University of Passau
Faculty of Philosophy
Department of Southeast Asian Studies

Harvest the Wind

The Potential of Wind Power as a Renewable Energy Source for Indonesia

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Dipl. Kulturwirt

Gunnar Braun

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submitted to:

Prof. Dr. Dr. h.c. Harald Hundius

Department of Southeast Asian Studies
University of Passau
Germany

submitted by:

Gunnar Braun

mobile: 0179-9042549
e-mail: Gunnar.Braun@web.de

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Glossary

ACE	ASEAN Center for Energy
ADB	Asia Development Bank
AIJ	Action Implemented Jointly
ASEAN	Association of Southeast Asian Nations
ASTAE	Asia Alternative Energy Program
AWEA	American Wind Energy Association
BAKOREN	Badan Koordinasi Energi Nasional (Energy Co-ordination Agency)
BAPPEDA	Badan Perencanaan Pembangunan Daerah (Bureau of Local Development Planning)
BAPPENAS	Badan Perencanaan Pembangunan Nasional (Bureau of National Development Planning)
bfai	Bundesstelle für Außenhandelsinformation (German Information Agency on Foreign Trade)
BMG	Badan Meteorologika dan Geofisika
BOT	Build-Operate-Trade
BP	British Petroleum (officially renamed to Beyond Petroleum)
BPPT	Badan Pengkajian dan Penerapan Teknologi (Agency for Assessment and Applications of Technology)
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
COP	Conference of the Parties
CSIS	Center for Strategic and International Studies
DGEED	Directorate General of Electricity and Energy Development
DJLPE	Directorat Jenderal Listrik dan Pemanfaatan Engergi
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
KfW	Kreditanstalt für Wiederaufbau
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (National Space and Aeronautics Administration)
LIPI	Lembaga Ilmu Pengetahuan Indonesia
MEMR	Ministry of Energy and Mineral Resources
MOP	Meeting of the Parties
MPR	Majelis Permusyawaratan Rakyat (People's Consultative Assembly)

Glossary (continued)

NGO	Nongovernmental Organization
NREL	National Renewable Energies Laboratory
NTT	Nusa Tenggara Timur
NTB	Nusa Tenggara Barat
PLN	Perusahaan Listrik Negara (National Electricity Utility)
PPA	Power Purchase Agreement
PRESSEA	Promoting Renewable Energy Sources for Southeast Asia
PT	Perseroan Terbatas (Limited Liability Company)
RUKN	Rencana Umum Ketenagalistrikan Nasional (General National Electrification Plan)
SHS	Solar Home Systems
USAID	United States Agency for International Development
WTG	Wind Turbine Generator

Glossary of Technical Terms

AC	Alternating Current
BOE	Barrel Oil Equivalent
CO_2	Carbon Dioxide
DC	Direct Current
GW	Gigawatt
GWh	Gigawatt-hours
IDO	Intermediate Diesel Oil
kV	kilo Volt
MW	Megawatt
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
Tcf	Trillion cubic feet
W_p	Watt peak

Acknowledgements

Approaching the end of my university program of languages, economics and cultural studies on Southeast Asia I planned to connect the cultural area of Indonesia with my private interest in sustainable development and renewable energies. Discussing this idea with friends from the Sustainable Development Forum Passau, e.V., it didn't take too long before I decided to look into wind energy in Indonesia. This decision included a number of uncertainties. Where should I get the financing from for research in Asia? Who would possibly assist a technological nobody on a topic like wind energy?

With my non-technical background in mind, I started to look for input and support from people who well understand what it takes to construct, operate and maintain a Wind Power Turbine. After several months and a couple of rejections, I was very happy when I found that Detlef Matthiessen, Managing Director of the German Federation of Wind Power in Kiel had accepted me as an intern for the months of February and March 2002. Without the insight offered from their work and the assistance of Lennart Reeder in the final phase, this thesis would surely suffer from technical shortcomings as they were anticipated in the very beginning.

The next big challenge was financing. I am very thankful to my parents that they agreed on prolonging my studies by one semester and thus making practical research possible at all. I am also very appreciative of the University of Passau of providing me with a scholarship for the flight for my research journey to Indonesia during the month of April 2002.

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I would also like to voice my long lasting gratitude to my former host families in Slippery Rock, Pennsylvania, USA, who made it possible for me to achieve my current capacity of the English language. They have tried hard this time, and previously for more than ten years, to dissolve what remains of German influence in my writing. Unfortunately they could not always achieve the target.

Finally I express my thanks to my family, who was ever supportive throughout my studies. Special thanks and regrets for less time to spend with him, go to my son Silas. He is a great source of inspiration and a terrific motivation to study the promising future of wind energy.

Gunnar Braun
Passau, 19. July 2002

1 Introduction

The most common statement on wind energy in Indonesia is that there is no such thing in the country. And if this is not convincing, people add that the wind conditions do not allow the use of wind energy. Both assumptions caught the authors attention and made him curious of the true potential for renewable power from wind in a country that covers a vast area of tropical seas. A nation with people like the Buginese, who have sailed the oceans within living memory, furthermore a nation that is situated along the international routes of century-long trade by sailing vessels, should have at least some potential for wind energy utilization.

Wind is the driving force behind sailing ships and wind turbine generators (WTG). Sailing boats have lost the race against modern ships with diesel powered engines and have disappeared from the transportation sector. Wind turbine generators, however, just pick up ever more momentum and supplement diesel engines in the energy sector. They are a promising contribution to the world’s energy supply and a field of sophisticated high technology. In Europe their production is one of the few industries not suffering from the recent economic stillstand. Wind, its fuel for electricity generation, comes from the earth's solar powered climate cycles providing inconceivable large resources. However, wind regimes do not provide all regions on earth with the same capacities of wind power. For the implementation of wind power in Indonesia, the archipelago's wind conditions have to be investigated carefully. Current knowledge of wind speeds and the air's density do not draw a very promising picture. Yet, measurements have not been very detailed.

Wind power is a renewable energy source that offers some advantages compared to other sources. In contrast to the combustion of fossil fuels in conventional power plants, a wind power turbine does not produce any greenhouse gas emissions from its immediate operation. Thus, while conventional power plants combust their own basis of existence, wind power contributes to the conservation of moderate and stable climatic conditions. In return stable winds allow for sustainable supply of energy for mankind.

Indonesia, the forth most populated nation in the world, carries quite a large share of mankind. Consequently it has a large demand in energy which is constantly growing and has to be satisfied in environmentally sound ways. This is of additional importance since the country already suffers from pollution from various sources such as forest fires or heavy traffic in the cities. Indonesia needs to diversify and change its power supply to provide sustainable living conditions for its increasing population. Yet, sustainability does not only include a clean environment, but also favorable social and economic conditions. Wind power application can contribute to both of these factors, too. Indonesia, that is currently recovering from the financial crisis in 1997/98, could use WTGs as a means to catch up with recent technological developments. Experience with the production of mini hydro power turbines for export, proves that this is possible. Socially, WTG application in Indonesia can be of importance for rural electrification helping to provide proper health care and access to the media.

This paper presents an introduction to present-day Indonesia. It reviews the energy market and the potential of wind in the country. Finally it will discuss some incentives which could make the use of wind power in Indonesia a realistic option.

Indonesia is a country of diverse landscape, ethnic groups and historical development. Not all aspects of life can be considered, but chapter two tries to give an insight to Indonesia's current political, social and economical situation. Matters of energy are generally highly connected to the status and the development of a society. Therefore, the political framework can support certain choices in the energy sector or it can entirely prevent particular developments. Indonesia, for example, faces a very bad investment climate, which can be attributed to various reasons. Politics of autonomy, social upheaval with concern over security matters contribute as much as domestic and international economic circumstances. As such, chapter two introduces the reader to Indonesia and sets the stage for a deeper look at the energy market and wind power.

Chapter three provides the basic data on the energy market of Indonesia. For comprehensive information it describes the general energy mix before it turns to the electricity market, which is the interesting sector for wind energy. It displays the necessity for power plant development to secure supply past the year 2003. Further, it informs about the current situation of Independent Power Producers (IPP), the state of liberalization of the electricity market and the infrastructure of the power grid. An outlook into the future development of the electricity sector will conclude this chapter.

After these basic conditions for wind power utilization, in chapter four the reader is filled in on the history of wind power application in Indonesia. It will continue to collect and review the existing data of the Indonesian wind regime. This data is the prerequisites for any wind power application. The existing stock of wind turbines will be discussed before prospects for the implementation of wind power lead to chapter five.

In this concluding chapter the author has identified three prospective incentives that can contribute to future use of WTGs for electricity production. Two of them appear as rather odd conclusions at first sight. However, cost and demand structures in Indonesia have their particularities and have to be considered as specific Indonesian. The Clean Development Mechanism (CDM), presented as the third incentive, is an international tool, that has the potential to play a considerable role in Indonesia's overall energy strategy.

The information in this paper has been collected from many sources. Handling it sometimes seemed like working on an incomplete puzzle. The author has picked bits and pieces to compile the paper presented in interviews, from drafts on Indonesian legislation, from the Internet, but also from established monographs and institutions. He has tried to put together a comprehensive report. However it has some shortcomings. It was impossible for example to arrange an interview with the Renewable Energies Network Indonesia (RENI) or the Indonesian Renewable Energy Society (IRES), which probably could help with further insights. Comparable data did not always carry the same unit, making comparisons difficult. Furthermore, data available did not always provide all the information that would have been necessary or interesting for the paper, resulting in some vagueness that should not lead to false conclusions. Inaccurate data is marked as such or commented in the foot notes.

After all, the author is confident to present a good overview on the potential of wind power utilization in Indonesia.

2 The Framework of an Ailing Nation

Indonesia is the largest tropical archipelago in the world, among its outstanding flora are the famous *Rafflesia arnoldii, the giant amongst flowers* and also *Amorphophallus titanum*, the largest inflorescence of its kind. On the human side of superlatives, Indonesia has the largest existing Buddhist monument and the highest Muslim population of any nation in the world. Yet, Indonesia also suffers from probably some of the worst political, economical and social problems in the world. Rather than the beauty of its flora illuminating the 17000 islands, the dragon of the Komodo Islands, another feature of Indonesia, resembles the current situation best. This dragon is a Jurassic beauty, it is mostly sleepy, yet ferocious at times but generally full of power. Most people keep a distance to it, and only some approach it respectfully, but in its own manner the dragon captivates them all. The Tiger that Indonesia meant to be, has disappeared. It may surface again, if Indonesia manages to establish an accountable political elite, a stable economy and proceeds with its decentralization efforts without dissolving the national unity.[1]

The country ‘below the winds’[2], between 6°08’ north latitude to 11°15’ south latitude, and 94°45’ to 141°05’ east longitude, has seen first encouraging, later disturbing political developments since Soeharto’s fall in 1998. It has not been able to concentrate its sources and use politics to get itself out of the difficulties caused by the Asian crisis. Since then Indonesia and its population of 207 million have been drifting along, hindered to put themselves back on their feet, by their own political class who are mercilessly exploiting their people. Furthermore global economic trends deepened the crisis and some international institutions such as the International Monetary Fund (IMF) applied inappropriate measures to the country.[3] In addition, a great number of local ethnic groups challenge the unity of the nation. Its far stretching territory is centered around the island of Java that has been the focus of political decisions throughout the Soeharto era. The political class was then, and still

[1] Deuster: 2002, p. 5.
[2] Ibrahim: 1688 as quoted in Reid: 1988, p. 1.
[3] Schwarz: 1999, p. 5.

is to the present, dominated by the Javanese, who have just begun to make way for independence of the region's governments, who in response are only beginning to learn about their new power achieved in new legislation.

2.1 Indonesia's Politics and its Society

During the early 1990s Indonesia had grown to a considerable economy catching up with the other so-called Tigers in the region, Thailand, Malaysia and Singapore. Thirty years of authoritarian rule under General Soeharto had turned the agrarian nation of the 1960s into a newly industrialized nation with great ambitions to catch up with the industrialized countries. Soeharto's reign seemed stable and under way to be passed on to some successor yet to be found.

In summer 1997 however, the financial crisis struck Southeast Asia causing ailment and omissions from past decades to came to the surface. The lack of a political class capable of handling political renewal proved to be disastrous for the economic well being of the country. Soeharto himself was unable to keep control and giving way to pressure from the streets he had to resign on 21. May 1998. Turmoil had hit the country that experienced not only the worst economic turn down of any nation after the Second World War, but also faced a situation that in some areas resembled a civil war.

Three different Presidents have since tried to put Indonesia back on track, but none of them has been very successful. President Habibie laid down autonomy laws to curtail separatist movements on the periphery of the archipelago. He also surprised the entire world with his sudden acceptance of a referendum by the East Timorese people about their independence. Not backed by any of the new major political groups and continuously mentioned in connection to the former Soeharto era and its shortcomings, Habibie had to pass power on to Abdurahman Wahid after the elections in 1999. Wahid's presidency lasted almost twice as long, but with his deteriorating health, corruption charges, few achievements to present and his insistence on plans for martial law in January 2001, Wahid was impeached from office by the People's Consultative Assembly (MPR) in July the same year. His vice-president, Megawati Sukarnoputri, the daughter of the founding father and former Indonesian president Sukarno, has been in charge since. Her politics do not reveal any major changes and Indonesia has returned to business as usual, with its money politics, including the buying of votes, corruption and its incapability or unwillingness to make serious reforms. The business climate has remained bad and only recently, with the debt rescheduling by the Paris Club, Indonesia's economy got some breathing space. Yet, the political environment stays a fledgling democracy.[4]

The Indonesian society is as diverse as the terrain of the country. Plenty of different ethnic groups blend in with each other, which has been just as much caused by a historical process of many centuries as it has been deliberately directed by the states transmigrasi program over the last two decades and the migration to the cities. Transmigrasi meant to ease the enormous population pressure on the central island of Java and it first seemed to be a good initiative. Although it also helped to develop some of the outer islands, it ultimately caused plenty of conflicts in the periphery, which have just surfaced recently. During Soeharto's authoritarian regime these problems were ignored and suppressed by the central government.

One instrument of government in Indonesia is the Pancasila. It is used to tie the diverging cultures together, was often called upon by former President Soeharto and is still part of today's politics. It lists five basic principles of the Republic of Indonesia, which are the believe in:

1. Almighty Divinity,
2. Humanity that is just and right,
3. The unity of Indonesia,
4. Democracy guided by the wisdom of representative deliberation,
5. Social justice for all Indonesians.[5]

The almighty divinity is mirrored in the fact that every Indonesian must belong to one of the five large congregations of Catholic, Protestant, Muslim, Buddhist or Hindu believe. Yet, most people in Indonesia rather turn to mystical practices than to any church for their spiritual well being. The Muslim group with over 80 percent of the

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[4] For this political overview see: Schwarz: 1999, pp. 1-15; FEER: 2002, pp. 122-129; Eklöf: 2002, pp. 235-242; Crouch: 2002; Dhume: 2002, p. 39.
[5] Mulder: 1996, p. 56.

population is the religious majority, however it is split up into a vast number of subgroups forming several Muslim communities. Muslims are not a solid social force in Indonesia that speaks with one voice and are therefore politically no threat to democracy. However, some call for amendments to the constitution to recognize Islamic Law.[6]

Yet, religion does play an important role in today's society and on the political agenda. Most of the turmoil on the Outer Islands during recent years can be attributed to conflicts between religious groups. The Moluccas, Aceh and Poso on Sulawesi have probably all seen religious motivated riots. Yet there are many voices charging various groups within the Indonesian society and in the political class with misusing religious believes for political purposes.

A major problem for Indonesia's society remains poverty. The country had left the worst poverty behind by the mid 1990s with supposedly 11 percent of its people living below the poverty line. But with the financial crisis millions of people slumped back into poverty. The percentage of the population in poverty sky-rocketed to more than 30 percent and still remains high. Unemployment rates of 40 percent[7] in 2002, including underemployed people leave little hope for change.[8]

With the end of Soeharto's 'New Order' regime in 1998, Indonesian society was released from political deprivation. Students took to the streets and voiced their concerns about the future of the Nation. They struggled to open up a new era of political participation. On the gates of their campus', to which they were restricted, they fought bloody fights with the military. Their struggle for a change in politics has not proved very successful to date, but their challenge of the institutional establishment did provoke change. Hundreds of Nongovernmental Organizations (NGO) have emerged in the past four years and have started to participate in many fields of society. They are developing ideas, organizing local and national interest groups and building bridges to the international community. They have become a back bone of the Indonesian society displaying one of the few true changes in the country.

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[6] Harold Crouch notes that the parties bringing forward such demands "received only 14 per cent of the votes in the last election.“ Crouch: 2002.
[7] Crouch: 2002.
[8] Schwarz: 1999, p. 4.

Politics and society in Indonesia are still looking for some kind of consolidation of the new conditions. They have not been very successful in overcoming the former shortcomings but rather remain at a standstill. Yet, as this study will show for the energy sector, some promising developments are under way and have to be supported if they are to flourish. What Indonesia needs is a consolidation of the weak democracy that allows future development and does not result in stagnation. Its society does have the potential for this. Yet it has to get rid of old habits and most important of all, it should dismiss those with a stronghold in power.

With appropriate legislation in place for some of the problems and further reforms in the pipeline, that are yet to be initiated, Indonesia has a good chance to get its economy back on track.

2.2 Macro-Economic Conditions

Indonesia's economy grew at 3.3 percent in 2001, exceeding most of its neighbors and slowing down from 4.8 percent in the previous year 2000. Compared to pre-crisis growth these rates are rather low but they are back up from minus 14 percent in 1998. At the present speed, the economy will return to 1997 per capita output within five years, in 2007. An increase of growth to 6 percent would cut this to only three years. Yet, this is not to be expected. That means that Indonesia will take much longer than anticipated to pay back the staggering 139 billions US-Dollar of external and 66.5 billions US-Dollar of internal debts, which cause a tremendous burden of interest payments of 29 trillion Rupiah or 1.7 percent of GDP and 60 trillion Rupiah or 3.5 percent of GDP respectively. With much higher interest rates and shorter maturities the potential problems associated with the internal debts are greater.

The situation in Indonesia is not very promising, and little signals a turn to the better.

> „Confidence is still above the low point reached in June-July 2001, and the economy outperformed most of the region in 2001. However, the economy is weakening and the momentum of reform has slowed noticeably as the concern for maintaining stability has taken priority over action."[9]

[9] Deuster: 2002, p. 15.

When Megawati took over the presidency in summer 2001, hopes of continuous reforms and successful management were raised. Some of these expectations were met, such as the restructuring of debts by the Consultative Group on Indonesia in November 2001, the approval of a new letter of intent with the IMF in January 2002, the rescheduling of debts by the Paris Club in April 2002, cuts in fuel subsidies without incurring further protests and keeping the lid on the budget deficit target.[10] These achievements signal a sense of stability and show that Indonesia is moving in the right direction. The recent rise of the Rupiah to 8500 to the US-Dollar supports this development.

But with Megawati entering office concerns were also raised that economic reform could slow down. Privatization of state owned enterprises, for example, proceeds at a slower pace than expected, hampered by claims of local governments which do not want foreign investors to move in while trying to secure their individual funds of extra income. Calling off the sale of PT. Gresik Cement to a Mexican investor was just one of the shortcomings Megawati's government has to sign responsible for. These developments disturb potential investors and prolong deliberately the desperately needed return of foreign capital.[11]

Imports and exports have been down again in 2001 after a strong increase in the year 2000. The deterioration of the world's economic climate has contributed to that, especially after 11. September 2001, but it also correlates with a domestic decline in investment. Slight hope comes from an increase of 4.1 percent in exports in December compared to the month of November, yet imports in December 2001 remain low, at levels recorded at the height of the crisis in 1998.[12] Goldmann Sachs expects non-oil and gas exports to remain flat at 45 billion US-Dollar in 2002 and a slight increase in imports to also 45 billion US-Dollar.[13]

Indonesia's economy was „sinking at a standstill"[14] as the Center for Strategic and International Studies (CSIS) titled a 2001 report. It is obviously still not moving, but basic economic premises seem slightly better this year. They have to be supported by responsible politics, if they are to help the country to gain some strength

[10] Deuster: 2002, p. 15 and Dhume: 2002b, p. 39.
[11] Deuster: 2002, pp. 15-17.
[12] Deuster: 2002, p. 32 and CSIS: 2001, pp. 342-344.
[13] Dhume: 2002a, p. 54.
[14] CSIS: 2001.

again. In the long run these politics and the structure of the economy will have to change significantly to bring back development to Indonesia and finally make it sustainable.

2.3 The National Strategy on Sustainable Development

Indonesia has been a participant in the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, also known as the Earth Summit. At this conference the concept of sustainable development has been agreed upon as the underlying guideline for development within the global community. Indonesia has been constantly taking part in the following global process of establishing the concept.[15] On a national basis it has included the concept in its legislation and administration. Concerning participation of the Indonesian society in those proceedings, tremendous change occurred after Soeharto's fall in 1998. In preparation of the 1992 Earth Summit Indonesia's government, at that time still authoritarian under Soeharto, was in control of the few national Nongovernmental Organizations (NGO) and steered some of them into 'voluntary' preparation of the national contribution to Rio.[16] In the following process of political liberalization under Soeharto and definitely since 1998, NGOs have become able to act more freely and have contributed considerably to the latest developments in politics on sustainability. In 1997 Indonesia has adopted a National Agenda 21 and just recently, in May 2002 it has presented its first comprehensive assessment of Agenda 21 for sustainable development. The study reveals that during the ten years since Rio, sustainable development has taken up its stance both within the Indonesian non governmental movement and within its legislation and administration. Yet practical implementation still has to be put into action.[17] To help to achieve this goal Indonesia is in the process of setting up a National Council for Sustainable Development. The Council will be responsible to provide and

[15] For details on climate change commitments see the chapter on the Clean Development Mechanism. See also obligations from membership of i.e. the World Trade Organization (WTO), Asia-Pacific Economic Cooperation (APEC) and ASEAN Free Trade Area (AFTA).
[16]Hikam: 1999, S. 227f.
[17] From Crisis to Sustainability: 2002, p. 1.

coordinate a National Strategy on Sustainable Development as it is supposed to be presented in Johannesburg.[18] But beyond it's assessment Indonesia is not expected to present a profound national strategy yet.

[18] www.worldsummit.org. Each nation state is supposed to prepare a National Strategy on Sustainable Development within ten years after the Rio Summit.

3 The Basic Conditions for Wind Power

Where ever you see a wind turbine working it appears to be as simple as a child's wheel spinning in the wind. As with the wind for the child's wheel, obviously the site for a wind power plant has to be a location of good wind conditions. Besides that a tower, a generator and a rotor seem to be all you need. But there is much more to it. There is the infrastructure of electricity transport to –as most wind power stations need some initial electricity- and away from the turbine. It has to be connected to a high voltage power grid for long-distance transport if the produced electricity is not directly used in the area. Otherwise local distribution lines are needed. Backups might be necessary for calms with no wind power supply in case it is a plant off the grid serving remote households or industry. For the realization of wind turbine projects the infrastructure around the site is also essential. Generally turbines of the megawatt class for example need a 600 t crane to be set up, a technical tool available throughout Europe and North America, but not necessarily in the rest of the world.

Essential for the implementation of wind power in Indonesia are the conditions of the energy market. Regional demand is as much of interest, as the structure of the power grid or the energy prices to be able to compare the actual conditions with the wind power turbines capabilities. An insight into Indonesia's primary energy supply will give an idea of the potential of the entire market and the challenge for renewable energies to substitute fossil fuels in the long run. As Indonesia is expected to turn from a net export nation to a net import nation concerning oil and gas within the next 10 years[19], the contribution of fossil-fuel-free renewables to the energy supply is of growing interest.

3.1 The Energy Market

Indonesia's energy market is still predominantly based on fossil fuels. It is extremely heterogenic regarding regional supply and demand for electricity. The central

[19] bfai: 2001, p. 20-22.

islands of Java and Bali are the main area of production as well as consumption. Within Java and for the entire nation, as a single region, Jakarta has the greatest demand for electricity.[20] With about 60 percent of Indonesia's total population Java also has the highest demand for final energy from other sources such as fuels, oil and gas for transportation, industry and households. In the year 2000 electricity was available to 74 percent of the households in Jakarta, while only to 56 percent on Java and Bali and even lower 52 percent nationwide. The electricity market is therefore mainly divided into the two regions of Java-Bali and the Outer Islands, with established structures of power plants and a mature power grid concentrating on Java following the distribution of supply and consumption.[21]

The institutions responsible for energy throughout Indonesia are monopolized for the various sources and kinds of energy. Sectorial companies for coal, gas, oil and electricity have long been established during the Soeharto reign over Indonesia. Today their monopolies start to be challenged. In the mining of coal and in the production of electricity a number of Independent Power Producers (IPPs) have been allowed into the market. Yet, they are completely dependent on the national monopolies because they can only sign contracts with the monopolists and have to sell to them their coal or electricity. In the medium term the national energy companies are planned to be privatized and released from their competence in contracting with IPPs and setting regulations for the energy market. Those responsibilities will be handed over to independent state agencies.[22]

In 2000 revenues from the state's oil and gas exports have contributed 27.3 percent[23] to the national budget. As the crisis in Indonesia prolongs and the international economic prospects do not allow for other commodities to add up to the national budget directly or via taxes, the export of energy resources will remain essential to the government of Indonesia.

[20] PLN: 2001, p. 1.
[21] National Assessment: 2002, 2.2.1.
[22] Botschaft Jakarta: 2002.
[23] bfai: 2001, p. 5.

3.1.1 Primary Energy

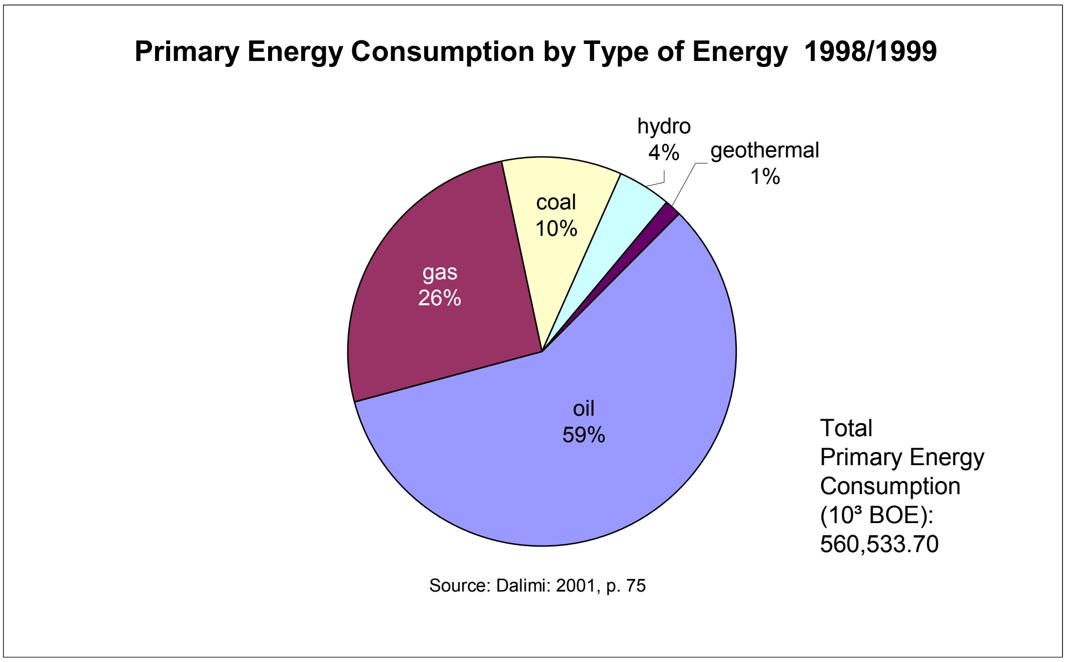

Figure 1: Primary Energy Consumption by Type of Energy 1998/1999.

Indonesia is rich in natural energy resources and therefore independent in its energy supply. Its consumption of primary energy in 1998 adds up to 560.6 million BOE, which consisted of the various kinds of energy as shown in Figure 1.[24]

In 1998 the Asian Crisis had resulted in a decline of energy consumption in Indonesia that has recovered quickly to pre-crisis amounts by 2000. The growth in consumption is expected to return to pre-crisis growth rates in medium terms. Yet this will depend on the speed of recovery from the crisis and the impact of current economic slowdown. Gas and coal are expected to grow in proportion of the total energy supply by 2020. Oil will gradually become less important since Indonesia will turn from a net-exporter to a net-importer by 2011.

A study by F. Gerard Adams on the demand for energy after the Asian Crisis in several East Asian countries including Indonesia takes into consideration two different scenarios: a) a gradual return to Gross Domestic Product (GDP) growth and b) a stagnation of GDP growth. The study develops the correlation between the energy sector and GDP development and presents demand projections for 2010 and 2020.

[24] Dalimi: 2001, p. 75.

Following those, even in the stagnation scenario energy demand will still increase by nearly 50 percent to the year 2010 and will more than double until 2020 with the year 2000 as the base line. If continued growth at pre-crisis rates were the case, increases would result in 2.5 and 6 times higher demand respectively.[25] Regarding the fact that within the last two decades energy consumption per GDP has steadily declined for Indonesia those predictions may have to be adjusted downwards, giving credit to higher efficiency.[26]

Renewable energies play a limited role in the composition of Indonesia's energy supply. Their share of 5 percent in the total primary energy supply derives mainly from hydro-power. A minor contribution comes from geo-thermal. Before the crisis other renewables were under way to contribute at least in rural electrification. But plans to distribute Solar Home Systems (SHS) have been cut back tremendously. The remaining projects have a hard stand since few people have the financial power to pay 300-500 US-Dollars for a solar-panel of 50 W_p per unit.[27] Mini-hydro and biomass fermentation and combustion have achieved more attention lately, while wind-power has no importance so far. Only a small number of low scale wind turbines have been installed for water pumping, battery charging or lighting.

The final energy consumption in Indonesia is distributed between the various kinds of energy as shown in figure 2:

[25] Adams: 2002, pp. 3-13.
[26] Alisjahbana: 2001, p. 366.
[27] see: Tjarinto: 2001, pp. 190-199.

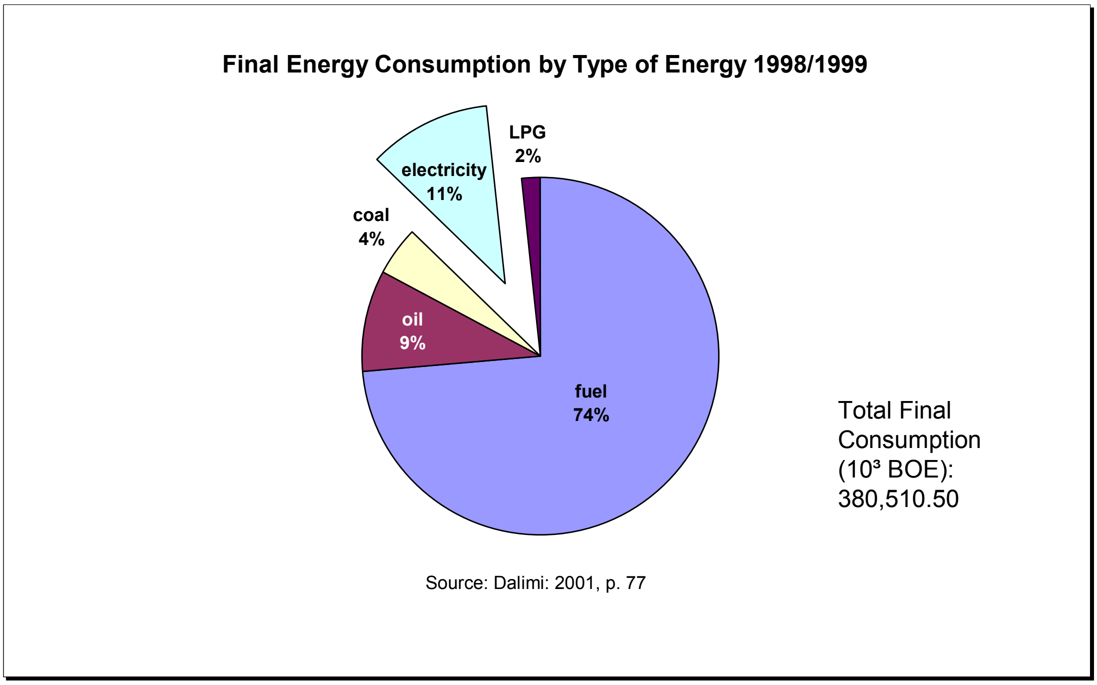

Figure 2: Final Energy Consumption by Type of Energy 1998/1999.

The largest part of final energy still comes from fossil energies such as fuels and oil. They are mainly used in the transportation sector and in equal shares in industry and households. Coal combustion is entirely industrial as well as 99 percent of Liquefied Petroleum Gas utilization. Electricity is not yet part of the transportation sector's consumption. Thus, almost in parity, electricity is only used by both industry and households.[28] Its share of eleven percent of the final consumption may grow in the future if out-dated technical equipment is replaced and diesel motors in agricultural processes for example will be supplemented by electrically powered engines.

The overall consumption of primary energy by sectors is as follows in figure 3:

[28] Alisjahbana: 2001, p. 366.

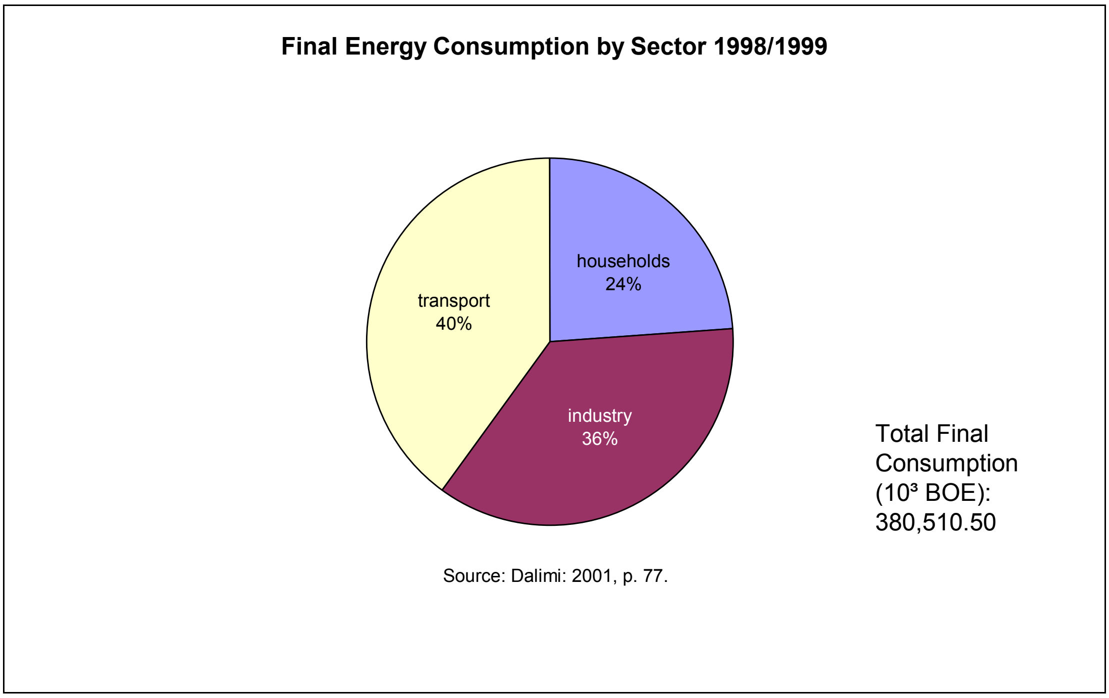

Figure 3: Final Energy Consumption by Sector 1998/1999.

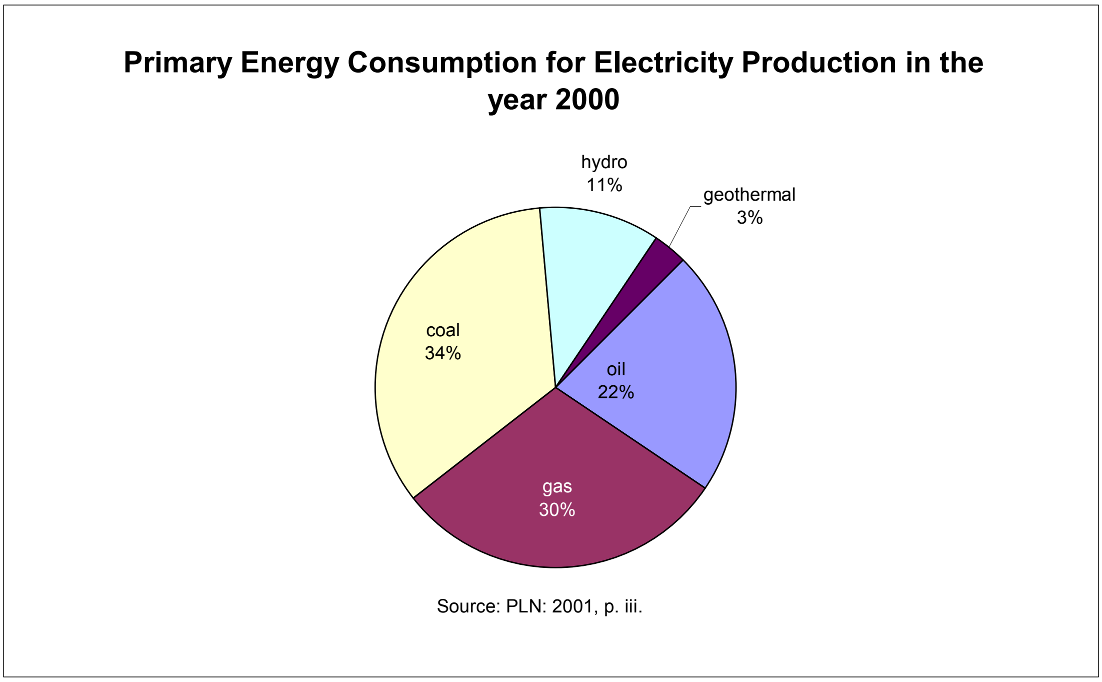

Figure 4: Primary Energy Consumption for Electricity Production 2000.[29]

[29] Unfortunately it was not possible to obtain data on the percentage of electricity production in total primary energy consumption. Own calculations from the PLN data on gas, oil, coal and fuel consump-

The generation of electricity, too, still relies predominantly on thermal sources as shown in figure 4. Total electricity generation in 2000 accumulates to 93.325,28 GWh with 74.918,41 GWh or 80 percent produced in thermal power plants.[30] Primary energy from renewable sources for electricity generation only comes from hydro and geothermal power and marginal contributions from SHS and biomass combustion.

3.1.2 Structure and Institutions

Indonesia's energy market is a market of monopolized state companies. They share out between each other the entire energy resources and the production of electricity by the specific types of energy as presented in table 1.

Company	Responsibilities
PT. PERTAMINA (PT. Perusahaan Pertambangan Minyak dan Gas Nasional)	oil, gas, geo-thermal
PT. PGN (PT. Perum Gas Negara)	gas (transport and distribution)
PT. PLN (PT. Perusahaan Listrik Negara)	electricity
PT. TBBA (PT. Tambang Batubara Bukit Asam)	coal (distribution)

Table 1: Monopolies on energy production and distribution.[31]

For their kind of resources, these companies are responsible for the operational business of the state controlled energy. They produce, distribute and sell their product in their own responsibility. Only in coal mining and electricity generation have

tion of the different generation plants may be possible but are beyond the scope of this paper. Still an approximation shall be submitted. For Germany, the energy report of the German Ministry for Economics and Technology states the effectiveness for coal fired power plants at 34-37 percent and for combined cycle applications at 60 percent. Lower standards in Indonesia may therefore allow the assumption of 33 percent effectiveness for power plants there. Total final energy consumption of 380,510.50 BOE includes 11percent of electricity or equal to 41,856.16 BOE. Since 84 percent of the electricity production comes from thermal energy such as coal, oil, gas and other fuels, 35,159.17 BOE of the 41,856.16 BOE account for combustables. Thus, at an effectiveness of 33 percent, approximately 105,500 BOE of primary energy consumption are for electricity generation by thermal power plants. This would resemble about 18 percent of primary energy, which seems low, but could be correct since primary energy in Indonesia includes fuel wood and kerosen for direct applications such as cooking or lighting, mostly provided by electricity in industrial societies.

[30] PLN: 2001, p. 22 and 25.

[31] bfai: 2001, p. 8.

Independent Power Producers (IPP) so far entered the market.[32] They always have to cooperate with one of the state owned enterprises and depend on their willingness and ability to purchase privately produced products. In the electricity sector 29 Independent Power Producers have been active in the late 1990s, but only 9 or 10 successfully deliver power so far.[33]

Administration, research and development, the above named state enterprises and regional offices are centrally coordinated by the Ministry of Mines and Energy.[34] The various directorates under the Ministry sign responsible for the policies in the different sectors. They prepare and propose new developments and restructure the specific markets. These directorates cooperate with several institutions for statistics and research that do not necessarily clearly distinguish the resources. Badan Koordinasi Energi Nasional (BAKOREN) for example is a central agency that provides national plans such as the last Energy Conservation Master Plan (RIKEN) in the 1990s. Table 2 lists some of the important organizations for renewable energy development in general and for wind energy in particular:

Abbreviation	Indonesian full name	English full name	task (i.e. in the wind sector)
ACE	ASEAN Center for Energy		Organization established by EU and ASEAN; coordinates and arranges technical cooperation; supports research for renewable energies
BAKOREN	Badan Koordinasi Energi Nasional	Energy Co-ordination Agency	inter-ministerial national energy policy and decision making agency; coordinates the national energy program
BMG	Badan Meteorologi dan Geofisika	Agency for Meteorology and Geophysics	runs over 70 meteorological stations throughout the country collecting weather data including wind speeds
BAPPENAS	Badan Perencanaan Pembangunan Nasional	Bureau of National Development Planning	national and local bureaus prioritizing renewable energies and rural electrification, determines government support for projects
BAPPEDA	Badan Perencanaan Pembangunan Daerah	Bureau of Local Development Planning	

[32] bfai: 2001, p. 8.
[33] The German Embassy's report mentions 10 IPPs in operation by 1999, while the University of Indonesia's Energy Outlook (Dalimi: 2001) only lists 9 companies in private electricity production.
[34] Its organization chart along with that of the Directorate General for Electricity and Energy Development and the structure of PT. PLN is included in the appendix.

Selected Institutions continued:

Abbreviation	Indonesian full name	English full name	task (i.e. in the wind sector)
BPPT	Badan Pengkajian dan Penerapan Teknologi	Agency for Assessment and Application of Technology	technology research, development, demonstration and testing etc.; implementation of projects; measurement of wind speeds;
DJLPE	Direktorat Jenderal Listrik dan Pemanfaatan Energi	Directorate General of Electricity and Energy Development (DGEED)	main actor in the field of fossil and renewable energies; coordinates inter-agency cooperation; is responsible for SPPA (Small Power Purchase Agreement) project developments
LAPAN	Lembaga Penerbangan dan Antariksa Nasional	National Space and Aeronautics Administration	measurements of wind speeds, implementation of projects
MEMR (formerly MME)	Ministry of Energy and Mineral Resources		main actor within BAKOREN; supervisor of the state-owned utilities and energy service companies

Table 2: Selected Institutions of the energy sector.[35]

With the new autonomy of the provinces and regions since 1999 industrial development is in the hands of local governments. But national economic planning, high tech development and natural resource conservation remain at national level. For the electricity sector PLN clearly stays the central organization to cooperate with. Yet there are some ways to realize private power generation without PLN.[36] For foreign investors the regulation in law No 22/1999 on borrowing capital from overseas can be an obstacle to financing regional power projects. It permits for external credits to regional governments only if they have authorization through the central government. This may lead to collisions whenever the otherwise independent regional government is not in line with Jakarta and therefore make financing of regional projects a problem.[37]

3.1.3 Foreign Trade

Energy resources are the major source of foreign currency income for Indonesia. The most important trade partners for oil, gas and coal are within the Asia-Pacific region. Japan (32.4%), Australia (21.1%) and South Korea (13%) are the main buy-

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[35] Compiled from PRESSEA and Dalimi: 2001.
[36] For those possibilities see the chapter on Independent Power Producers.
[37] Jakarta Post: 2001a.

ers of oil, while Japan, South Korea and Taiwan purchase the entire Liquefied Natural Gas (LNG) exports. More than half of the exports of coal go to Japan, Taiwan and South Korea.

In 1998 Indonesia exported a total of 247 million barrels of crude oil of different quality[38], approximately 2 Trillion cubic feet (Tcf) of gas and 46.9 mio tons of coal. The growing demand of oil domestically and decreasing oil production at the same time is expected to result in a turn around of net-exports of oil to net-imports around 2010. This will force Indonesia to raise financial sources to guarantee its energy supply with oil through expanded gas and coal export. For the development of gas projects Pertamina, Conoco and BP are involved, while doubling the exports of coal over the next five years will be contributed to, besides others, by two Australian firms, the Clough Group and Broken Hill Proprietary. It is also planned to enlarge capacities in oil by Unocal and Exxon in Kalimantan and Java respectively. Oil imports are still predicted to rise from 195.9 million barrel in 2001 to 196.7 million barrel in 2011 and 441.9 million barrel in the year 2020. Yet, these predictions based on the reserves of oil may be preliminary. [39]

> "Ratio of reserves to current production is widely used as indicator for future availability of natural resources. From this indicator, based on proven reserves, Indonesian current rate of oil extraction will last for only 9 years, while based on total reserves (proven and potential reserves), the current rate of production will be maintained within the next 17 years. This indicator, however, should be observed more carefully, since historical data on this ratio seems to be relatively stable. These observations indicated that the rate of oil production discovery seems to be accompanied by the same rate of new discovery resulting in relatively stable ratio of proven reserves to current production during [...] 1980 to 1997[...]."[40]

Manfred Kleemann mentions in 1994 that all oil reserves throughout the Indonesian archipelago may sum up to 30-40 billion barrels that again equal about 17 more years of exploitation.[41]

Today's import of oil is necessary, because Indonesian refineries are not entirely capable of providing certain qualities of refined oil for the domestic market. Also

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[38] Indonesian oil is exploited mainly in Kalimantan, Central-Sumatra, West-Java , Aceh and Irian Jaya. Its quality varies, depending on the region from API 22°-37°, with prices similar to other international brands such as West Texan, Brent or Dubai oil and even higher revenues for Sumatran (Minas) oil. bfai: 2002, p. 13 and eia: 2002, p. 2.
[39] For this and the previous paragraph see: bfai: 2001, pp. 11-16; and eia: 2002, pp. 2-4.
[40] Alisjahbana: 2001, p. 361.
[41] Kleemann: 1994, p. 57.

do some Arab nations import their crude oil and process it, before it is sold in Indonesia. In the near future it will be exported to third parties such as China, too.[42]

3.2 The Electricity Market

The Indonesian electricity market is one of two kinds. There is the market for Java-Bali and the market for the Outer Islands. Java and Bali accumulate 75 percent of 20.7 GW installed generation capacity and almost 81 percent of the electricity sold by PLN.[43] The Outer Islands, including Sumatra, Kalimantan and Sulawesi have a different structure apart from Java-Bali both in power generation and in distribution. On Java and Bali hydro power, gas and gas-steam combined contribute the largest quantities to the production of electricity and less than one percent come from diesel plants. On the Outer Islands 46 percent of installed power generation capacity are diesel generators. Long distance transmission of electricity via a high voltage grid is only on Java and Bali existent. But even there the entire system is not yet set up and the 500 kV grid will not be completed before 2004.[44] Growth rates of energy demand throughout the last two decades have been around 12-13 percent, the financial crisis of 1997 causing only a temporary ditch.[45]

The structure of the electricity market is determined by the concentration of facilities and consumption on Java. Its organizational structure has been set up by PLN and splits up the archipelago into twelve districts (Wilayah). Each of those has a regional office and is responsible for production and distribution in the area and the infrastructure necessary therefore. With a change in law, starting June 2002, the regions are allowed to develop their own regional electrification plan parallel to the national electrification plan.[46]

3.2.1 Supply

The supply with electricity in Indonesia has to keep pace with the rapid growing demand. In medium terms production of electricity will grow tremendously from

[42] eia: 2002, p. 3.
[43] PLN: 2001, p. iii.
[44] Confidential interview with an industry insider, Jakarta, 24. April 2002.
[45] Botschaft Jakarta: 2002, p. 5.
[46] Confidential Interview, Jakarta, 22. April 2002.

now 93.325 GWh to 191.751 GWh in the year 2010.[47] Djoko Prasetjo and Budi Chaerudin determine that PLN's inability to invest in the construction of new power stations will actually force the Java—Bali system to limit its growth of demand to 4.2 percent until 2005. Then the entire generation capacity will be used up and no reserve margins will be left. With growth rates far beyond this limited growth Indonesia is in pressing need of private investment to the energy sector.[48]

> "Currently, the installed generating capacity in Java-Bali is 18,467 MW. [...] The peak load was 13, 041 MW recorded on 13 November, 2001. While Outer Islands have total generating capacity of 5,421 MW, with total peak load of 3,520 MW. [...], several systems have already experienced power shortages, while some others are having only marginal power capacity reserve."[49]

> "High inflation and reduced economic activity make it difficult for the Government to raise electricity tariffs quickly to meet costs which have risen sharply through the Rupiah's depreciation. As a result, the state-owned utility, Perusahaan Listrik Negara (PLN), is incurring heavy losses. Without reform, it cannot survive."[50]

Generation of electricity consists of various types of power plants. Figure 5 shows the capacity of the specific generation technologies and their share in the total installed capacity. Table 3 illustrates the distribution between regions and generation types on Java-Bali and the Outer Islands.

[47] ACE: 2002.
[48] Prasetjo: 2002, p. 2.
[49] Prasetjo: 2002, pp. 3-4.
[50] ADB: 1999.

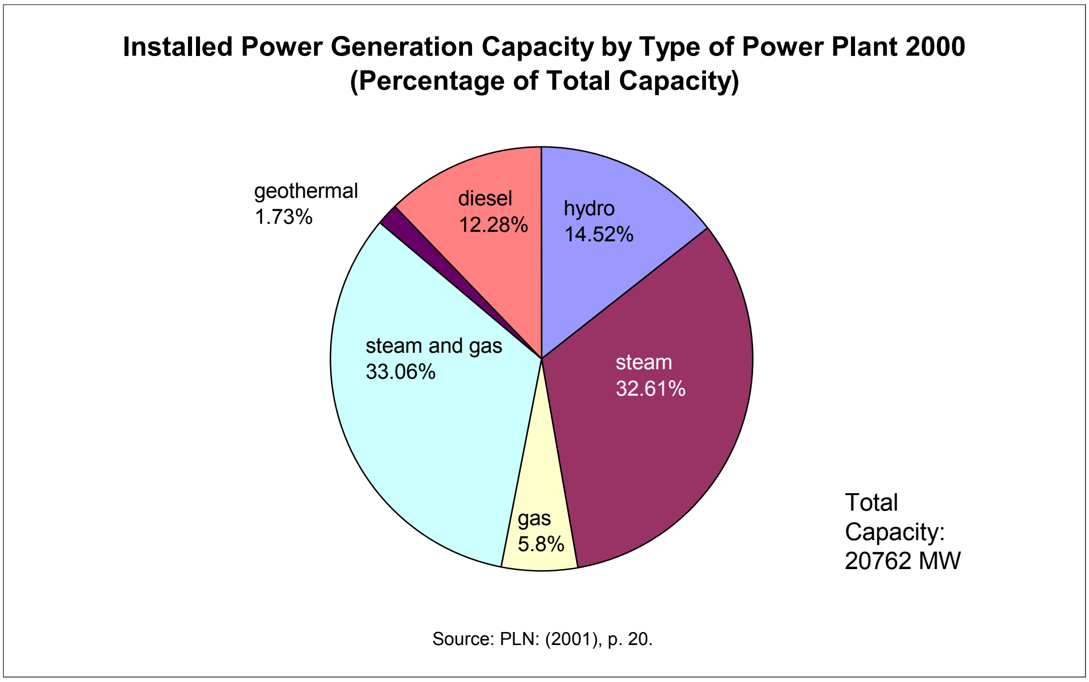

Figure 5: Installed Power Generation Capacity by Type of Power Plant 2000.

Power Plant	Outer Islands	Java-Bali	Total
Hydro	624	2,387	3,011
Combined Cycle			
-Gas fired	878	3,267	4,145
-Oil fired	-	2,136	2,136
Steam			
-Gas fired	-	1,000	1,000
-Oil fired	310	800	1,110
-Coal	590	4,200	4,790
Geothermal	20	360	380
Gas Turbine	558	1,228	1,786
Diesel	2,441	114	2,555
Total	5,421	15,492	20,913

Table 3: Installed Capacity of Generation Plants (MW), end 2001.[51]

A benchmark for the retail price of electricity from coal fired power plants are renegotiated 4.8 US-Dollar cent/kWh for the contract between PLN and PT. Jawa

[51] Source: Prasetjo: 2002, p. 4. Notice the small difference in total capacity compared to the data from PLN's Report 2001 used for figure 5.

Power[52]. Supposedly PLN's own cost per kWh is around 5.5 US-Dollar cent[53]. With an average customer price of 3.7 US-Dollar cent/kWh the necessity of subsidies is obvious. To decrease this gap, electricity prices are being increased at 6 percent quarterly.[54] PLN own statistic lists average generation costs of 1.85 US-Dollar cent/kWh[55] for the year 2000. Costs for each kWh from hydro power are clearly lower with 0.4 US-Dollar cent/kWh, while gas has the highest costs at 4.05 US-Dollar cent/kWh. Electricity from diesel generators was 2.9 US-Dollar cent/kWh in 2000. Yet, this depends very much on the type of diesel fuel combusted and the regional cost of the fuel. Fuel costs may vary more than 100 percent across regions and fuel types. Within the same kind of diesel differences are still enormous. In 2000 High Speed Diesel in Sulawesi Utara cost 158 percent of its price in Medan, northern Sumatra.[56] As subsidies are decreased, fuel costs have become much higher and diesel is now 1000 Rupiah/liter on Java and up to 3000 Rupiah/liter in remote areas where transportation of the fuel adds up to the costs.[57] So diesel generation becomes extremely expensive in some areas and a combination with wind power generation might become economically viable, where energy demand, high fuel prices and good wind conditions correlate.

3.2.2 Demand and Consumption

PLN's statistic of the Indonesian energy market for 2000 includes a list of waiting customers that displays about two thirds of the applicants for a grid connection as not yet served with electricity. Figures for 1998 present the same ratio. It is obvious that PLN confronts a larger demand than it is able to cover. Supply in Indonesia is lower than the actual demand for electrical energy. One result of this is a significant captive power capacity of about 5,000 MW for Java-Bali and close to 3,000 MW for the Outer Islands.[58] Since PLN is heavily indebted and incapable of

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[52] PT. Jawa Power operates Paiton II, one of three coal fired power plants at the Paiton site in eastern Java. With a 50 percent share it is basically a subsidary of Siemens.
[53] Confidential interview with an industry insider, Jakarta, 24. April 2002.
[54] Confidential interview with an industry insider, Jakarta, 24. April 2002.
[55] 148 Rp/kWh at an exchange rate of 1$ to 8000 Rp. The following costs are calculated at the same exchange rate from PLN data of the year 2000.
[56] PLN: 2001, p. 24.
[57] Confidential Interview, Jakarta, 22. April 2002.
[58] see Prasetjo: 2002, pp. 9-10; PLN 2001, p. 26; Dalimi: 2001, p. 95.

providing new generation sources to meet growing demand, these capacities have been identified by PLN to help to supply the PLN's grid. These facilities are mainly stand-by generators privately owned by the industry and could provide additional 400 MW in 2002.[59] But private generation may also contribute to PLN's problems as soon as fuel prices climb to new height due to cuts in subsidies. Those who are self-reliant on generation combusting subsidized fuels so far may then turn to PLN for energy.[60]

PLN sold a total of 79,165 GWh to its customers in the year 2000, spread over four groups of customers as illustrated in figure 6. The group 'others' includes electricity for social institutions, government buildings and public street lightning.

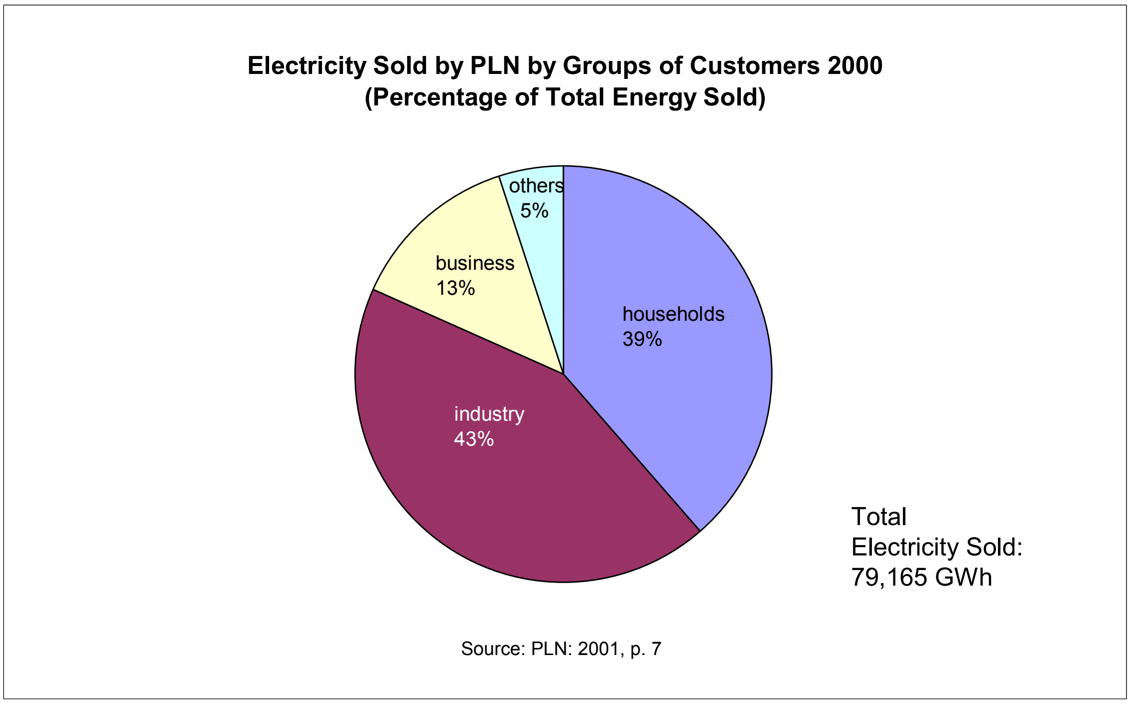

Figure 6: Electricity Sold by PLN by Groups of Customers 2000.

In line with the regional distribution of population energy demand is highest on Java. Almost 80 percent of the electricity sold is purchased within Java. On the Outer Islands about half of the consumption is used up by Sumatra.[61] In many areas demand is outpacing supply with the result of black outs and insecure electricity supply.

[59] Prasetjo: 2002, p. 10.
[60] Botschaft Jakarta: 2002, p. 6.
[61] PLN: 2001, p. 7.

On Lombok, east of Bali, peak loads reach 65 MW while the system is only capable of generating 57 MW.[62]

> "In facing power shortages especially during peak load periods, and to increase the efficiency usage of energy resources, PLN is currently evaluating possibility to launch Demand Side Management (DSM) that requires close co-operation with customers on voluntary basis. It is estimated that on the first stage of DSM programs, it would be able to reduce the peak load of Java Bali system by 140 MW just by introducing energy saving lamps."[63]

At the same time demand is still growing in correlation with but even above Growth Domestic Product (GDP). An annual average growth of close to 10 percent will put further stress on the electricity system.[64] The overall supply is expected to stay behind demand in 2003. In addition, insufficient infrastructure of the power grid makes it impossible to match differences in peak flows across different time zones or regions of different demand curves.[65]

3.2.3 Liberalization of a Growing Market

Liberalization of the Indonesian energy market is necessary for at least three reasons. First, Indonesia's state budget is charged with high subsidies for the electricity sector each year. In 2000 400-500 million US-Dollar[66] put a curb on the national budget, while Indonesia has the lowest energy prices in the region[67]. Prices have to rise, but will only be kept at an acceptable level through competition.[68]

Secondly, without the help in supply from private operators, indebted PLN will not be able to secure the electricity supply beyond the year 2003. Help from foreign investors may only be expected under business circumstances that allow independent operation of power plants. Liberalization from a state monopoly is therefore necessary.

The third reason proposed here is the fact that regional supply has so far been regionally organized, but without proper legal status. It was tolerated wherever PLN

[62] Kompas, 2001b.
[63] Prasetjo: 2002, p. 10.
[64] From Crisis to Sustainable Development: 2002, p. 15.
[65] bfai: 2001, p. 20.
[66] Kompas: 2001a. Depending on the currency equivalent, 3.9 trillion Rupiah mentioned in the Kompas arctile exchange to 400-500 million US-Dollar.
[67] Botschaft Jakarta: 2002, p. 6.

had no grid or was not capable of providing energy at all. Liberalization might give currently private organized supply the opportunity to contribute to regional electrification.

Liberalization is on the way, but not easily realized. In fall 2001 a new electricity bill was expected to pass Indonesia's House of Representatives in March 2002. By that time it was postponed for a June 2002 session. For the investment climate it would be important, that the bill is passed rather sooner than later, but for the basic changes it will impose, a few months are not of much importance:

> "The salient features of the proposed power bill are: 1) PLN will lose its monopoly over the country's power industry; 2) private sector to be allowed to do business in power generation and retailing, as well as with PLN; 3) the government will control power distribution and transmission networks, and charge producers a fee for using them; and 4) all power producers will sell their power to the public through competitive bidding. Producers which offer the cheapest prices will be allowed first access to the government-owned network.
>
> The proposed power bill would allow the country's power sector to adopt a new system called "the multi-sellers and multi-buyers system", with power prices to be determined by free market mechanism.
>
> Presently, there are several sellers and only one buyer, the PLN, which monopolizes the right to sell power to the public.
>
> After the passage of the new bill into law, the government would allow for a seven-year transition period in the most developed regions in preparation for the implementation of the free market system."[69]

Within that period it is probably crucial for future players to gain a foot hold in a later liberalized Indonesian energy sector both on Java and in the provinces of the Outer Islands. The impact of the autonomy of the provinces, "as embodied in Law No. 22/1999 on regional administration and Law No. 25/1999 on fiscal balance"[70] will further push proponents to get their positions right. Local governments will probably soon decide over their medium term regional power mix and the partners they set it up with. Independent Power Producers who already know the market and closely follow recent developments may reach the pole position to enter the liberalized market.

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[68] The above mentioned renegotiation of the Paiton II power project points to a retail price around 5 US-Dollar cent. PLN's internal costs are supposedly slightly higher than the 4.93 US-Dollar cent that have been accepted by Jawa Power.
[69] Jakarta Post: 2001 as quoted in: ACE: 2001a.

3.2.4 Independent Power Producers

Since October 1999 IPPs are part of the Indonesian power sector. With the Paiton I Project (consisting mainly of Edison Mission Energy and General Electric from the US and Mitsui from Japan[71]) the era of absolute monopoly of PLN had ended. Yet, their business did not start out smooth at all, as they had to face judicial disputes with PLN and had to renegotiate their Power Purchasing Agreement (PPA) just as Jawa Power with Paiton II had to.

Since then, the present situation of IPPs has clearly improved. Renegotiations have been successful for Paiton I+II, although at the cost of prolonged return on investment for the power stations. This signals the will for cooperation on both sides. The rescheduling of those PPAs was necessary because of the recent exchange rate changes. IPPs and suppliers of coal and oil are mostly paid in US-Dollars, while PLN's customers pay in Rupiah, which results in a tremendous deficit. PLN's losses exceed the capacity and the political will of the government (and the International Monetary Fund) to fill the gap by subsidies. Under this growing pressure PLN has now managed to restructure its operations and save on operational expenditure.[72] With PLN's huge debt and its need of private investment to jointly guarantee electricity supply in Indonesia, the situation is in favor of the IPPs. So IPPs will have to play an important role in the future supply of electric power.

> "Demand is increasing by 9% in Java and Bali, and 11% in other parts of Indonesia. But, significant need for investment is not matched by the availability of public capital. Therefore there is a need for private sector involvement, yet the existing institutional arrangements are not conducive for private investment."[73]

Indeed, a major stumbling block is Indonesia's bureaucracy. Institutional change is still slow and unpredictable in an insecure political environment. But pressure from growing demand and the lacking ability of PLN to invest, forces Indonesian politics into setting a framework attractive for potential investors. Otherwise not only more than 20 districts already experiencing black outs will sit in darkness, but also

[70] Jakarta Post: 2001a.
[71] bfai: 2001, p. 8.
[72] Prasetyo: 2002, p. 9.
[73] From Crisis to Sustainable Development: 2002, p. 15.

Java-Bali, presently the most reliable power system, will see lights out.[74] The reforms presented in the above part on liberalization give hope for a more stable and reliable environment in the near future.

Generally those who want access to the grid have to be allowed in. Contracts are negotiable, but tariffs for electrical power, electricity transmission and distribution often cause problems. For industrial estates[75] or for isolated towns, IPPs can operate their own local and limited grid and even sell electricity to PLN. In other areas of low or no PLN presence in the grid, too, IPPs are already allowed to take over the electricity supply entirely. Build-Operate-Trade (BOT) agreements, common with the above mentioned IPP projects, then may include transmission and distribution. But this possibility has not been tested in reality, yet.[76]

3.2.5 Power Grid

In Europe the transcontinental power grid enables net work operators to buy and sell energy from Gibraltar to the North Cape. In Indonesia, that stretches even further from Sumatra to Irian Jaya, a long distance transmission grid is only existent on Java-Bali, resembling maybe France or Germany. Support from Sumatran power plants for the Java-Bali grid or potentially even Kalimantan and Sulawesi is impossible to date. But power transmission within regional systems can have significant results on efficiency and reserves.

> „It follows from this that the total short term reserve requirement for each subsystem is reduced when several subsystems are integrated into one. It is also obvious that several small subsystems have more to gain with respect to reserve requirement than large subsystems. This depends on the fact that in a small system, the largest unit is probably larger in relation to total system capacity than in a large system.“[77]

Indonesia is short of reserve margins throughout most of its regional systems. Investment is rare both domestically and from abroad, so power plants will be realized at the cheapest sites for the next few years. This includes repowering of power plants mainly on Java with the consequence that power has to be transferred to re-

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[74] Jaensch: 2001, p. 3.
[75] An insider from the electricity industry mentions two projects: Cikarang Listrik Indonesia and Texmaco in Karawan, West Java.
[76] Jaensch: 2001, p. 4.
[77] Wangensteen: 2001, p. 4.

gions of shortages such as southern Sumatra. To be able to fight black outs Indonesia is constructing a Java-Sumatra connection via sea cable until 2005.[78] Similar developments take place in sub regions of Kalimantan and between Bali and Java to enlarge transmission capacities. The 500 kV grid on Java is almost complete and should be fully operating in late 2003.[79] On Sulawesi, Kalimantan and Sumatra some 150 kV and 275 kV circuits do exist, but they are also only regional systems. Connections of 275 kV in between Sumatra's sub regions are not planned before 2007.[80] Sulawesi has partial capacities up to 150 kV. On the Moluccas, Nusa Tenggara and Irian Jaya only distribution circuits up to 20 kV do exist.[81]

In an article on the interconnection of isolated power grids Ivan Wagensteen concludes for different countries, what definitely also applies for the vast sub regions of the national electricity grid in Indonesia:

> "One important aspect in a competitive setting is how different factors affect market price. If one country has a surplus of cheap electricity and correspondingly low prices and another country has comparatively high generation cost and high prices, it is evident that an interconnection will affect the price level in the two countries. On the low price side the price will go up and on the high price side the price will go down. So generators in the low price country will probably benefit from an interconnection and generators in the low price country will suffer. The consequences for the electricity consumers will be vice versa."[82]

In fact, regional autonomy, with local parliaments striving to control their own energy supply, may bring Indonesia even closer to the situation described by Wangensteen than its sub regions already resemble.

Grids in Indonesia have to grow mature. Yet, in some areas it might be an alternative to concentrate on expansion in the grid for distribution and install small local power plants instead of investing into long distance transmission and then depend on centralized power generation far off the own region. Here again, the autonomy of the provinces could interfere and may support such a strategy.

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78 ACE: 2001b. Actually two lines are under way. An AC 150 kV with a capacity of 200 MW is currently under construction and "To transfer 1,120 MW (4 x 280 MW) of power by bipolar two circuit operation in long term [...]" a submarine cable DC 200 kV link is planned.
79 Confidential interview with an industry insider, Jakarta, 24. April 2002.
80 Prasetjo: 2002, p. 6.
81 PLN: 2001, pp. 27-28.
82 Wangensteen: 2001, p. 3.

3.2.6 Electricity Outlook

Indonesia has a population of 207 million people. It has grown rapidly at 1.8 percent annually since 1980[83] and there are practically no signs of a slow down, resulting in an estimated population of more than 250 million inhabitants by 2010. With 79,165 GWh consumed in 2000, each Indonesian accounts for an average of 382 kWh per year. Therefore these additional 43 million people would consume further 16,426 GWh at steady per capita consumption but in fact almost 100 percent increase, or approximately 186,000 GWh in demand are expected for 2010.[84] Thus, PLN estimates supplementary 18,865 MW necessary to meet 2010‘s demand. Presently this growth in capacity is planned for as listed in table 5. The development of demand and capacity for the Java-Bali grid until 2004 is forecasted as shown in table 4. The peak loads included illustrate the urgency of action. With a current failure rate of 10-20 percent, Indonesia will experience problems in 2003.

	2000	2001	2002	2003	2004
Installed Capacity (MW)	18,608	18,608	18,608	18,608	19,928
Peak Load (MW)	12,231	13,326	14,392	15,680	17,200
Reserve Margin (%)	52	40	29	19	16
Additional Capacity Required* (MW)	---	---	102	1,776	2,432

Table 4: Capacity and Demand Forecast on the Java-Bali Grid.[85]
* to maintain a minimum reserve margin of 30 percent

[83] FEER: 2002, p. 12.
[84] DESDM: 2002, p. 10-18.
[85] Source: Confidential information from an industry insider, Jakarta, 24. April 2002. Of the installed capacity a 10-20 percent rate of failure has to be admitted: Confidential interview with an industry insider, Jakarta, 24. April 2002.

Power Plants	Additional Capacity			
	Jawa-Bali		Outer Islands	
	MW	%	MW	%
Hydro	1000	7.9	1829	29.1
Steam Coal	6720	53.4	1230	19.6
Geothermal	0	0.0	81	1.3
Combined Cycle	2220	17.6	666	10.6
Gas Turbine	2640	21.0	2000	31.8
Diesel	0	0.0	479	7.6
Total	12580	100.0	6285	100.0

Table 5: Required additional generation capacity until 2010.[86]

To accomplish this expansion of more than 90 percent of the current capacity Indonesia is in search of adequate mechanisms. PLN will contribute new power plants if it is able to recover from its present debt. Captive power will be activated to be fed to the public grid. The investments will total several billion US-Dollar within the next ten years. [87] The General National Electrification Plan, Rencana Umum Ketenagalistrikan Nasional (RUKN), for 2002 lists a total of more than 33 billion US-Dollar of investments needed: almost 19 billion US-Dollar for power stations, 3 billions for transmission and relay stations, 5.2 billions for distribution and 6.2 billions for rural electrification. The plan only includes Nanggro Aceh Darussalam and Northern Sumatra to be electrified 100 percent by 2010. Most other areas are supposed to see an increase anywhere between 25 percent to 100 percent from their current status. In total this equals 8,847 villages to be electrified.[88]

As mentioned before IPPs will also pitch in their share. However, institutional arrangements as well as economic development will be decisive for that. An instrument that the Indonesian government is recently pushing to the front are small scale power projects implemented on private or community basis. An internal paper from the Directorate General of Electricity and Energy Development, still a draft in spring 2002, has been used for this study. It has the title ‘SKEMA PSK TERSEBAR’ or ‘Pembangkit Skala Kecil Teknologi Energi untuk Rakyat dengan Sumber Energi Ter-

[86] Source: Prasetjo: 2002, p. 4.
[87] According to an article in FEER, 28 Octorber 1993, 49.5 trillion Rupiah (23.57 billion 1993-US-Dollar) will be required in the periode from 1999-2009. See also: Botschaft Jakarta: 2002, p. 1.
[88] DESDM: 2002, pp. 12-29. For the costs see p. 29.

barukan', which translates to 'Spreading Small Scale Power Generation' and 'Small Scale Power Generation Technology for the People using New and Renewable Energy Sources' respectively. On 12. June 2002 the paper was signed and is now valid for action.[89] The program aims at contributing to the installed generation capacity and introducing environmentally sound energy technology. It is supposed to follow a line of action taken by both PLN and the people:

1. The utility PLN declares its true cost of supply/prime costs for low and medium voltage power grids.
2. The people (small business, individuals, co-operations) build small scale power stations up to 10 MW and connect them to the grid.
3. The utility PLN buys the produced power slightly below true costs of supply/prime costs.
4. Prime costs will be determined by regional PLN offices.
5. The type of small scale power generation plant implemented will depend on the potential of new and renewable energy sources in the region.

The paper stresses four beneficiaries of the program:

1. The nation profits from conserving its natural resources by utilizing renewable energies, deploys an industry in support of the energy sector and generates new employment.
2. PLN expands its ability to serve demand without additional costs and still earns a small margin.
3. The people as producers gets business opportunities and as consumers it gets sufficient energy supply.
4. The environment suffers less from emissions.[90]

[89] GTZ: 2002. The paper signed only allows for small-scale power plants up to 1 MW, while the draft still proposed 10 MW as the top limit.

[90] DJLPE: 2002. Internal paper from the Directorate General for Electricity and Energy Development; translated from Indonesian. A more detailed draft including precise proceeding directions for various organizations involved has been in circulation during spring 2002.

Some projects have already been implemented under the framework of PSK. Regional Non Governmental Organizations (NGO) have specialized on the realization of small scale power generation projects. Under the PSK "Purchase tariffs will be calculated at 80 and 60% of PLN's announced 'Electricity Base Price' (Harga Pokok Penjualan - HPP) for interconnection at medium and low voltage respectively.[91]

With the ongoing developments, the energy mix of electricity generation will change significantly over the next ten years. Figure 7 displays its projected composition in the year 2010.

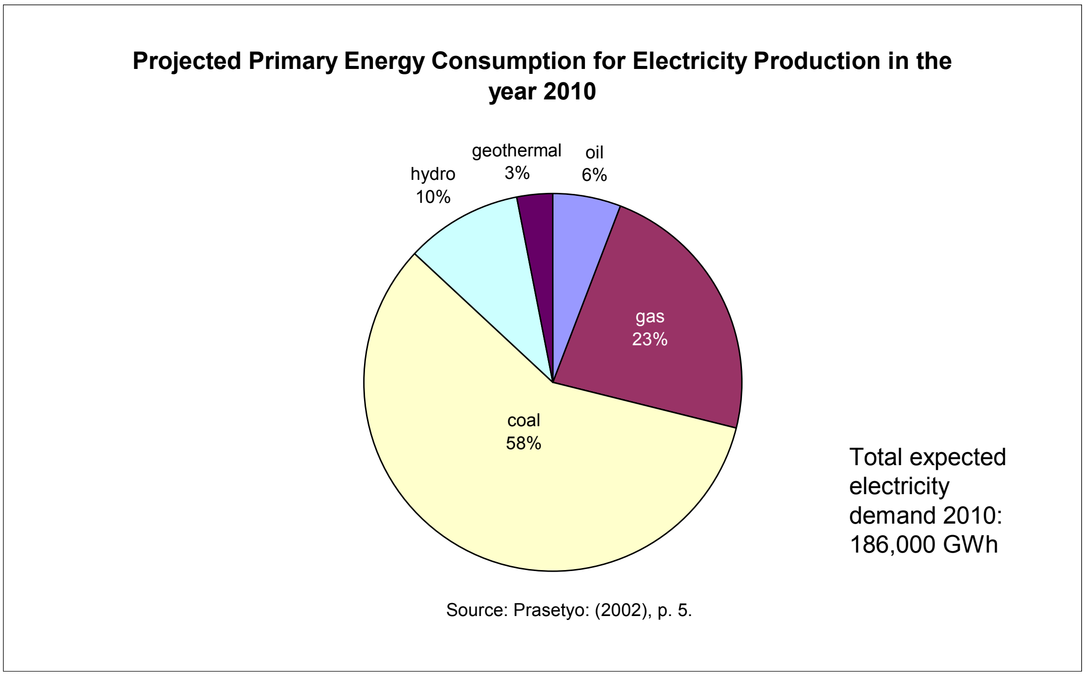

Figure 7: Projected Primary Energy Consumption for Electricity Production 2010.

The share of renewables is proclaimed to stay the same. Contributions from gas and oil will decrease while coal, as the long lasting fossil energy resource, will grow by nearly 70 percent.

This still predominantly fossil energy mix illustrates the obvious need for further renewable energy sources. Restricted resources of oil and gas, dependency on foreign currency income from those (plus coal) and commitments to international cli-

[91] GTZ: 2002. For example IBEKA – Institut Bisnis dan Ekonomi Kerakyatan [Business and People's Economics Institute] is an organization in Bandung that installs mini hydro generators and educates staff for their maintenance. Another NGO operating a mini hydro power plant is the `Lembaga Pemerhati Wanita, Anak dan Lingkungan (LPWAL)`, [Organization for Women's, Children's and Environmental Concerns].

mate conservation treaties suggest that every kWh from renewables is, in any way, a net profit for Indonesia.

4 The Prerequisites for Using Wind Power

For wind turbine generators (WTG), just as for conventional power plants, certain requirements have to be met before any current flows from the generator. Customary power stations are capital intensive. For their sheer size, they need maintenance and most important of all, they demand some kind of fuel. At the Paiton site in Indonesia, for example, a large harbor for coal vessels, serving PLN's, Jawa Power's and Paiton I's power plant had to be part of the investment. A constant flow of coal from the nations coal mines is essential for operation.

For wind power, of course, it is the flow of wind that has to be guaranteed. The foundation of a WTG may only be laid where the wind conditions, the constant provision of a plants fuel, is ensured. Yet, sometimes the perfect site for a WTG may not be the first choice of the people affected. Social and cultural obstacles are not part of wind power's history but it is still recommendable to investigate the local circumstances first to know reservations within the population to avoid frustrations. Finally laws and regulations from the government, both regional and national, should be considered for potential projects.

4.1 The History of Wind Power Application

Wind power has been utilized by mankind since ancient times. Sailing ships have crossed the oceans thousands of years ago. It is believed that Egyptian sailors travelled as far as from Africa to South America.[92] Along the far stretching coasts of Indonesia, that also has the name "Below the winds"[93], sailors have formed the viable grid for many centuries.

Wind application as a technical tool also reaches back far into time. In Indonesia it might have been the Chinese who brought wind power applications to the area; since they have had trading connections to the Indonesian archipelago dating back

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[92] Sustainable Energy Authority: (2001), p.1. For the contribution of sailing nations and their sailing techniques see Thor Heyerdahls studies, for example his book "Kon Tiki". Heyerdahl's thesis' are not unchallenged, yet they emphasize the early achievements in wind power application for sailing.
[93] Ibrahim: 1688 as quoted in Reid: 1988, p. 1.

into prehistoric times.[94] One could assume that their early knowledge of wind mills in the fourteenth century might have reached Indonesia, too. Yet, we have no evidence of any Chinese wind mills in Indonesia prior to the Dutch arrival, even though there were animal-driven and water-powered mills.[95] Thus the introduction of wind mills has to be attributed to the Dutch.

> "I argue that the introduction of Dutch mills in the seventeenth and eighteenth centuries could be regarded as a 'first mechanical revolution' in the relevant parts of Asia, particularly in and around Batavia, the Jakarta of today. However, I hasten to add [...] that it was a fairly slow process, and a revolution on a very limited scale. It may be assumed that it was also a 'revolution' with a rather modest impact."[96]

Dutch wind mills were only used for wood sawing on Java. There is no evidence that they have been installed for sugar processing or water pumping either on Java or on the Outer Islands. Saw mills were first introduced in 1675 in the Bay of Jakarta, formerly known as Batavia, to support work at the dockyards. This lasted throughout the 18th century. Outside of Batavia two other mills are recorded in Demak and Tegal. All mills have suffered a great deal from British attacks on the dockyards in the bay and local upheavals at the other sites. The costly investment to set up wind mills thus was challenged by turmoil and destruction.[97]

Proof on continuous use of wind powered mills was not available for the 19th century. In 1970, when he first went to Jakarta, Tjarinto S. Tjaroko, Co-Director of the ASEAN Center for Energy, tells a number of mills still working in the Jakarta region. He mentions five or six multi-blade mills used for water pumping and specifies two sites in Rawamangun and Sawer.[98]

After the oil crisis' in the 1970s the development of renewable energy sources was on the agenda in Indonesia as much as anywhere else in the world. Of course wind power was investigated, Isril Haen, for example, now working for Lembaga Ilmu Pengetahuan Indonesia (LIPI), the Indonesian Institute of Sciences, developed individual WTGs of the Savonius type. Blades of 2.5 meter height and a diameter of 1.8 meter were made of zinc and placed on top of a 3 meter lattice tower. They were capable of pumping water from an altitude three meters below the water pump placed

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[94] Hall: 1994, pp. 3-11.
[95] Boomgaard: 2000, p. 6; see also Djojodihardjo: 1979, p. 2.
[96] Boomgaard: 2000, p. 4.
[97] Boomgaard: 2000, p. 6-7.

at the foot of the tower. At a wind speed of 3 m/s spinning at 60 to 70 rounds per minute the mill pumped about 1-1.5 liter of water per second. Its cut in wind speed was at 1 m/s when the pump was connected and 0.5 m/s without any application. Two installations of that kind were set up under a government program called Pegembangan Technologi Berdesaan[99] near Brebes, Java during 1980 and 1982.[100] They had the name PAKAROS for Pompa Air Kincir Angin Rotor Savonius[101].

A few years earlier Tjarinto S. Tjaroko was experimenting with wind power in the Yogyakarta region at Parangtritis beach. His main problem was the deterioration of the material due to corrosion from the salty winds. Data from this project is not available any more. Supposedly research has been continued by LAPAN.[102]

A co-operation between LAPAN and the German Institute for Aviation[103] had set up two WTG of the type Aeroman 11 kW in Samas, Yogyakarta and in Citeireum, West-Java in the 1980s. They were run for demonstration and testing purposes.[104]

> "Other villages are experimenting with wind as well, according to Prof. Sastroamidjojo of the Solar Energy Research Centre at Gajah Mada University in Jogjakarta, who presented a paper this summer at an Asian studies conference in Australia. In the Javan community of Ciparanti, a 2-kW turbine manufactured by Australian firm Survivor Energy Systems serves two mosques, two Islamic schools, an office, a community center, and 48 households, and in another Javan village, Bulak Baru, a Dutch 2.5-kW unit is installed and operating in a project coordinated by Indonesia's aerospace institute LAPAN."[105]

To the author's knowledge the project in Ciparanti has been canceled and the Survivor turbine moved to Jepara, where LAPAN is testing various kinds of WTG. Yet, conclusions for the first five months from an evaluation study by LAPAN are: the system has been successfully tested; it was a stable supply of energy; local people without previous knowledge in technical maintenance were able to maintain the system; and it could be set up without heavy equipment.[106] The installation in Baluk Baru is also referred to by Martin Moeljono, however it is not clearly listed in a compilation

98 Interview with Tjarinto S. Tjaroko, Jakarta, 18. April 2002.
99 Development of Rural Technology.
100 Interview with Isril Haen, Bandung, 25. April 2002.
101 Wind Powered Water Pump Rotor Savonius.
102 Interview with Tjarinto S. Tjaroko, Jakarta, 18. April 2002.
103 Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt.
104 Moeljono: 1998, pp. 58-59.
105 Wind Energy Weekly, 7 November 1994 as quoted in RSVP: 1995.
106 LAPAN: 1993, p. 8.

of wind-based power units in the "Energy Outlook & Statistics" by the University of Indonesia.

Prof. Sastroamidjojo himself is running a foundation near Yogyakarta, Java, that constructs wind turbines of the Savorius kind for water pumping. He is convinced that low-tech application is the only way to introduce wind power to Indonesians.[107]

Wind power projects have been ongoing for the last two decades in Indonesia. Some are research and development projects. Some are for commercial purposes. Obviously not all have been accurately recorded or published. However the historical development displays that wind power applications are part of the Indonesian research on power development and known to the scientific community even though the applications are at low technical development standards. During the interviews conducted for this paper Indonesian scientists were highly interested in new developments as presented in company brochures on current WTG. Some of them left the impression with the author and some frankly stated, that the performance of WTG with rated power over 1 MW was new to them.

More recent developments of projects still in place and operating will be illustrated by the existing wind power applications in the following section.

4.2 The Existing Stock of Wind Turbine Generators

The most comprehensive list of wind turbine generators (WTG) applied in Indonesia is currently found in the University of Indonesia's "Energy Outlook & Statistics"[108]. For Java it compiles 31 sites with up to 12 WTGs each and 24 sites with up to 104 WTGs on the outer Islands including Bali. Only five are directly used for water pumping while all the others generate electricity for various applications besides pumping, such as lighting, public TV, battery charging and communication. Refrigeration and desalination are listed for two sites. Throughout Indonesia there are a total of 641 WTGs. The majority of them have capacities of less than 10 kW, while a few reach 14.4 and 15 kW. None are installed that resemble several hundred kW or even MW loads like WTGs now commercially applied in large numbers in Europe, North America and also India.

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[107] Visit to the foundations construction shop, meeting with Prof. Sastroamidjojo, Yogyakarta, 05. April 2002.

Indonesia’s wind power ambitions are of consistent but limited character. The capacities of installations have not markedly changed since the early 1980s while in other parts of the world wind power has experienced a rapid development. Lack of finances and low technical standards are the main obstacles for greater use of modern technology. Yet, wind conditions are not the worst in some areas and still have to be better explored.[109]

> “In other Indonesian wind news, Westinghouse Electric Corp. has had success with hybrid systems in three villages there, according to Art Lilley at Westinghouse. ‘Hybrid power systems integrate renewable energy technologies with diesel generators, batteries and inverters to provide 24-hour AC power to remote communities,’ Lilley writes in a soon-to-be-published article.
>
> Lilley noted that in 1991 Indonesia's Agency for the Assessment and Application of Technology (BPPT) contracted with Westinghouse subsidiary Integrated Power Corp. (IPC) to electrify the three villages, all of which are located on Indonesia's eastern islands. The communities chosen were Julingan and Tanglad, two neighboring settlements on the island of Nusa Penida near Bali, and Bonto on Sumbawa Island, which is several hundred miles to the east. All three are comparably sized, with about 200 homes and 1,000 inhabitants apiece.”[110]

Besides these, there are only two explicitly described wind hybrid systems listed in the data on wind power in Indonesia. In addition to the above-mentioned projects by IPC, another one exists in Sukabumi, West Java, and there was – though it is still listed in the University of Indonesia's statistic- a system in Ciparanti, West Java, that has been cancelled as already mentioned in the section on wind history. The WTG in Sukabumi is the only hybrid system privately owned.[111] Generally WTGs are run by the state or run for scientific research. Only three projects on Java and four on the Outer Islands are private initiatives. The largest consists of eight 0.10 kW WTGs in Toraja, South Sulawesi, a mountainous area with passes prospective for wind power.

BPPT has prepared a Renewable Energies Database that also gives an insight into existing wind power use as well as to the potential of wind throughout the archipelago. According to Dr. Ir. Didik Notosudjono Msc of BPPT it is supposed to go

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108 Dalimi: 2001, pp. 114-115.
109 See the following chapter on the wind regime.
110 Wind Energy Weekly, 7 November 1994 as quoted in RSVP: 1995.
111 Dalimi: 2001, p. 114-115.

online soon.[112] The website has a good lay-out and gives fast access to the data supplied. Yet, the web page has some shortcomings from the author's point of view. The pre-sentation does not distinguish between existing sites and measurements of wind potential, so the user cannot detect on the general map whether upon his mouse click he is going to look at implemented projects or data on the potential of wind power. Furthermore, in the current version, data on the sites of implementation most often fail to show the average annual wind speed. Presenting the wind data would make the entire database more complete. A glossary of Indonesian abbreviations would also be of great help to users from abroad.

Compared to the rapid development of wind power in other parts of the world, development in Indonesia is stagnant; but continuous research and repeated pilot projects keep a window open to introduce more sophisticated systems. With the growing gap between power demand and supply Indonesia will invest several billion US-Dollars into its power plants within the next ten years. WTGs may be financed where appropriate wind conditions make their utilization applicable.

4.3 Indonesia's Wind Regime

Some studies on prospects of wind power utilization in Indonesia offer very general figures on the wind conditions such as 3-5 m/s average wind speeds for the whole of Indonesia. The statement itself may be correct; but even if specific islands are mentioned in particular, these reports are not of much help. Indonesia covers a region that, projected on Europe, stretches from Gibraltar to the North Cape. Wind patterns are not of such extensive character and have to be described more precisely. The fact is that so far Indonesia's wind potential has not sufficiently been studied to come up with details. Yet, even the study with largest number of sites measured, by Badan Meteorologika dan Geofisika (BMG), the Indonesian Meteorology and Geophysics Agency, only provides data from 70 meteorological stations. The German Meteorological Service in comparison measures at 350 locations for Germany alone.[113] In addition it is hard to find out about local conditions at measurement sites. To the author's knowledge for example, some are at airports that are

[112] Interview with Dr. Ir. Didik Notosudjono Msc, Jakarta, 23. April 2002. I am grateful to Dr. Notosudjono that he kindly provided me with the unpublished website.

usually not constructed at locations exposed to strong winds. Readings from such locations probably won't deliver appropriate data for the region.

However, these reservations in mind, the wind data for Indonesia may still give some preliminary insight into the nation's wind regime. There have been measurements conducted by three different national institutions. BPPT has contributed data from 10 sites. BMG has compiled information from 70 meteorological stations nationwide for the period from 1975 to 1989 and from 1990 to 1995. LAPAN has carried out an investigation in 28 locations. The National Renewable Energies Laboratory (NREL) in the United States in cooperation with USAID and Winrock International has prepared wind maps for Sumba and West Timor. In addition, a minor source of data by BMG from 1974 could be included into this study.

BPPT's data was collected during research on solar radiation for the use of photovoltaic systems. Readings from eight sites with maximum and minimum wind speeds are as follows: "Serpong (2,6 m/s; 0,1 m/s), Pontianak (1,5 m/s; 0,4 m/s), Banjarmasin (1,9 m/s; 0,2 m/s), Samarinda (1,9 m/s ; 0,1 m/s), Manado (2,8 m/s; 0,2 m/s) Palu (3,5; 0,8 m/s), Maumere (3,9 m/s; 0,7 m/s) and Waingapu (3 m/s; 1 m/s)"[114]. These results are not of much interest as they have been concluded from singular measurements of only one hour duration with six month intervals.[115]

BMG's readings listed in the appendix are from an altitude of 24 meters. In the period from 1990 to 1995, 70 locations were included in their measurements. Unfortunately, the data does not cover the entire period, but was collected at the various sites during this time. For all the data in the appendix, derived from the previously mentioned University of Indonesia statistics, Martin R. Moeljono and Harijono Djojodihardjo, no circumstances under which the measurements were collected are stated. For measurements by BMG from the 1970s, Didik Notosudjono along with Harijono Djojodihardjo criticizes inappropriate locations, inadequate anemometer technology and gaps of up to one hour in between the single readings. This data therefore has to be interpreted very carefully.

Since 1998 BMG also conducts a daily wind prognosis. It is a large scale forecast based on satellite data from a Japanese satellite ADEOS. However, its data is

[113] Deutscher Wetterdienst: 2002.
[114] Notosudjono: 2000, p. 38.
[115] Notosudjono: 2000, p. 38.

not useable for wind power research. Yet it displays an important aspect in that it reveals that Indonesia does not lie within the typhoon corridor of either the Indian nor the Pacific Ocean. This piece of information is certainly interesting for feasability of wind power plants, for loan agreements, securities, as well as for insurance considered for potential future projects.[116]

The most promising wind data project has been realized by LAPAN. It concentrates on the eastern provinces of Indonesia since the data from BMG, insufficient as it may be, suggested the best prospects for wind power utilization in those areas.[117] Its readings shows intervals of 10 minutes, and for 12 sites covers a total of twelve months. It reveals that true annual average wind speeds for any location within Indonesia appear to exist only at these twelve locations (No. 1-12 in table 6).

No	Site location		Year of Instal-lation	Period of Measure-ment	Average Wind Speed m /sec		Period of Measure-ment	Average Wind Speed m /sec		
					10 m	24 m		10 m	24 m	15 m
1	Bulak Baru – Jepara	Java	1993	Jan – Dec` 94	3,9	4,6	Jan – Aug` 95	3,8	4,3	
2	Nangalabang – Manggarai	NTT	1993	Jan – Dec` 94	2,6	3,6	Jan – July` 95	2,2	3,2	
3	Bungaiya Selayar	South Sulawesi	1993	Jan – Dec` 94	3,7	4,9	Jan – Sep` 95	4,1	5,2	
4	Nangalili - Manggarai	NTT	1993	Jan – Dec` 94	3,7	4,5	Jan – Aug` 95	3,6	3,9	
5	Komodo - Manggarai	NTT	1993	Jan – Dec` 94	2,7	2,8	Jan – July` 95	2,3	2,7	
6	Pasir Putih – Manggarai	NTT	1994	Jan – Dec` 94	1,7	3,5	Jan – July` 95	2,7	3,1	
7	Doropeti - Dompu	NTB	1994	Jan - Dec` 94	3,1	3,6	Jan – Jun`95	2,9	3,5	
8	Bajo Pulau - Sape	NTB	1994	Jan – Dec 94	3,1	3,5	Jan – Jun`95	3,0	3,1	
9	Sambelia - Lotim	NTB	1994	Feb – Dec 94	3,2	4,0	Jan – Jun`95	2,5	3,7	
10	Tembere - Lotim	NTB	1994	Feb – Dec` 94	3,8	4,0	Jan – Jun`95	3,1	3,5	
11	Maubesi - Rote	NTT	1994	Feb – Dec` 94	3,2	4,3	Jan – Aug` 95	3,5	4,0	
12	Nangara Laut Kendari	Southeast Sulawesi	1994	Nov - Dec` 94	1,1	1,8	Jan – Sep` 95	1,4	2,2	2
13	Tinobu – Kendari	Southeast Sulawesi	1994	Dec 1994	1,8	2,1	Jan – Sep` 95	1,6	2,1	2
14	Paudean - Bitung	North Sulawesi	1994	Dec 1994	2,4	2,5	Jan – Sep` 95	2,2	2,9	2,6
15	Libas – Minahasa	North Sulawesi	1994	Dec 1994	2,6	2,9	Jan –Mar` 95	3,1	3,1	3

116 Moeljono: 1998, p. 57.
117 Wibawa: 1996, p. 28.

16	Palakahembi	East Sumba	1994	Dec 1994	3,0	3,5	Jan – Sep` 95	3,7	4,8	3,5
17	Watumbelar	East Sumba	1994	Dec 1994	2,1	2,4	Jan – May `95	2,1	2,5	2,6
18	Unpati Ambon	Molucca	1995				Jan – Sep` 95	1,5	1,8	1,6
19	Namaelo	Molucca	1995				Jan - Aug` 95	1,7	1,9	1,7
20	Selayar Lotim	NTB	1995				Jan - Sep` 95		2,7	1,6
21	Giligede – Lobar	NTB	1995				Jan - Sep` 95	3,9	4,2	3,4
22	Nangadoro, Dompu	NTB					Jun - Aug` 95	3,7	4,7	
23	Pai – Bima	NTB	1995				Jun - Aug` 95	3,8	4,4	
24	Sajang – Lombok Timur	NTB	1995				Jun - Aug` 95	3,7	4,8	
25	Kute Lombok Tengah	NTB	1995				July - Sep` 95	3,7	4,7	
26	Sibuwoli Ngada	NTT	1995				Jun - Aug` 95	2,7	3,7	
27	Ujung Manggarai	NTT	1995				Jun - Sep` 95	2,9	3,1	
28	Papagarang Komodo	NTT	1995				Jun - Aug` 95			

Table 6: Wind Data by LAPAN.[118]

Two maps are included in the appendix, that show the wind potential for Sumba and West Timor as calculated by the US' National Renewable Energy Laboratory (NREL). These results seem very promising, yet the author cannot judge the validity of this research. The participating partners(NREL, USAID and Winrock International) have considerable experience in wind power projects.

The report from the wind-diesel-hybrid project in Ciparanti, Java, gives daily average wind speeds for five months, from May to September 1993 with the following distributions of monthly averages: May 3.34 m/s, June 3.30 m/s, July, 3.46 m/s, August 5.19 m/s and September 4.01 m/s.[119] However, only year-round observation is suggested to provide relevant data of an annual average wind speed. The south-westerly monsoon supposedly picks up in June and lasts until September, but 1993's data shows it as delayed until August. Thus full year coverage is essential.

[118] Source: Notosudjono: 2000, p. 39. The data has been crosschecked by the author with the original data from LAPAN during research in Jakarta, April 2002. It is also in accordance with the data presented by Moeljono: 1998, pp. 83-86.
[119] LAPAN: 1993, pp. 12-16.

Three conclusions may be drawn from all these measurements.

1. Several locations in Indonesia show good to excellent potential for wind power application.[120]
2. Vast areas of the Indonesian archipelago are not sufficiently invested for the use of wind power.
3. Further research is necessary to map Indonesia' s wind potential as a base for commercial utilization of wind power.

According to the maps from the NREL, both Sumba and West Timor should consider developing part of their energy supply in wind power. The LAPAN measurements show that the following locations should review their energy supplies and further check their local potential for wind power: Jeparang on the north coast of Central Java, Kalianget and Madiun in East Java, Bungaiya Selayar in South Sulawesi. The above-mentioned data from BMG for 1974 referred to by Harijono Djojodihardjo suggests rechecking the conditions in South Sumatra and Aceh. Yet those are closest to the equatorial calms adjacent in the west of Indonesia. The 1974 BMG data compared to the measurements from the 1990s further suggests for Denpasar to crosscheck the results. There is a large gap between the first reading of an annual average wind speed of 4.33 m/s and 2.39 m/s in 1992.

Thus diversification of the energy supply including wind power can be an option in certain regions of Indonesia and may be promising in further districts. From the present situation of the wind data it may be concluded that its implementation can be considered, but will have to await more detailed wind studies to guarantee the right choice of sites and to avoid negative impact on the developement of wind power in Indonesia due to insufficient information.

4.4 Prospects for the Implementation of Wind Power

In the short run prospects for wind power in Indonesia are not very good for several reasons. The above reviewed data on the wind regime is not sufficient. Research for more detailed information will take time and is not available in the near future. From political and economic points of view, the higher cost of renewable energies in comparison to conventional energy sources draws the consequence of further fossil energy use as the first choice. Large amounts of national resources in coal, oil and gas support this argument. Furthermore renewable energies in Indonesia, as much as anywhere else, are still often perceived as energy sources not capable of contributing a considerable amount of energy to the national supply. The fact that renewable energy technology is mainly to be imported is just another of the disadvantages of the Indonesian market. A major obstacle to any investment in the Indonesian power sector is the centralized bureaucracy. Tjarinto S. Tjaroko complained in the interview that an investor has to fly to Jakarta personally even for small investments of ten thousand US-Dollars, for permissions for power grid connection and further papers from the DJLPE. This adds to the cost and thus discourages any initiative for low scale investment.[121] Yet, with the autonomy of the regions this may change, and there are also other recent developments that offer a more promising perspective on the prospects for wind power in Indonesia.

Energy is at the forefront of the assessment on sustainable development strategies as well as on the political agenda. Politicians regard it as a basis for social and economic development and also as a central concern for future ecological prosperity of Indonesia. The reduction of subsidies on fuel prices has more than once led to upheaval on the streets throughout the archipelago. However, even with growth outpacing installed capacity by 2003, affordable energy has to be guaranteed, while prices have to meet true costs of supply. Air pollution from outdated power plants as well as from thousands of diesel generators has to be tackled as Indonesia's energy consumption is growing steadily by 8.9 percent per year.[122] In addition, political commitments in the international arena such as the participation in the UNFCCC set the agenda in favor of renewable energy for Indonesia.

Of course, its realization is far from a breakthrough. But programs such as "Spreading Small Scale Power Generation"(PSK) with projects of up to 10 MW pre-

[120] Interior WTG sites in Germany have average wind speeds between 4-5 m/s. This may be viewed as a benchmark for acceptable wind conditions. Yet, insiders from the wind energy industry suggest wind speeds no lower than 6 m/s for interior sites of WTG. Erneuerbare Energien: 2001, p. 35.
[121] Interview with Tjarinto S. Tjaroko, Jakarta, 18. April 2002.
[122] Council for Sustainable Development: 2002, p. 5.

pare an investment climate in favor of wind power. The RUKN includes wind as a primary energy source in the plan for diversification of the electricity supply through PSK.[123] The positive developments in Europe, the USA and India might signal Indonesian decision-makers the feasibility of wind power projects. Experiences from pilot projects in Indonesia further enhance that development and should be supplemented by international experience in hybrid systems.

> "Hybrid Power Systems
> Lessons Learned
>
> • Nothing is maintenance-free. A maintenance support infrastructure must be established and nurtured from the very conception of a project.
> • Repairing equipment in remote locations is difficult and expensive. Multiple systems in a region are required to develop and sustain a cost-effective support infrastructure.
> • Retrofitting expensive hybrid power systems in a village without first addressing end-use appliances, metering and switches is a mistake.
> • Hybrids have large swings in short-run marginal costs. Tariff structures or load management can be important tools.
> • In pilot projects, robustness and reliability are more important than energy conversion efficiency.
> • Resist the temptation to field the "latest and greatest" until it has been thoroughly tested under controlled conditions.
> • The transition from the pilot phase to commercial replication can be difficult. The more the pilot project can be set up to look and act like a business, the easier the transition.
> • It is often more economic to install a new, appropriately sized diesel than to use the existing, oversized, poorly maintained one.
> • There is no substitute to a dedicated, influential, local champion.
> • The time from initial interest in renewables to commercial replication takes 4- 6 years, in a positive institutional climate.
> • Hybrid systems are a potentially significant solution to rural ac electricity needs, but further technology development, systems integration, simplification, and industry expansion will be required."[124]

Considering these aspects, wind power projects in Indonesia are feasible, as the example of Tanglad and Julingan on Nusa Penida and Bonto on Sumbawa testify. Thus the government's plans for rural electrification[125] with investments of 6.2 billion US-Dollar[126] can be achieved with the help of wind power until 2010. Adequate concepts for small to medium-scale wind power applications can get their share from these investments. In accordance with the above-quoted recommendation not to

[123] DESDM: 2002, p. 7.
[124] NETL Publications: 2001.
[125] See chapter 3.2.6 Electricity Outlook.
[126] This is the investment necessary to meet the electrification rate depicted in the RUKN. Yet, on the one hand Indonesia does not have the financial power to invest this sum, on the other hand, still not all villages are electrified if the RUKN could be carried out.

'field the latest and biggest' a limit in rated power could be at 500 kW[127]. Wind turbines up to this load are reliable and thus will keep a lid on the costs of maintenance.[128] The possible advantage of wind power stations in costs will be discussed in the following section on strategic potential.

With regard to the lack of data on the wind regime, further research into the subject has to be part of any prospects for wind power in Indonesia. Currently, no such activities take place on the national level. Yet there are two projects from international organizations that could include Indonesia's wind regime in their program. Tjarinto S. Tjaroko, Co-Director of the ASEAN Center for Energy refers to a call for papers for research projects under the European Commission-ASEAN Energy Facility. The European Commission provides a fund of 6.5 million Euro for studies on energy in the ASEAN member countries with an emphasis on renewable energies.[129] Investigation in specific regions or even sites for wind power implementation in Indonesia could be part of this program. A reasonable project could be implemented from a growing number of mobile communication towers that are set up throughout Indonesia. These towers could be considered as the basis for anemometer installation and could help to keep costs down for new measurements if their locations and technical prerequisites are in favor of good measurement conditions.

Such research could supplement efforts by the World Bank through its Asia Alternative Energy Program (ASTAE) to support Southeast Asia with regional wind maps. Recently Cambodia, Laos, Thailand, and Vietnam are investigated with a model called MesoMap.

> "MesoMap offers several advantages over conventional wind resource assessment methods and simplified wind flow models such as WASP and WindMap. First, it operates without the need for surface wind data -an important attribute for regions such as Southeast Asia where reliable and consistent measurements are scarce. Second, MesoMap models important meteorological phenomena not represented in simplified wind flow models. The phenomena include mountain waves, winds driven by convection, sea and lake breezes, and downslope (thermal) mountain winds. Finally, MesoMap directly simulates long-term wind conditions, thus eliminating the need

[127] 500 kW is already quite a lot of power for example in rural areas. WTG of that size should be used in commercial projects, supporting the national supply through PLN. Rural electrification probably has to see installations of a smaller scale.
[128] ISET: 2002.
[129] Interview with Tjarinto S. Tjaroko, Jakarta, 18. April 2002. Information can be obtained at the Europe Aid Web site: http://europa.eu.int/comm/europeaid/index_en.htm and on the Web site of ACE: http://www.aseanenergy.org/EAEF.

> for uncertain climatological adjustments using correlations between short- and long-term surface measurements."[130]

Immediate implementation of large scale wind power projects in Indonesia, both in number as well as capacity, is unrealistic and should not be expected. Yet, with careful investigation of appropriate sites for wind conditions, potential of customers and the infrastructure, investors could take the step into the Indonesian market. In the long run, presence in the archipelago may be of advantage for suppliers as well as wind farm developers. Economies of scale will further decrease the costs of wind energy and penetration of surrounding markets will make supply of WTGs and spare parts for maintenance less costly. Last, but not least, the growth in demand of electricity in Indonesia will result in heavy investment into new generating capacities at least within the next ten years.

[130] ASTAE: 2001, p. 5. The Wind Energy Resource Atlas developed by ASTAE provides data for Cambodia, Laos, Thailand and Vietnam only.

5 The Strategic Potential of Wind Power

Successful application of wind power in many countries throughout the world displays the potential it has to advance power supply towards a future power mix which is economically, socially and environmentally secure. Thus it can contribute to sustainable energy security. For a nation like Indonesia sustainable energy policy and generation must be an essential goal. It is facing a growing population while at the same time striving for economic development that will further push demand for electricity.[131] With the current mix of final energy mirrored in a high fossil primary energy mix, Indonesia will face further pollution from emissions and economic challenges through the import of primary energy past 2011. It will experience the consequences from dependency on power imports, which may include security matters to be dissolved politically, but also possible social unrest. The poor cannot afford expensive fuel resulting from imports that follow possible rising world energy prices or currency exchange rates. They will ultimately take to the streets again.

Politics and the general situation in Indonesia do not adequately acknowledge these problems. Yet, recent developments do signal some change in views. As an example for wind power, the program ‘Spreading Small Scale Power Generation’ and recommendations from the report on the implementation of Agenda 21 in Indonesia to increase the share of renewable energy in national energy production[132] point into that direction. Of course one can write what one likes on paper, and limited budgets and bureaucracy may remain obstacles for the development of wind power in the future. But the positive developments should be respected and encouraged, especially since ideas and techniques take time to spread. For example, unleaded fuel, introduced in Europe in the 1980s, took twenty years to reach Indonesia.[133]

So what are the chances to support wind energy development in Indonesia? From the authors point of view there are three considerable incentives, two from current and predicted market developments and one political one. First, the market gives

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[131] See chapter one for population growth.
[132] Ministry for the Environment: 2002, p. 17.

wind power a chance through growing demand and –second- altering price and cost structures. Third, there is the Clean Development Mechanism (CDM) as a rather new tool. It is a political mechanism from the Kyoto Protocol to help internalize external costs from emissions of green house gases. It encourages financial and technical transfer from industrialized to newly industrialized and developing countries. As such there is strategic potential for wind power in Indonesia.

5.1 Challenging Conventional Costs

Assuming the conclusion from chapter four that sites of sufficient wind conditions are available in Indonesia, another major obstacle commonly referred to is the cost of renewable energy production in general and wind power in particular. But what has been true in the past should be reviewed on the basis of data from recent experience in growing wind energy markets such as Europe, North America and India. It should then be compared to the alternative sources of electricity production. In this paper diesel generators and small-scale hydro power projects are perceived as the main competitor of wind power applications.

Feed in tariffs for wind energy in Spain of 6.9 Euro cent per kilowatt hour and 4.4 Euro cent in Denmark[134] have come within the range of conventional energy production costs in Indonesia. Of course this has to be considered within the circumstances of tax reduction, low-interest loans and further conditions of the local energy market, but these figures may be regarded as benchmarks for wind power production. Even in Germany, viewed as a rather expensive wind power market, critics of the high feed in tariff of 9.1 Euro cents/kWh argue that true costs of production for specific sites are around 7 Euro cents/kWh.[135] Yet, there remain sites that still have higher costs.[136] The American Wind Energy Association publishes on the Internet, that in “1980, electricity from wind cost 40-50 US-Dollar cents/kWh. Today, wind

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133 Laksamana: 2000. The article referred to states that in 2000 Pertamina’s efforts to reduce lead pollution by introduction of unleaded fuel has only achieved 5 percent of reductions. Laksamana.net is an Indonesian Internet portal on politics and economics.
134 Farhandi: 2002, p. 3.
135 Comment from the audience at the conference “Windkraft in Deutschland”, Bremen, Germany, 28. Feb./ 01. March 2002.
136 The Author is grateful to Robert Schulze Hönighaus, who made data on a private WTG near Lippstadt, Germany available. For the years 1998-2001 it has average costs per kWh of 7.7 cent Euro/kWh excluding interest and 10.2 including interest, at linear deduction.

systems in areas with good wind resources can produce electricity for less than 5 US-Dollar cents/kWh--a decrease of 85 percent in just 15 years."[137] The National Wind Technology Center as quoted in a graph by Schippmann predicts a maximum decrease in costs to 3-5 US-Dollar cent/kWh by 2005.

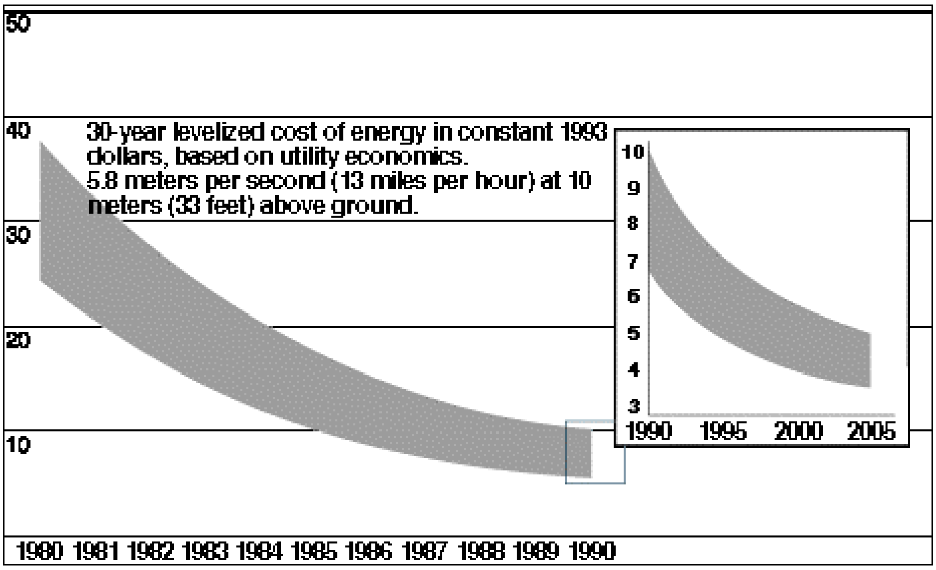

Figure 8: Cost of Wind Energy (US-Dollar cent/kWh).[138]

Comparison of Costs in US- Dollar cent/kWh (1996)	
Coal	4.8-5.5
Gas	3.9-4.4
Hydro	5.1-11.3
Biomass	5.8-11.6
Nuclear	11.1-14.5
Wind	4.0-6.0
Wind (Germany)	up to 10.0*

Table 7: Comparison of Costs for Various Energy Sources (US-Dollar cent/kWh).[139]

This range of production costs from four to eleven US-Dollar cent per kWh is also applicable in Indonesia as has been discussed before. Yet it is not easy to calculate true generating costs for PLN. The data presented in their annual report is in

[137] AWEA: 2002.
[138] Source: National Wind Technology Center as quoted by Schippmann: 2001, p. 8.
[139] Schippmann: 2001, p. 7. The original data was obtained from the AWEA.

Rupiah and as such it is difficult to handle and compare to figures in US-Dollar. The following table may illustrate that.

Problems of comparing PLN's generating costs/kWh				
	costs in Rp/kWh	annual Currency Equivalent (1$=x Rp)	costs in $/kWh at annual Currency Equivalent	costs in $/kWh related to 1995
1995	157.05	2249	0.07	0.07
1996	156.11	2342	0.07	0.07
1997	186.16	4667	0.04	0.08
1998	211.50	10632	0.02	0.09
1999	221.36	10000	0.02	0.10
2000	231.92	8500	0.03	0.10

Table 8: Problems of Comparing PLN's generating costs.[140]

It is basically the same problem that PLN confronts servicing their commitments to IPPs, but here it could give the impression that energy production in Indonesia has become really cheap. Yet, true generating costs are at an average 5.5 US-Dollar cent/kWh. For IPPs such as Jawa Power it is obviously lower since they are able to agree to a price of 4.8 US-Dollar cents/kWh in their Power Purchase Agreement (PPA) with PLN, renegotiated in spring 2002.[141] All in all costs from wind power are still on the upper edge of average production costs for electricity, but technical development, economies of scale and acknowledging external costs of conventional energy sources tighten the gap between wind energy and other resources.

Considering generating costs, one of the most important aspects to look at is the development of installation costs for Wind Turbine Generators (WTG). Their price has significantly decreased within the last decade. Current prices very much depend on the technical fittings of the WTG. High rated power or the height of the tower applied will affect costs significantly. Also negotiations between the WTG supplier and wind farm developers can result in very different terms of contract and WTG costs.

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[140] Own calculation on the basis of PLN's cost/kWh for diesel generation. This is a very limited and simple illustration of the problem of comparing costs. No data was available taking for example inflation and thus purchase power changes into account. Another factor not considered here but important to operational business are the difficulties of IPPs to acquire cheap and long performing loans in Indonesia whereas PLN receives state loans at favorable conditions.

List prices, although they are not always in relation to the actual prices negotiated, are within a range of 600 to 1000 US-Dollar/kW installed capacity.[142]

PLN kindly provided the author with data on the installation costs for diesel generators. Thus, depending on the invitation of tenders for diesel generating projects, costs vary from 780 to 1200 US-Dollar/kW. Interestingly enough 1200 US-Dollar/kW are noted for bilateral projects for example with the German Kreditanstalt für Wiederaufbau (KfW), while invitations from PLN are around 800 US-Dollar/kW. High-speed diesel ranks lower at 800 US-Dollar/kW compared to medium speed diesel at 1000 US-Dollar/kWh.[143] These investment costs are not any cheaper than the costs for WTGs. WTGs, however, have fewer hours at full load than diesel generators. Possible lower than rated returns of electricity production along with logistics, transport and import taxes will add to the overall cost of WTGs, but should not exceed the advantage of free fuel for the power plant. Diesel at isolated sites is especially expensive because it has to be shipped there first. However, this argument is less convincing for Java and Bali than for the Outer Islands. The general hike in fuel prices in contrast does apply in all regions and will have considerable effects. As noted earlier, PLN expects people self-sufficient in their electricity supply at the present to turn to PLN for supply because of rising fuel costs.[144] This could also become the case on the Outer Islands. Thus, competitiveness of wind power compared to diesel generators can be the case.

To set up WTG certain requirements of the infrastructure have to be met. Depending on size and height, the nacelle and the tower will be tons in weight. Logistic demand for the installation may include transportation and setting up the tower and nacelle. Trucks, cranes and roads must be suitable to carry loads of up to 60 tons for tubular towers and WTG of the MW class. The lack of such infrastructure for most places in Indonesia is, besides costs, another reason to restrict the rated power to 500 kW. Towers may also be set up as lattice towers, thus causing less logistical

[141] PLN's data and the PPA price for Jawa Power are both information from a confidential interview with an industry insider, Jakarta, 24. April 2002. The 5.5 US-Dollar cent for PLN include transmission and distribution costs/kWh.
[142] Farhandi: 2002, p. 8-14.
[143] Information received via e-mail, 23. April 2002.
[144] Jaensch: 2001, p. 3. A January 2002 US-Embassy paper reports such turn-offs of diesel generators and connecting to PLN as anecdotal evidence, yet suggesting that it already does happen. US-Embassy. 2002, p. 3.

problems and expenditure. They also allow for cranes capable of lifting the nacelle to be positioned on top without an extra crane. Another option might be co-operation with the military, where it is able to provide machinery. Yet, Indonesia's military has to be dealt with carefully.

There are, of course, various other determinants influencing the financial burden of wind power as an energy option. These might be costs of financing, load capacities of the single WTG or of entire wind farms. Yet, not all can be taken into account individually for this study. The aspects further reviewed for Indonesia in this paper are energy costs, installation costs and aspects of the surrounding infrastructure. Others will be included where they influence the aspects noted.

5.1.1 The Java-Bali-Grid

Generally WTG with energy costs at levels of competition to conventional energy are applicable throughout the archipelago. But, this competitiveness may be easier to reach if large-scale applications for considerable power supply are projected. Economies of scale from large orders do show a decrease in equipment costs and advantages from spreading infrastructure costs.[145] In Indonesia only Java provides the preconditions for such large-scale projects. It has the power grid necessary to transmit and distribute power from concentrated electricity production at wind farms and also the market to sell it. Concerning logistics, one may expect suitable roads for transportation of heavy machinery only on Java, if at all.

Only 56 percent of the households on Java and Bali have electricity. So apart from large scale application, small scale wind power projects can be interesting to those, who live in remote areas with adequate winds. For them it might be faster to install a communal WTG than waiting for PLN to construct distribution lines or provide a local diesel generator. Of course there is also the option to buy a diesel generator for the village. But actual installation costs can be lower for WTGs than for diesel generators, as has been discussed above.

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[145] Farhandi: 2002, pp. 11-12.

5.1.2 The Outer Islands

On the Outer Islands 33 percent of the electricity production of 18,407 GWh is produced by 3,593 diesel generators.[146] Their geographical distribution makes maintenance, fuel delivery and thus reliable operation expensive, time consuming and difficult.[147] Ways to challenge these costs are therefore an important task for the electrification of these islands in general and for the diversification of the supply in particular. In the price list of diesel fuels in PLN's 2001 report, differences of up to 63 percent or close to 300 Rupiah in between various regions are stated. The absolute amount of these differences in prices is even higher at present-day since fuel prices increased by almost 100 percent within two years. Prices for industrial diesel oil (IDO) have increased from approximately 550 Rupiah[148] in 2000 to 1100 Rupiah[149] by 2002.

In addition, with PLN incapable of new investments, individuals, communities and industries on the Outer Islands will have to reorganize themselves their less sophisticated power grids that are difficult to mature and to interconnect, and also their power supply, as fuel prices keep rising. The new autonomy of the regions can support possible initiatives to diversify the local power supply, if regional administration will be allowed to review projects locally and submit permissions. Constraints such as flying to Jakarta for permits have to be solved so community or private investment becomes viable.

From the technical side, systems have been developed that can contribute to stable electricity supply at affordable costs.

> "Wind retrofits to diesel power plants are primarily useful in large systems with good wind potential and high fuel costs. In plants with many large diesels, where there is always a demand for power, the wind power is used to offset power production by the generators. The addition of the wind power may also reduce the number of generators operating at any given time, thus reducing the diesel maintenance requirements. Because system dynamics and power stability are of primary concern, [...] wind penetration is usually only a fraction, from 20% to 50%, of the average load. [...] This approach can be very cost effective but is capital intensive due to the cost of the wind

146 PLN: 2001, p. 22.
147 Baring-Gould: 1997, p. 6.
148 PLN: 2001, p. 24.
149 US-Embassy: 2002, p. 1.

> turbines and controls. The potential cost savings depend on the wind resource, diesel maintenance costs, and the fuel price."[150]

In a pilot project in Pariti, West Timor, wind supplements to an existing diesel generator providing 12 hours of electricity throughout the night, proved cost effective in calculations with wind speeds set above 5.56 m/s and fuel costs for diesel of 17 US-Dollar cent/liter.[151] Installation costs were estimated at around 60,000 US-Dollar for the WTG[152]. Current developments in fuel price hikes towards world market prices coming close to the assumed 17 US-Dollar cent/liter[153], make effective wind energy use a realistic option.

5.2 A Contribution to Meet Growing Electricity Demand

Indonesia is facing tremendous growing demand in electricity within the next decade. In its current situation it is unable to tackle this challenge by itself and will need help from abroad, from international institutions as much as from private investors. These may follow conventional paths to enlarge generating capacities, but acting environmentally, socially and economically responsible can also scatter seeds for a sustainable energy mix. This section will give a broad view on Indonesia's prospectives to use wind power to meet demand.

It has been described in chapter three that the structure of the energy sector on Java-Bali and the Outer Islands falls apart. In accordance to that, possible contributions of wind power to the growing demand are also differentiated between these subdivisions.

5.2.1 The Java-Bali-Grid

The latest electrification plan presented by the Indonesian government provides regional information on the growing demand. The paper anticipates an increase of demand from 70,387.4 GWh in 2001 to 147,088 GWh for 2010 for the Jawa-Bali grid. To answer this demand *repowering* of several former gas and gas and steam

[150] Baring-Gould: 1997, pp. 6-7.
[151] Baring-Gould: 1997, p. 7.
[152] Unfortunately the study does not mention the size of the WTG. However, the existing diesel gensets had 20 kW capacity each.
[153] US-Embassy: 2002, p. 3.

power plants is under way. Repowering means to recover formerly closed power plants, overhaul them and reconnect them to the grid. These measures will put off the predicted power gap until 2004, but will not solve it. Beyond the year 2003 further investment is necessary.

Repowering might be the choice to consider again, after all existing capacities have been reactivated. It might be a way to set up the first WTGs in Indonesia in support of the weak grids. The term is not only used for repowering of conventional plants, but also for WTG sites in Europe. Turbines of low rated power at locations with good wind conditions are replaced by more sophisticated WTGs with higher rated loads. They are reused at other sites if possible, but available sites already become rare, at least in Germany. Thus WTGs with a rated power of up to several hundred kW are forming a second hand market for WTGs. These could boost development in other countries such as Indonesia, if those are aiming at developing a wind power sector within their energy market. At the present various institutions look for concepts to facilitate transportation, technical education of maintenance personnel for the new sites and financing of such technical co-operation.[154]

This option could possibly become a win-win situation: Indonesia could meet part of its growing energy demand avoiding black-outs by using an environmentally sound power source and changing its energy mix towards a cleaner supply, which is less dependent on fuel imports. At the same time it can develop capacities for WTG maintenance and catch up to the present standards in WTG-technology. The German side could sell its surplus of WTG from repowered sites and could possibly open up new markets for its wind industry. Indonesia might still reject this as ‘capitalist colonialism’. Yet, co-operation right from the beginning, for example through joint take-down of the WTG in Germany and the option for licensed production in Indonesia finally resulting in subdivisions or local companies, might convince decision-makers in Indonesia. Another profit for all sides would be decreasing green house gas emissions two-fold: with larger amounts of green energy from the repowered site and additional savings from the recycled WTG. The target of sustainable development through renewable energies would be fully achieved if social developments such as education and better health care made possible where electricity was formerly limited or not available at all become additional benefits. The latter can be accomplished with conventional energy sources, too of course, but not in a sustainable manner.

5.2.2 The Outer Islands

The concept of repowering could be applied on the Outer Islands as well. Yet, their demand is much lower in sum and for most locations dominated by rural electrification needs and less by large demands for industry or cities. A lack of transmission and distribution lines makes electricity transport difficult. Since small scale WTGs from repowering in the rated power range of several dozen kW load are rare, new WTGs have to be the main choice for rural electrification with stand-alone systems.

Predicted growth rates outside Java-Bali all exceed 100 percent within the period 2001 to 2010. Some regions already have negative reserve margins and few have the option of repowering old conventional power plants or even expecting new ones to go online soon. Therefore the RUKN is considering new investments of up to 6.23 million US-Dollars for the electrification of villages. For all the subdistricts of PLN on the Outer Islands a list of proposed new power plants, an appendix to the RUKN, does exist that are planned to help to meet the growing demand. Unfortunately the appendix itself was not available to the author.

The wind power industry in Europe and North America tends to develop ever-larger projects. For the Outer Islands in Indonesia it may want to rethink strategies of decentralized power supply with the above discussed hybrid systems or storage systems. Several companies are developing such systems and there are countries with significant experience in this field.[155] Indonesia itself does have projects that prove the feasibility of wind-hybrid systems. To make them more sophisticated may not only be interesting for export to developing countries with little financial power,

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[154] For example, Detlef Matthiessen, Managing Director of the German Federation for Wind Power, is reviewing possibilits for projects with WTGs from repowering.

[155] P&T Technologies for example offer a system for desalination and fresh water supply with backups of the conventional kind or hydrogen for the future. Bergey Wind Power Co. is another supplier of small scale hybrid applications. In Canada the problems its vast country side brings along for energy supply have resulted in combining conventional generators with wind supplements. Alaskan towns far off any kind of grid, too, have some field experience with wind-diesel hybrids. Remote research stations, i.e. for Test Ban Treaty Monitoring in the Antarctica, have been successfully supplied with WTG in combination with other sources. See: Singh: 2001, p. 4; NETL: 2001, 18.

but also to replace diesel generators in the USA with an installed capacity of 102,000 MW in 1996.

The social benefits from rural electrification are commonly known and include better health care, education, access to the world media and even population control. To enhance such development by wind power as a renewable energy source would be a clear commitment to sustainable development as brought forward in the review of Agenda 21.[156]

An argument often used against wind power utilization is the fact that wind does not constantly blow. The vast area of the Indonesian archipelago makes transport expensive and sometimes not reliable. Yet, if fuel for the diesel generator is not shipped regularly to a village, a diesel power plant may become less reliable than a WTG depending on the local wind resource. As such local demand may rely on supply from WTGs while still connected to other power sources.

5.3 Choosing the Site

The predominant prerequisite for wind power utilization remains the condition of the local winds. Next in line follow fuel prices, electricity prices, local demand and infrastructure. Their indicators make evaluation of economic efficiency possible. Then bureaucracy, environmental impact and reservations from the local public also have to be considered. This section will review these aspects and propose some potential sites for wind power application that have been previously discussed and can be conservatively estimated for their suitability on basis of the information collected.

Electricity prices and the bureaucracy due to its -still- centralized character are the same throughout Indonesia and have been discussed above. Any impact on the environment or landscape as well as reservations from the local people have not been regarded as major obstacles in any of the interviews conducted. From distance they are hard to judge and thus they will not be reviewed. Local demand and infrastructure as well as the fuel prices will be two of the parameters examined. These, too, are of limited character since the data available for them is attributed to regions rather than specific sites. Only the wind conditions, with the reservations noted in the chapter on wind, are true data for the particular location.

Wind speeds in Indonesia have to be further observed throughout the country. Yet, assuming considerable potential at sites with wind speeds of more than five meter per second, the following sites will be reviewed for further requirements:

Location	**BMG 1974 (m/s)**	**BMG 1975-1989 (m/s)**	**BMG 1990s (m/s)**	**LAPAN (m/s)**	**NREL (m/s)**
Kalianget, East Java		3.76	5.40		
Iswahyudi Madiun, East Java	6.04	4.06	5.57		
Buluh Tumbang Tanjung Pandan, South Sumatra		2.21	5.56		
Bungaiya Selayar, South Sulawesi				5.05	
Kupang, West Timor		4.43	5.51		4.3-5.0

Table 9: Average Annual Wind Speeds at Sites Reviewed for WTG Application.

Actually, except for two other ones, these are all locations with measurements of average wind speeds above 5 m/s. One additional site with an average wind speed of 5.32 m/s in West Nusa Tenggara, Pasirpanjang was measured by BMG in 1974. Another one, Tardamu in East Nusa Tenggara has an average wind speed of 5.11 m/s and was included in BMG's 1990s measurements. They are not further discussed because for now it was not possible to locate them exactly.

The good average wind speeds make the sites listed above prospective for the implementation of WTGs, although one has to recall the circumstances of the measurements. Only readings from LAPAN -and not even all of those- were observed for a full twelve-month period. Therefore Bungaiya Selayar, South Sulawesi, providing full twelve month observation, is the only location with reliable wind data. Rather disturbing is the data from the 1975 to 1989 measurements by BMG. They might be regarded as better findings since they are the average of several years[157] but the criticism by Harijono Djojodihardjo and Martin R. Moeljono of inadequate measurement conditions and intervals limits their significance.

The two locations on Java, Kalianget and Madiun, could be connected to high voltage transmission lines and might even be close to the 500 kV circuit for Java-Bali.

[156] National Assessment: 2002.
[157] Calculation on basis of the data by BMG in the appendix. The average wind speeds calculated do not include a total of 15 annual average wind speeds, but only data from 10 to 14 years.

A potential site in these areas may also be in reach of sufficient transportation infrastructure. Questions of demand should be no problem on Java-Bali, with growth figures of 8.8 percent annually.[158] Fuel prices, according to PLN's data for the year 2000, have been in the upper half of the national range of costs and have experienced large hikes since. Further reduction in subsidies[159] on fuel prices will contribute to a stronger position of wind power in competition with diesel generators. The consumer price for industrial diesel oil has recently met 1100 Rupiah/liter or about 13 US-Dollar cent/liter. The above-mentioned project on wind-diesel hybrids at Pariti, West Timor supposedly becomes economically efficient at 17 US-Dollar cent/liter diesel. The current 13 US-Dollar will further increase in the future and thus come close to making wind power utilization cost efficient according to the project results from Pariti.

Buluh Tumbang Tanjung Pandan on the island of Belitung in South Sumatra is within one of the regions listed by the RUKN as already experiencing black outs.[160] Additional power sources from new plants and repowering or captive power will not be sufficient and new capacities will have to be installed. Thus wind power could become an option from the demand side of view. The island has a population of about 210,000 inhabitants. The conditions of the infrastructure of transport and the power grid are difficult to judge. High voltage transmission lines are available in South Sumatra, but probably not on the island of Belitung. Roads are usually in worse conditions than on Java, yet not necessarily bad in the region. Therefore lattice towers and small applications with light nacelles may be the local choice. The fuel prices in Southern Sumatra are about the same as on Java, yet island locations usually make fuel more expensive. Thus wind power could be a competitive source of energy for the island of Belitung.

Bungaiya Selayar is also situated on an island, off the cost of South Sulawesi. It is one of the few locations that already sees wind power generation. 108 WTGs are set up on the island contributing to the supply of about 100,000 people. In addition to their demand the tourist industry could be an interesting component as the island is known for terrific diving. A repowering project within Indonesia could be an option for

[158] DEDSM: 2002, p. 10.
[159] US-Embassy: 2002, p. 3. In 2002 fuel prices for industrial kerosene, ADO and IDO are supposed to reach 75 percent of the Mid Oil Platts Singapore (MOPS) prices.

this site. The existing WTGs with a rated power of 0.3 and 0.1 kW could be used for new projects if larger and more sophisticated WTGs replace them for Selayar. Additional shipping costs would have to be calculated into such a project since Sulawesi is far off the international traffic lines. Yet this remote location has not affected fuel prices, as listed in PLN's 2001 report, to be much higher than anywhere else in Indonesia, allowing the conclusion of fair transportation costs.

Kupang might be the most promising of the above locations on the Outer Islands. It is the capital of West Timor with about fifty to sixty thousand inhabitants. The good wind conditions directly near the town make transmission lines a minor concern and could make direct distribution possible. Systems used for the supply of drinking water in joint application with electricity production might be an option here. Drinking water is usually bought in bottles in Indonesia. It could make sense to include its supply in the long run in a more complex strategy of utilities for Kupang. Extreme loads from wind could then be balanced out by additional water production. The entire region offers a potential of 400,000 customers. However, West Timor is one of the most remote regions of Indonesia and transportation of heavy machinery could cause some difficulties. Fuel prices are rather low according to PLN but have also experienced increases. Transportation of fuel to the island becomes more expensive with higher fuel costs and in an interview possible costs of up to 3000 Rupiah/liter have been mentioned.[161] That would equal 35 US-Dollar cent/liter. In Kupang a WTG with a rated load of 1.5 kW, has been in operation by LAPAN since 1993.[162]

These examples are potential locations to introduce larger scale WTGs in Indonesia. They might be considered for projects connecting repowering in Europe with realistic options for economic wind power utilization in Indonesia. Additional options spark up as wind mapping in Indonesia proceeds. The maps from the National Renewable Research Laboratory, for example, suggest going to locations further east from Kupang on East Timor. The maps reveal ideal wind conditions in the mountains. But existing grids and thus lower investment for WTG infrastructure are an argument for first steps in Kupang.

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[160] DESDM: 2002, p. 17.
[161] Confidential Interview, Jakarta, 22. April 2002.
[162] Notosudjono: 2000, homepage on Kupang District.

The reviewed sites may also become a starting point for the implementation of the Clean Development Mechanism from the Kyoto Protocol. With the incentives from this tool of climate conservation, wind power grows more promising for Indonesia.

5.4 The Clean Development Mechanism as an Incentive for Investment

> “Carbon dioxide is the principal greenhouse gas. According to the 1990 scientific assessment by the Inter-governmental Panel on Climate Change, stabilization of carbon dioxide concentrations in the atmosphere at present-day levels would require reductions in annual emissions from human sources of more than 60 per cent. The less onerous scenario of maintaining atmospheric emissions at 1990 levels would lead to an eventual increase in atmospheric concentrations of about 50 per cent.“[163]

This has been the alarming result of the research by the Intergovernmental Panel on Climate Change (IPCC) in the early 1990s. Indonesia has followed this research from the beginning as it might be one of the nations heavily affected by climate change. Rising sea levels or shifting equatorial storm regimes could have tremendous impact on the archipelago.

The IPCC collects and reviews data relevant for climate change caused by mankind. It has elaborated the report that led to the United Nation Framework Convention on Climate Change (UNFCCC), which was signed at the 1992 Earth Summit at Rio de Janeiro, Brazil. Indonesia signed this declaration of intent and ratified it in 1994. The stated objective of the convention was “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”[164]. Each signatory is supposed to submit a ‘National Communication’, which has been presented by Indonesia during the 1999 Conference of the Parties V in Bonn, Germany.

After 1992 it took another five years before the intentions stated in the UNFCCC were formed into a legal and political binding international treaty. This contract, the Kyoto Protocol was signed in 1997. Actually it is not a separate contract but, according to the name, a protocol that lays down certain fundamentals for protection of the atmosphere. The signatories from the developed nations will, in the pe-

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[163] Chisholm, et al.: 1996, p. 43.
[164] UNFCCC: Article 2.

riod from 2008 to 2012, reduce their greenhouse gas (GHG) emissions to 5.2 percent below their national levels in 1990. The protocol comes into action as soon as at least 55 states have ratified the treaty and at the same time meat a total of 55 percent of the emissions of CO_2 from industrial states in 1990.

This goal may be achieved soon, since the European Union has ratified the protocol and Japan has decided to follow this summer. Thus the necessary 55 states are already participating. Unfortunately, they only emit 35 percent of total CO_2 emissions, whereas Russia, with 17 percent of world emissions, has become the key to action.[165] Indonesia, which signed the protocol in 1998, is one of the remaining nations in line to ratify. According to participants in the national proceedings in Indonesia, the country will ratify the paper at the latest in August, at the World Summit on Sustainable Development in Johannesburg.[166]

In article 6, 12 and 17 the Kyoto Protocol provides strategies to support international co-operation on the reduction of GHG emissions. One of these strategies is the Clean Development Mechanism.

5.4.1 The Kyoto Protocol's tool

The goal of the UNFCCC is to gain control over anthropogenic GHG emissions into the atmosphere. As atmospheric airflows do not consider national borders the objective is of global scope. This makes some kind of coordination necessary to motivate and enable mankind worldwide to participate in this process. The Clean Development Mechanism (CDM) is exactly that tool with high expectations on its implementation.

It is a flexible mechanism that allows countries with GHG "limitations and reduction commitments (Annex B countries) to engage in project-based activities in developing countries, with the two-fold aim of assisting developing countries to achieve sustainable development and helping Annex B countries to meet their emission reduction targets"[167]. For their financial and technical aid to non-Annex B coun-

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[165] Süddeutsche Zeitung: 2002, p. 6.
[166] Confidential Interview, Jakarta, 24. April 2002.
[167] NSS-Program: 2002, p. xii.

tries developed nations can obtain units called certified emission reductions (CER).[168]

CDM projects follow a path along six subsequent steps. First the project has to be developed with criteria for adequate implementation. Validation of the project design will follow in the next step before financing can be acquired. For the latter governments can provide resources or article 6 of the protocol also allows for legally installed developers to provide money. That means that local developers take over part of the national obligations. They will contribute to the target of emission reduction in search of economic measures to meet their own GHG emission limitations. Wind power projects have been considered an option and thus could be promising in Indonesia, too. In the fourth step of monitoring the project, data on GHG mitigation is collected that in the following step five will be verified by independent observers. Finally CERs in accordance to the project will be issued.[169] These steps are supervised and controlled by various institutions at different levels. “The key institutions involved in the CDM regulatory framework are the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP), the Executive Board of the CDM, accredited operational entities, national CDM offices, and project operators.”[170]

5.4.2 Wind Energy Projects in Indonesia under the CDM

On the current list of Action Implemented Jointly (AIJ) projects for Indonesia in the *National Strategy Study on Clean Development Mechanism in Indonesia*, one of several projects on renewable energies includes wind power.[171] A simple calculation of the project cost per ton of CO_2 reduction results in lower costs for the project including wind power compared to other initiatives listed. So wind power does seem prospective for the CDM in Indonesia. Interestingly enough wind power as a renewable energy source is not considered as a mitigation option in the National Strategy Study. Yet, mini- and micro-hydro power plants are considered good mitigation op-

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[168] Annex B countries are mainly the members of the OECD plus several industrialized countries committed to pitch in their share in reduction measures.
[169] See CDM Project Activity Cycle in: OECD: 2000, p. 7.
[170] OECD: 2000, p. 8.
[171] NSS-Program: 2002, p. xxvii.

tions and the study generally promotes fuel switches from fossil to non-fossil fuel as a "most promising technology option"[172] for GHG reduction.

It is surprising that wind energy -as part of a renewable energy project listed as already implemented and concluded with the transfer of the technical applications to the Government of Indonesia[173]- is not considered a future mitigation option. This is even more surprising, since other options included for the power sector have higher costs of investment per installed kW than WTG. Mini-hydro for example, in a project near Bandung, has been realized at costs of 15 to 30 million Rupiah per kW capacity, depending on the size of the power plant.[174] That equals about 1500 to 3000 US-Dollar per installed kW and displays costs that can be easily met by modern WTGs, even allowing for transportation costs to Indonesia as long as applications have to be imported. In their first edition of 'Mini Hydro Power News' the GTZ, Bandung notes costs for one project at 1500 to 2500 US-Dollar per installed kW including transmission and distribution.[175]

The CDM aims at reducing CO_2 emissions at reasonable costs. Wind power is a renewable energy source with practically no emissions at all after construction. It has displayed steadily decreasing costs over the last decade. As such, at locations with favorable wind conditions, wind power can contribute significantly to CO_2 emission reductions and produce reductions that may be accredited as certified emission reductions (CERs). Therefore, where the wind regime in Indonesia produces such conditions, the CDM can contribute to the transfer of WTG technology, financing of urgently needed power supply and diversification goals in the electrification of Indonesia. The CDM is a tool only applicable where co-operation is achieved. Thus, Annex I countries to the Kyoto Protocol, who actually carry the burden of the CDM, may want to consider propping up their wind power industry through the CDM. This may be perceived as a move of pure self-interest but under the UNFCCC it should be regarded as a way to create a win-win situation for partners in the international struggle for protection of the atmosphere.

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[172] NSS-Program: 2002, p. 35.
[173] NSS-Program: 2002, p. xxvii.
[174] Confidential Interview, Bandung, 25. April 2002.
[175] GTZ: 2000.

The history of the climate change convention and the Kyoto Protocol along with the idea of sustainable development and the fact that atmospheric changes are a common global challenge suggest that joint global efforts to fight this threat are possible. Wind power can contribute to this fight and should be considered as a realistic option within the implementation of the CDM in Indonesia. The CDM is meant to built bridges that carry financial burdens, cross technological gaps and thus help secure an environment worth living in. As a tool the CDM itself is not able to achieve this. It is the people who need to pick up the tool and use it.

6 Conclusion

Wind power in Indonesia is something you have to believe in. You find little proof of it, cannot easily picture it but yet, you know it is there. This paper has made some effort at lifting the haze that lies on wind energy use in Indonesia. The country 'below the winds' has some good potential to utilize wind energy. However, it is not in the state of immediate implementation. Several prerequisites have to be met, before wind energy can become an option.

First of all, the wind regime has to be adequately mapped in accordance with international wind resource assessment methods. Direct measurements may be one way to achieve this. They have to be conducted at standard heights, where disturbance of the wind flow is low. Dataloggers have to read five-minute intervals for at least twelve months to receive true average annual wind speeds. However, this method might be too ambitious for the whole of Indonesia. Thus, other methods of wind mapping such as Mesomap which do not need local measurements to obtain valid data have to be considered. The existing data is preliminary, except for a few locations that are mainly in East Nusa Tenggara. At those locations and in regions with general readings of good wind speeds, direct measurements should come into place to encourage wind power assessment and development.

Indonesia is a nation with a still highly centralized administration. Research and development of energy projects in general, and of wind power pilot projects in particular are either in the hands of national research institutions or the state owned enterprises. This indicates that momentum for development and new initiatives has to come from the center. There are, however, minor prospects from political autonomy of the provinces and regions. As the process of decentralization proceeds, present conditions unfavorable to private investment may change. An example of new legislation pointing into that direction, is the small scale power program PSK TERSEBAR.

This program, and hopefully others that will follow in the near future, aims at securing the supply for the tremendously growing demand for electrical power. Indonesia will face enormous energy growth until 2010 and beyond, due to high increases in population and a changing consumer patterns. Modern applications using electrical energy cause supplementation of traditional energy sources. New power plants are urgently needed. At the same time the Indonesian government is reducing subsidies in the entire energy sector. Customer prices per kWh of electricity and also fossil energy costs increase and help renewable energy sources to gain weight. Mainly mini hydro, but also biomass and photovoltaic systems are already considered an option. The comparison of installation costs of mini hydro, diesel and WTG plants has shown that wind energy can be a competitor to conventional diesel plants as well as to mini hydro applications. So while political and administrational matters may be settled over the next few years, wind farm developers should conduct some economic efficiency calculations. Current data suggests that they will come up with cost effective small scale applications for isolated grids. The installation of large numbers of WTGs in wind farms for supplementing or supporting conventional large scale power plants is a question of infrastructure. They might be applicable on Java, where a sufficient grid for transmission will be available soon and roads and harbors allow handling of heavy machinery.

Four sites with good wind conditions are particularly promising for wind power application: Kupang on West Timor, the island of Selayar in South Sulawesi and the two towns Kalianget and Madiun on East Java. All of them have been previously or recently provided with WTGs. Kupang and the two Javanese towns are near existing demand, and Selayar has prospects for demand from tourism. Other prerequisites are in place for some, but not all of these locations.

These sites could be considered for wind power implementation under the umbrella of the Clean Development Mechanism. This tool from the Kyoto Protocol can contribute to the development of wind power, while fulfilling its primary target of greenhouse gas mitigation. Indonesia is an active participant in the international debate on climate change and also on sustainable development. Applying the CDM with the utilization of wind power, Indonesia can contribute to the prevention of climate change and support its own ambitions to achieve sustainable development domestically. Managing economic recovery including renewable energies is a long term investment for Indonesia. The nation cannot afford to stay behind international technological developments and thus undermine its people's future opportunities to develop sustainable energy resources. Wind power turbines are high-tech applications that Indonesia can finance with the help from the CDM.

There are still only few people in Indonesia, who really anticipate wind power to be a potential power source. The international community, and in their own interest the wind power industry itself, should support them in their struggle for further research and development. Wind power in Europe took a long time to prevail; unleaded fuel took twenty years to reach Indonesia. The Directorate General for Electricity and Energy Utilization has put up a small WTG in front of the main office in Jakarta for promotional purposes, as they say. Promotion, however, is usually aimed at receiving attraction for, selling or implementing the promoted object. Faith in wind power, thus, seems to withstand doubts and preliminary data. With joint efforts it could eventually outpace those who object.

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