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Research Article

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Model of pollution impact for policy design in controlling dioxin/furan emission (Case study: Metal ferrous and nonferrous industry in Cilegon)

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ABSTRACT

Industrial development, not only produces positive impact, but also the negative ones, that are the existence of pollution. Metal industry produces dioxin/furan air pollution that adversely affects living organism, both long-term and short term. This research aims to formulate policy alternative in controlling dioxin/furan pollution in developing a dynamic model of the impact of pollution of the environment, social and economic. Specific steps were executed for to estimate the emission discharged from metal industry; computing the level of emission impact on social, economic and environmental factors; and establishing the recommendation of the alternative policy for decreasing dioxin/furan pollution. The methods used were the emission factor, dispersion method, dynamic system and Multi Criteria Decision Analysis (MCDA). The result showed that the dioxin/furan emission in the assessed area had reached 9.38–13.54 g TEQ yearly for the annual production as much as 1.874– 2.152 million ton. Based on the simulation, if there was no emission reduction policy, the result would be an emission increase of 278% from 1995 up to the end of 2025, a decrease as the air quality by 0.45–0.49; 1,092 potential cancer cases, as well as the social cost. However, by the emission reduction of 46.1%, there would be a significant improvement. Based on MCDA analysis, the best alternative policy is environmental-based policy, compared to "Do Nothing" and "economic-based" policy. Environment-based policy is controlled and reduction of dioxin/furan emission that conducted by the "Command and Control" and "Economic Instrument" policy system.

Keywords: pollution impact, dioxin/furan, emission, dynamic model

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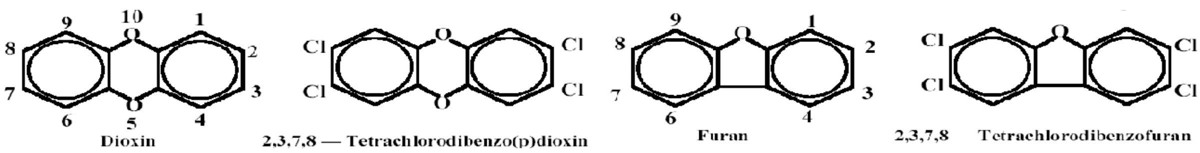
INTRODUCTION

Developments in technology and industry provide positive and negative impacts for human life. The positive impact is expected to raise human welfare, but the negative effects can degrade the quality of human life. As a consequence, the amount of raw materials and industrial waste is increasing, both in terms of quality and quantity. This might impact the increase in pollution and environmental damage, either occurred in the air, soil or water. Type of pollutants from chemical compounds, there is persistent compound, which is resistant to the degradation of physical or metabolic. One persistent compound is dioxins/furans that are produced from the combustion process of inorganic or organic compounds. Dioxins and furans are two different compounds, but have their physical or chemical properties are almost identical [1,2]. Compounds of dioxins/furans consist of chlorine and phenyl (benzene ring group, Figure 1.).



One of the properties of dioxins/furans is, they have a negative impact on the environment that is very slow degradation, either on land, air and water [3]. Pollution that is caused by the dioxin/furan compound is having a devastating effect on the long-term and short-term on the health of living beings and the environment. Dioxins/furans are harmful to human health and the environment, such as, can trigger cancer, allergies and damage the nervous system (either central or peripheral). Dioxins/furans may also interfere endocrine system that causes damage to the reproductive system and the immune system in living organisms, including the fetus [4,5]. More broadly due to the pollution of these compounds are the social and economic losses.

Contamination of dioxin/furan can cause a decrease in air quality, such as the iron smelting industry in the Netherlands led to contaminated air quality by dioxin/furan of 22,700 pg TEQ/g dust [6]. Another example is in Germany, the average concentration of dioxins/furans from the chimney waste incinerator was 8 ng I-TEQ / m3, whereas the concentration limit is 0.1 ng I-TEQ/m^3 in 1994 [7]. A decrease air quality, will indirectly reduce the function of the environment or environmental degradation.

The Indonesian government has yet to give special attention to the danger of contamination of dioxin/furan even it was estimated that in 2000 the total emissions of dioxin/furan was 21.126 g TEQ *(Toxic Equivalent)* [8]. This amount is quite high when compared with other countries, such as China 10.200 g TEQ in 2002/2004 [9]. It is seen from the absence of the policy or regulations governing these pollutants. Not look a like the developed countries such as America, Japan and countries in Europe that have had the rules for dioxins/furans which belonged to the POPs (Persistent Organic Pollutants). Some countries apply the rule's tolerance threshold are allowed of dioxin concentrations in the human body or Total Daily Intake (TDI) for dioxin range from Japan 4 pg TEQs/kg-day, WHO 2.3 pg kg-day^{-1}, the United Kingdom 2 pg kg-day^{-1}, and the European Union 2 pg kg-day^{-1}. The United States does not have a TDI standard, but does have a suggested reference dose of 0.7 pg kg-day^{-1} [10]. In Canada 10 pg/kg body weight/day, and Germany 1 pg/kg body weight/day. The result of research the University of Kiel and the Environmental Protection Agency [11] shows the normal adult human body can accept dioxins as much as 1-10 pg/kg body weight/day without harmful to health. A concentration that is considered safe in infants was 0,008 pg/kg body weight/day [12]. According to [13], when exposed to dioxin concentrations of 1 pg/kg body weight/day, the risk of getting cancer is 1%.

Pollution will also have implications on costs. The extra cost that must be paid by a company to reduce the level of pollution is called abatement cost. This reduction can be accomplished through changes in technology (for example, add a filter on the dust expenditure), scheduling (for example, reducing the hours of operation) or raw material changes [14, 15]. To raise awareness of the countries in the world, in May 2001, there was POPs Convention hosted in Stockholm, Indonesia also took part in the convention. The Convention aims to protect human health and the environment from persistent organic pollution. One of the points of agreement generated is provided to reduce emissions of dioxin/furan [16]. Therefore, the Indonesian government needs to prepare a set of policies and regulations on pollution control of dioxin/furan. In the period of 7-8 years, the US managed to reduce emissions of dioxins/furans drastically. This substantial decrease is due to the success of the US government to set strict restrictions on the use of an incinerator in the industry that has the potential to emit dioxin/furan. In addition to strict regulation, monitoring and control conducted also continuously [17]. In Japan, dioxin is a dangerous pollutant substances (Hazardous Air Pollutants) are preferred handling. In 1999, the Japanese government has set a special step of handling the type of dioxin to prevent and regulate the disposal of environmental pollution by these compounds. This regulation establishes the basis of assessment and standards (environmental, disposal) and the regulatory [18].

One of the constraints on the research dioxin/furan is required the expensive costs of analysis. Moreover, the very low of dioxin/furan concentration levels requires highly sensitive equipment. To overcome these obstacles, the modeling approach is expected to be one of the solutions. Studies dioxins/furans by using models, in general, is still a separate study. Research on dioxin/furan for the calculation of the impact of pollution on the economy is also still not a lot to do. Studies have been conducted generally focused on the effects of dioxins/furans in the health and use of technology to reduce pollution. Development of dioxin/furan pollution models have not been publicized very much. Whereas, by knowing the value of environmental damage caused by emissions of dioxins/furans, it can be used as a basis for decision-makers to make policy. It is expected by knowing the value of the economic losses caused by the emission of dioxins/furan, then the whole society will be more aware of the amount of losses resulting pollution. Estimation and the impact of pollution will be mapped through a dynamic model where simulation results can be used as a basis for policy-making scenario. The alternative policy that will be built based on the quantification of the variables involved in the model. This information is expected to be input as supporting the decision and policy makers.

EXPERIMENTAL SECTION

Estimation of emissions and concentration

Estimates of emissions of dioxin/furan into the environment for each year, (expressed in g TEQ for each year) are strongly influenced by activity data that is the production generated or raw materials used [11, 19]. Determination of emission factors can be done by using the Standardized Toolkit issued UNEP [19]. The value of emission factors depending upon the category and sub-category of an activity. Moreover, emission factors are also determined by the type of technology and the spread of media types of emission.

The concentration of pollutants into the air is affected by the dispersion factor, which is also determined by meteorological conditions. Dispersion factor is as well used to describe the effect of distance the spread of the ambient concentration. Especially for dioxins/furans, [20], as well as [21] using an ISC model, that is a model which has been modified Gaussian dispersion equation. In related with sub-model used to estimate the impact of dioxin pollution/furans in terms of counting the number of cancer cases used equation based on [20].

The research was conducted in the Cilegon industrial area (Industrial Estate Cilegon Zone, KIEC). Type of industry within the region is potentially industries emit dioxins/furans through the burning of materials containing non-ferrous metals and iron (ferrous and non-ferrous) according to Standard Toolkit [19]. There are five industries in Cilegon area that potentially emit dioxins/furans. There is one industry that has three major divisions, so that overall. There is seven samples industry.

Research Model

The models that will be built into the research are the impact of pollution emissions of dioxins/furans models, which is a dynamic model, and the policy formulation models. Each model requires data and has a different basis for calculation. In general, the basic calculation of the modeling study using time-series data for 10 years, namely from the year 1995- 2004, while the data is being used are primary and secondary data.

The output of the regression analysis and simulation of dynamic systems will be input for the multi-criteria analysis, which is as the basis for various policy scenarios to be taken in controlling the contamination of dioxins/furans caused by the industry. Scenarios are developed based on three alternatives, first, the policy alternatives that take place as it is now or not doing anything (Do nothing, DN), second, an alternative policy-based economy (Economic Driven), and third policy-based environment (Environment Driven).

RESULTS AND DISCUSSION

Estimates of emissions and concentrations

Estimates of dioxins/furans emissions from industry mill non-ferrous metals and iron in Cilegon area from 1995-2004 amounted to 9.38 to 26.98 gTEQ derived from the total production of 1.87 to 5.21 million tonnes. In 2002, China which produces 182 million tons of steel resulted a 127-1820 gTEQ dioxins/furans emissions. Emission's data show that emissions from process category ferrous metals contributed the largest emissions in China [22], but not in Indonesia. In Indonesia, the emissions of dioxins/furans originating from the metal industry are the 4th largest source of emissions of dioxins/furans [8].

Based on research that has been done [8] Achmadi (2003), with emissions of 21 126 gTEQ for Indonesia, taking into account the population, the exposure per person/day/kg.bw reached 4686.3 pgTEQ. Meanwhile, when examined emissions generated from this study were derived from the metal industry ferrous and non-ferrous in Cilegon and Serang, the exposure per person/day/kg body weight has reached 205.13 to 325.96 pgTEQ. This figure exceeded the threshold limit of the maximum that has been determined by WHO or EPA which is 10 pgTEQ, so that emissions of dioxins/furans must be reduced.

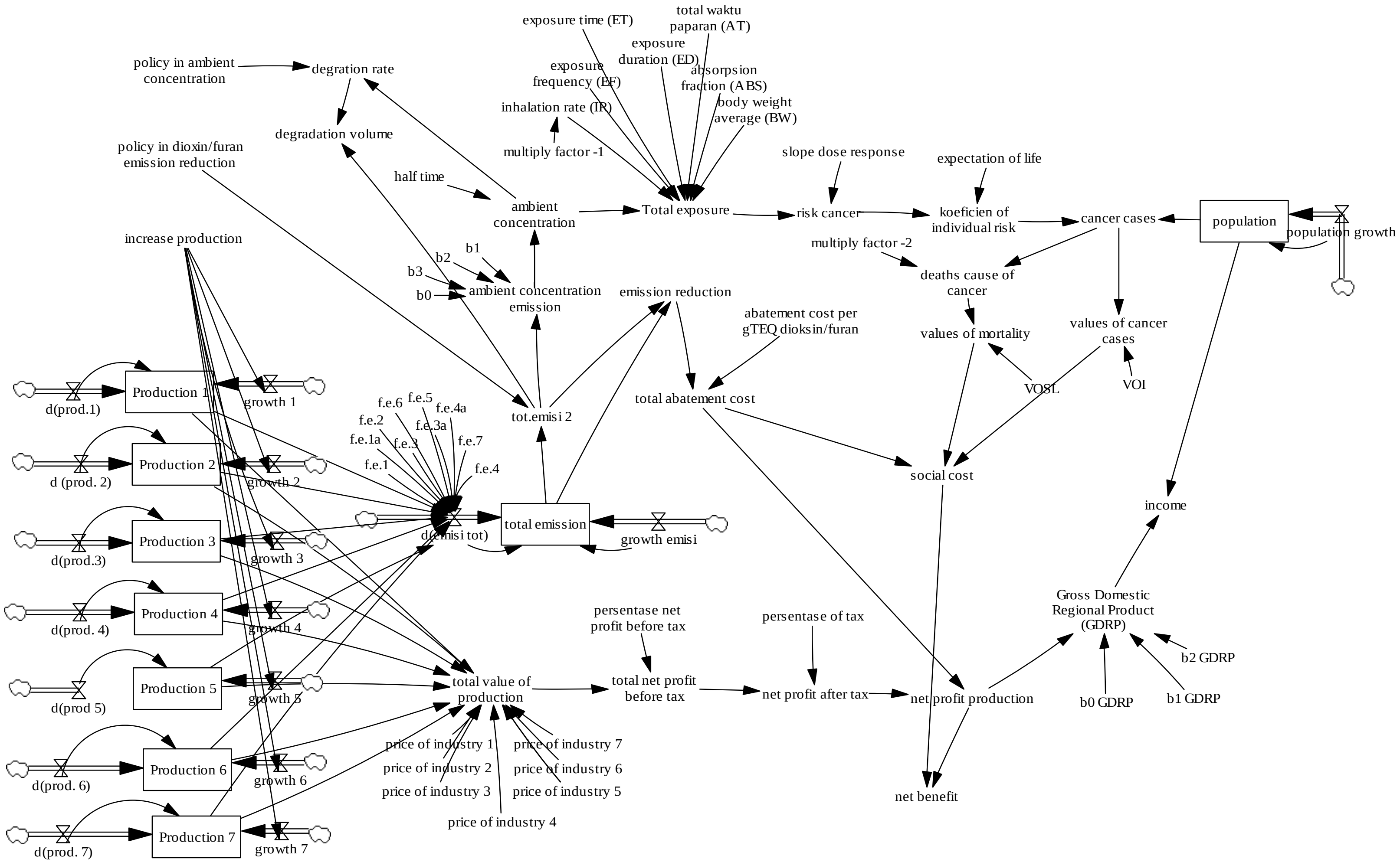


Figure 2. SFD of the impact dioxin/furan pollution

The results showed that the concentration is directly affected by the emissions, wind speed, temperature, distance deployment and indirectly affected by the stability of the weather. The calculation of the emission concentration of dioxin/furan to some area can be an agglomeration of emission concentrations in the surrounding areas [23, 24]. In this study, the concentration of dioxins/furans used is spread 36 km distance, which affects the surrounding society and economy and the concentration is 62,850-96,165 pgTEQ/m^3.

Model of impact dioxin/furan emissions and result of simulation

Stock Flow Diagram (SFD) of dynamic model

Models that built a dynamic system is a comprehensive model of sub models (a part of the model) which have been studied previously. Model the impact of emissions of dioxins/furans only takes into account emissions from industries that have been mentioned that are 7 (seven) industrial metals that emit of the air.

SFD the dynamic systems model is shown in Figure 2. Theoretically, the greater the resulting production, the emissions are released is also higher, which causes the ambient concentration as well increased. This will give a negative impact on the environment, so the air quality is diminishing. The higher the concentration in the ambient will significantly affect the potency of cancer cases and deaths, socially will have an impact on the population. Of course, the existence of environmental degradation and cancer cases will have an impact not only on the social, but also to the economy. Economically, the increase in emissions will lead to increased social cost, so the net benefit would be reduced. On the other hand, the increase in production will provide increased benefits to the industry, so it will be able to improve the local GDP. The dynamic model consists of sub-model of production with its growth; sub-model of the impact of the environment, such as emissions, concentrations in ambient and the rate of degradation; sub-model of the impact of the social, such as the potential of cancer, deaths and their social cost and sub-model of the impact of the economy, such as the abatement cost, the net benefits and the net profit.

The simulation will be done by variables changes, such as: simulation baseline (0% emissions reduction), simulation of technological improvements (30.3%, 40.7% and 46.1% emission reductions with abatement cost / g TEQ 1, 2, 3), and simulation of the increase in production of 3.8% (with 0%, 30.3%, 40.7% and 46.1% emission reduction).

Simulation Results

Environmental Impact

Environmental impacts were analyzed based on emission variables, ambient concentration and rate of degradation. In this case, the rate of degradation is an decrease of air quality that is ratio between ambient concentration and standards of ambient concentration. Based on the simulation of baseline for total emissions (Figure 3), it is estimated that dioxins/furans emissions will increase very quickly if there is no reduction in emissions. If we do nothing, an increase of 278% of emissions will occur from the amount of emissions around 11.01 gTEQ in 1995 to 41.69 gTEQ at the end of 2025. Of course, this will be the impact of the ambient concentration. Ambient concentrations ranged from 0.57 to 5.92 pgTEQ/m^3 from the year 1995-2025. When referring to the standards issued by WHO in 1998 [25] the concentration of dioxins/furans in Cilegon and Serang has exceeded the threshold. Meanwhile, when referring to the standards issued by Rao and Brown [26], the concentration has exceeded the threshold concentration in 2008. Japan has also issued a threshold of standard ambient concentration, namely 0.6 pgTEQ/m^3 [7,27]. In this case, Indonesia has not been determinted threshold for ambient concentrations of dioxins/furans.

(a) (b)

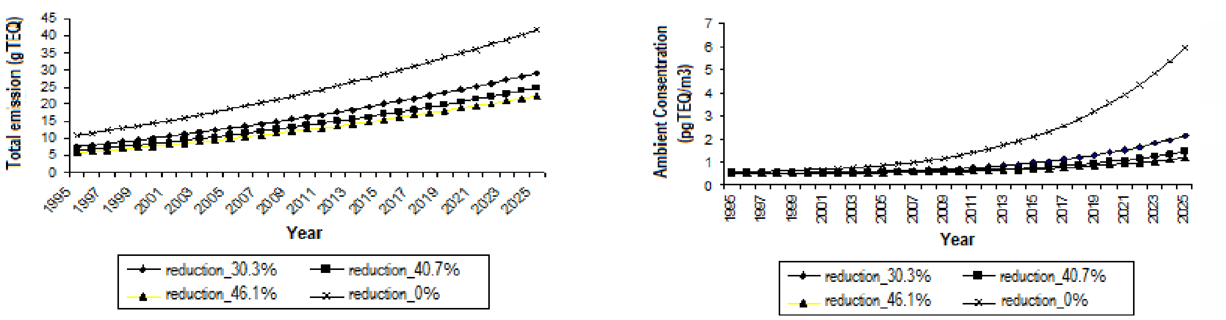


Figure 3. Simulation results of (a) the emission total, (b) the ambient concentration

A 46.1% reduction in emissions can decrease the ambient concentration and environmental degradation rate from 0.63 to 3.75% and ambient concentration 5.61-80.01%. For industry, the emission's reductions will have an impact on costs. It must be balanced with a production increase of the industry. Assuming a 3.8% increase in production, it will have a significant impact on the total emissions in the ambient concentration and the rate of degradation as in Table 1.

Table 1. Results of simulation estimated the total emissions in the ambient concentration and the rate of degradation with the increase in production and an emission's reduction in 1995-2025

Variable	The average percentage of the addition/subtraction with the increase in production of 3.8%, and assuming a reduction in emissions by:			
	0%	30,3%	40,7%	46,1%
Total emission	+ 11,70	- 22,14	- 33,76	- 39,79
Ambient concentration	+ 36,29	- 28,15	-39,53	- 43,77
Degradation rate	+ 0,57	-1,58	-2,51	-3,03

Social impact

Estimation of social impact is assessed by a potential of cancer, deaths and social cost. The result of simulation of potential cancer cases and deaths is given in Table 2. The 46.1%% reduction in emission will reduce the cancer cases and death by 69%. However, if there is an increase in production by 3.8% and 46.1% reduction in emissions, it will cause a reduction in cancer cases and deaths by 76%.

Table 2. The results of the simulation estimate the potential cancer cases and deaths by assumption of emission reductions in 1995-2025

	The number of cases with the assumption of emission reductions:			
	0%	30.3%	40.7%	46.1%
Cancer cases	1092	485 (-55.6%)	377 (-65.48%)	336 (-69.23%)
Deaths	175	78 (-55.43%)	60 (-65.71%)	54 (-69.14%)

According to previous research, if many cases of cancer occur due to dioxins/furans, then 16% of the cases will result in death [20, 28]. This rate is used to estimate mortality. The highest estimate of the potential cancers would have implications for the socio-economic and the value of statistical life (VOSL) as well as the value of injury (VOI). In Indonesia, VOSL value is very low when compared with the VOSL from other countries. When quantified, based on the model output, the health value due to cancer cases and deaths that occur due to emissions of dioxins/furans from the year 1995-2025 is an IDR 5.86-177.00 billion.

If policy interventions are not developed to control emissions of dioxins/furans, ambient concentration will increase, and cancer cases will increase linearly. Dioxins/furans are substances that are harmful for the body. Even if in minute quantities, these chemicals may be toxic for the body, and can accumulate in fat tissue.

The reduction of emissions has an impact on the social cost. Calculation of social cost is not just based on estimates of cancer cases and deaths, but also includes the abatement cost. Although the estimated of potential cancer cases and death have been reduced, but the abatement costs to the industry may have a considerable impact that needs to be taken into account when estimating social costs. This also causes the social cost of emissions reduction 46.1% greater than the social cost reduction of 30.3%. The greater the reduction in emissions, the greater the abatement cost.

Emission of dioxin/furan will provide estimates of the social impacts that need to be considered, especially in cancer cases and mortality. Although it takes a long time to see the effect of the dioxin/furan emission, but these emissions cannot be ignored, because it is accumulated, thus endangering future generations as well.

Economic impact

The impact of the economy will be assessed with total abatement cost, profits, and net benefit. The reduced emissions can be done by industries with technological improvements, which have an impact upon the costs of industrial. Reduction in emissions will also be followed by the abatement costs that must be paid by the industry to improve the environment. The abatement cost per gTEQ depending upon the technology used. Estimated entire abatement costs increased during the period 1995-2025, with the assumption that the greater the reduction in emissions, the whole abatement cost would increase. Total abatement costs will reduce the net profit of the industry, because the industry to spend additional costs to reduce emissions of dioxins/furans. It based the simulation, abatement costs have a small value when compared with the net profit of the industry. Assuming a 46.1% reduction in emissions, then the net profit will be reduced from 4.25 to 6.79%. Based on estimates of abatement costs that must be paid, the industry should reduce emissions and expend abatement cost because evidently a profit of industry is significantly not reduced. On the other hand, the reduction of emissions indicates that the industry concerned with the environment.

Table 3. shows the data related to the impact of the assumption of an increase in production of 3.8% of the net profit, the net benefits and abatement cost. Increased production, followed by a reduction of 46.1% has the best impact of the economy and the environment.

Table 3. The impact of the assumption of an increase in production of 3.8% of the net profit, the net benefits and abatement cost

Variable	Percentage (%) increase in value, assuming emission reduction			
	0%	30,3%	40,7%	46,1%
Net Profit	3.67- 48.50	3.68 - 48.60	3.70 - 48.82	3.83 - 50.12
Net Benefit	3.79 - 38.53	3.81 - 43.41	3.86 - 45.96	4.15 - 50.07

The results of the dynamic simulation can explain the impact of emissions of dioxins/furans to the environment, economic and social. In the long term, when we do nothing, it will cause damage to environmental aspects, community or social as well as the economy. On environmental aspects, the losses will occur due to environmental degradation and the increasing concentration of dioxins/furans in ambient. The losses occurred in the social aspect, namely an increase in cancer cases and deaths that lead to increased social cost. Losses that occur on the economic aspects, for instance the net benefits are on the wane.

Alternative Models of Policy and Policy Implications

An Alternative Model of Policy

The model of alternative policy is such as the emission reduction policies, the increase production policy and establishes of ambient concentration's policy. The optional policy model is performed using the method of multi criteria analysis software with PRIME and dynamical simulation results using the data as well as the qualitative judgement. The stages are performed on the model development policy alternatives [29] that determine the criteria (sub attribute) as well as sub-criteria, which will affect alternative policies are taken. This research uses the criteria of environmental, social, economic and goverment/institution. Sub-criteria selected based on variable contained in the dynamic systems as well as for government criteria used qualitative judgement. Value tree for criteria and sub criteria in Fig. 4.

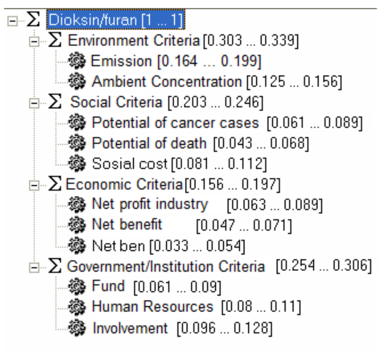


Figure 4. Value Tree for criteria and sub criteria

The next stage is the determination of policy alternatives that will be used as a reference scenario as well as its weighting. There are three alternative policy scenarios are used, that are 1).The scenario I, Do Nothing; 2). The scenario II, policy-based environment (Environment Driven) that is an emissions reduction of up to a maximum of 46.1%; 3). The scenario III, policy based economy (Economic Driven), that is the increase in industrial production, which is assumed to be 3.8% of production. Figure 5 is the alternatives of PRIME analysis with each criteria.

Alternatives

Name	Environment Criteria	Emission	Ambient Concentra.	Social Criteria	Potential of cancer	Potential of death	Sosial cost
Do Nothing		22.63968857	1.459270988		20	3	25689.48382
Environment driven		12.20279218	0.663352323		9	1	27367.91366
Economic Driven		25.21578904	1.931209422		27	4	33997.64279

Figure 5. The alternatives of PRIME analysis with each criteria

Based on the output of PRIME, the dominant policy alternative is an alternative environment-based policy, namely the presence of emission reduction up to 46.1%. These results are in accordance with the value intervals that have been produced and are reinforced with a value decision rule as the final output (Figure 6). The decision rules stating how much damage will be accepted if the policy alternatives are implemented. Decision rules in this research show that the smallest losses retrieved when the scenario-based environmental policies are implemented, because it has the smallest possible loss (-0.201).

Decision Rules

	Maximax	Maximin	Central Values	Minimax Regret	Possible Loss
Do Nothing					0.432
Environment Driven	✓	✓	✓	✓	-0.201
Economic Driven					0.432

Figure 6. Decision rules for alternative policy of dioxins/furans

Policy implications

In the case of dioxins/furans, policy alternatives best obtained through the application of dynamical systems and multi criteria analysis that is an alternative environment-based policy. This aspect is related to controlling reduction of emission dioxin/furans. The impacts of emissions of dioxins/furans to the human being are indirectly and take time until the impact can be seen.

Macro Policy

In the context of the macro policy, showing that air pollution, in particular emissions of POPs include dioxins/furans, are still not aware of. Although Indonesia has signed the Stockholm Convention on POPs, but Indonesia still does not have a specific policy regulating device for controlling dioxin/furans. In addition, an understanding of dioxin/furan among the public as well as government authorities is also unknown. On the other hand, the level of pollution of dioxins/furans in Indonesia has been quite high [8].

Macro policy in economic criteria requires improvements such as creating a stable and conducive economic growth. This will have implications for the increasing industrial growth as well as the development through the investment. Economic growth is closely related with the improvement in the social field, namely an increase in employment opportunities and people's income, because most of the people in the area of research are workers in these industries. However, the growth within the industry will have an impact of the increase in pollution and has been proven by the results from this study, namely the increase in production will increase the concentration of emissions linearly. As consequently, on the macro policy in economically needs to be included in emission's policy control.

In the industrial sector, Act No. 5 of 1985 about Industry can be used as a basis for policy development in order to prevent the occurrence of air pollution from industrial activity. The regulation describes prohibitions for the activities within the industry to pollute the environment. Every industrial activity is obligated to draw up environmental management documents the activities within the industry at the time of filing a business license. The document contains information of emission that issued by industry and the setting of emission standards that is stated in Decree of the Minister of Environment, but the emission standards for dioxins/furans are not yet listed.

To control dioxin/furan, inclusion parameters of dioxins/furans in Government Regulations No. 41 of 1999 regarding air pollution control, becomes important. Dioxin/furan emission parameters can also be added on Government Regulations No. 74 of 2001 about management of hazardous toxic materials. In Government Regulations, organoclorin use of POPs and PCBS had been banned, but has yet to include the dioxin/furan compounds. Although dioxins/furans is the derivation of pesticide that the rule has been listed in the regulation of hazardous toxic materials, but dioxin/furan need listed clearly as hazardous materials. This is because, the sources of the dioxin/furan are not just from pesticides, but also comes from a variety of sources. Dioxin/furan compounds can as well be added to the regulation of the quality of raw emission's sources in Decree of the Minister of Environment No. 13 in, particularly in industries that potential emit dioxin/furan emissions, for example, paper industry, iron/steel industry, cement industry, chemical industry and incinerators. At the national level, Governments should undertake an inventory of emissions of dioxins/furans periodically. This is intended so that the emissions can be detected accurately.

Expected with the determination of standards and regulations for air pollution parameters that include the dioxin/furan, or in other regulations, can increase the awareness among the public and the trade of emissions and environmental threshold is met. The setting of standards for threshold should be done based upon the research. There are three standard designs, i.e. determination of ambient standards, setting emission's standards and the setting of standards of technology. The third such as standards are intended so that emissions are expended be restrained. The setting of these standards can be done by interdepartmental coordination, for example, in the standard ambient concentrations for an assignment, afterwards of health also needs to be involved; on the determination of the emission's standards and technologies, after that Ministry of Industry and Ministry of Trade needed to be involved. The economic impact is on the existence of a standard assignment tax environment for the industry to exceed the emission's standards in the form as a fine. The value of fines can be set according to the abatement cost and social cost to be born. The incoming funds originating fines can be managed in a container that its use is returned for repair to the environment, infrastructure and facilities.

The industry should be removing the social cost, then the image of the industry will be better, so that the trust and support from the community are increasing and will affect the work environment is conducive. As compensation to the industry, subsequently the local Government ensures a work environment that is safe and contributive. Government or Ministry of Environment can also create a public campaign to arouse the society will impact emission of dioxins/furans on health, so that the public is becoming concerned. It is expected the public can participate in controlling industries that emit emissions of dioxins/furans.

Micro Policy

Micro policies are policies that particularly for industrial metals and non-ferrous metal and for emissions of dioxins/furans. The micro policy will identify the quantity of emission reductions from industry, the introduction of technology, and the role of Local Government (LG) for monitoring, information in the public and pollution control of dioxins/furans.

The model results show that the best alternative policy option is the reduction of emissions. Emission resulting from industrial metals and non-ferrous metals in this research in 2004 was 11.03 to 11.86 gTEQ/year. When assessed upon the basis of population, average weight and TDI, in the same year emissions allowances are 0.3931 g TEQ/year. Emission reduction that must be done is amounted to 10.667 g.TEQ/year or 97%. Based on three types of technology, the technology at the abatement cost in use can reduce emissions up to a maximum of 46.1%, so it is still a necessary decrease of 50.9%. Reduction of it can be done with technology or other improvements of technology. Setting these emissions need to be supported by policies on the level of regional/national.

Emission control can be done by two treatments that are the primary treatment and secondary treatment, both among them involve technology used [7]. Primary treatment that is preventing the formation of dioxins/furans, which can be done by substitution of raw materials, the factory operating modifications or change designed factory. Secondary treatment is reducing emissions of dioxin/furan to the outside of the environment, which can be done with the introduction of technology to the industry.

Emission reductions can also be done by setting the technology for high chimney and the distance from the settlement. The Government may issue a policy or rule about a minimum chimney height should be used as well as the nearest distance between residential and industrial areas, because the distance distribution and high chimney are very influential in the magnitude of emission concentrations are acceptable.

Excellent cooperation between Government and industry is a good example for the case of dioxins/furans in the USA. The USA can reduce dioxin emissions of 99% from 1987 until 2010 because the USA Government issued strict rules that must be obeyed by the industry. The greatest reduction was caused due to changes in technology for the incinerator, which is the greatest source of emissions of dioxins/furans in America [30]. In addition to the incinerator, the source of dioxins also comes from societal sources (e.g., burning garbage in the open air) and natural sources (e.g., forest fires. To address it, the US-EPA did campaigns that are intended to educate the public to be more aware of the dangers of dioxins in the environment by not burning trash carelessly. In Brazil, the organization which is responsible for establishing national norms and standards of pollution control is CONAMA ("Conselho Nacional do Meio Ambiente" - National Council of the Environment). It established that dioxin and furan emissions can not exceed 0,5 ng TEQ/Nm^3 during thermal treatment of waste [31].

In Japan, controlling emissions of dioxins in the national agenda is handled directly by the Government. The planned decrease in emissions of dioxin reaches 90% starting from 1997 to four years to the future, by conducting monitoring and evaluation each year [27]. Policies are that use more leads on Command and Control (CAC), with regulations and standards issued by the Government of Japan, in addition to using tax instruments to the mechanism of investment facilities. UNEP also proposed, control emission's dioxins/furans can be done from the industry itself, i.e. in primary or secondary [7]. Industry can choose how to the best control the technology effectively and efficiently. Indonesia may follow the example of the USA and Japan in controlling emissions of dioxins/furans. In addition to setting a TDI and quality of ambient, the Government along with industry can agree on regulations regarding operational industrial combustion or industrial potential dioxin/furan emissions, e.g. combustion temperature or high chimney, which is used. Determination of ambient concentration should set more specific based on research, similar to the TDI also relies heavily on the condition and health of the local community.

Based on the macro and micro policy which has been examined, later the policy instrument used is a combination between the CAC and the determination of the fines/tax called Economic Instruments (IE). According to the Stockholm Convention, emission of dioxins/furans is emissions that must be eliminated, so that based on the source (in this study is the industry), afterwards control or monitor can be done by the industry. The Government should make strict regulations to control emissions emitted by industry, so that the CAC is the instrument must be carried out with a supported IE.

CONCLUSION

Based on the analysis that has been done in this research, some conclusions can be stated as follows:

1. Dynamical Model to measure the level of dioxin/furan emissions impacted environmental, social and economic factor successfully built and can do a simulation to calculate the impact of such emissions.
2. In the period 1995-2025, the emission's reductions amounted to 46.1% will affect the reduction at the rate of degradation of 0.63-3.75%, ambient concentration 80.01-5,61%, lowering the potential cancer and deaths amounting to 69%, reduced net profit of 4.25-6.79% and reduced social cost area on 7.69-16.27% of net profit. An increase over the production of 3.8% with emissions reductions 46.1% will impact the rising the net benefits of orders of 4.16-50.07% and abatement cost 0.20-26.19%. In spite of the reduction in emissions will only slightly reduce the net profit of the industry, but not necessarily the industry wants to do it. In this case, it is a very important role of Governments in defining the policies.
3. Compared to the economic-based policy and Do Nothing, Environment-based policy alternative gives the smallest impact on emissions reductions based on the model of policy alternatives. Control pollution of dioxin/furan can be done by applying a policy mix of CAC System, that is with the determination of the standard technology, ambient concentration and maximum allowable emissions; and economic instrument systems (EI), that are the determination

of the fines. The funds generated from fines must be returned for repair the environment. Channeling and utilization mechanisms need for improvements in the environment.

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