Impact Analysis of NPP Construction on National Economy using EMPOWER Model

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ARTICLE INFORMATION

ABSTRACT

IMPACT ANALYSIS OF NPP CONSTRUCTION ON NATIONAL ECONOMY USING EMPOWER MODEL. The Nuclear Power Plant (NPP) could be one of the generation technology options to fulfill the mandate of Government Regulation No. 79 of 2014 which targeted the New Renewable Energy (NRE) portion in the national energy mix amounted to 23% by 2025 and 31% by 2050, while the realization of NRE until year 2019 is 12,6%. Any implementation of a new project or industry will have an impact on both national and region economy, and NPP project is no exception. This study aims to analyze the impact of nuclear power plant development on the national economy sector. The economic parameters analyzed in this study focused on gross domestic product (GDP) and employment. The analysis was done by using Input Output model with EMPOWER(An Extended Input-Output Model for Impact Assessment of Nuclear Power Plants) model released by IAEA as a tool. Construction period for 2 units of NPP 1000 MWe is assumed 10 years including site preparation. The results of the analysis showed that NPP construction has a significant impact on GDP and employment absorption. Each of module (A, AB, ABC and ABCD) had an impact of GDP increase of 0.021%, 0.033%, 0.040% and 0.040% respectively when compared to the GDP gained without any NPP construction. As for the amount of employment creation in module A, AB, ABC and ABCD respectively equal to 66,083, 107,693,86,081 and 85,449. It can be concluded that according to the analysis provided by the EMPOWER, the construction of a NPP has positive impacts on the national economy.

ABSTRAK

ANALISIS DAMPAK PEMBANGUNAN PLTN PADA EKONOMI NASIONAL DENGAN MODEL EMPOWER. Pembangkit Listrik Tenaga Nuklir (PLTN) dapat menjadi salah satu opsi teknologi pembangkitan untuk memenuhi amanat PP No 79 tahun 2014 yang mengamanatkan target porsi Energi Baru Terbarukan (EBT) dalam bauran energi nasional sebesar 23% pada tahun 2025 dan 31% pada tahun 2050, capaian target sampai tahun 2019 baru 12,6%. Setiap implementasi proyek atau industri baru akan memberikan dampak terhadap perekonomian wilayah, tak terkecuali proyek PLTN.   Penelitian ini bertujuan untuk menganalisis dampak dari pembangunan PLTN terhadap perekonomian nasional. Parameter perekonomian yang dianalisis focus pada Produk Domestik Bruto (PDB) dan penyerapan tenaga kerja. Analisis dilakukan dengan Metode Input Output dengan bantuan model EMPOWER (*An Extended Input-Output Model for Impact Assessment of Nuclear Power Plants*) yang dirilis oleh IAEA. Masa konstruksi untuk 2 unit PLTN berdaya 1000 MWe diasumsikan selama 10 tahun termasuk untuk penyiapan tapak. Hasil analisis menunjukkan bahwa pembangunan PLTN memberikan dampak yang signifikan terhadap PDB dan penyerapan tenaga kerja. Untuk modul A, AB, ABC dan ABCD masing-masing memberikan dampak peningkatan PDB sebesar 0,021%, 0,033%, 0,040% dan 0,040% jika dibandingkan dengan perolehan PDB tanpa adanya pembangunan PLTN. Adapun jumlah tenaga kerja yang terserap pada modul A, AB, ABC dan ABCD masing-masing sebesar 66.083, 107.693, 86.081 dan 85.449. Dapat disimpulkan bahwa berdasarkan analisis dengan model EMPOWER, pembangunan PLTN mempunyai dampak positif pada perekonomian nasional

Kata kunci: Analisis dampak, PLTN, PDB, tenaga kerja, EMPOWER

1. INTRODUCTION

Propelled by economic development and population growth, the electricity demand is expected to increase fast in Indonesia. Based on the National Energy Planning, the target of installed capacity in 2025 is 135 GW and 443 GW in 2050, meanwhile until 2019 installed capacity only 69.1 GW [1]. Achieving this goal requires large increases in electricity supply and the Indonesian power sector needs to develop accordingly.The Nuclear Power Plant (NPP) could be one of the electricity generation technology options to fulfill the mandate of Government Regulation No. 79 of 2014 which targeted the New Renewable Energy (NRE) portion in the national energy mix amounted to 23% by 2025 and 31% by 2050 [2].

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Investment has an important role for the process of economic growth, increased output, job creation and additional community income that can reduce poverty. Investment can increase production capacity through capital accumulation so that it can encourage increased output and drive sustainable economic growth [3]. Investment not only affects the formation of national output but can also affect the reduction in unemployment. Investment will produce technical advances that support the achievement of the economy on a larger scale so that investment can affect the economic prosperity of a nation because investment will meet everything needed by a population that is always increasing [4]. The role of infrastructure as a locomotive of national and regional development is urgently needed to drive economic growth. From a macroeconomic perspective, the availability of infrastructure services affects the marginal productivity of private capital, whereas in the context of the micro economy, the availability of infrastructure services affects the reduction of production costs [5].

The construction of nuclear power plants is as a form of investment. At the construction stage will require goods and services both in the national and regional scope. The need for goods and services during the construction of nuclear power plants will be able to drive other economic sectors as well as job creation. As an illustration, the results of a survey of national industry participation in the construction of nuclear power plants will be around 25% [6]. This means the construction or investment costs of the nuclear power plant are 25% from the whole investment will be part of the domestic portion.

For this reason, it is necessary to analyse the economic impact of the development of the nuclear power plant, particularly the impact on the national economy. As a first step, it is important to know in general the state of the economy which sector is dominant in the demand for output, the structure of output and the structure of value added, both according to the business sector and its components as well as the structure of the final demand. In addition, it also needs to be explored sectors that have a high degree of dispersal and sensitivity (backward and forward linkages effect), as well as an analysis of labour needs.

An input-output model was applied for the analysis of the economic impacts of NPP development. This input-output model was first developed by Professor Wassily Leontief in the late 1930s. For this development, he won the Nobel Prize for economics in 1973 [7]. In its development, methods derived from an I-O table are increasingly being used as practical and quantitative economic analysis and planning tools [8][9][10][11].

The IAEA has outlined how data,technical and economic parameters from nuclear power plants can be used in analyzing the impact of nuclear power plant projects on the economy in Korea [12]. The economic parameters analyzed in this study are gross domestic product (GDP) and employment. Basically, GDP is the amount of goods and services produced by all economic units in a country in a certain period of time (generally annually or quarterly) [13]. The model released by the International Atomic Energy Agency (IAEA) in October 2014 (revised in December 2015), the An Extended Input-Output Model for Impact Assessment of Nuclear Power Plants (EMPOWER) will be used in this impact analysis [14][15][16]. This study aims to analyze the impact of nuclear power plant development on the national economy sector, and focuses only on GDP and job creation impact of nuclear power plant construction activities, not including the impact of nuclear power plant operations

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2. EMPOWER MODEL

The analytical method used in this study is the Input-Output method and a module called EMPOWER developed by IAEA. Using this tool can be simulated the effect of NPP constructionon macro economic. The effect on increasing demand will cause on the production of commodity and as well as the production of other commodities (multiplier effects) [16].

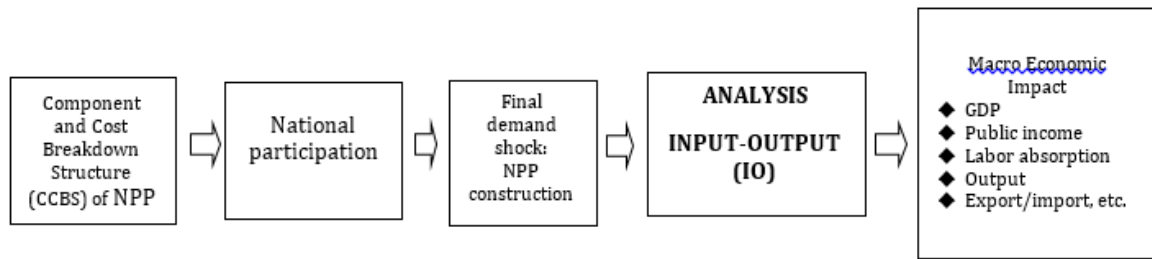The EMPOWER model is a form of an advanced version of a simple static Input-

Figure 1. Logical Framework

Output model, where the framework model of the EMPOWER is designed for impact analysis involving 4 scenarios or modulesof calculating impacts, namely:

1. ModuleA is the indirect effects scenario. In this scenario, the calculation of the impact of an industry or new project includes direct effects and indirect effects.
2. Module AB is the indirect andinduced effects scenario. In this scenario, the calculation of impacts includes not only direct effects and indirect effects, but also involves induced effects.
3. ModuleABC is the indirect andinduced effects & labour market response scenario. This scenario is basically an impact calculation with the AB scenario added by the response of the labour market.
4. The ABCD module is the indirect and induced effects & labour market response and feedback scenario from financing of investment. This scenario is basically an impact calculation with the ABC scenario coupled with feedback from investment financing.

The sequence of scenarios for the impact calculation of A – ABCD illustrates the additional structure of the impact, where each version of the scenario from AB to ABCD each combines all versions of the scenarios below plus one additional feature.

The basic IO equation for symmetric IO tables is expressed in Equation (1) [15][16][17].

$$X = A^d X + cp + f^* + f^{new} \qquad (1)$$

Where:
X   :gross output column vector
Ad   : input coefficient matrix

cp   : column vector of private consumption which is assumed to be an endogenous variable
f *   : another final demand column vector which is an exogenous variable
f^{new} : vector column demand of new industrial or project activities

3. METHOD

The impact of the NPP construction on the national economy was analyzed according to the logical framework presented in Figure 1. The analysis of the component and cost breakdown structures, and the cost components of the nuclear plant construction indicate the final demand for inputs that will be acquired. This value will be used as a shock in an input-output analysis to calculate the macroeconomic impacts.

The first step in the study is the analysis of the main components of the NPP and the preparation of the Input-Output Table (IOT). The component analysis provides data on demand for products of several economic sectors that serve as inputs to the input-output analysis. The results of the input-output analysis include indicators that show the impacts of the power plant construction on the economy. The EMPOWER developed by the IAEA was used for the impact assessment.

3.1 Input Output Table

The IOT used in this study is a 35 × 35 industry-by-industry table taken from the World Input-Output Database [18]. It is adjusted by using the Indonesian IOT for the year 2010. The reason for not using the Indonesian IOT is that it is not assembled industry by industry [19].

The top five industries (manufacturing, agriculture, forestry and fishing, wholesale and retail trade and repair of motor vehicles, mining and quarrying, and construction)with the largest sectoral value added produced about 70% of the total gross value added at basic prices in that year [20].

3.2 NPP Component Costs

The main components of the construction costs comprised of direct cost (equipment, building and civil engineering cost, contingencies and possibly the initial core fuel) that are directly related to the work on the buildings and plant systems; indirect costs (owner's cost such as the costs of land acquisition, power and water supply, and consulting if needed as well as interest during construction).

Table 1. Summary of Construction Cost [21]

No.	Item	Cost (million USD)
1	M & E system cost	6,107
2	Building cost	571
3	Civil cost	987
4	Initial core fuel cost	553
5	Contingency	1,644
6	Owner's cost	1,385
	Total	11,247

Table 1 shows the investment costs of 2 x 1000 MW NPPs obtained from the feasibility study of the non-site aspects,where Interest During Construction and Tax not included, and Figure 2 states investment disbursement during the construction period. Construction period for 2 units of NPP 1000 MWe is assumed 10 years including site preparation starting from year 2025.
Based on construction costs then the cost per year is outlined based on the nuclear power plant construction schedule (disbursement). It is seen that the equipment component accounts for more than 50% of the total construction costs and the peak of financing occurs in 2030 to 2032.
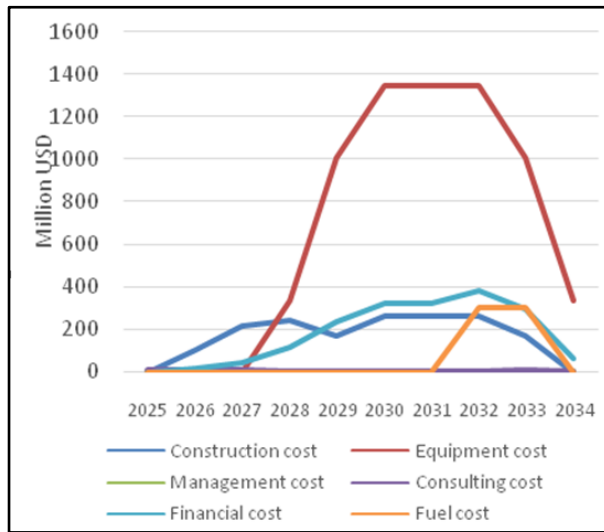

Figure 2.Investment disbursement for each cost component

3.3 National Participation

The capabilities of domestic industries to produce the NPP components can give information of economic effect. However, only Balance of Plant (BOP) components, few Nuclear Island component and Turbine Generator can be produced by domestic industries. This information estimates the domestic cost, and also all service activities in connection with NPP construction that can be provided by national industry that could contribute domestic cost.

The level of national participation can be calculated by Equation (2) [22].

$$P = \sum \left[P_i x \frac{B_i}{B} \right] \qquad (2)$$

Where:
P : Total possible national participation ratio (%)
Pi : Possible national participation ratios in each area (%)
Bi : Estimated detailed cost of each area
B : Estimated total cost of NPP construction

Based on the results of previous studies and data on the ability of the current national industry, it has been estimated the level of national industry participation in the construction of nuclear power plants. The share of components that can be produced locally is around 25% (based on total

investment costs) for the first NPP [23][24][25][26][27]

3.4 Domestic Cost Mapping in Economy Sector according Input-Output Table

After identifying which components can be produced by domestic industry then price can be predicted. Match the component to the Input-Output Table to identify which industry sector produces this component. Then, the calculation of price of component for each input-output table economic sector can be done. Finally we can get the nominal of industry sector.

The impact analysis should start from the *Component and Cost Break-Down Structure* analysis. This shows that there is a limited capacity of the domestic industries to supply component in the building of the NPP. Only around 25% of the total construction costs are spent within the country. Therefore, impact analysis should show how the domestic industries be influenced by the project.

Based on industrial survey, areas and participation rate are as follows:
- Civil Works, Building and Structure (70%)
- Low Pressure Heater (10%)
- Piping and Valves (5%)
- Tanks (10%)
- Electric Power Systems (5%)
- Installation and Test Operation (40%)

The areas where we can participate are adjusted to the sectors in the input output table. As an example: civil works, building, structure, installation and test operation is construction sector in IOT.Then share of domestic or local contribution become as shown in Table 2.

Table 2. Share of domestic

	Cost	Domestic portion	Share of domestic
Construction	1714	1199.8	0.70
Equipment	6722	1008.3	0.15
Management	20	0	0
Consulting	69	0	0
Financial	1812	634.2	0.35
Fuel	609	0	0
Total	10,946	2,842	0.26

2. RESULTS AND DISCUSSION

Based on the features of the national economy and the assumptions presented in the section 3, the impact analysis shows how the domestic industries are influenced by the NPP construction project. Charts in this section present the impacts in percentage terms relative to the Baseline case in which no investment is made to build a NPP. As the scope of the impact calculations is broadened to include more impact and feedback mechanisms (i.e. moving from Module A to ABCD), results always include impacts of the previous steps.

4.1. Results by impact mechanisms

According to the assessments provided by the EMPOWER, the construction of a NPP has positive impacts on the national economy. The impacts are proportional with the amount of money spent for construction activities in a given year and the contribution of the domestic industries in that year. Direct and indirect impacts measured according to the seven macroeconomic indicators: GDP, production, Export, Employment, Disposal Income, Public Saving and Import (calculated by Module A) are presented in Figure 3. Even Impact on Public Net Saving is negative but give positive impact to national economy by reducing deficit budget. Extending the scope of the macroeconomic impact assessment to include the repercussions of direct and indirect impacts of increasing personal incomes through employment creation by the construction work — which, in turn, leads to higher household expenditures on goods and services purchased from different sectors — provides the induced impacts of the nuclear plant construction. Results for the induced effects (calculated by Module AB) are presented in Figure 4.
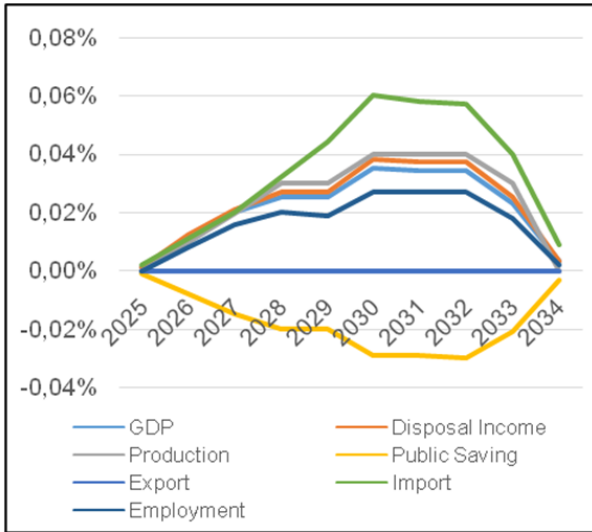
Figure. 3. Direct and indirect impacts of the NPP construction (change relative to the Baseline case).
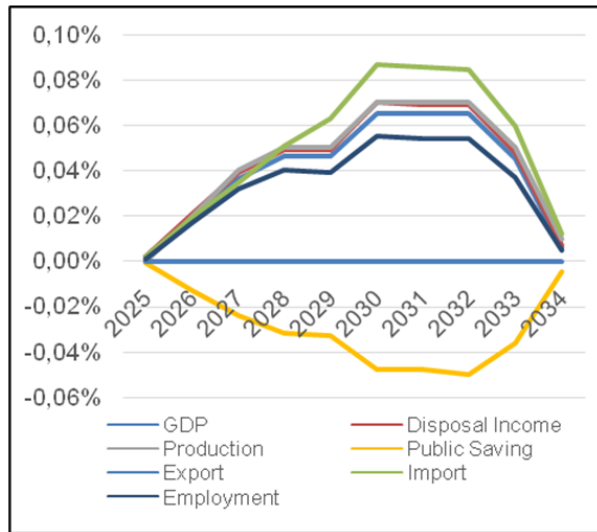

Figure. 5. Labour market impacts of the NPP construction (change relative to the Baseline case)
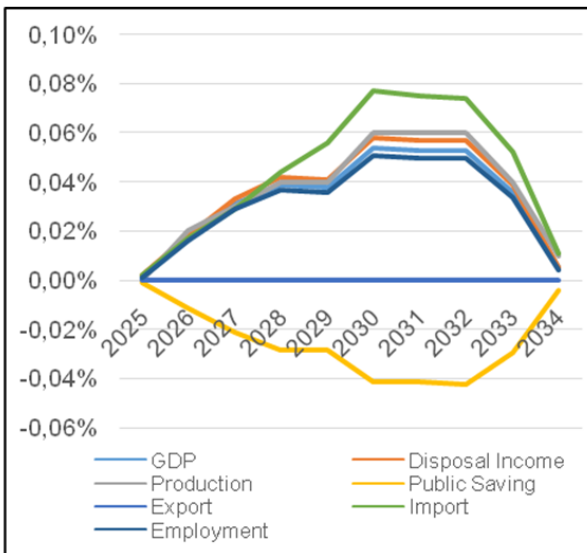

Figure. 4. Induced impacts of the NPP construction (change relative to the Baseline case).

The NPP construction generates changes in the Indonesian labour market with feedback on the rest of the economy. The representation of the labour market in the EMPOWER imitates a wage bargaining or a wage curve model. Increasing industry wage rates affect employment. Labour market and the resulting wage effects can also bring about changes in output prices. Results of the combined calculations of the labour market and the price effects (calculated by Module ABC) are presented in Figure 5.

The ex-ante financing of the nuclear plant construction can be realized by increasing the households' tax rate and/or by decreasing public transfers to households in a revenue-neutral manner during the construction phase. Accordingly, taxes increase and/or transfers decrease to cover a predefined share of the construction costs by the government. The new tax rates and/or the new transfers affect the disposable household income that triggers changes across the whole national economy. The resulting impacts (calculated by Module ABCD) are presented in Figure 6.
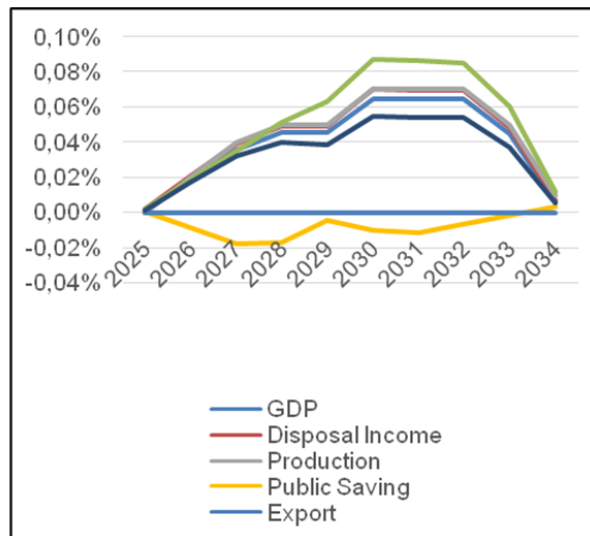

Figure. 6. Impacts of ex ante financing of the NPP construction (change relative to the Baseline case).

Relative to others indicators, impacts on imports show the largest effects of the NPP construction. As noted above, the reason is that almost 75% of the investment costs are spent on importing equipment for the plant. Similarly to some other indicators, the impacts on imports are very similar in the case when the labour market feedback is considered (calculated by Module ABC) to the case when consequences of financing are also included (calculated by Module ABCD).

4.2. Impact on GDP

The construction of NPP is projected to have positive impacts on the Indonesian economy. Results of the EMPOWER show that the total GDP in 2032 amounts to 35,540,665,551 million Rupiah in the Baseline case and it increases by about 0.016% to 35,546,257,543 million Rupiah when the NPPs is built and its direct and indirect effects are considered (Module A). The increase in GDP would be 0.021% if induced effects are also considered (Module AB), and 0.023% if labour market responses are also accounted for (Module ABC). The impacts on GDP are very similar to the labour market results (Module ABC) when effects of financing are also included (Module ABCD). The changes induced by the NPP construction in GDP under the four main impact mechanisms are presented in Figure 7.
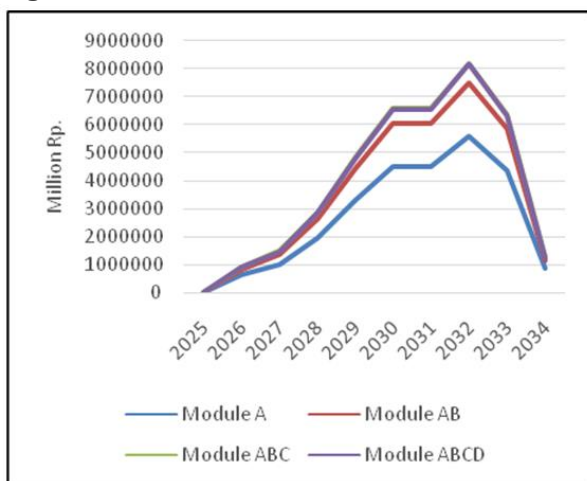

Figure. 7. Effects of the NPP construction on GDP under the four main impact mechanisms (change relative to the Baseline case).

An important question for policy makers and planners is how the construction of the NPP will affect the total production output value. Only a few of the 35 sectors in the national IOT are directly affected by the NPPs construction activities namely construction, basic metals, financial services, other business activities, chemicals and electric equipment. The sector most affected by the nuclear plant construction is machinery, i.e. the manufacturing sector. The reason is that the output of the manufacturing sector is used by various other sectors such as construction, mechanical and electrical equipment. The changes triggered in the total output by the NPP construction under the four main impact mechanisms are presented in Figure 8. The impacts on total output are very similar in the cases of labour market feedback (Module ABC) and when effects of financing are also included (Module ABCD).
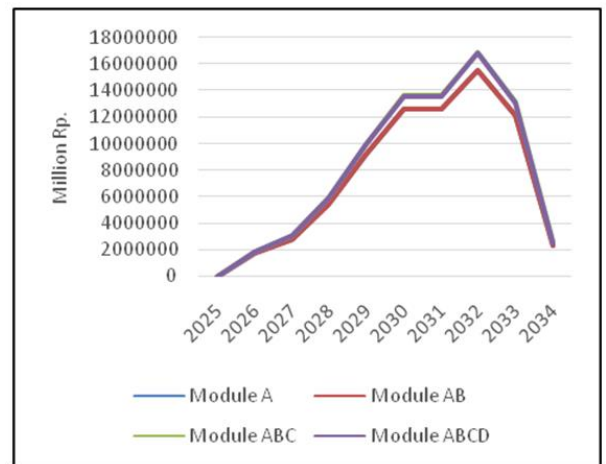

Figure. 8. Effects of the NPP construction on the total production output value under the four main impact mechanisms (change relative to the Baseline case).

4.3. Impact on Employment

Impacts of the NPP construction on employment is another issue of key interest to politicians and decision makers. The plant construction in Indonesia is estimated to create 66,083 jobs as direct and indirect impacts, 107,693 jobs when the repercussions of direct and indirect impacts of increasing personal incomes through employment creation by the construction (induced impacts) are also included, 86,081 jobs when labour market feedbacks on the

rest of the economy are also counted, and 85,449 when impacts of the ex-ante financing of the plant construction from increasing the households' tax rate and/or from decreasing public transfers to households in a revenue-neutral manner during the construction phase are also considered in the assessment. The last two numbers show that the difference between the results of labour market impacts (calculated by Module ABC) and the results of the financing impacts are very close. Results in relative terms compared to the Baseline case are presented in Table 3.

Table 3. Impact on Employment

	Module A	Module AB	Module ABC	Module ABCD
2025	0	0	0	0
2026	2,234	3,488	2,789	2,773
2027	3,427	5,348	4,277	4,252
2028	5,809	9,321	7,452	7,394
2029	8,755	14,370	11,488	11,378
2030	11,378	18,621	14,884	14,742
2031	10,813	17,678	14,130	13,993
2032	12,624	20,726	16,564	16,564
2033	9,352	15,338	12,256	12,139
2034	1,689	2,803	2,240	2,213
Total	66,083	107,693	86,081	85,449

As the scope of impact calculations is gradually broadened from assessing only the direct and indirect impacts of the NPP construction (in Module A) to include more impact and feedback mechanisms such as induced impacts resulting from increasing personal incomes due to employment creation by the construction work and the ensuing higher household expenditures (in Module AB) and further to consider additional adjustments in response to changes in the labour market (in Module ABC), all the way to incorporate the impacts of ex ante financing of the related investment costs (in Module ABCD), results always include impacts calculated in the previous steps.
This pattern can also be observed when comparing the results for particular impact indicators across the extending scope of impact mechanisms. For most indicators, the calculated impacts become higher as more response mechanisms are included. The only exception is disposable income that declines slightly when effects of financing the nuclear plant investments running through the national economy (due to the funds diverted to cover the construction costs) are also included in the scope of the macroeconomic impact analysis. The difference between the results of labour market impacts (calculated by Module ABC) and the results of the financing impacts (calculated by Module ABCD) are very close for the other indicators.

5. CONCLUSION

According to the assessments provided by the EMPOWER, the construction of a NPP has positive impacts on the national economy. All aggregated indicators (GDP, disposable income, production output value, exports, imports, private consumption and employment) increase, except net taxes for the government that show some decline during the construction period. The impacts are proportional with the amount of money spent on construction activities and with the contribution of the domestic industries in a given year.
The results of the analysis showed that NPP construction has a significant impact on GDP and employment absorption. Each of module (A, AB, ABC and ABCD) had an impact of GDP increase of 0.021%, 0.033%, 0.040% and 0.040% respectively whencompared to the GDP gained without any NPP construction. As for the amount of employment creation in module A, AB, ABC and ABCD respectively equal to 66,083, 107,693, 86,081 and 85,449 jobs.
Accordingly, the assessed impacts are increasing as the scope is extended, i.e. moving from Module A to ABCD.

ACKNOWLEDGEMENT

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