lack of finance for RE	Lack of finance for RE
	Domestic commercial financing for fossil fuels	Domestic and external financing for fossil fuels
	External financing for fossil fuels	
Knowledge and competencies	Poor project implementation	Weak institutional capacity
	Lack of coordination	
	Delays in decision making	
	Lack of public consultations on RE projects	
	Unreliable dispute resolution for contracts	
	Lack of long-term planning	
	Lack of skills for renewable energy technologies	Lack of skills for renewable energy technologies
	Lack of research and data	Lack of research and data
Exogenous Factors	Fossil fuel reserves	Fossil fuel reserves
	Geopolitical Influences	Geopolitical Influences
	Geographic barriers for RE	Geographic barriers for RE
	Economic growth	High public and industrial demand for fossil fuels
	Urbanization	
	Industrial demand	
	Lack of capital for RE/Poverty	Limited fiscal space
	Low mature financial sector	
	Power supply crises Insufficient Awareness of RE	Power supply crises Insufficient Awareness of RE

Table 17. Themes for Opportunities to Escape Carbon Lock-in in IPV

Category	Themes from coding	Umbrella themes
Opportunities	Renewable energy potential	Renewable energy potential
	Carbon market development	Carbon market development
	Electric Vehicle (EV) Deployment	Electric Vehicle (EV) Deployment
	Energy efficiency policies	Energy efficiency policies
	Green jobs policy	Green jobs policy
	Nuclear program	Nuclear program
	Increased external financing for sustainable energy	Increased external financing for sustainable energy
	Local government bans on coal	Local government bans on coal
	Decarbonization initiatives of the private sector	Decarbonization initiatives of the private sector
	Liberalization of the electricity retail market	Liberalization of the electricity retail market
	Competitive auctions for RE	Competitive auctions for RE
	Commitment of central leadership	Commitment of central leadership
Levers	Declining availability of external finance for fossil fuels	Declining availability of external finance for fossil fuels
	Coal price volatility	Coal price volatility
	Decreasing costs for RE	Cost competitiveness of RE
	FDI interest in RE	
	Shrinking international market for coal	Shrinking international market for coal
	Growing global renewables market	Growing global renewables market
	Conflict from coal mining operations	Conflicts between coal miners and communities
	Burden of disease from fossil fuels	Negative externalities of fossil fuels
	Negative effects of fossil fuel production on livelihoods	
	Public awareness and resistance to fossil fuels	Public awareness and resistance to fossil fuels