Appendices

Appendix 1: Q&A of GFI Analysis

Quote from JCOAL @1st Working Group	Remark/Question	Answer
To forecast the GFI, the historical GFI is regressed with several variables. Each variable will have its own historic and forecast data.	What are examples of variables in this statement? If it refers to, let us say, total capacity or total renewable energy capacity, would it not result in multicollinearity? If it refers to the energy availability factor, how do we forecast the future values of this variable? Can gross domestic product (GDP) be one of the variables?	A validation check was done and so far optimised by the data obtained. => see validation graph
In several countries, the GFI is found to increase year by year with their economic growth.	Please clarify the statement. If one country has positive economic growth but with high efficiency (decouple GDP from electricity consumption), would the country have increased GFI value?	According to our analysis, the GFI will increase with rising solar and coal availability factors. The GFI should be considered with the quality of generation flexibility.
Countries with a high share of hydro and gas generation are supposed to have no future issues of grid flexibility.	Is there any rule of thumb that defines the relationship between the hydro or gas generation share and the GFI value? Or is it country specific?	Normally, gas thermal can be operated flexibly. Hydro, especially small and pumped hydro, is also positioned as a mid-merit generation.
	Would implementing other grid stability measures, for example, BESS or demand response, reduce the GFI of one country?	Although the stability measures cannot be reflected in calculating the GFI value itself, they might be practically effective and consider adding the proposed recommendations.

The GFI of many countries will be increasing from 2030, especially Indonesia, Malaysia, the Philippines, and Viet Nam.	What are the contributing factors of increased GFI in these countries: the MW of renewable energy, the MW of coal, the energy availability factor, or both?	The main factors are coal and solar availabilities.
	For Malaysia, the data behind this analysis refers to Peninsular Malaysia or Malaysia as a country (including Sarawak)? The grids are separated from each other.	Currently, whole country data were obtained.

Appendix 2: List of Members of the 1st Working Group for the ERIA Study

Country	Institution	
Indonesia	Ministry of Energy and Mineral Resources (MEMR)	Mr Senda Hurumzan Kanam, MSc. Deputy Director for Electricity Cooperation, Directorate of Programming (as a guest member)
		Mr Pramudya, ST, MT, Policy Analyst, Directorate of Programming
		Mr Hery Wahyudi Wibowo, ST, MT Electricity Inspector, Directorate of Electricity Engineering and Environment
		Mr Andi Hanif, ST, M.Eng. Electricity Inspector, Directorate of Electricity Engineering and Environment
	PT. PLN (Persero)	Mr Arief Sugiyanto Manager of System Planning for Java, Madura, and Bali
	PT. PLN (Persero)	Mr Herian Atma Engineer of System Planning for Java, Madura, and Bali.
Malaysia	Energy Commission (ST)	Ir Mohd Helmi bin Mohd Zaihan Assistant Director
	Grid System Operator (GSO)	Ms Rose Adila binti Bujal Senior Engineer
Philippines	Department of Energy (DOE)	Ms Melanie C. Papa Senior Science Research Specialist, Power Market and Development Division – EPIMB
		Mr Noriel Christopher R. Reyes Senior Science Research Specialist, Power Planning and Development Division – EPIMB
Viet Nam	Ministry of Trade and Industry (MOIT)	To be confirmed on Monday 14 June
	Viet Nam Electricity (EVN)	To be confirmed on Monday 14 June

Appendix 3: Minutes of the 1st Working Group Meeting on 'The ERIA Study on Enhanced Flexibilisation of Coal-fired Power Plants for Optimal Grid Stabilisation in the ASEAN Region'

Opening address by Dr Han Phoumin, ERIA

Carbon neutrality becomes a globally shared value and objective, given the imminent threat of climate change. Given the efforts by ASEAN towards renewable integration, the study comes at the right time when the region needs to see a range of measures for grid stabilisation, including the flexibility of coal power generation. I think coal would be resilient in power generation if it can really play a role in flexibilisation for grid stabilisation.

ASEAN still relies on fossil fuels in both the power and industry sectors. And coal will remain a reliable energy source in ASEAN, since the environment, affordability, and energy security are considered in the choice of energy sources. Coal is affordable and economically competitive. However, coal utilisation must be with clean coal technology, given the environmental requirements.
ERIA hopes to convey the recommendations, once provided under the study, to the relevant institutions and the power utilities in the region trying to identify their energy transition paths and the measures to be taken.

The MC expressed appreciation to Dr Phoumin and asked Mr Senda, Deputy Director for Electricity Corporation, Directorate of Programming, Directorate General of Electricity, Ministry of Energy and Mineral Resources (MEMR) of Indonesia, to deliver his keynote address.

Keynote address by Mr Senda Hurumzan Kanam, MEMR, Indonesia

The study on increasing flexibility of power plants needs to be carried out to improve the reliability and stability of the grid system. Due to the increased penetration of intermittent variable renewable energy sources, mainly wind and solar, the large penetration of PRA in the grid is not only due to the effort of various countries to achieve the target of the Paris Agreement and net zero emission. It also due to the lowering cost of PRA production and the development of energy storage technology that has been introduced into this system. The main approach to improving systems security and stability applies smart grid technology or grid modernisation.
One grid modernisation approach is to apply automatic generation control or AGC to respond actively to the fluctuations of PRA penetration on the system grid. In addition, the operation of a large system that works as a baseload is necessary to increase the ability to change the demand for a sudden increase, especially during the peak load in the afternoon, which forms a duck curve. Such situation is caused by the increased penetration of PRA, especially solar power plant which can only produce during daytime

when household demand remains low and cannot supply during nighttime.

When demand increases with this heavily burdened coal plant that usually operates as a baseload, it is necessary to study and modify the operation of the coal plant so that it can respond to the changes in demand, following the duck curve, and changes in the supply of PRA that are intermittent. The ability to respond to the change in demand and supply to ensure stability depends on the (unclear) of each coal plant.

We have compiled a grid code regulating PRA intake in the system must be stable first before entering the system. In the future, our grid code has recommended wind power integration in Indonesia by utilising batteries to reduce its intermittency.

In Indonesia, to overcome the issue of location installer, we will implement a system with a floating solar power plant and a hydropower plant before introducing it into the grid, which we expect for reduced PRA appropriation. For example, in Lampung and [unclear], we plan to build a solar power plant system equipped with battery storage to supply the peak load at 18:00–20:00 to overcome the duck curve of increasing load before battery storage, and ancillary service (BA) introduces it into the grid.

In Europe, [unclear] demand occurs during the summer and the winter, where there is no demand in summer and high demand for heating in winter. However, the opposite occurs when there is a high solar energy supply in summer and a low supply in winter. To overcome this fluctuation of excess power during the summer season, the German government stores excess power produced from wind and is reused in the winter, which they call green hydrogen. From experience in Indonesia and Germany, we can learn the flexibility of coal power plants in the future by utilising storage technology, such as batteries and hydrogen.

In Indonesia, we tried to clean up our coal plants by introducing carbon capture and utilisation storage, or CCUS technology. Captured CO2 from coal-fired power plants will be injected into depleted oil gas fields nearby. Besides that, the excess power from the coal plant used in the operation of a large amount of PRA from solar will be stored in batteries or hydrogen storage. This energy storage will be utilised during the peak load. The hydrogen produced from this process is called blue hydrogen.

The next anticipated phase is to combine coal plant and hydrogen plant integrated with an ammonia production process so that the product can be exported as ammonia. With a strong commitment from both countries' governments and the industry sector, I am confident that this collaboration will inspire us further to join in relevant activities in the future and that innovation in the technology development of Indonesia and other ASEAN member states will progress.

The MC gave a briefing on the meeting agenda and the schedule.
The Working Group members introduced themselves and shared their thoughts on the study and the relevant issues.

Mr Pramudya, MEMR, Indonesia
I am in charge of the national electricity planning and evaluation. In the same context, we evaluate the plans of the PLN, RUPTL, the 10-year national power infrastructure development plan for power generation, transmission, distribution, and substation. I hope through this study, we can put together our knowledge to find a better solution for coal-fired power plants for a flexible and better grid. I joined another ERIA study on ASEAN interconnection, so it is my pleasure to participate again as a working group member.

Mr Hery Wahyudi, MEMR, Indonesia
My task is to support the government for technical proficiency and share the recognition of electrical safety with all relevant industry players and suppliers.

Mr Andi Hanif, MEMR, Indonesia
I am in the same team as Hery-san working as a national electrical inspector. I hope I can provide advice and support to the study team in the context of my daily work and duties.

Mr Arief Sugiyanto, PLN, Indonesia
I am in charge of the system branding for Jaffa, so I am working with the MEMR for RUPTL formulation. So, we – Mr Herian and I – are from the utility side, and Mr Pram is from the regulatory side. This is the first time I have joined this study on flexibility for coal-fired power plants, so I am interested in seeing the result and interim report of this study, especially regarding the technical capability of coal-fired power plants and the cost. Maybe later we can discuss this more. As Mr Senda said, in the future, we will have a lot of renewables coming into the system, and we need more flexibility from the existing power plants.

Mr Herian, PLN, Indonesia
I am working in the system planning division, which, together with the Directorate General of Electricity, drafts the RUPTL, the power development plan for Indonesia for the next 10 years. We hope that by working in this group, we can learn what technology is applicable to allow us to incorporate more renewable energy in the future.

Ir Mohd Helmi bin Mohd Zaihan, EC (ST), Malaysia
I am from the Energy Commission of Malaysia, currently in the electricity market operations unit. We are responsible for regulating the electricity supply industry – from generation, transmission, and distribution to retail.

Ms Rose Adila, GSO, Malaysia
I am from the grid management unit, coordinating the grid system for the power plant in Peninsular Malaysia. As the representative of GSO, I am looking forward to the study's outcome. Our main concern is system security. We hope that the technology or the recommendation from the study can benefit grid stability and power generation.

Ms Melanie Papa, DOE, Philippines
I am assigned to the unit that oversees the implementation of our wholesale electricity spot market. I am committed to participating and contributing to this study in whatever way I can.

Mr Noriel Christopher, DOE, Philippines
I am also from the Electric Power Industry Management Bureau of the Philippines, Department of Energy. But I am in a different division from our Power Planning and Development Division. My main task is more on generation planning of the power sector and mostly on crafting our power development plans.

Updates of each country's situation were presented according to the alphabetical order of the country names. Mr Pramudya, MEMR, Indonesia, made the first presentation for Indonesia.

Next, Ir Mohd Helmi bin Mohd Zaihan, EC (ST), Malaysia, did the country presentation. The floor was opened for questions as Dr Murakami requested time to ask Malaysia.

Dr Murakami, JCOAL Study Team
Thank you for your presentation. You mentioned 400 MW of BESS; 100 MW is relatively larger if BESS is connected with a standard solar plant or wind plant. So, which part of the grid are you planning to install BESS?

Ir Mohd Helmi bin Mohd Zaihan
Actually, we will ask the grid system operator to study this before deciding where to put BESS. We don't have any specific plan yet where to put BESS.

The Philippines also requested an opportunity to ask a question to Malaysia.

Ms Melanie Papa
Also, regarding the battery energy storage systems, may I ask how you treat or make transmission charges to those BESS? In the case of the Philippines, we don't have a policy yet when it comes to charging them for transmission. Whenever they draw power from the grid, they are being charged those transmission charges. How do you treat those systems in Malaysia?

Ir Mohd Helmi bin Mohd Zaihan
Similarly, currently, we don't have any charges in place in Malaysia. But we are conducting a study with a consultant to provide a framework for the charges. So, we are still unsure whether to park the BESS as part of the generation or part of the ancillary services and the charges. But we are still conducting studies, and we expect these to be completed by the end of this year.

Ms Melanie Papa
I see, so we have a similar dilemma. Yes, thank you.

Ir Mohd Helmi bin Mohd Zaihan
Yes, similar dilemma and the price is quite high for BESS. Maybe we can collaborate later to see how it goes in the Philippines as well.

Ms Melanie Papa
We will wait for the development in your country when it comes to those systems.

Indonesia was the third questioner about Malaysia's presentation.

Mr Hery Wahyudi
I have two questions for you. The first is how long is the time horizon for your PDP, and how often do you have to revise this document? For what reason? The second question is, I saw that you have a projection for a capacity mix for the next 20 years, if I'm not mistaken. Is there also a projection for the energy mix?

Ir Mohd Helmi bin Mohd Zaihan
Yes, we do have. For the power generation planning, we have a 10-year plan. The latest one that we published is from 2021 until 2030. There is no set timeline, but we usually conduct a study every year and maybe publish it in 5 or 10 years. But it depends on government policy. In any case, we do the studies every year. But currently, it is pretty difficult to make projections because the pricing and the demand are not yet stable due to the COVID-19 situation.

Mr Hery Wahyudi
And how does Malaysia set the target of a minimum share of renewables? In the case of Indonesia, it is 23% by 2025.

Ir Mohd Helmi bin Mohd Zaihan
We have a similar target, and it is about 35% something if my memory serves me.

The two representatives from the Philippines made their presentation.
Indonesia asked questions to the Philippines.

Mr Andi Hanif
I have three questions regarding your presentation. The first question is: so there are different corporations in your electricity business system, which involve different electricity sectors. Is that correct or not? The second question is, in the electricity generation sector, are there different corporations as well or none? For example, there are corporations, especially for our coal power plants, and other corporations for hydropower plants. Are all power plants under one corporation?

And then, the third question relates to what you said about the archipelago, which is very interesting. It is the same condition as our country Indonesia. So, there are different corporations on different islands, or is the corporation at the national level? Those are my three questions.

Ms Melanie Papa

The Philippines has multiple generation companies, and the government no longer owns them. When we had our electric power industry restructured in 2001, we sold the generation facilities owned by the government one by one. Now, private corporations own almost all generation companies. And it depends on those corporations what type of plant or fuel they will put up for their plants.

Mr Noriel Christopher

As mentioned by Ms Melanie, the Philippines' generation sector has been privatised. But regarding your third point on the Philippines being an archipelago, to help clarify that concern, let me differentiate that in the Philippines, there is what we call a grid area and an off-grid area. So, what we call a grid area refers to those areas in the main islands connected to the Philippines' national transmission lines or transmission highways.

In terms of the participation of the stakeholders in the grid areas, these are mainly private companies that put up these generating facilities and provide power to the grid. The transmission lines are owned by the government. But in terms of the operation and maintenance and the continuous improvement of these transmission facilities, the government signed a concession agreement with a private company, called the National Grid Corporation of the Philippines, to help the government extend the lines and be the one in charge of the system operations.

As for off-grid areas, at least for those areas where we currently have no private sector participation yet, the government is in charge of providing electricity to those islands not connected to the main grid. So, usually, these generating facilities are owned by the National Power Corporation. But, somehow, in terms of the participation of the private sector, we are also slowly opening these areas to private companies who might be interested in putting up generating facilities in those areas as well.

Mr Andi Hanif

I would like to know about the corporations you mentioned in your presentation. Which corporation is the largest in terms of the area it covers and the capital?

Mr Noriel Christopher

Okay, in terms of the share of these private companies in the generation sector, Ms Melanie can provide additional information. But in terms of our EPIRA Law, or the restructuring act of the power industry of the Philippines, we have a limit of 30% share of these companies in the total ownership base of our generating facilities. So, in terms of the specific companies that compose the largest shares in this mix, San Miguel

Corporation, Aboitiz Power Corporation, and First Gen Power Corporation are the major players in the Philippines' generation sector.

The other member from Indonesia asked a question to the Philippines.

Mr Hery Wahyudi
I would like to know about the Philippines' national target for greenhouse reduction in 10 years, 20 years. Also, what percentage of consumers have smart metres installed in place?

Mr Noriel Christopher
For the greenhouse gas emission reduction targets, I do not have the specifics of that information per sector. But in terms of our NDC commitment, we have submitted a 70% conditional target, depending on the support we will get from the international community in meeting the reduction target.

I currently do not have the numbers per sector, but I will try to get those and inform you after this meeting. But then, going to your next question, in terms of the number of smart metres currently installed, we also do not have the specific numbers now. But in terms of our shift to the smart grid framework policy, we still have a long way to go in terms of the number of end users. We only have a small number of end users already using smart metres, and these are coming in mostly from our private distribution utilities. So, the challenge now is to also increase the level of smart grid adoption, especially in our electric cooperatives. So far, the business sectors are the main areas of demand growth.

Dr Phoumin, ERIA was the next questioner.

Dr Phoumin
I would like to ask for a bit of clarification. In the Philippines' case, I think it's very interesting for the rest of ASEAN regarding the electricity market. The country has been moving from the vertically integrated electricity market towards more liberalisation.

I just want to know when it is moving, let's say, for power generation towards a private company. Does this private company remain with some long-term contracts with the grid operator as the off-taker, or is it based on demand and supply? If they are moving towards market liberalisation based on demand and supply, how can they ensure that they can attract investment in power generation if investors feel uncomfortable about how they're going to supply or sell their electricity without the long-term contract? Appreciate your clarification.

Ms Melanie Papa
The Philippines' electricity market is a gross pool market, meaning those who have bilateral contracts – the generation company with a contract with a distribution utility – still transact through that market. So, they will only have to pay the portion that is not contracted.

They will still set their obligations through the bilateral contract; then beyond that bilateral quantity, they will have to pay in the market. So, if ever the demand of the distribution utility goes up, that's the time they buy their quantity from the market.

So, it is sort of a shield. They are being shielded whenever the prices in the market go up because there are existing bilateral contracts, whether long term or short term. So, all transactions are seen and monitored through that market. Noriel, you may want to add?

Mr Noriel Christopher

I will make a supplementary clarification. It is a gross pool, and bilateral contracts are declared in the market on top of the spot declarations. For your information, most of our contracts are still under a bilateral agreement in terms of the share of bilateral contracts in the Philippines. Around 90% and 10% are transacted through the market as spot quantities. So, regarding the function of the market, in terms of dispatch, all generators, even if they already have bilateral contracts, still bid their output hourly. But as Ms Mel mentioned, we are shifting to a 5-minute interval market. After running, the market operator will provide a dispatch and a merit order table containing the dispatch of capacities after all the bids have been entered. This will be provided to our system operator. So, the system operator will be the one to follow this dispatch based on existing protocols.

So, regarding the dimension of encouraging more investments through this market, we are also trying to explore additional areas where we can encourage investments through our recently established renewable energy market for the transaction of renewable energy certificates and our reserve market. This is also to facilitate the reserve provision for an optimised energy and reserve provision within the market structure. Our current structure of providing reserves is just a one-on-one contract with the generator and the system operator. So, hopefully, by introducing the reserve market, we can encourage more generating companies to provide reserves and additional capacities, which the Philippines also needs. So, hopefully, we were able to provide clarification on the questions raised.

Before the presentation on the interim report, the JCOAL Study Team introduced themselves. Mr Oda, as Director of the International Collaboration Department, is the team leader. The by-country analytical reviews are handled by Mr Otaka for Indonesia, Ms Yamada for Malaysia, Dr Murakami for the Philippines, and Mr Ozawa for Viet Nam. Mr Teuchi handles the meeting organisation and will undertake a part in conducting surveys to support the elaboration of the study report.

The Study Team made the presentation.

Ms Yamada

The next slide shows the preliminarily provided questions and requests for clarification from the two representatives of Malaysia.

The first is quoting the JCOAL slide. To forecast GFI, the historical GFI is regressed with

several variables. Each variable will have its own historic and forecast data. The remarks on questions are what are examples of variables in this statement? If it refers to, let us say, total capacity or total renewables capacity, would it result in multicollinearity?

If it refers to the energy availability factor, how do we forecast the future values of this variable? Can the gross domestic product be one of the variables? A validation check was done with the data obtained. Dr Murakami is asking you to see this validation graph on slide 14.

Dr Murakami made an additional clarification.

Dr Murakami
Horizontal is the data obtained from the duck curve, and vertical is estimated, that is the calculation data. So, the regression is very good. So far, this is the limitation of the regression. But we estimated this validation to be very good for establishing the multivariate regression.

Ir Mohd Helmi bin Mohd Zaihan
May I know what are the variables used?
And is it possible to include GDP in the GFI formula? Does GDP affect GFI?

Dr Murakami
As slide 14 says, I picked up four from the parameters: coal availability factor, renewable energy availability factor, nuclear availability factor, and solar availability factor. These four parameters are much related to the GFI. Then at the right bottom, the parameters are clarified as W1, W2, W3, and W4. You can see that W1 and W4 are much higher than W2 and W3. That means coal availability and solar availability factors constitute the main component of the GFI. That is the result of regression.

Including GDP in the GFI formula would probably be possible. GDP may affect GFI. However, GFI is calculated as the max ramp rate divided by the total installed capacity.

Ir Mohd Helmi bin Mohd Zaihan
I wonder if the same formula with W1, W2, W3, and W4 applies to all countries?

Dr Murakami
Yes, I use the same formula because I estimate this relation using the EIA data and the duck curve obtained from the public domain, which is the regression base. After that, we can get the regression formula to calculate each GFI from ASEAN.

Ms Yamada
The next question is that in several countries, this was what we say in our slides: the GFI is found to increase year by year with economic growth. Please clarify the statement. If one country has positive economic growth, but with high efficiency, decouples GDP from

electricity consumption, this is not happening I think or the country has increased the GFI value. And the recommendation, according to the team's analysis, is that the GFI will increase, mainly due to the increasing availability factors of solar and coal. The GFI should be considered with quality of generation flexibility.

The next is whether any rule of thumb defines the relationship between the share of hydro/gas generation with GFI values. Or is it country-specific? And our answer is that usually gas, thermal can be operated flexibly. Hydro, especially small hydro, and pumped hydro also positioned are deemed mid-merit generation.

And the next is about whether implementing other grid stability measures such as BESS, demand response would reduce the GFI of one country. And the answer is although the stability measures cannot be reflected in the calculation of the GFI value itself, they might be practically effective and will consider adding the proposed recommendations. So, this is what you have given as the remarks and questions on this part of the table. We will be trying to incorporate it in the forthcoming report.

As for 13, we have two questions; one is that the GFI of many countries will be increasing from 2030, especially Indonesia, Malaysia, the Philippines, and Viet Nam. And your question is what the contributing factors of increased GFI in these countries are: the megawatt of renewable energy, the megawatt of coal, energy availability factor, or both? The main factors are coal and solar availabilities and later, you can refer to the regression equation and coefficient.

The other is about slide 13, for Malaysia. The data behind this analysis refers to Peninsular Malaysia or Malaysia as a country, including Sarawak. The grids are separate from each other, and our answer is that we collected the data, the whole country data. So, it is not part of Malaysia but the national data. Do you have any comments? Is it all right?

Ir Mohd Helmi bin Mohd Zaihan
Later, we might like to have separate data for Peninsular Malaysia,

Ms Yamada
Well noted. We can work on that. But it is clear that we have this national data, and based on that, we have done this initial analysis. So, we have two for the rest: one is slide 16, about coal outcomes for less than 50% in the generation mix. And your comments about GFI (Note: see Appendix I) would help us appreciate the analysis and findings more. So, we will be addressing this request from you.

Ir Mohd Helmi bin Mohd Zaihan
Yeah, I think for the comment for slide 13, particularly for Peninsular Malaysia, I do not think you need to provide separate data. For example, Indonesia has thousands of islands, so I think the data can be used. We only have two main islands in addition to the Malay Peninsula.

Ms Yamada
Yeah, thank you for saving us. So, the last one is about slide 23, the chart: are the measures applicable to new coal plants through design or adapted to existing coal plants? Maybe we can list or differentiate between the two?

The other is whether the study team can include the problem or scenario that the machines will experience when in the cycle mode (Pmin-Pmax-Pmin). Also, what are the risks that the coal plant will face if they are run in the cycle mode without any modifications to the machine? So, that means you would like to have some kind of case-by-case analysis on this aspect of machinery and equipment and prevention or solution measures?

Ms Rose Adila
That is right. We also would like to know the impact on the machine we put on cycle mode: is there mechanical stress, or are there problems controlling the steam temperature?

Ms Yamada
Our team thinks we should first know exactly the specifications you have in mind when you ask this question.

So if we do this, it is not a case study because it is about this flexible operation of coal-fired power plants, for grid stabilisation. But then, if there are any contributing factors, it would be very good for us to do some case analytical work. For that, maybe we can ask any of your power plant specifications, and Ozawa-san can advise you; we can also make some recommendations on that. At this moment, that is our initial idea on this because how much mechanical stress on the equipment depends on the type and specification of such equipment. And it would be different from one to the other.

Ms Rose Adila
I also would like to know whether the technology you recommend on this slide can be implemented in both the conventional coal power plant and the super-critical coal power plant. Can it be used for both?

Ms Yamada
If you would like to discuss whether a particular technology can be introduced to the existing power plant, it is important to think about the technical applicability and economy of the plant, since in most cases some modifications will be required upon introducing additional equipment. So, it would be better to discuss such matters by looking into the conditions and requirements to find out if the envisaged introduction will benefit the overall operation of the power plant. Let us discuss this further with you later by email.

Ir Mohd Helmi bin Mohd Zaihan
You think that is a separate topic from this study.

Ms Yamada
No, it is not a separate topic. But it is within the context of enhancing the data results of this study. That is what we want, do you agree?

Ir Mohd Helmi bin Mohd Zaihan
Well noted and agreed to communicate later.

The following are the questions and requests for clarifications by Indonesia.

Mr Arief
I would like to know how flexible coal-fired power plants would be after modification. I think in your presentation, it is only 5%, that is the first question; the second question is about the cost required for such modification. And the third is a request to provide the successful case examples in Japan or any other country.

Ms Yamada
The 5% the slide mentions is how much we can change the rate per minute. It is a per-minute rate. The minimum loading value is in the next slide. Emerging economies have generally achieved between 30% and 50%. According to our experience in Japan, this can be lowered to 15%–25%. We will try to provide further details of the actual case example in Japan and other countries.

Mr Arief
So, the ramp rate is only up to 5% per minute with coal-fired power plants? With a gas turbine, we could ramp up/down at 20% per minute.

Ms Yamada
We know that the ramping rate usually varies between 1% and 2%, which can be technically possible without damaging the machine, between 3% and 5%. You are right, gas is definitely more flexible or easy to implement in flexible operation.

Mr Arief
I thought it could be more flexible; it could be more than 5%.

Ms Yamada
That is as long as we know what has been proven so far. However, we must pursue the possibility for further improvement.

Ms Yamada
The minimum load operation in the slides was already done in Japan, especially in the

Kyushu area, under similar climatic conditions as ASEAN countries. PV solar is at its peak; it can address over 90% of the demand.

Mr Arief
I would like to know what needs to be modified and how much it costs to modify to have more flexibility.

Ms Yamada
We do not have updated and detailed cost information. For practical purposes, you might like to ask manufacturers such as Mitsubishi Power directly. They will come up with very useful and accurate cost information if you provide them with the relevant specifications and conditions of the power plant. That said, as you indicated, we will try to cover general considerations and information about the cost of the study.

Malaysia asked the next question.

Ms Yamada
What will the coal plants face if they have been running the site [Unclear]. I think this is also the same as in the previous one: depends on what power plant and what kind of specifications you have in mind when you ask these questions. These will also be discussed later on.

For changing burners, it would take maybe 4 to 5 months. But that also depends on how many burners you would change.

Ms Rose
So, do they have to change all the burners or just a few?

Ms Yamada
That is actually optional; depending on how much flexibility you would like to achieve through the retrofit. I think it is 40%–50% usually. But 25% is very far from that. If you think 35% is okay, it's not too much. I think the modification will be less. But when you want to go to that extreme side, then it will take more time. In that case, I think it is better for you to give some case examples so we can study.

Ms Rose
One last question: For the HP (high pressure) bypass system, for example, the steam bypass spray, this can be installed to the existing coal power plant or the new one?

Ms Yamada
According to Ozawa-san, a bypass can be added to this existing power plant. That is very much possible.

Next and the final questioner was the Philippines.

Mr Noriel
Yes, just a question regarding the specific type or age of the coal plant on which these improvements can be applied. Is there a limit? Or, can you include these improvements within the system of old coal-fired power plants

Ms Yamada
Theoretically, from the team's point of view, that is also applicable to existing power plants. But let us look at this slide. There are roughly three key points. One is improving loading rate; two is optimising the minimum load; and three is reducing start-up time. This start-up time reduction is applicable to new power plants, while one and two can be for both existing and incoming power plants.

All presentations and Q & A sessions are over, and the tentative schedule was announced.

Ms Yamada
Let us clarify the upcoming study schedule just verbally. After this meeting, we will work on the respective parts of the report individually. Murakami-san will elaborate on this GFI thing. Some details and technical issues will be pursued by Ozawa-san as well.

During such work, we will interact collectively and/or individually with you for further advice, comments, and information. That will be done while we closely communicate with Dr Phoumin of ERIA. As I said, the second and last meeting will be in ERIA in October. Then the final report will come in mid-November 2021.

But if you are available and willing, we may have some by-country interactions, maybe for 20 minutes or so on MS Teams; that is, if email is not enough. All such options will be arranged if the relevant members agree.

Closing remarks by Toshiyuki Oda, JCOAL

Today we had a long and meaningful discussion. It was meaningful for us in the Study Team because we learned about the latest energy situation in Indonesia, Malaysia, and the Philippines through each presentation and advice. Such information will constitute part of the valuable data under the study.

I think we provided useful information to the Working Group members. We introduced the results of the initial analytical work on the GFI, relevant issues of load changes, and key technical points about potential flexibilisation through coal-fired power plants.
What would be required to materialise action towards flexibilisation implementation, we would need to hear from boiler manufacturers and relevant specialists while we share the outcomes of the initial and theoretical discussions like what we have done today.

I hope we can furnish an excellent final report in November 2021.
At the end of the session, a group photo was taken, and the meeting was closed.

Appendix 4: List of the 1st Working Group with Viet Nam, Working Group Members for the ERIA Study

Country	Institution	
Viet Nam	Vietnam Electricity (EVN)	Mr Minh Quang, Deputy Manager of Power System Analysis and Planning Department, National Load Dispatch Centre
	Vietnam Electricity (EVN)	Mr Nguyen Tuan Anh Senior Expert of Technical and Operational Department
	Vietnam Electricity (EVN)	Ms Nguyen Minh Hai Expert of International Relation Department

Appendix 5: Minutes of the Kick-off Meeting with Viet Nam on 'The ERIA Study on Enhanced Flexibilisation of Coal-fired Power Plants for Optimal Grid Stabilisation in the ASEAN Region'

(Meeting held virtually on 29 June 2021)

The meeting was started with greetings by EVN and JCOAL.

Welcome Address by Mr Toshiyuki Oda, Director of International Collaboration Department, JCOAL

The last couple of years saw an impressive global shift with all kinds of new and renewable energies as quite valuable and available options. JCOAL has been enhancing its efforts to engage in new fields and even changed its name to Japan Coal Frontier Organization. We will remain keen on working extensively for efficient, affordable, and sustainable energy for all, which is the shared spirit of SDG7.

Prevention of possible grid fluctuation is one of the most important actions we shall take while the massive introduction of renewables proceeds. Existing power plants with flexibility, including coal-fired power plants, are expected to address the issue collectively. At the same time, full attention is paid not to damage the equipment and efficiency to the extent such operation is no more economically viable.

As you might know, the essence of the final report will be incorporated into the comprehensive policy recommendations of ERIA that are to be submitted at the annual East Asia Summit. In this context. I am grateful for your participation today and would appreciate the forthcoming cooperation by EVN.

Keynote Address by Ms Luong Thi An, Deputy Director General of International Relations Department, EVN

Today we have Mr Nguyen Tuan Anh, Senior Expert of Technical and Operational Department; Mr Minh Quang, Deputy Manager of Power System Analysis and Planning Department, National Load Dispatch Centre; and Ms Nguyen Minh Hai, Expert of International Relations Department.

First of all, I would like to thank JCOAL for organising this meeting to better understand the study and participate in this interesting programme.

We believe that, through this study, we can get more outputs and understanding about how to improve the coal-fired power plant operation in Viet Nam. Then we hope to report to our EVN management to mobilise our resources to participate in this study and cooperate with you in our best efforts. We appreciate the continued collaboration between EVN and JCOAL. Thank you very much once again, and we look forward to seeing you in Viet Nam very soon after the COVID-19.

Now I would like to leave the floor to our colleagues from the national dispatch centre and engineers from the technical and operational departments for further discussion and presentation.

The MC asked everybody to turn on the video for a group photo before Ms An left the meeting.

Madam An
Thank you very much for the group photo. Please send us our photo after the meeting is over. Thank you.

Introduction of JCOAL team members

Dr Kazuyuki Murakami
My name is Kazuyuki Murakami. I have recently left the international collaboration department. My recent focus, amongst others, is bilateral cooperation with Viet Nam. I now belong to the R&D department, where I oversee technical studies on carbon neutrality as programme manager. In this study, I am in charge of grid fluctuation and analytical work for the Philippines.

Mr Masahiro Ozawa
Good afternoon, everybody. My name is Ozawa. I am an expert in thermal power plants, especially coal-fired boilers and environmental treatment. I worked with Mr Tang 3 years before. In this study, I will be in charge of Viet Nam.

Mr Shinjiro Teuchi
Good afternoon, I am Shinjiro Teuchi. Nice to meet you. I have been working at JCOAL for 10 years. I am a geologist. I belong to the international collaboration department. This is my first year to be in this project. I am very happy to be part of this scene.

Ms Yamada
Hi, everybody. I am Yamada, working for the international collaboration department of JCOAL. I am in charge of the part of Malaysia under this study. We have another colleague, Mr Otaka, who is working on the Indonesia part. Unfortunately, he has another meeting but will come to this meeting later on.

Today I will do the emceeing. Now, may I introduce the background of the study and what we will do under this study. This will be followed by your presentations on the current situation and updates on the relevant issues. Finally, the team will present the current progress by introducing the interim report summary using slides.

Introductory presentation by JCOAL

Ms Yamada clarified the slides on the study overview.

We know that all ASEAN countries made commitments not long after the international agreement had been in place. So, we very much appreciate it. That is why all AMS, not only Viet Nam, are trying hard to address emission reduction requirements mainly through renewable energy introduction.

As far as my memory serves me, a few years back, Viet Nam was committed to approximately 20%–21% renewable energy share target in the electricity mix as of 2030. And now Viet Nam revised it to 32%. That is the highest of all AMS targets. In fact, in 2019, it's done, you know, solar development from the previous 100 MW to almost 5,000 MW.

In the meantime, renewable energy is substantially variable and intermittent. And so that's why we have to do something about it. It's not only in Viet Nam; it is also in Japan. So, the ongoing massive introduction of renewables will enhance energy sustainability and resilience; we are sure about it. But that is if the existing fossil fuel power plants are appropriately controlled and operated with enough flexibilisation as per the requirements by the grid through the introduction of techniques, best practices, and technologies such as IoT and AI. But the situation may vary from one country to the other, even within ASEAN. As Oda-san said, gas power plants will be given the role.

However, some countries, where coal power is dominant over gas power, must do it with coal-fired power plants, as we have seen in the case of India. That is why we are here today.

And now. I would like to ask my junior colleague, Teuchi-san, to present the rest of the three slides about objectives, study methods, etc.

Taking the opportunity, let us clarify why we do this study and how ERIA will be utilising the outcome of the study. ERIA is an international research institute mandated to engage in joint study activities for policymaking in ASEAN. Their annual reporting and ultimate forum of discussion are the East Asia Summit (EAS), which is in the framework of ASEAN +6 member states (Australia, China, India, Japan, Korea, and New Zealand), to enhance the outcomes of the cooperation. Therefore, from any field of study, whether this is renewable or coal or whatever it is, ERIA will incorporate the outcomes of the respective studies into their report of recommendations at the EAS.

At the same time, every study will be reported to each target country. So, we will share all the reports and outcomes with the respective target countries: Viet Nam, Indonesia, Malaysia, and the Philippines. So that is my supplemental explanation.

Presentation by Viet Nam

Mr Minh Quang, National Load Dispatch Centre
Thank you very much for your introduction.

From our side, I will present the review of the grid system and the renewable energy development situation in Viet Nam. Firstly, some introduction about Viet Nam's installed system. This shows different types of power generation technology in Viet Nam.

So, you can see, we have a lot of volume in northwest Viet Nam; in this area, we have some big hydropower plants. This is the location where we have a lot of hydropower plants. We have many coal mines in the northeast and a thermal coal-fired power plant in this area. We have mostly the hydropower plants in the centre and the south. In the central and south, since 2019, we have had a lot of newly developed renewable energy power plants.

We primarily have solar power plants in central and south Viet Nam. In the south of Viet Nam, we also have some gas turbine power plants. So, as you can see in the slide, there is a mix of different types of technology. You can have the data in the slide. This is the share of energy production in 2020.

Under total demand, one size of our power system was nearly 250 million GWh in 2020. This is the simple map of Viet Nam's power network. You can see the shape of our country; we have a narrow country, and very long, from north to south. From the north to the centre, we have two 500 kV circuits of the advanced system; and from the centre to the south, we have four circuits in the power network. We plan to have our systems further extended and enhanced throughout the future. This is crucial, you see, in terms of the required energy production and the increasing peak load.

The rate of demand increase is nearly 10% per year. This is the data as of May 2021, when we had nearly 17,000 MW of wind and solar energy. It is about 25% of the national installed total capacity. In terms of different types, we have 142 power plants for the solar farm. The total installed capacity is 8,800 MW, and we have a lot of rooftop solar. So, we have more than 7,600 MW of solar, and we have more and more wind power plants in the system.

This is the data for the end of May. But now we have more than 700 MW of wind in the system. We plan to have about 5,000 MW of wind power plants in the system at the end of this year.

We have more and more wind energy power plants, and they just started in 2019. In 2 years, we have around 17,000 MW of renewable energy, which caused many problems to our power system, especially congestion. So, you can see that wind energy is very highly concentrated in some areas in the south and the centre of Viet Nam – about 17,000 MW. That is why we cannot catch up with the development of renewable energy power plants, and that is why we have congestion in some areas in the power system caused by renewable energy.

We also have the problem of surplus power generation because of wind energy. We had to transfer power from the centre and the south to the north. But we have cared for the limit in the connection from the north to the centre. So, we cannot transfer much power as much as we wanted from the centre to the north. That is why we had the problem of renewable energy surplus at some point last year, and we cannot transfer those power plants or energy to the north.

We have other issues caused by renewable energy power plants, such as system inertia. So, the more renewable energy power plants we have, the lower the system efficiency compared to the initial conditions of the power system. However, it is sometimes possible for us to improve the situation and get the system back to work at the near-initial efficiency.

In our case, we have an action plan for integrating renewable energy formulated through a project we did in 2018, assisted by international consultants from the US. They drew an action plan for different levels of renewable energy integration. That is why we have speedy integration of renewable energy power plants, and we can now manage the situation. Other than that, it is pretty good.

One solution to congestion issues: solar makes the power increase very fast during the day. As the discharge capability of the grid is very limited, a lot of solar power can cause congestion to the grid. In Viet Nam, we use the AGC system to manage that. With the AGC system, we can monitor the situation of the grid. When the transmission line is overloaded, we will signal our plants and ask them to reduce the reactive power automatically through the AGC system. Then as power plants' active power options are released, grid stability remains in the acceptable range, so the system is not overloaded. To control the renewable energy power plant, we also have many monitoring systems, such as the SCADA and WAMS systems. We have to wire our monitoring system as well. It is still under the power quality monitoring tools in the renewable energy power plant, which helps us control and monitor the renewable energy power plant quite well.

This year, we have a new PDP8. You can see that this is the preliminary share of the draft PDP8. In terms of installed capacity, we plan to have 28% in 2030 and, in 2045, 42% of installed capacity. Compared to the max, the peak demand in 2030, we may have 50% of the renewable energy compared to peak load. In 2045, in some situations, we may have 75% of the load covered by renewable energy. So, this is a brief introduction to Viet Nam's power system and the situation of renewable energy integration into the grid.

Q & A

Question by Dr Murakami

Thank you very much for the very informative presentation. I learned a lot. I have several questions, but I will ask about three. The first one is regarding rooftop solar. The capacity of rooftop solar is almost comparable to renewable solar. So, is it connected to grid utilisation? The second question is on a BESS solution. According to your plan, a BESS solution will be considered when the renewable share reaches about 40%. So, a large

volume of BESS will be required. What do you think about that? The last one is on international cooperation. Your last slide implies that you have already cooperated with ADB and GE. If possible, may I know the drawing of that comparison? Thank you very much.

Mr Quang

For the first question on solar rooftop, as I explained in my slide, we now have more than 7,600 MW of solar rooftop in the power system. It is connected to the power system's medium and low voltage sides. On the question about BESS, we think that energy storage is one of the very good solutions to the situation in Viet Nam. However, the problem is that we do not have the mechanism to integrate BESS yet, so the regulation and issues with MOIT. The Ministry of Industry and Trade is not clear enough. If many investors want to invest in BESS, there is no guideline; they do not know how to do it. If we restore BESS into the system, they do not know how much we will get paid. For example, they do not know how much we will get paid for 1 day absorbed power during the daytime in the renewable energy power plant, and in the night time when they release the power from BESS.

We need to look at the policy from the government to provide investors with the incentive mechanism for them to invest in BESS. Regarding your third question on international cooperation, we did two projects in the past, one with GE. That project studied the integration of renewable energy into the system and how BESS can help release the congestion in the grid. The second study with ADB focused more on the frequency of regulations. Both projects were finished last year.

Question by Mr Masahiro Ozawa - When will the PDP 8 be issued?

Mr Anh

Okay. So normally, it should be issued at the beginning of the year, but now it is still under discussion.

Presentation by JCOAL

Mr Quang

We come from the national load dispatch centre. I would like to ask about the technical measures you explained in the slide. We are very interested in improving the performance of thermal coal-fired power plants, so as I presented, we have a lot of renewable energy power plants in our system. That is why we want to have flexibility in operating the various systems. Currently, our thermal coal-fired power plants are not feasible enough. So, for your information, the minimum load usually is about 70%.

In the slides you presented, the minimum load can be reduced from 30% to 50%, and it can be further reduced to about 15% or 25% of the total load. So, we would like to compare the load to what we have. We would like to know how to do this because our

coal-fired power plants are quite old and the technology is not very good. How can we improve the existing power plants? Is there is a solution? This is our concern about the new power plants in the future. Thank you.

Ms Yamada
All right, I think Ozawa-san will address that. But I want to clarify that part of the answers is already summarised in the slides that Ozawa-san explained. So, regarding what you say, 30% to 50%, 50% is being achieved already by emerging countries with coal-fired power plants. So that 15% to 20% refers to what we are doing in Japan, and I think in some countries. So, now, Ozawa-san would be revisiting some of the points in his slides.

Mr Masahiro Ozawa
Coal in this slide is not anthracite but bituminous. We are aware that mainly bituminous coal is used in Japan, while anthracite is dominant in Viet Nam. With anthracite coal, it is very difficult to reduce the minimum load. It would be advisable that imported coal power plants be utilised for flexible operation in Viet Nam. So, if you reduce the minimum load by coal, it will yield. I recommend you reduce the minimum load by using imported coal. This key point of wide range burner is concentration adjustment ring. This divides the primary air into the main zone and weak zone. The high concentration zone is easy to fire, so that minimum load is reduced, but this is with bituminous coal. As I said, it is very difficult to fire.

Ms Yamada
I think Ozawa-san has already addressed your questions. As we understand, all the contents of this slide will be explored and developed into a more extensive analysis and recommendation in our forthcoming report. So, questions like what you have already asked and are going to ask will be very good inputs for us to have a more extensive range of solutions in the report. So, further questions or any request for clarification would be very much appreciated. Anybody else? Or you can ask as many as you want.

In the coming study period, we plan to have another meeting with all the target countries. Three other countries will be joining us. That will be in September when we provide the draft final report. We conduct the meeting in English because the report will be in English. We also have to report to ERIA in English. In summary, we like to do some direct interactions by email.

Ms Hai
Noted. The final report will be prepared by the end of the 2021 fiscal year, right?

Ms Yamada
This report will be furnished in November 2021, so in September 2021, we will have another meeting when all the four ASEAN countries are getting together to see our draft final report. Towards that meeting, we must work hard. As for the part of Viet Nam, we might be coming up with some questions, for which your help and advice are crucial.

Ms Hai
Thanks, yes, of course. You can send emails to the international relations department, where the coordinator will distribute them to relevant participants in this programme of EVN. Then we will get back to you by email as well.

Ms Yamada
Yes, thank you very much. Before closing this meeting, let me inform you that we would like to share your presentation with the Working Group members of Indonesia, Malaysia, and the Philippines. Before the meeting, we emailed you some of the presentations. We would appreciate your cooperation. The minutes of today's meeting and the last meeting will be shared with you.

Ms Hai
Yes, agreed and thank you.

The meeting was closed.

Appendix 6: List of the 2nd Working Group Members for the ERIA Study

Country	Institution	
Indonesia	Ministry of Energy and Mineral Resources (MEMR)	Mr Pramudya, ST, MT Policy Analyst, Directorate of Electricity Program Supervision
		Mr Hery Wahyudi Wibowo, ST, MT Electricity Inspector, Directorate of Electricity Engineering and Environment
		Mr Andi Hanif, ST, M.Eng Electricity Inspector, Directorate of Electricity Engineering and Environment
	PT. PLN (Persero)	Mr Arief Sugiyanto Manager of System Planning for Java, Madura, and Bali
	PT. PLN (Persero)	Ms Ira
Malaysia	Energy Commission (ST)	Ir Mohd Helmi bin Mohd Zaihan Assistant Director
	Grid System Operator (GSO)	Ms Rose Adila binti Bujal Senior Engineer
Philippines	Department of Energy (DOE)	Ms Melanie C. Papa Senior Science Research Specialist, Power Market and Development Division – EPIMB
		Mr Noriel Christopher R. Reyes Senior Science Research Specialist, Power Planning and Development Division – EPIMB
Vietnam	Vietnam Electricity (EVN)	Mr Nguyen Minh Quang Deputy Manager of Power System Analysis and Planning Department, National Load Dispatch Centre
	Vietnam Electricity (EVN)	Mr Nguyen Tuan Anh Senior Expert of Technical and Operational Department
	Vietnam Electricity (EVN)	Ms Nguyen Minh Hai Expert of International Relations Department

Appendix 7: Minutes of the 2nd Working Group Meeting on 'The ERIA Study on Enhanced Flexibilisation of Coal-fired Power Plants for Optimal Grid Stabilisation in the ASEAN Region'

(Virtual), 22 October 2021

The meeting was opened with the welcoming remarks by Dr Phoumin, Senior Energy Economist, ERIA

Dr Phoumin

The ASEAN member states (AMS) are now preparing for the near-future energy transition, which will require more flexibility in the grid. Accordingly, the flexibility of coal power plants will be crucial. With the information provided by this study, such energy transition will be going well. At the 1st Working Group meeting, we learned the optimum flexibility. For example, one of the study highlights is how grid fluctuation occurs and how we can control it.

Since coal power has been supporting the growth of the AMS and can play a role in flexibilisation in parallel with other flexible fuels, I hope this study will fit into ASEAN's policymaking. I hope this meeting will finalise the direction and conclusion of the study. I hope the result will be very interesting for all policymakers. I wish you a worthy discussion today. Thank you so much.

The Viet Nam representative made brief remarks as it was her first time to discuss with all other country representatives.

Ms Hai

Good afternoon, ladies and gentlemen. I am from the international relations department of EVN Viet Nam. Today we also invited a representative from the technical and operational department of EVN and the national load dispatch centre to join the meeting. Thank you for the final draft of the study.

The Team presented the background of the study, the GFI method and projected grid fluctuation by GFI, key technologies for flexible operation at the coal-fired power plant, and storage technologies, for which a Q & A session was conducted.

The Philippines asked a question about the GFI forecast for Thailand.

Mr Noriel

Okay. I have a question specifically on slide number 10, point number 2, regarding which you said that Thailand does not have grid fluctuation concerns. Can you explain a little bit more about that?

Dr Murakami

Thailand is shown in purple, and that means a low GFI. In this GFI calculation, the component of GFI, I mean dependence of GFI, is coal availability and solar availability. So, regarding Thailand, coal availability. Thailand has a gas-linked generation mix. Coal availability is rather small, which makes total GFI low. So, the tentative conclusion is that no major grid fluctuation will occur.

Indonesia asked a question about the presented storage technologies.

Arief

I would like to ask some questions about slide number 23. Are these not commercially available yet?

Dr Murakami

So far, the left-hand side is in Minami Soma. There are also other sites in Nishi Sendai, which are commercially operated. This is the example of the grid connecting substation. So, regarding industrial use, many smaller sizes of lithium-ion energy storage are being operated.

Arief

Are these types of batteries already available in the market?

Dr Murakami

Yes, sodium-sulphur is widely available, mainly in industrial areas, such as the automobile industry, since their production system may not allow the intermittent supply of electricity. So that is used for that the application of an uninterrupted power supply. Redox flow is most recently re-developed; now, it is being applied widely.

Arief

I suppose each type of battery has its characteristics, for example, high energy density, mass, lots of capacity, and so on. Which one is the best in your opinion? We would like to consider this kind of battery for implementation.

Dr Murakami

That is a very good question. Lithium-ion has an advantage for energy density, but the issue is cost. So, it uses very rare metals with a relatively shorter period compared to the other two technologies. Also, currently, the cost of lithium-ion is higher than the other two types, as we observe in the market in Japan. But it may depend on which country makes this BESS. China is now mass-producing good lithium-ion batteries at relatively affordable prices. That said, in terms of duration, sodium-sulphur has an advantage. So, these are the main factors you might like to consider.

Arief

Yes, of course, we have to consider the lifetime application cost.

Dr Murakami

My personal opinion is redox flow is very easy for operating. It requires only maintaining metal ion tanks. The reaction needs room temperature under NAS batteries; redox flow ones need about 300℃ operating temperature. In the case of lithium-ion, extra care should be exercised for safety. So, my tentative conclusion is: redox flow would be more advantageous. We can expand the capacity of the other metal ion tanks.

Arief

How about the impact on the environment?

Dr Murakami

Yes, basically, there is no concern about the surrounding environment because the material is circulating inside and will not go outside. Please visit the website links shown in the slide. Thank you.

The other Indonesian representative, also from PLN, asked about the cost implications of flexibilisation.

Ms Ira

About slide number 4, I missed some information about the flexibility of the cost involvement. For example, how many percent is the flexibility to be increased?

Dr Murakami

This slide shows the modification of coal-fired plants. The first one is improving the loading rate. The second one is optimising the minimum load. The third one is reducing the start-up time. Flexibility improvement depends on the grid situation. And if grid fluctuation is mild to the extent it can be followed by flexible operation, coal-fired power plants can contribute through such kind of modification and flexible operation with rapid rolling up and rolling down, operating at minimum load. In any case, it depends on the degree and volume of fluctuation.

Ms Ira

You mentioned grid flexibility. The capacity of the cost in the power plant itself in slide number 14 only increased slightly, maybe from 3% typically to under 5%? Can it be higher than that? Is it possible to be higher than 5%?

Ms Yamada

I think further load change rate might affect the mechanical part of the facility. It is impossible to increase the load change rate exceeding 5%. It is about the load change rate and is different from the minimum loading rate.

Malaysia asked a question.

Rose

On slide number 15, I would like to ask about your experience in Japan. In changing burners, is it only one row or two rows, and how long can we go for the lower load? Let's say, in a 100 MW coal-fired power plant, if we change only one- or two-row burners, how far can the load reach? For example, the loading rate can be controlled from 100 up to 10?

Mr Ozawa

In Japan, the wide range burner is used by one or two mills, the total mill is six or four, and change of burner is for one or two mills. What they usually do at coal-fired power plants in Japan is to replace just one or two out of six mills for a wide range burner. So, you asked us if it is possible, if it's being done in Japan or not, and the normal practice is that one or two out of six mills use wide range burners. Let me give you an example of a small plant, a 33 MW plant. That plant has two mills and four burners for one mill and four burners for the other mill. So, they just replace four burners for one mill for wide range burners. Then, they can bring down that minimum load by 20%. Another example is a 250 MW plant with 4 mills and 24 burners. Two mills and eight burners out of them were changed for wide range burner utilization.

The Team started with the subchapter on Indonesia, and another Q & A session took place. A JCOAL Team member asked a question to the Indonesian representatives.

Ms Yamada

I have a question about the situation in Indonesia. I have just seen the RUPTL and the working group members' presentation. You say that this biomass coal firing at about 30 out of 52 or 53 coal-fired power plants is mainly owned by PLN. Tests were conducted, if I'm not wrong, for the biomass cofiring rate of 5%.

And then your target is 20% to 30%. That is actually a lot; you might have CFB boilers in mind, but not all of them are CFBs; some of them are PC boilers. So, what is your perspective on conducting all these things up to the implementation stage in this context? Because your NRE target in 2025 is 23%, and most of that will be achieved by cofiring biomass on those coal boilers. The graph shows that the renewables share is about 17%–

18% in 2024, and in 2025, just 1 year later, it is 23%. So, I am wondering. What are your perspectives?

Arief

Okay, Ms Yamada, as we know, with the COVID-19 pandemic, our demand is not as initially projected. Lower electricity demand and then with the objective of 23% renewable energy in 2025. So, we don't need a new one with this existing power plant because we already have a power supply capacity. We use the existing coal-fired power plant and use biomass for coal firing. Yes, for now, we have already implemented a power project of 5% portion of biomass in the global power plant. As of now, we are yet to have a coal-fired power plant that cofires biomass. However, in 2025, all of PLN's coal-fired power plants will do cofiring. That is why from 2024 to 2025, we will have a very high rate of biomass and coal cofiring power plants in Indonesia. We also increase a lot of renewable energy, including solar and wind power, not only coal firing. So, as you see, maybe we can go further.

If you see here, from 2019 to 2021, we reduced coal, and then we increased renewable energy, which is solar power. So, we can say this will replace the outgoing capacity because we have 51.6% of renewable energy. We will develop further in the next 10 years, mostly from hydro, solar, and renewable energy.

The two representatives from Malaysia presented the subchapter on Malaysia, followed by their comments.

Ir Helmi

Yes, Ms Yamada, regarding the forecast for coal usage in the future, our prime minister has already announced in our 12th national plan that there will be no more nuclear power plants in Malaysia to achieve carbon neutrality by 2050. So, that forecast will be updated later, and if it is published, I will try to share it with you.

Ms Yamada

The 12th national plan says that Malaysia will have no more coal power plants, while in the 2021–2039 peninsular plan, 2,800 MW will be replacing the retiring plants though they are all in the brownfield. How shall we understand this?

Ir Helmi

I am not sure whether the government will allow us to install a new power plant to replace the old ones or there will be no new coal power plants. But I will try to find out for you. The 12th Malaysia Plan has been published already.

Ms Yamada

All right. So, how about the renewable energy transition roadmap?

Ir Helmi

SEDA, the sustainable energy authority, has not published the latest one. But I will try to find out when they will publish it.

Ms Yamada

Thank you very much, Helmi-san.

Rose-san, we have a question about the three cycles you mentioned in our email communication. My colleagues say that this is usually two cycles, not three. But you have three cycles of load variation in a day. In our understanding, it would be normally two cycles. So why three cycles?

Ms Rose

Okay, currently, we normally experience approximately 70% reduction in coal-fired power generation during difficult hours in the early morning . The flow is slow during that time; solar generation starts to rise around 9 a.m. and reaches our morning peak at around 11 a.m. At the peak time, that is, 0.30 pm to 1.00 pm, solar power generation reaches the maximum level. That is the severest period when we need to reduce even more. During that time, our load is lower due to lunchtime typically, so you have to reduce more. Then we can start increasing the load at around 4:00 p.m.

The two representatives from the Philippines presented the Philippines' subchapter, after which they spoke.

Mr Noriel

Good afternoon to everyone, participants, and the moderator for today's meeting. As a comment from the Department of Energy, Philippines and per the provided presentation material, yes, as of now, coal power generation is a big part of our generation mix. Based on our 2020 figures, it is around 57% of our total generation. The reference material for this study is the 2018–2040 Philippines energy plan. As stated earlier, what we did with our 2018–2040 energy plan, published a few weeks ago, the Philippines targeted 85% renewable energy mix by 2030 and 50% by 2040. These are recently published numbers, and one of the limitations, I guess, which JCOAL has also experienced, is the specific number of power plant units built since these are based on the different operational categories, such as baseload, mid-variable peaking, flexible, etc.

But one of the improvements we tried to work on is to itemise those new capacities based on their actual operation or actual technologies, which you can see in the recently published plan in the Philippines. But for now, based on what was presented, we take note of the flexibilisation measures recommended based on the study.

We note that to achieve our renewable energy targets, a major part of our generation mix will mostly come from our variable renewable energy sources, such as solar and wind, and the development of hydro facilities in the country. We note that there is a need to have a more flexible operation of systems, especially gas and hydro facilities, to help us mitigate the entry of VR and the consideration of energy storage, particularly battery energy storage systems.

There are also ongoing parallel studies on battery deployment conducted in the Philippines, which include looking into how much battery capacity the Philippines can put up to assess the system and make it more flexible. So, I guess, for now, these are our initial comments, which were presented. Thank you for providing these recommendations in the report. The 2020–2040 plan is already downloadable at the DOE site.

Ms Melanie

If I may add to his comment. I just want to put a positive comment on your recommendation, specifically on tariff, except incentives or exemptions for large-scale battery storage systems. During our first meeting, I recall I said that we are conducting a

study on exempting battery storage systems from transmission charges during their loading operations. So, it is good to note that it is included in your recommendation. This study, once concluded, can support our study to make that policy possible in the Philippines. Once completed, we can share it with our principals, so they can support our study.

The Viet Nam representatives presented the Viet Nam subchapter, after which they spoke.

Ms Hai

Mr Hai and Mr Kwan, who have been following the projects for EVN since the first working group meeting, cannot attend the meeting today because they have another meeting at the same time. But we have another representative, Mr Tuan. Unfortunately, his mic is muted due to some urgent things coming up.

Ms Yamada

We know it is not possible to tell us. But everybody is wondering when PDP8 will be officialised.

Ms Hai

I will update this information by email.

Ms Yamada

That's not the major question. The major thing is you and your colleague members from EVN will comment on this presentation so that Ozawa-san can reflect everything in his subchapter. I will ask Dr Phoumin to wrap up the discussions and questions of our Working Group members. Also, please give us additional comments and instructions you might like to make.

Dr Phoumin, ERIA, commented on the presentation and discussion.

Dr Phoumin

I think the discussion was basically on the report already. I looked at the report, and it is really interesting. As we know, coal can be more flexible in accommodating renewables. I think this is a big message. I also think each country study is tailored to meet the needs of a particular energy mix of the country during the energy transition. I do not see any further comments from my side. I think this is sufficient.

Finally, Dr Han Phoumin, ERIA, thanked the Working Group members and the Team, expressing his expectation to work together continuously.

Dr Phoumin

Yamada-san, Dr Murakami-san, Otaka-san, Ozawa-san, and distinguished Working group members of this study, thank you so much for supporting this study. It will be very important for ASEAN's energy transition, particularly since each country will need to look into its energy mix. And seeing the whole energy system, I think we have a robust energy supply. At the same time, as we are getting pressure to shift the energy system, we still rely on coal. So, it is not practical to phase out coal power generation too early.

We still rely on coal during the energy transition and make the whole energy system more robust to respond to the increase in renewables, particularly solar. The study has highlighted the backup capacities from various build-ups – from hydro, battery storage, or hydrogen. We can say this is what we are looking for: to optimise energy and see how coal can play a critical role during the energy transition.

I would like to appreciate the contribution of these important members. Let me once again thank you all, and I hope to see you sometime. After this, the JCOAL team will properly finalise the report and submit it to ERIA.

We look forward to receiving the final report. Thank you.