Methods

Identifying finance needs for a just transformation of Indonesia's power sector

Methodological approach, data inputs and assumptions used in final report

February 2024

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Introduction

This document is a methodological appendix to the report 'Identifying finance needs for a just transformation of Indonesia's power sector'. It sets out further details of our approach, data inputs and assumptions and is intended as an accompaniment to the report and JET-FIN tool – a publicly available Excel file, which includes core data, calculations and related analysis – which are both published alongside.

These materials are available for download from the publication page:

https://newclimate.org/resources/publications/identifying-finance-needs-for-a-just-transformation-of-indonesias-power

Acknowledgements

This study greatly benefitted from insights and review from colleagues, including Frauke Röser, Jamie Wong, Markus Hagemann, Anna Nilsson (NewClimate Institute) and Raditya Wiranegara, Julius Christian, Wira Agung Swadana, Daniel Kurniawan and Fabby Tumiwa (IESR) as well as editorial, design and communication support from Aman Gill-Lang and Polina Korneeva.

We are grateful for valuable input from discussions held with a wide range of stakeholders involved in the Indonesian JETP process, including members of the JETP Secretariat and JETP Working Groups, the International Partner Group and representatives of the Government of Indonesia.

We would like to thank the German Federal Foreign Office for providing the necessary funding for this work. The views and assumptions expressed in this report represent those of the authors and not necessarily those of the funder or stakeholders consulted as part of the research.

Contents

A note on reading this methodological appendix…

This document is organised into discrete sections, which set out our methods used for identifying different elements of potential finance needs for a just transformation of Indonesia’s power sector. Each section builds on content in the full report and should ideally be read as a complementary resource in combination with the information presented there.

Accompanying Excel-based tools (JET-FIN, EIM-ES and AIRPOLIM-ES) with relevant data and calculations are published alongside this study to enhance transparency, allow others to view more detailed results, test alternative data and assumptions as well as apply the models to alternative countries, or contexts. These are available online at: https://newclimate.org/resources/publications/identifying-finance-needs-for-a-just-transformation-of-indonesias-power

List of abbreviations

AIRPOLIM:	Air Pollution Impact Model
APS:	Announced Pledges Scenario (in IEA Energy Roadmap)
CAPEX:	Capital expenditures
CCS:	Carbon Capture and Storage
CFPP:	Coal-fired power plant
CIPP:	Comprehensive Investment and Policy Plan
EIM-ES:	Economic Impact Model for Electricity Supply
GFANZ:	Glasgow Financial Alliance for Net Zero
GCPT:	Global Coal Plant Tracker
GoI:	Government of Indonesia
IEA:	International Energy Agency
IESR:	Institute for Essential Services Reform
IHD:	Ischemic heart disease
IPG:	International Partners Group
IPP:	Independent power producer
IUP:	Izin Usaha Pertambangan (mining licence holders)
JET-FIN:	Just Energy Transition Finance tool
JETP:	Just Energy Transition Partnership
LCOE:	Levelized cost of electricity
LRMC:	Long-run marginal cost
LUT:	Lappeenranta-Lahti University of Technology
MEMR:	(Indonesian) Ministry of Energy and Mineral Resources
NO_x:	Nitrogen oxides
NZE:	Net Zero Scenario (in IEA Energy Roadmap)
OPEX:	Operational expenditures
QGIS:	Open-source Geographical Information System mapping software
PLN:	Perusahaan Listrik Negara (Indonesian state-owned utility)
$PM_{2.5}$:	Particulate matter
PPA:	Power purchase agreement
RUPTL:	Recana Usaha Penyediaan Tenaga Listrik (electricity business plan)
SO_2:	Sulphur dioxide
WACC:	Weighted average cost of capital
VSL:	Value of a statistical life
YLL:	Years of life lost

Electricity sector pathways

Description of approach

Electricity sector pathways

APPROACH

We analyse finance needs for two scenario pathways, one that aligns with the JETP targets as well as one that explores the implications for a more ambitious, 1.5°C-aligned, trajectory

SETUP

- **ROBUST MODEL**: National energy system modelling with a robust and transparent set of data inputs, assumptions and calculations is a fundamental starting point to identify energy transition finance needs.
- **COMPREHENSIVE DATA**: Model setup should incorporate the best available information in terms of technology, costs, policy, demand growth, deployment rates, etc., and test a range of sensitivities, informed by literature and stakeholder consultation.
- **AMBITIOUS**: The development of energy transition pathways should be informed by the latest scientific evidence on the alignment of emission trajectories with the global temperature goals enshrined in the Paris Agreement.

OUR APPROACH

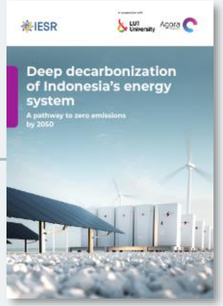
- Our analysis is based on existing modelled pathways, jointly developed by the International Energy Agency (IEA) and the Indonesian Ministry of Energy and Mineral Resources (MEMR), as an input.
- We use the IEA Roadmap's Announced Policies Scenario ('APS'), which is the basis of the JETP Joint Statement targets, to inform a 'JETP' scenario. We also use its more ambitious 'NZE' scenario that represents a 1.5°C-aligned pathway for the Indonesian energy sector, to inform a 'JETP+' scenario.

- We extract public data from the IEA's report, including annual capacity, generation, storage, grid expansion requirements, etc., and map these in the JET-FIN tool to a more granular technology list.
- Our interpretation of the pathways is complemented by a range of additional data sources, including: the Global Energy Monitor; the information platform SIPET; the Danish Energy Agency and MEMR's Technology Costs Catalogue; IESR's Deep Decarbonization report, amongst others, as well as expert inputs.
- Further details of our methodology are set out in the following slides and are also available to review in the JET-FIN tool.

Electricity sector pathways

We analyse finance needs for two scenario pathways, one that aligns with the JETP targets as well as one that explores the implications for a more ambitious, 1.5ºC-aligned, trajectory

- While the IEA report offers aggregated technology data (e.g., solar), for selected technologies we further distinguish between sub-types of the same technology in the JET-FIN tool (e.g., solar utility, floating, and rooftop), using insight from a range of Indonesian modelling exercises, such as IESR, LUT and Agora's Deep Decarbonization report and input from experts at IESR.
- The more detailed technology breakdown in the JET-FIN tool (see next slide) allows users to assess the implications of different technology choices, for example in terms of costs and associated investment requirements over time, or resource needs.



- We use data from the Global Energy Monitor and the information platform SIPET to derive estimates of the age of the current stock of capacity in order to determine a profile of expected natural retirement over time and consequently identify the new additions in capacity required by the scenario in each year.
- Natural retirement ages of different technologies (or 'technical lifetimes') are based on the Danish Energy Agency and MEMR's Technology Costs Catalogue.
- We estimate the finance needs for all new additions in the power sector as of 2023.

Electricity sector pathways

APPROACH

We analyse finance needs for two scenario pathways, one that aligns with the JETP targets as well as one that explores the implications for a more ambitious, 1.5ºC-aligned, trajectory

TECH LIST

Fuelled technologies

- Coal
- Coal with CCS
- Gas open cycle
- Gas combined cycle
- Gas with CCS
- Oil
- Nuclear
- Biomass

Non-fuel technologies

- Utility solar PV
- Rooftop solar PV
- Floating solar PV
- Onshore wind
- Offshore wind
- Geothermal
- Large scale hydro
- Small scale hydro

Energy storage technologies

- Hydrogen
- Batteries

Infrastructure: Fossil phase-out

Description of approach

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Targeted public finance can compensate for some or all of the losses coal plant owners / operators potentially face as part of negotiated deals to either retire assets early or curtail their operations (or both)

- We carry out a deep-dive analysis using the JET-FIN tool of the existing *and* planned coal plant fleet in Indonesia to estimate potential compensation for coal plant owners to incentivise:

  A. Early retirement of plants

  Closure or re-purposing of units prior to end of their technical lifetime

  B. Curtailment of operations

  Flexible operation of plants which reduces their capacity factors to below their typical / expected levels

KEY STEPS

1. Determine the list and capacity of coal units operational in each year and the order of prioritisation for early retirement
2. Determine the total need in each year over modelling horizon to retire plants early
3. Apply early retirement profile to coal fleet according to prioritisation
4. Determine the need to reduce coal generation (curtailment) from remaining plants in each year over modelling horizon
5. Apply curtailment of generation profile to remaining operational coal fleet
6. Estimate potential compensation for plants retiring early and/or curtailing generation using different approaches

There are different possible approaches to estimate the amount of appropriate compensation required to offset potential losses and agree commitments for early retirement or curtailment with coal plant owners

- In Indonesia coal plants are either owned by the state-owned utility PLN, or by IPPs who typically have long-term power purchase agreements (PPAs) of around 25-30 years with PLN to offtake their electricity output under ‘take-or-pay’ contractual terms.

Breakdown of existing + pipeline of approximately 70 GW of CFPPs in Indonesia

Possible estimation methods to determine potential losses

Foregone operating profit: Estimate of the net operating profit the unit would have continued to earn in the years between its early retirement and the end of its technical lifetime in order to pay back upfront capital costs and provide a return on the investment

Capital recovery: Estimate of the net operating profit the unit would require in each year between its early retirement and the end of its technical lifetime in order to recover upfront capital investment (i.e. avoid making a loss)

Book value: Bespoke valuation of the plant at a given point in time taking into account its physical condition as well as projections of future revenues and costs (typically based on confidential data hence not used here)

Selection of either one of these methods, or alternative approaches, as well as the critical details of precise data inputs and assumptions, will ultimately be decided by parties negotiating a compensation agreement. Estimates here are intended to provide an order of magnitude assessment of potential amounts at the national system level under certain defined parameters.

Deep-dive focus on coal plants:

Unit level analysis to derive early retirement and curtailment requirements and associated potential losses to match electricity sector pathways

Early-retirement of coal units alone is not sufficient to cut coal generation, and associated emissions, to align with the electricity sector pathways.

Over time coal plants are increasingly operated flexibly to provide stability to the grid as a complement to increasing penetration of intermittent renewables, such as solar PV and wind.

Coal plants owned by IPPs typically have ‘take-or-pay’ power purchase agreement (PPA) contracts which oblige PLN to pay them even when they are not needed to supply electricity to the grid.

Similarly, PLN may have expected to run its fleet of coal plants at higher capacity factors when making their initial investment decisions in the units.

We therefore estimate the potential costs of curtailing generation from CFPPs for both PLN and IPPs.

KEY STEPS TO DETERMINE CURTAILMENT

- Calculate the annual available capacity from all eligible units over time (2023-2050) considering their natural retirement age and accounting for early retirements (in previous step).
- Derive an estimate for annual generation from available capacity in each year using a ‘base’ capacity factor that reflects ‘take-or-pay’ contractual terms, or expected operations at the time the initial investment decision was made.
- As a default we use a ‘base’ capacity factor of 80% for units connected to the Java-Bali grid, and 86% for all others, which the user can adjust.
- Estimate the annual difference between total generation using the ‘base’ capacity factor for all units and the target generation in the respective scenario to determine total annual curtailment across the coal fleet.
- Apportion the required curtailment, relative to generation under the ‘base’ capacity factor in each year across all operational units equally (no prioritisation) so that the total generation for CFPPs aligns with the scenario levels.
- Required curtailment for each unit in each year – i.e. the reduction of generation at each CFPP relative to its approximated PPA terms or initially expected operations – is then used to estimate potential compensation for diminished net operating profit.

Deep-dive focus on coal plants:

Unit level analysis to derive early retirement and curtailment requirements and associated potential losses to match electricity sector pathways

Our analysis, tailored within the JET-FIN tool to the Indonesian coal fleet, includes all coal units that are either marked as:

- Operational in the Global Energy Monitor's Global Coal Plant Tracker (GCPT) from January 2023;
- Committed projects in the latest RUPTL 2021-30 and therefore eligible to enter operations as per the Presidential Decree on Renewable Energy (Perpres 112/ 2022); or
- Marked as captive (off-grid) units in the pipeline in the CGPT or the Coal Asset Transition Tool's dataset, supplemented by additional data from a variety of government sources collected by IESR.

KEY STEPS TO DETERMINE EARLY RETIREMENT

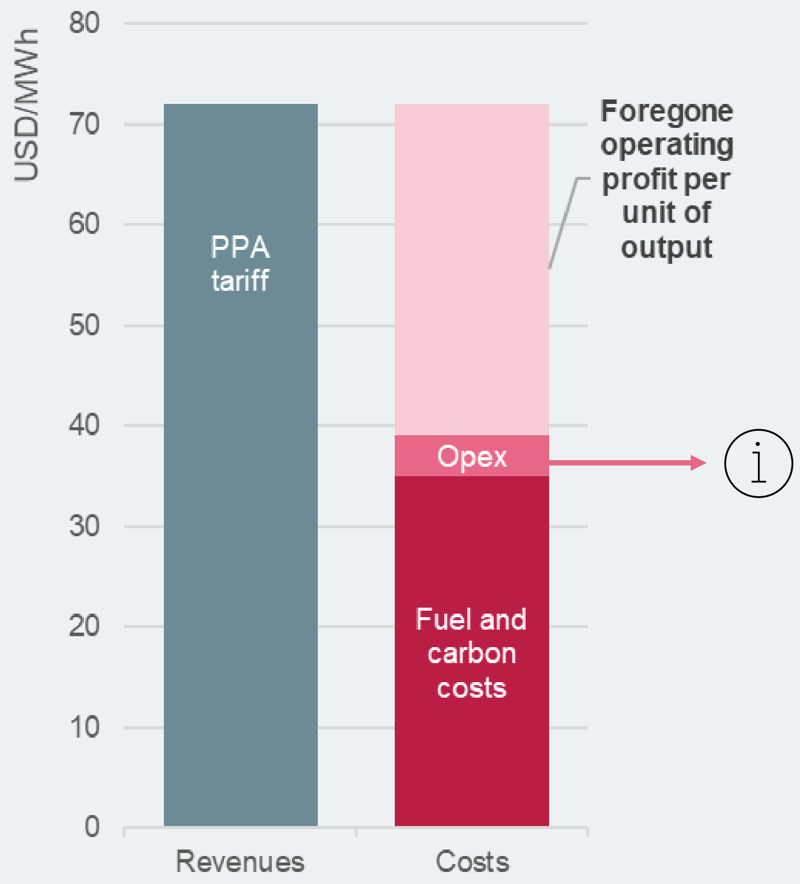
- Calculate the annual available capacity from all eligible units over time (2023-2050) considering their natural retirement age and compare it to the total 'target' coal capacity per year in the APS and NZE scenarios.
- Apply a default lifetime of 30 years for all CFPP (as per the Danish Energy Agency and MEMR's Technology Costs Catalogue), which users can adjust.
- Following the IEA's APS and NZE scenario we start retiring CFPP in 2031 and 2025 respectively (again user configurable).
- The annual difference between the available capacity and target capacity in the respective scenario is the amount of coal capacity that needs to be retired in each year.
- We retire units following a defined prioritisation order until the available capacity matches the target capacity for on- and off-grid CFPP in each year to determine the years of early retirement at the unit level.
- Users have the option to choose between different prioritisation methods in the JET-FIN tool to determine the order in which CFPP are retired: "by age" (default) retires the oldest units first; "by annual CO2 emissions" retires the most polluting units first; and "random" randomly orders the retirement of coal units.
- Users can also determine their own prioritisation for the retirement of units, e.g. based on fuel type; plant efficiency, location, health impacts, etc.

Foregone operating profit

Capital recovery

Book value

- To determine estimates of 'foregone operating profit' from early retirement and curtailment, we follow a similar approach to Transition Zero's Coal Asset Transition Tool and use their estimates of PPA tariff prices as well as fuel and carbon costs.
- For units not included in the Coal Asset Transition Tool, we derive and use average tariff prices as well as fuel and carbon costs per region, differentiating between captive and non-captive plants.
- Fixed and variable operational cost estimates are taken from the Danish Energy Agency and MEMR's Technology Costs Catalogue.
- Under this approach coal plant owners would receive full compensation for their expected net revenues over the asset's remaining natural lifetime. These cover both upfront capital costs and any return on the investment and are therefore likely to reflect the **high end of potential compensation packages**.



Illustrative example of calculation of foregone operating profit based on generic estimates of PPA tariff levels and relevant costs. In the JET-FIN tool we use plant specific data (where available) and apply a similar approach for IPPs as well as PLN plants. Even though PLN plants do not have PPAs this approach can serve as a proxy to reflect expectations at the time of their initial investment decision.

In the case of *early retirement* the units will neither incur fuel and carbon costs, nor any fixed or variable operational costs as the asset is shut down (or repurposed).

In the case of *curtailment* the units will not incur fuel, carbon or variable operational costs corresponding to the generation curtailed, but will continue to faced fixed operational costs (e.g. workforce at the plant, annual maintenance, etc.).

- Foregone operating profit
- **Capital recovery**
- Book value

- To estimate the amount of money that would allow investors to recover their upfront capital investment in coal units (‘capital recovery’) we follow the approach set out in IESR and the University of Maryland’s study on [Financing Indonesia’s coal phase-out](#).
- Capital expenditure estimates are taken from the Danish Energy Agency and MEMR’s [Technology Costs Catalogue](#) (differentiated by the coal combustion technology), using 2020 real cost estimates as a proxy for actual capital investment.
- By default we use a weighted average cost of capital (WACC) of 10% and lifetime of 30 years for all units to derive a capital recovery factor, which users can configure at unit or portfolio level.
- This approach effectively covers costs, but does not cover any provisions for coal plant owners to make a positive return on their initial investment, thus likely reflects a **lower end of potential compensation packages**.

Capacity	**1 GW**
Capital cost	**1.65 USDbn**
Annual generation	**7.5 TWh**
Lifetime	**30 years**
Capital recovery factor (0% WACC)	**0.03**
Capital recovery factor (10% WACC)	**0.11**

$$\frac{\$ \times \text{CRF}}{\text{Annual generation}}$$

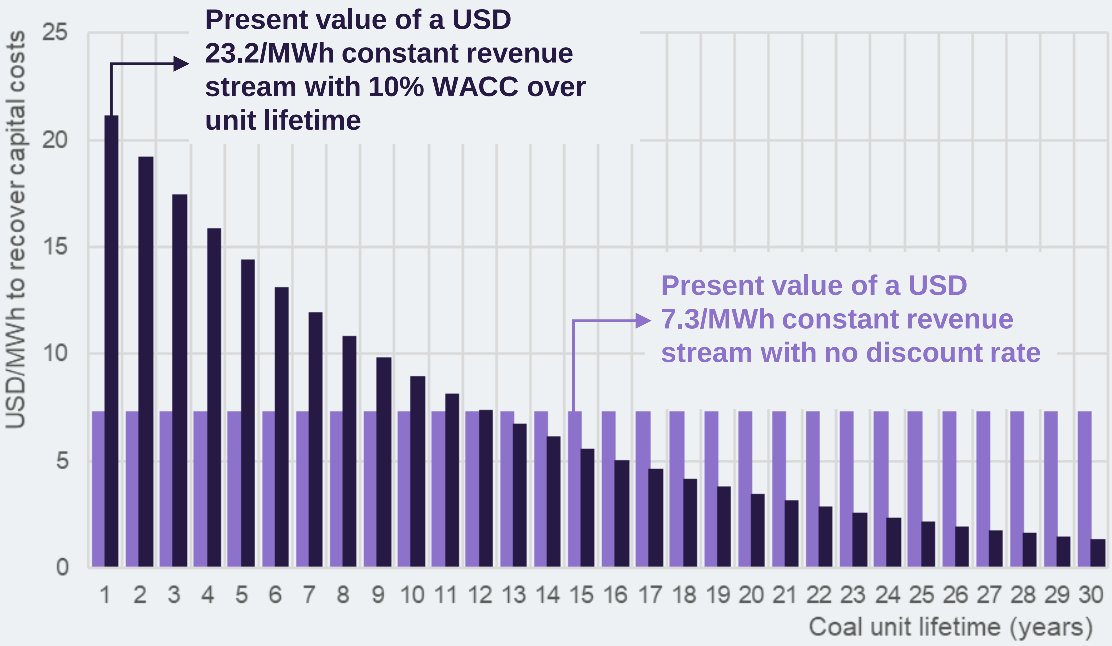
Capital recovery (0% WACC)	**7.3 USD/MWh**
Capital recovery (**10% WACC**)	**23.2 USD/MWh**

Illustrative example of calculation to derive estimate of net revenue required per MWh of output over asset lifetime to recover capital costs under different WACC levels

Foregone operating profit

Capital recovery

Book value



- We derive the value, denominated in real terms, per unit of generation over the plant's lifetime required to recover upfront capital costs: USD 23.2/MWh in this illustrative example, with a 10% WACC.
- Our estimates for capital recovery requirements associated with *early retirement* multiply this value by the expected generation in each year between the early retirement date and the natural retirement date.
- To estimate the potentially unrecovered capital associated with *curtailment* we also add an estimate of fixed operational costs expressed per unit of expected generation in each year. We then multiply the sum of the upfront capital costs and fixed operational costs (both expressed per MWh) by the difference between the generation estimated using the 'base capacity factor' up to the end of its natural lifetime and the curtailed generation level.

Foregone operating profit

Capital recovery

Book value

- Our estimates of potential losses based on 'capital recovery' implicitly assume that unit owners recover their upfront capital expenditure in a uniform manner across the lifetime of the asset and that the offtake price they receive for generation in any given year covers this, their operating costs as well as an appropriate return on their investment.
- This simplified approach is more suited to an electricity market structure such as Indonesia's where IPPs are typically offered long-term PPAs with guaranteed pricing and the vertically integrated state utility, PLN, acts as both supplier and offtaker.

- An extended version of the 'capital recovery' approach, which may be more appropriate in competitive market structures with more dynamic electricity pricing and dispatch of generators, could involve:
  - **Determining how much of their upfront capital an asset owner has recovered to date** by collecting annual offtake revenues as well as costs faced by generators; and
  - **Forecasting future capital recovery for the remainder of the natural lifetime** of the asset by estimating offtake prices, demand, and costs.

Foregone operating profit

Capital recovery

Book value

- We do not include any estimates of potential losses for early retirement or curtailment based on a unit's book value as this is typically a highly bespoke calculation that requires detailed information on the physical condition as well as economic prospects of each individual plant.
- In addition to the resource intensive process of collecting and processing information to determine the book value of assets at any particular time, critical inputs are typically confidential, or can be based on subjective opinion, which introduces an information asymmetry between plant owners and any party seeking to offer compensation for potential losses.
- Asset owners tend to have an incentive to overstate the book value as this can improve their overall balance sheet as well as access to new capital.

Infrastructure: Clean build-up

Description of approach

Finance needs to deliver a 'clean build-up' of energy infrastructure in the coming decades are large and investments will need to mostly offer commercially attractive returns, supported by targeted public funds

- We calculate the total investment needs for a 'clean build-up' by estimating the following costs for key technology types in each year and applying these to the electricity scenario pathways:
  - **UPFRONT CAPITAL EXPENDITURE (CAPEX)**
  - **FIXED OPERATIONAL EXPENDITURE (OPEX),**
  - **VARIABLE OPEX**
  - **FUEL**
  - **(CARBON EMISSIONS – USER CONFIGURED)**

KEY STEPS

1. Determine new capacity and grid addition requirements by technology in each year for the scenario pathway
2. Determine the total operational capacity and generation by technology and year over the modelling horizon
3. Identify estimates of relevant costs to plan, construct and operate capacity over time as well as cost of capital (WACC)
4. Multiply capacity additions, as well as operational capacity and generation in each year by relevant costs
5. Identify potential role for public finance to unlock required private / commercial investments

We derive total investment needs for a ‘clean build-up’ by estimating capital costs, fixed and variable operational costs, fuel costs (and carbon costs) for key technology types in each year…

IDENTIFYING INVESTMENT COSTS OVER TIME

- We derive capital costs as well as fixed and variable operational costs for new build technologies, including storage solutions, based on data from the Danish Energy Agency’s and MEMR’s Technology Catalogue.
- To account for improvements in efficiency as well as global and domestic economies of scale, we apply technology-specific learning curves for capital and operational costs. In the JET-FIN tool users can choose between linear learning curves based on projections in the Technology Catalogue or to input data manually.
- Due to their bespoke nature (highly dependent on national / regional conditions) we include distribution and transmission costs directly from the IEA’s Net Zero Emissions Roadmap.
- Default fuel costs for coal, natural gas, oil, nuclear, and biomass are based on IESR’S Deep Decarbonisation study over time. The user can choose between alternative fuel cost projections or input data manually. By default, we assume constant fuel efficiency over time and per technology type.
- Capital costs are allocated to the years prior to new capacity entering operation, based on estimates of construction duration in the Technology Catalogue. All other ongoing operational and fuel / carbon costs are allocated to the years in which they are incurred.
- Users can enter an annual carbon price into the JET-FIN tool (not used in default results).

APPLYING TO SCENARIOS

… And applying these investment cost estimates to the scenario pathways with a focus on finance needs for clean infrastructure development

- All applicable costs per unit (e.g. per MW of installed capacity, or per MWh of generation in a given year) are multiplied by the respective capacity or generation in a scenario for each technology type over the modelling horizon to derive annual investment needs.

  (see Electricity sector pathways section above for more detail)

- Whilst there is continued investment in expanding coal and gas capacity as well as operation of fossil-fuelled plants in the JETP scenario, **our analysis focuses on the build-up and operation of clean technologies as key drivers of the energy transition**.

Just social transition

Description of approach

Employment focus

Description of approach

To deliver on the key objectives of a JUST energy transition, **vulnerable communities – particularly in regions dependent on coal mining and its use** – are likely to need support to ensure they benefit from the opportunities of a growing clean energy system

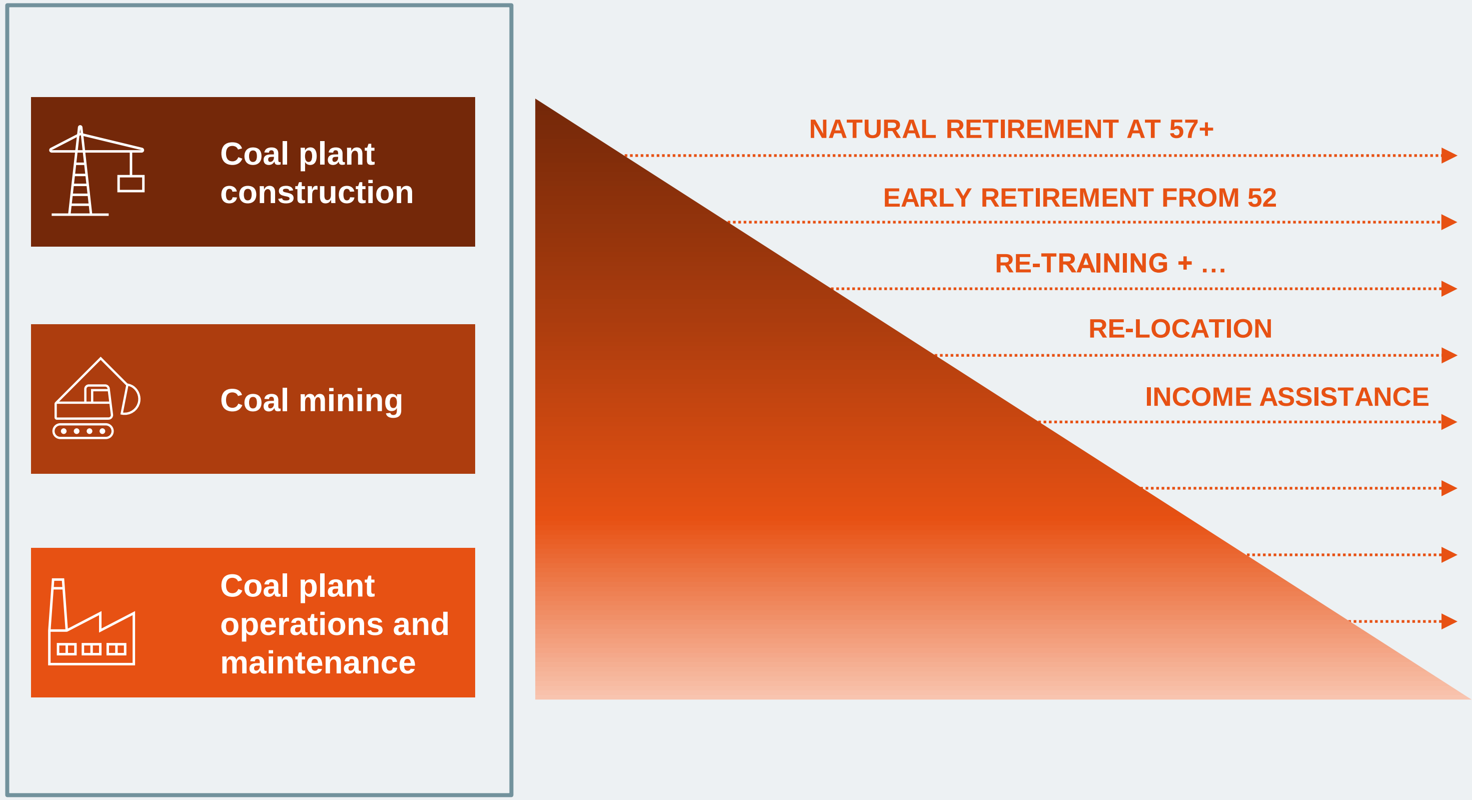
- We assess potential finance needs to support a just transition focusing on coal-sector workers and their communities.
- Coal mining, as well as a large share of coal power plants, are concentrated in East and North Kalimantan and South Sumatra.
- We estimate the potential number of workers that may require support due to reduced employment opportunities over time and approximate potential public funding needs to support either early retirement (for older workers) or retraining and relocation.
- Our quantitative estimates only cover a subset of likely overall costs to support workers and affected communities to successfully transition away from coal sector activities.

KEY STEPS

1. Estimate annual employment across electricity supply technologies for scenarios in Economic Impact Model for Electricity Supply (EIM-ES)
2. Deep-dive focus on coal sector jobs, broken down into jobs supported by capital expenditure, operations and mining
3. Identify estimates of age profile of current coal sector workforce and model natural annual turnover of employees
4. Determine annual estimates of workers exiting coal sector and whether suitable for early retirement or retraining
5. Identify potential costs to support early retirement or retraining / relocation of coal workers that stand to lose their jobs over time

Natural retirement, early retirement and re-training provide pathways for workers to transition out of the coal industry in the long-term and can be accompanied by further measures that compensate workers' financial losses directly

BREAKDOWN OF EMPLOYMENT IMPACTS INTO THREE CORE ELEMENTS OF COAL VALUE CHAIN

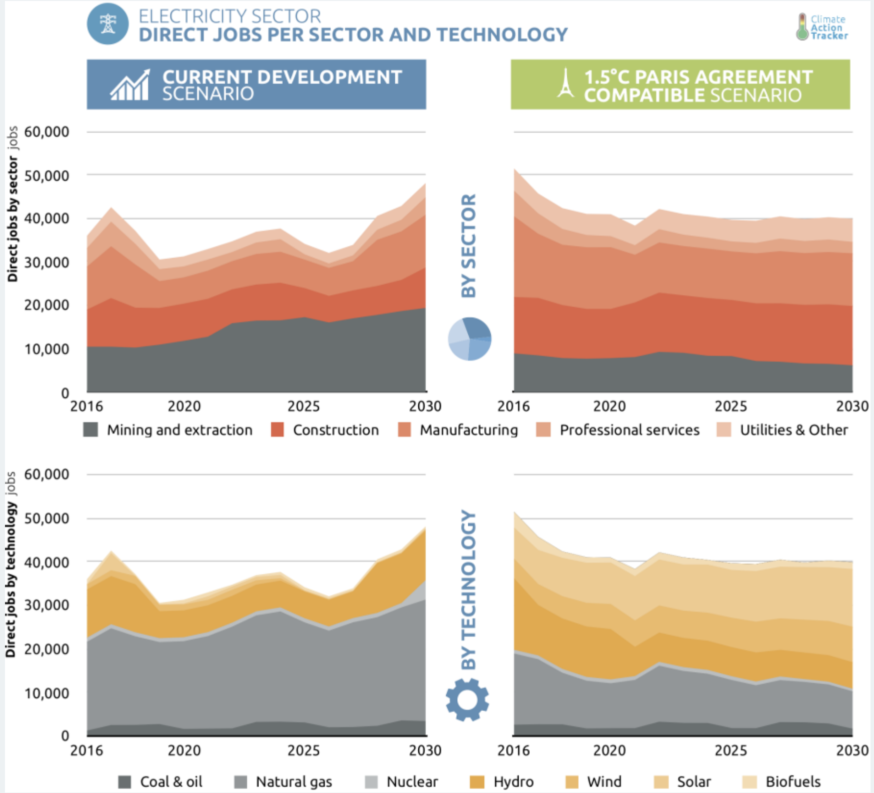


The employment transition may impose significant financial burdens to families of coal workers who are laid off or voluntarily choose to leave their jobs as a result of the phase-out of coal from the Indonesian, as well as global, energy system. In the short-term, households facing a loss of income could be supported through **temporary income assistance**, paid until workers successfully find re-employment.

The geographical distribution of where current coal workers live and work and where new employment opportunities are located may pose another barrier to coal workers accessing new jobs. **Relocation allowances** can help alleviate some of the financial burdens of, for example, transportation, housing and other costs associated with moving, enabling workers find to re-employment sooner, as they do not have to rely on building up enough financial buffer for this kind of transition.

We use the Economic Impact Model for Electricity Supply (EIM-ES) – an Input Output based tool – to derive national estimates of employment and wider economic impacts of scenario pathways

- The EIM-ES is a transparent, Excel-based tool that estimates the domestic employment impacts of investments in the electricity supply sector within a country to aid policy decision makers.
- The model covers all relevant electricity generation technologies - both low carbon and fossil fuel-based plants – in order to provide an assessment of employment creation as well as job losses under different future pathways for the development of the electricity sector.
- It also provides information on wider economic indicators such as investment requirements, economic value added and trade.



Illustrative example of estimates of direct employment from an application of the EIM-ES in South Africa
Source: Climate Action Tracker, Scaling up climate action in South Africa, 2018

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INPUTS

- Capacity additions and retirements per technology for each year
- Electricity generation per technology for each year
- Investment costs by technology broken down into component parts with local content share assumptions
- National Input / Output statistical table
- Average salaries by economic sector

CALCULATIONS

- Calculates **employment and wider economic impacts over time** of different electricity sector scenarios
- Estimates employment levels based on local investments and salary levels
- Applies country- and sector-specific economic multipliers

OUTPUTS

- Model estimates **direct, indirect and induced** employment and can compare results across scenarios
- Direct employment results calculated **over time, by technology and sector** of the economy
- Employment impact for different technologies can be compared **per MW, per GWh and per USD invested**
- Wider economic impacts include **investment requirements, economic value added and trade** indicators

Data inputs to the EIM-ES to estimate employment impacts over the modelling horizon are aligned with the electricity sector pathways and clean build-up analysis in the JET-FIN tool, complemented with additional information

CORE DATA ALIGNED WITH CLEAN BUILD-UP ANALYSIS

- Electricity sector pathways for the JETP and JETP+ scenarios are the basis of the **capacity and generation inputs**, broken down by technology and over time [see earlier section].

- **Investment costs** by technology are based on data from the Danish Energy Agency's and MEMR's Technology Catalogue, which include technology-specific learning curves for capital and operational costs.

- **Fuel costs** for coal, natural gas, oil, nuclear, and biomass are based on IESR'S Deep Decarbonisation study over time.

PLUS ADDITIONAL INPUTS

- **Input Output tables** reflect the structure of the Indonesian economy and interdependencies between different sectors. We use the 2021 edition for Indonesia from the OECD database, which captures sale and purchase flows across 45 sectors.

- **Annual salaries** by sector are sourced from the Statistical Yearbook of Indonesia 2022, published by Badan Pusat Statistik, and mapped to the 45 sectors represented in the Input Output tables.

- **Local content share** estimates for component parts of each technology are based on a previous study for coal and solar, minimum local content requirements and expert judgement.

A version of the EIM-ES used for this study is published alongside the report, which includes all input data, sources and calculations, to allow users to further review the analysis and test alternative pathways.

Available for download online here: https://newclimate.org/resources/publications/identifying-finance-needs-for-a-just-transformation-of-indonesias-power

Deep-dive into coal value chain employment: **Modelling the employment turnover of workers in the coal sector over the transition period provides insight into workforce exits that may need financial support for early retirement, re-skilling and re-location**

Coal plant construction

Coal mining

Coal plant operations and maintenance

KEY STEPS TO MODELLING WORKFORCE TURNOVER

- We first identify the annual employment estimates over the modelling horizon for workers involved in each of the three core elements of the coal value chain from the EIM-ES results.
- Second, we derive estimates of the age distribution of the *current* workforce in each of the three areas, using data from publicly available sources, including from PT Indonesia Power, IESR and Badan Pusat Statistik. We apply these age distributions to today's workforce.
- Third, we simulate the profile of employment into future years. In some years new entrants join the workforce as employment opportunities temporarily grow, for example for coal plant construction during this decade.
- In years in which the workforce shrinks, we assume that the oldest workers exit first (at or above the natural retirement age of 57), then workers aged up to five years younger than the natural retirement age (aged 52-56) who are suitable for early retirement, and then younger workers (aged 51 and below) who may need re-training and re-location support as well as temporary income assistance.
- For the workforce involved in coal mining, the operation of coal-fired power plants and the development of new coal-fired power plants, the characteristics of their respective employment transitions differ both due to timing of the transition as well as differing demographic characteristics of today's workforce.

Deep-dive into coal value chain employment: Estimating costs to support early retirement, re-skilling and re-location

Data availability of estimates of finance needs to support early-retirement as well as re-training / relocation and general income support are limited and mostly from high income countries. All inputs are user configurable in the JET-FIN tool and EIM-ES to facilitate further sensitivity analysis.

For workers existing 52-56 years

EARLY RETIREMENT

- To facilitate workers' exiting the coal industry, **early-retirement** is an option for older workers for whom the benefits of re-training and/or relocation to find new jobs are likely lower.
- Early retirement programmes implemented by other countries who are undergoing energy transitions away from fossil fuels (including Poland, Spain and Canada) have offered workers early retirement with a pension equivalent to 70-75% of their previous earnings, either for a limited duration or until workers are eligible for full retirement.
- We calculate potential financial support needs for workers exiting the sector between the ages of 52-56 by multiplying an estimate of their **salary by 75% until they reach 57**.

For workers existing below 52 years

RE-TRAINING

- Providing coal workers with opportunities for **re-training and re-skilling** so that they can take advantage of new job opportunities presented by the transition will require an expansion of educational institutions, such as vocational colleges, universities and other industry-specific programmes.
- For workers exiting the coal sector below the age of 52, we calculate potential re-training support costs by allocating **USD 2k** in funding per person (user configurable in JET-FIN tool). This is based on re-training support programmes implemented in Poland and Canada (approximately USD 8-10k per person), adjusted to account for the relative difference in GDP per capita to Indonesia.

INCOME + RELOCATION

- In some countries (such as Poland and Canada), workers have been offered 65-75% of their previous earnings as a **temporary income allowance**, either for a fixed duration or until they find re-employment.
- We calculate potential income support finance requirements by multiplying an estimate of **salary by 75%, for a period of 2 years in the case of workers exiting mining and plant operations, and just 1 year for workers exiting plant construction**, on the basis that for the latter skills in the construction sector are more easily transferable.
- We also add potential financial support needs of **USD 500** per worker to reduce the burden of **relocation**.

Rehabilitation of mining sites

Description of approach

Modelling the costs for rehabilitation of mining sites, including repurposing the site to contribute to greater social and environmental justice

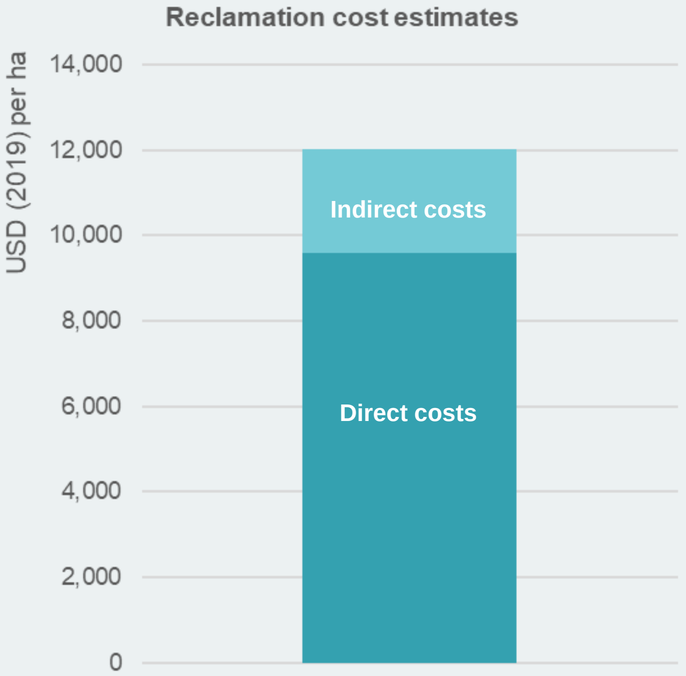
- We calculate the costs of reclamation and post-mining needs following coal mine closure and provide estimates of the investments needed to recover untreated land.
- Estimates are based on meeting the following regulations:
  - Law No.3 of 2020 concerning Mineral and Coal Mining
  - MEMR Ministerial Regulation No. 7 of 2014 concerning the Implementation of Reclamation and Post-mining
  - MEMR Ministerial Decree No. 1827 K/30/2018 concerning Guidelines of Good Mining Practice

KEY STEPS

1. Calculate the cost of activities included in the reclamation plan during the mining process as required by regulations
2. Calculate the cost of activities included in the post-mining plan after the mining closure as required by regulations
3. Identify estimates of the investments needed for recovery of abandoned and untreated land after the mining site closure
4. Identify the potential role of public finance in funding the environmental rehabilitation and social and economic development in the mining area

Reclamation is a compulsory activity performed by IUP holders during the mining process after the mining pits are closed. We estimate the cost incurred to reclaim land is in the order of USD 12,000 per ha based on available data.

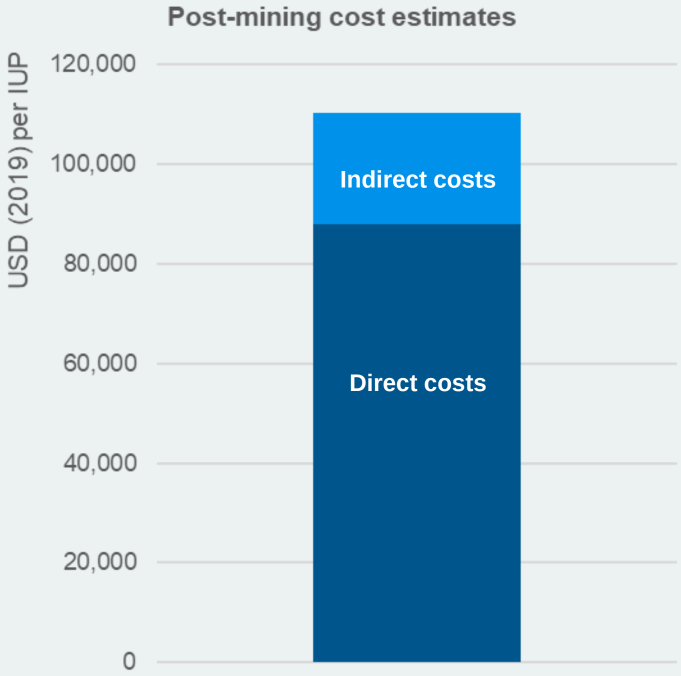
- Based on a range of existing studies (Hafifa et al., 2022; Saputro et al., 2023; Rahmi et al. (2020); Cahyana et al. (2020); Prasetya et al. (2023); Putri et al. (2022)) we identified the total cost of reclamation for IUP holders.
- Reclamation cost plans set out annual investment requirements, typically for five years. These include direct and indirect costs for the relevant activities. The reclamation cost plan is calculated based on the size of the pit, which on average is 15-20 ha.
- Direct costs cover activities, including: land arrangement; revegetation; preventing and controlling acid mine drainage; and civil work.
- Indirect costs cover activities, including: costs of equipment mobilisation and demobilisation; planning; administration; and supervision.
- Technically, reclamation is conducted within 30 days at the end of the production process in a mining area every year and will last for three years including the maintenance activities.



Source: Authors analysis of existing studies

Post-mining is a compulsory activity performed by IUP holders after the mining closure. We estimate post-mining activity costs of around USD 110,000 per IUP granted a licence for 5,000 ha.

- We calculate the cost of post-mining needs for a coal mine closure which covers estimates of the investment requirements for land recovery after all the mining sites are closed as per the licence. These costs will vary depending on the size of the land allocated to the IUP.
- Costs are calculated based on the activities set out in regulatory guidelines, based on estimates in a study by Khamim (2021).
- Direct costs cover activities, including: demolition of former mining sites; dismantling processing facilities; maintenance, monitoring and social, cultural and economic development.
- Indirect costs cover activities, including: costs of equipment mobilisation; planning; administration; and supervision.
- In practice, post-mining is started within 30 days of the completion of all mining extraction activities, or at the end of the license, and lasts for three years, including the maintenance process.



Source: Authors analysis of existing studies

Health benefits of a just energy transition

Description of approach

IESR Institute for Essential Services Reform

NEW CLIMATE INSTITUTE

Our analysis of air pollution health impacts allows us to quantify the substantial health benefits from transitioning away from a heavy reliance on coal, both in terms of lives saved as well as a monetary equivalent of the health benefits

- We use an Excel-based tool, the AIRPOLIM-ES, to estimate the mortality risk to populations exposed to ambient air pollution originating from the combustion of coal and calculate the health benefits from both early retirement of coal plants as well as the curtailment of their generation in the JETP and JETP+ scenarios.
- Our individual plant-level estimates show the avoided premature deaths and avoided years of life lost, broken down into impacts from three different pollutants and four adulthood diseases.
- In addition, we also monetise the health impacts, estimating the avoided cost of reduced levels of air pollution.

KEY STEPS

1. Estimate annual emissions from coal-fired power plants for different pollutants
2. Map exposed population across four distance bands in Indonesia and beyond its borders
3. Calculate the intake fraction and change in concentration in ambient air pollution for each pollutant
4. Quantify health impacts from air pollution per coal unit through concentration-response functions
5. Estimate the corresponding socioeconomic costs using the metric ’value of statistical life’

Individual power plant characteristics, e.g. lifetime; capacity; location; efficiency

Power plant operational assumptions, e.g. capacity factor; pollution controls

Population exposure estimates by distance (using GIS software)

Population characteristics, e.g. mortality rates; age split; life expectancy; growth

Scenario definitions, e.g. early coal-phase out

Calculates **the impacts of air pollution on mortality over time** at plant and national level

Based on estimates of **pollution intake**

Applies **country-specific** population and health metrics

Annual and lifetime emissions for CO_2; $PM_{2.5}$; SO_2; NO_X

Health impacts, including **premature deaths** and **years of life lost**

Results broken down **by plant, year** and **type of disease**

Health impacts reported both for the **analysis country** and for **other countries exposed to pollution**

INPUTS | CALCULATIONS | OUTPUTS

ESTIMATE EMISSIONS & CALCULATE EXPOSED POPULATION

We use a country specific emission factor from the GAINS database and the annual electricity generation to estimate the annual emission from CFPP for three pollutants: particulate matter ($PM_{2.5}$); nitrogen oxides (NO_x); and sulphur dioxide (SO_2). We apply the same “average” emission factor from the GAINS database to all coal units over time.

We use the open-source geographical information system mapping software (QGIS) and the WorldPop gridded population data to map the exposed population along four distance bands (0–100 km, 100–500 km, 500–1,000 km, and 1,000–3,300 km). To estimate population exposure in future years we use country-specific population growth estimates from the UN World Population Prospects. Location data for the coal units is taken from the January 2023 updated Global Energy Monitor’s Global Coal Plant Tracker database.

CONCENTRATION CHANGE AND INTAKE FRACTION & QUANTIFY HEALTH IMPACTS PER COAL UNIT

We use the intake fraction concept to estimate the change in $PM_{2.5}$ concentration based on pollutant emissions. Intake fractions represent the inhaled share of $PM_{2.5}$ by the population per unit of emitted $PM_{2.5}$, NO_x, and SO_2 from coal power plants. These fractions, derived from Zhou et al. (2006), help us infer the $PM_{2.5}$ concentration change.

To determine the increased mortality risk per tonne of pollutant emissions, we multiply the estimated $PM_{2.5}$ concentration change by the corresponding concentration-response function. Using mortality rates from the Global Burden of Disease project (2021) and age-weighted mortality rates by disease based on the World Bank data, we calculate years of life lost (YLL) using remaining life expectancy values from UN World Population Prospects for each age. The health impacts in other affected countries are estimated using the population characteristics (e.g., age distribution or growth rates) of the power plant's location.

Corresponding costs are calculated by multiplying the ‘value of statistical life’ (VSL) with the number of premature deaths. We use USD 640k as an estimate for the VSL based on Viscusi & Masterman (2017). We refrain from discounting the valuation of future health impacts, assuming that the VSL rises over time in line with Indonesia’s GDP which would counteract the effect of discounting.

Institutional capacity

Description of approach

Successful delivery of the just energy transition requires building institutional capacity to support a growing energy sector, particularly between national and sub-national government

- Due to limited data availability and the wide range of different potential governance approaches, resource and financial needs estimates for building institutional capacity included within the scope of this study are only indicative of scale and largely qualitative.
- We draw on parallel research to identify the institutional capacity needs for a just transition in Indonesia conducted by IESR and the Stockholm Environment Institute, which will be published in early 2024.*
- The findings from this study indicate that subnational government entities, in particular, are unaware of the changing energy landscape and the implications this will have for their administration.

KEY STEPS

1. Identify all relevant national and sub-national government departments that need to be involved in planning the energy transition
2. Develop a framework for institutional capacity across all relevant levels of governance
3. Develop questionnaires and interview government officials to take stock of their current available capacity and identify future needs to successfully steer the energy transition
4. Conduct focus group discussions to validate the responses and compare those with results from the literature review and institutional capacity framework
5. Identify required capacity and capacity gaps for different levels of governance

*This independent study was conducted as part of the Just Transition Project funded by the Ford Foundation.

Institutional capacity

APPROACH

Identification of all relevant national and sub-national government departments that need to be involved in planning the energy transition is a critical first step

National

- Ministry of National Development Planning (Bappenas)
- Ministry of Investment (BKPM)
- Ministry of Finance
- Ministry of Energy and Mineral Resources (ESDM)
- Ministry of Women Empowerment (PPPA)

Sub-national

- 6 provinces, 9 regional level
- Agency of Energy and Mineral Resources (DESDM)
- Regional Development Planning (Bappeda)

Institutional capacity

APPROACH

We determine existing capacity and future needs across all relevant levels of governance against a general framework for institutional capacity adapted to the Indonesian context

- The 'Ideal Capacity Framework' used in the study was adopted from Koop et al. (2017) and modified to adjust it to the Indonesian context. The framework consists of 9 key capacities that are grouped into three dimensions with multiple indicators (see table).
- Based on the different indicators, the authors developed questionnaires for both national and the sub-national levels of government.
- The results were quantified and ranked on a scale from 1 to 5 for each indicator, where 1 equals little to no current capacity available and 5 equals sufficient available capacity.

Ideal Capacity for Just Transition Planning
(Adapted from Koop et al., 2017)

Dimension	Capacity	Indicators
Knowledge	Awareness	Consciousness
		Sense of urgency
	Useful knowledge	Technical knowledge
Intention to participate	Stakeholder engagement	Stakeholder participation/inclusivity
	Communication	Transparency in information sharing
		Relationship between ministries/agencies
	Multilevel network potential	Vertical communication
		Room to manoeuver
		Clear division of responsibilities
		Authority
Action	Financial	Fiscal capacity
	Instrument	Clear strategic direction
		Organizational structure
		Organizational culture
		Monitoring and evaluation system
	Implementing capacity	Supporting regulations
		Local Government Readiness

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