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A comparative analysis of renewable electricity support mechanisms for Southeast Asia

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ABSTRACT

This study evaluates the applicability of eight renewable electricity policy mechanisms for Southeast Asian electricity markets. It begins by describing the methodology behind 90 research interviews of stakeholders in the electricity industry. It then outlines four justifications given by respondents for government intervention to support renewables in Southeast Asia: unpriced negative externalities, counteracting subsidies for conventional energy sources, the public goods aspect of renewable energy, and the presence of non-technical barriers. The article develops an analytical framework to evaluate renewable portfolio standards, green power programs, public research and development expenditures, systems benefits charges, investment tax credits, production tax credits, tendering, and feed-in tariffs in Southeast Asia. It assesses each of these mechanisms according to the criteria of efficacy, cost effectiveness, dynamic efficiency, equity, and fiscal responsibility. The study concludes that one mechanism, feed-in tariffs, is both the most preferred by respondents and the only one that meets all criteria.

1. Introduction

Southeast Asia—the ten countries of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam—faces a series of electricity and energy policy challenges. For these countries total energy consumption increased 4.2 percent per year from 1999 to 2009, coal consumption grew by 10.5 percent, natural gas by 7.5 percent, and electricity by 5.5 percent. Looking forward from 2005 to 2030, energy consumption is expected to grow 2.6 times and carbon dioxide emissions are expected to quadruple due to greater reliance on coal [1]. For some of the smaller Southeast Asian countries, electricity use is expected to grow 23 times current rates of consumption between now and 2030 [2].

In response to burgeoning demand for energy, the use of renewable electricity sources has grown in the past few years. The Philippines ranks second in the world for total geothermal electricity generation and Indonesia comes third, the Philippines is second for total biomass power, and solar photovoltaics have seen rapid annual growth in Thailand [3]. Yet using the most recent data available from 2007, renewable electricity accounted for slightly less than 17 percent of total supply, and this share was dominated by large-scale hydroelectric facilities. Fig. 1 and Table 1 show geothermal facilities produced less than 3 percent of the region's power, biomass less than 2 percent, wind and solar less than one half of a percent.

Why isn't Southeast Asia investing more in renewable sources of electricity? One 2007 survey concluded that Brunei and Singapore did not even have mechanisms to promote renewable energy. The assessment noted that Laos and Vietnam offered only short-term loans and that despite renewable portfolio standards in the Philippines and Thailand, investments in fossil fueled capacity continued to outpace investments in alternative sources. The study concluded that regulatory frameworks were not harmonized, too much variation existed between countries, many "improper policies and regulations" were in place, and the region as a whole was "not yet ready" for renewable energy [4].

Another recent assessment conducted by the International Energy Agency warned that conventional energy subsidies dominated the Southeast Asian energy market, support for renewable energy production was virtually nonexistent, countries suffered from huge gaps in policy and regulatory frameworks, and most investors and regulators lacked awareness of renewable energy technologies and the capacity to change course [5]. The assessment called for a removal of non-technical barriers to improve markets, attract investment, and foster innovation.

Based on extensive research interviews supplemented with a review of the peer-reviewed literature, this study evaluates the

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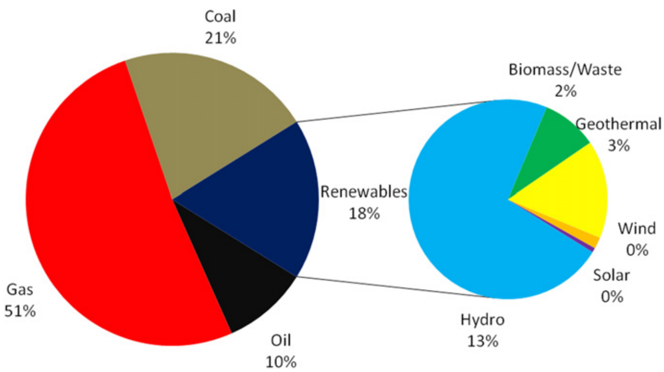

Fig. 1. Electricity Fuel Mix for the 10 ASEAN Countries (2007). Source: [106–109].

applicability of eight renewable electricity policy mechanisms for Southeast Asian electricity markets. It begins by describing the methodology utilized for these research interviews as well as some of the demographic details of respondents. It then outlines four justifications given by respondents for government intervention to support renewables in Southeast Asia: unpriced negative externalities, counteracting subsidies for conventional energy sources, the public goods aspect of renewable energy, and the presence of non-technical barriers. The article develops an analytical framework to evaluate eight commonly used mechanisms for harnessing the power of renewables—renewable portfolio standards, green power programs, public research and development expenditures, systems benefits charges, investment tax credits, production tax credits, tendering, and feed-in tariffs. It analyzes each of these mechanisms according to the criteria of efficacy (ability to encourage investments in renewable energy infrastructure), cost effectiveness (success at keeping electricity prices low), dynamic efficiency (ability to promote diversification), equity (applicability to a broad range of actors), and fiscal responsibility (ability to be financially self sustaining without government revenues). The study concludes that one mechanism, feed-in tariffs, is both the most preferred by respondents and the only one that meets all criteria.

The study's focus on Southeast Asia and renewable electricity policy is important for at least three reasons. First, a practically bewildering collection of policy mechanisms is available to policymakers around the world wishing to promote renewable electricity, making it difficult to identify optimal options. As of early 2009, policy targets for renewable energy existed in 73 countries worldwide including all 27 members of the European Union, 33 states in the United States, and 9 Canadian Provinces. No less than 64 countries had energy policies requiring the mandatory use of renewable energy. At least 37 countries had adopted some form of price-based support mechanism, 49 states and countries portfolio standards, and more than 30 countries tax credits, tax exemptions, and public financing [6]. This study boils these diffuse options down to the ones most applicable to Southeast Asia.

Second, discussions of energy policy in Asia are often dominated by the "big four" consumers China, Japan, India, and South Korea, in effect eclipsing Southeast Asian countries. Yet Southeast Asia is home to 10 percent of the world's population, 4.5 million square kilometers of land, and economies that produce $1.1 trillion in combined gross domestic product annually and annual total trade revenues of about $1.4 trillion. The region is larger in geographic size and population than the United States and contributed to 12 percent of the world's total greenhouse gas emissions in 2000. The region also features a mix of high and middle income countries such as Brunei and Singapore (which face energy challenges similar to those in Europe and North America) along with lower income countries such as Cambodia, Laos, and Indonesia (that face wholly different challenges such as energy poverty). Clearly these countries deserve a robust commentary about their energy and electricity policies, and a discussion of the options that best suit them can offer useful lessons for other countries and regions.

Third, it is essential that Southeast Asian countries begin rapidly investing in renewable forms of electricity supply. The Asian Development Bank warns that because of their unique geography, countries such as Indonesia, Philippines, Thailand, and Vietnam will suffer more from climate change than the global average [7]. These four countries alone are expected to lose 6.7 percent of combined GDP by 2100 if business as usual continues, more than twice the rate of global average losses. The ADB found that the energy sector would be the fastest growing contributor to the region's emissions, but also that aggressive investments in infrastructure such as renewable electricity could reduce 80 percent of emissions at a total cost below 1 percent of GDP by 2020. The key to capturing these benefits, however, is investing sooner rather than later. This study offers regulators a concise description of the policy architecture needed to incentivize that investment.

2. Methodology

To gain insight on the appropriate renewable energy policy mechanisms for Southeast Asia, the study relied on two years of research interviews supplemented with a review of the academic peer-reviewed literature. To get the broadest perspective possible, the author visited countries and institutions in Southeast Asia as well as those in Europe and the United States, which have a longer history of policy support for renewables. The author conducted 90

Table 1
Electricity Generation by Source for ASEAN countries, 2007 (billion kWh). Country totals and the numbers for ASEAN have been bolded.

	Oil	Gas	Coal	Hydro	Biomass/ Waste	Geothermal	Wind	Solar	Total
Brunei	0.031	3.069							**3.1**
Cambodia	1.102			0.058					**1.16**
Indonesia	21.3639	43.9845	40.2144	12.567	2.5134	4.02144	0.75402	0.25134	**125.67**
Laos	0.0328			1.6072					**1.64**
Malaysia	3.76504	64.69924	24.37368	6.24204					**99.08**
Myanmar	0.1192	4.47		1.3708					**5.96**
Philippines	6.41767	8.89845	16.39472	7.17269	3.82903	10.40849	0.5393	0.26965	**53.93**
Singapore	6.6744	29.2932			1.1124				**37.08**
Thailand	2.6136	96.7032	20.9088	9.1476	0.78408		0.39204	0.13068	**130.68**
Vietnam	6.5136	12.4844	7.5992	27.6828					**54.28**
ASEAN	**48.63321**	**263.602**	**109.4908**	**65.84813**	**8.23891**	**14.42993**	**1.68536**	**0.65167**	**512.58**

Source: [106–109].

semi-structured interviews at 43 institutions in 15 countries over the course of September 2007 to April 2009. Those interviewed were selected to represent a sample of the stakeholders involved in the electricity industry, including:

- Electricity suppliers such as electric utilities, load serving entities, independent power providers, energy trading firms, and transmission system operators;
- Regulatory agencies such as state ministries, planning offices, and utility commissions;
- Manufacturers including systems manufacturers, installers, trade groups and associations;
- Research institutes such as universities, research laboratories, and think tanks;
- Financial institutions such as banks and regional development banks;
- Other organizations such as the International Energy Agency and the Association of Southeast Asian Nations (ASEAN).

Interviews generally lasted between thirty and ninety minutes and were recorded and transcribed to ensure accuracy. Respondents were guaranteed confidentiality and anonymity to encourage candor and respect institutional review board procedures concerning research on human subjects. Although it is impossible to connect what was said with who said it, Fig. 2 offers some basic demographic information about participants and Appseca1 provides a list of their institutions. Statements made from the interviews are presented in this study as having a date, institution, and location but no name.

The author asked participants three open-ended qualitative questions and one quantitative question. The first three questions were open-ended. The author asked respondents to identify (1) the barriers to renewable electricity in Southeast Asia and elsewhere; (2) justifications for why government intervention may be necessary to promote renewables; and (3) the public policies that they believed could overcome those barriers in a Southeast Asian context. Participants were permitted to respond to each question for as long as they needed, and they were also asked to recommend

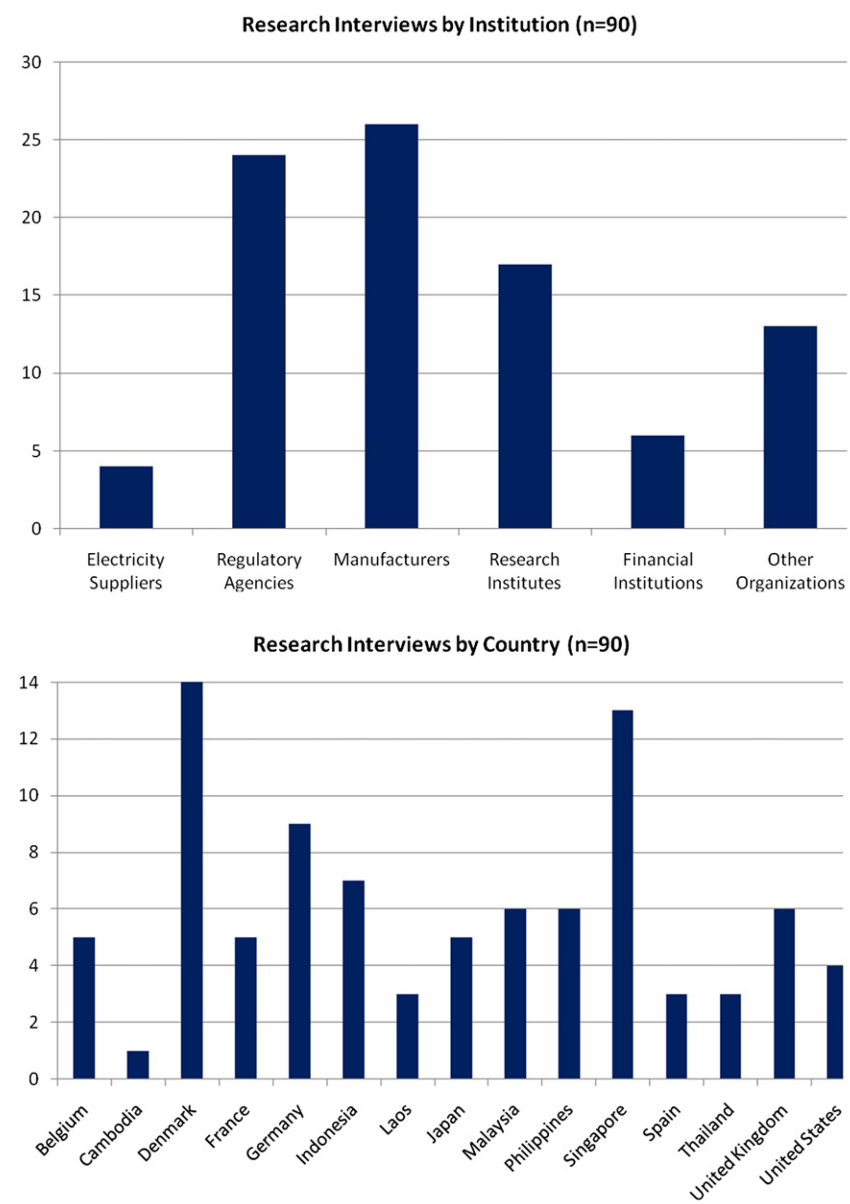

Fig. 2. Demographic Information Regarding Research Interviews.

literature confirming their points. The author occasionally followed-up with additional questions to solicit more comprehensive answers. At the conclusion of the interview the author posed one quantitative question asking respondents to rank a set of eight renewable policy mechanisms against each other.

The author selected semi-structured research interviews as a methodological tool because they were structured enough to ask the same set of questions, but open-ended enough to work those questions into a conversational flow. The interviews enabled the author to follow up immediately with unclear responses and explore answers in greater depth. Another advantage was that the interviews gave participants as long as they wished to answer questions, in theory providing more complete answers. One weakness to the approach, however, was the small sample of respondents (90 is infinitesimal compared to the number of people involved in renewable energy technology and policy) and the fact that respondents were speaking from their personal experience, interjecting a level of subjectivity into their comments. Another weakness was that respondents could conceivably give dishonest, incomplete, or inaccurate responses to hide feelings of embarrassment, nervousness, or lack of knowledge about the topic.

Still, the data from these research interviews do illustrate a consensus among participants concerning their perspective on public policy mechanisms. The section "Justification for Public Policy" presents the results from the first two questions concerning barriers and government intervention, the section after it, "Effective Public Policies," discusses the answers to the third question about policy mechanisms, and the final section assesses how respondents compared preferred policy mechanisms to each other.

3. Justifications for public policy

Participants indicated that public policy intervention was needed to promote renewable electricity for at least four interconnected reasons: unpriced negative externalities associated with electricity generation, historical subsidies for conventional forms of electricity supply, the public goods aspect of renewable electricity, and the presence of tenacious non-technical barriers.

3.1. Unpriced negative externalities

Participants stated that electricity prices in Southeast Asia (as elsewhere) do not reflect the true costs of generating power. Renewable electricity generation has many social and environmental benefits (or positive externalities) that are not captured in existing markets. As one respondent put it, "renewables bring many benefits which are not necessarily factored into Southeast Asian electricity prices such as employment, energy security, diversification of supply, economic competitiveness, reduced air pollution, and fewer greenhouse gas emissions [8]." Conventional coal, oil, natural gas, and nuclear units, by contrast, can produce severe negative externalities that are also unpriced.

For example, Thomas Sundqvist and Patrik Soderholm analyzed as many externality estimates they could find (132 in all) to determine the extent that positive and negative externalities were connected to sources of electricity supply (See Table 2) [9,10]. They found that net costs (negative externalities outweighed positive ones) ranged from a low of 0 ¢/kWh to a high of almost 73 ¢/kWh for various technologies, with a mean of 15 ¢/kWh for coal, 14 ¢/kWh for oil, 9 ¢/kWh for nuclear power, 5 ¢/kWh for biomass and natural gas, and less than 1 ¢/kWh for wind and solar. When updated to $2007 and weighted according to the global average, about 13.46 cents of negative externalities occur for every kWh of electricity [11]. When correlated with the amount of electricity generated in Southeast Asia, the toll from negative externalities becomes quite large. All non climate related externalities amount to about $69 billion in damages per year and, if priced conservatively at $20 per ton, emissions of carbon dioxide add another $20 billion, bringing the grand total close to $90 billion (see Fig. 3).

Table 2
Negative Externalities Associated With Different Sources of Electricity Supply, $1998 (US Cents/kWh). Mean numbers have been bolded.

	Coal	Oil	Gas	Nuclear	Hydro	Wind	Solar	Biomass
Min	0.06	0.03	0.003	0.0003	0.02	0	0	0
Max	72.42	39.93	13.22	64.45	26.26	0.80	1.69	22.09
Mean	**14.87**	**13.57**	**5.02**	**8.63**	**3.84**	**0.29**	**0.69**	**5.20**
SD	16.89	12.51	4.73	18.62	8.40	0.20	0.57	6.11
N	29	15	24	16	11	14	7	16

Source: [9,10].

Externalities may be worse in Southeast Asia because of the region's higher levels of poverty, warmer weather, and large oil and gas industry. One respondent indicated that because per capita incomes are generally lower in Southeast Asia, people lack the resources and capacity to avoid living near heavily polluted areas [12]. Environmental laws and regulations tend to be "weaker" in Southeast Asia compared to other industrialized countries [13]. The warmer climate decreases the efficiency of transmission and distribution lines (meaning more energy needs to be generated to reach consumers) and also results in greater air conditioning loads [14]. The exploration, onshore and offshore drilling, processing and refining from the region's large oil and gas industry create potentially serious risks to the local environment and community health. In Sidardjo, Indonesia, natural gas exploration and well drilling caused volcanic mud eruptions that have submerged four villages and dozens of factories, destroyed more than 11,000 homes, and ruined 360 hectares of rice and cane fields [15]. The International Association of Oil and Gas Producers has also noted that the amount of methane emissions per unit of production in this region is the *highest* in the world: about 2.8 tons of methane emitted for every thousand tons of gas produced, more than twice the global rate of 1.3 and nine times higher than the rate in Europe [16].

Yet because many of the costs of conventional technologies are unpriced in the market, it creates an incentive to overinvest in traditional technologies and underinvest in renewables.

3.2. Subsidies to conventional energy

Participants commented that energy subsidies have created an unfair market advantage for conventional fuels and technologies and distorted Southeast Asian electricity markets. One respondent indicated that "without additional government subsidies to counteract those given to conventional sources in the past, the supposedly liberal market will automatically switch back entirely to coal and lignite [17]." Even existing energy subsidies continue to favor conventional resources.

In many Southeast Asian countries, especially Indonesia, coal producers still receive government incentives for mining, exploration, development, and research. Oil and gas producers in Malaysia and Thailand receive depletion allowances, bonuses for enhanced oil recovery, tax reductions for drilling and development costs, fuel production credits, and research subsidies. Using the best available data, energy subsidies for Southeast Asian countries totaled about $61 billion in 2008. Fig. 4 shows that these subsidies were heavily tilted towards fuel subsidies (primarily oil, diesel, petrol), conventional electricity supply, and natural gas.

3.3. Public goods

Closely related to the discussion of externalities above (but classified separately by respondents) comes the notion of public

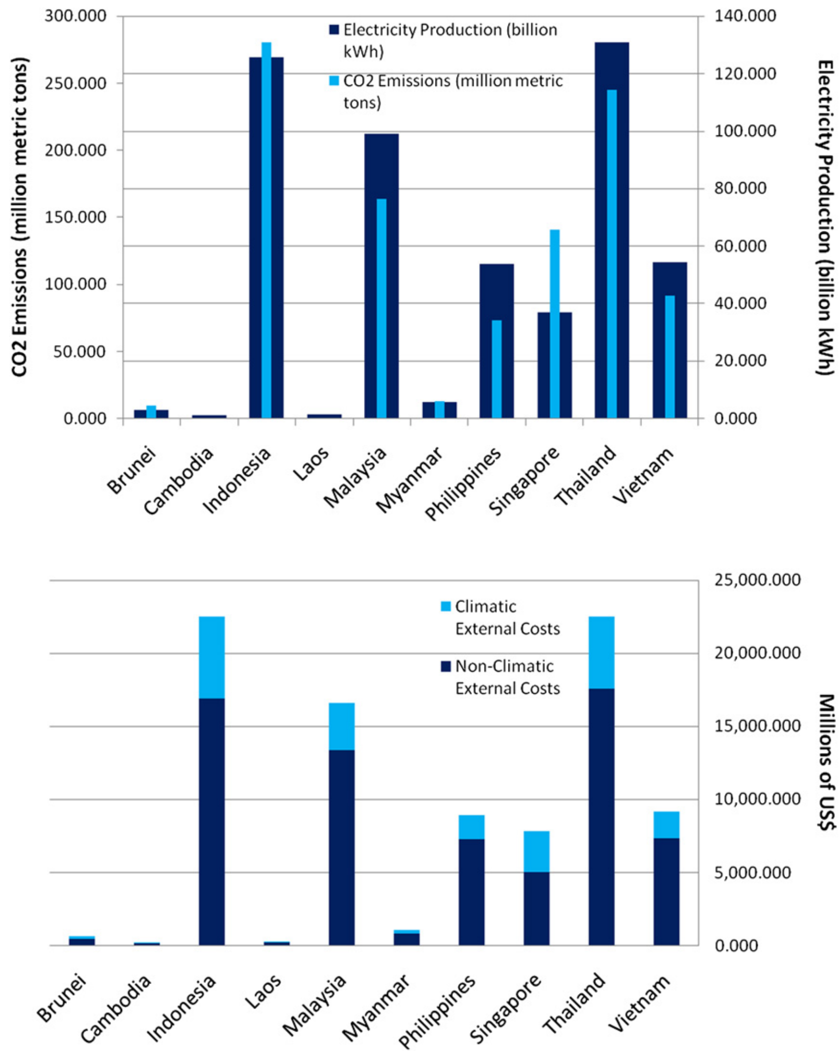

Fig. 3. Electricity Production and Carbon Dioxide Emissions for Southeast Asian Countries (Top Graph), External and Climate Costs (Bottom Graph) [Source: [107]].

goods. The concept of a public good goes back at least as far as Mancur Olson's classic text, which argued that groups will not organize themselves to promote collective interest because of their ability to benefit by doing nothing. Even altruistic and well intentioned people will not act in favor of the public good because they could rationally decide that their own contribution would be imperceptible. This social isolation of individuals, especially when the interests of the larger group are significant, causes free-riding behavior and results in a discrepancy between collective and individual interest [18].

At least some free riding appears to be occurring in Southeast Asia. One respondent indicated that renewable energy is a "common public good" making it subject to a "free rider problem where everyone benefits from Southeast Asian investments in renewable supply without having to pay for them [19]." In this way renewable energy is "similar to education, health care, and national security" and constitutes "an item that must be provided by government [20]." Markets, the thinking goes, provide optimal and efficient allocation of private goods but not public goods. Since the improved health, cleaner air, and enhanced economic strength created by renewable energy technologies are also public goods, its benefits are not efficiently allocated by existing electricity markets, necessitating government intervention.

3.4. Tenacious non-technical barriers

A final justification referenced by respondents relates to an assortment of non-technical barriers impeding the wider use of renewable electricity. These were loosely divided by respondents into information asymmetries and lack of knowledge, shortages of equipment, electricity restructuring, the first cost hurdle and investor bias, and predatory and discriminatory practices undertaken by incumbent firms. Table 3 presents a summary of these barriers.

Individuals and firms are limited in their ability to use, store, retrieve, and analyze information, and in Southeast Asia they may not know basic facts about the electricity sector or renewable energy resources. One respondent complained that "accurate and unbiased information about renewable energy options in Southeast Asia is usually unavailable, expensive, incomplete, difficult to obtain, or nonexistent [21]." Another respondent stated that in Thailand, rice mill owners and farmers are unaccustomed to thinking about biomass, biogas, and other agricultural wastes as sources of energy, meaning they "lack the basic background and knowledge needed to evaluate investments in renewable energy systems [22]." In Malaysia, regulators and investors "commonly see renewable energy as immature, exotic, unproven, and risky [23]."

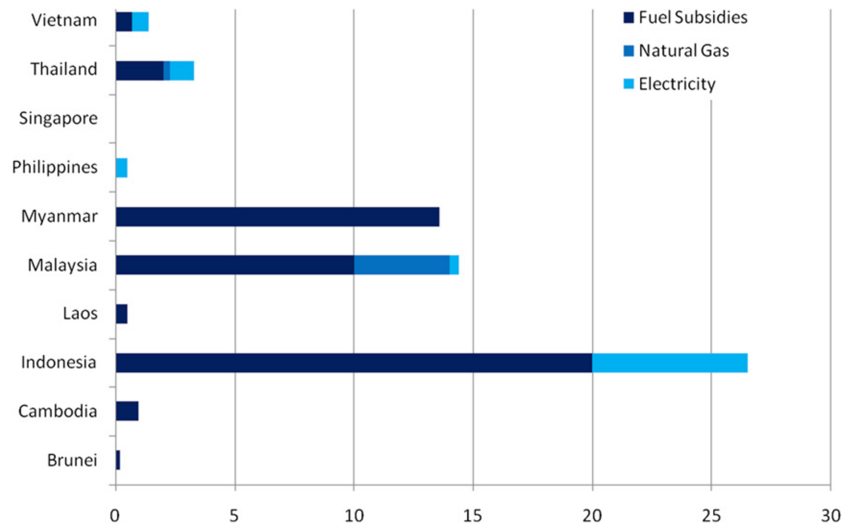

Fig. 4. Existing Energy Subsidies for Southeast Asian Countries (Billions of US$), 2008. Source: [110–113].

Yet another commented that an asymmetry of information exists in Cambodia between sellers and buyers (sellers know more so they "have an advantage to rip people off") as well as between good news and bad news ("horror stories of poorly performing systems are more commonly known than positive experiences") [24].

A second barrier relates to a lack of high-quality equipment. In Indonesia, one respondent argued that "affordable and high-quality components for small-scale solar, wind, and hydroelectric systems are in short supply [25]." In the Philippines, some of the commercial wind turbines have been disabled and dismantled so that valuable components and materials, such as copper and aluminum, could be sold on the black market [26]. In Myanmar, lack of components and improper maintenance of the country's few solar panels means that the average lifetime for a system tends to be 3 years instead of the 20–30 years found elsewhere [27].

A third barrier involves electricity market restructuring. In Southeast Asia, many electricity markets have been "deregulated" and "privatized" so that the government no longer controls all or some of the power sector. However, one respondent suggested that "this restructuring can hurt the penetration of renewable energy systems, as it creates pressure to keep costs low and focus only on the short-term [28]." In Thailand, restructuring has occurred with no independent regulator and no competition, only privatization, a "peculiar" kind of deregulation that has increased salaries for managers and provided higher shareholder returns at the expense of making investments in energy efficiency and renewable energy that would benefit customers [29]. In Singapore, the push for restructuring in the late 1990s led to an overbuilding of natural gas installed capacity, meaning that the existing number of power plants greatly exceeds demand. In 2007, about 57 percent of Singapore's installed electricity capacity did not operate continually. If all existing power plants were taken into account, and assuming that electricity demand grew at a rate of 5 percent per year, Singapore would not need to build any new capacity until about 2018, creating a huge disincentive to invest in forms of renewable supply [30].

A fourth barrier concerns the large amounts of capital needed to invest in renewable energy systems. Currently many investors in Southeast Asia have "short investment horizons" and make decisions based on "short-term electricity sales and contracts, meaning they prefer low-capital cost systems with rapid payback [31]." Respondents indicated that obtaining financing for wind and solar projects is "expensive" [32] and "difficult to obtain [33]." Another respondent noted that "renewable energy is capital intensive, and without government support to cover high up-front costs most investors and firms will shy away from the sector and pursue other opportunities [34]." One operator of a renewable energy facility in Singapore indicated that they could easily "triple the capacity of techniques such as anaerobic digestion and bio-methanization but financiers simply aren't interested because of the capital costs involved [35]."

A final class of barriers relates to predatory and discriminatory practices undertaken by incumbent firms. These firms use their market power or influence with regulators to make entry into the electricity sector difficult. In Thailand, one respondent said that "there is a widespread sentiment among renewable energy producers that interconnection standards and regulations are too onerous, as existing system operators and utilities set high requirements to minimize the risk that they could lose market share to independent power providers [36]." In Cambodia and Laos, another respondent argued that "most electric utilities have fiercely resisted attempts from rural electric cooperatives and other actors to introduce smaller-scale run-of-river and mini-hydro schemes [37]." In the Philippines, incumbent transmission and

Table 3
Non-Technical Barriers to Renewable Electricity in Southeast Asia Identified by Participants.

Barrier	Brunei	Laos	Vietnam	Cambodia	Malaysia	Indonesia	Thailand	Philippines	Myanmar	Singapore
Lack of Knowledge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Information Asymmetries				✓	✓		✓			
Shortages of Equipment						✓		✓	✓	
Electricity Restructuring							✓			✓
First Cost Hurdle/Investment Bias					✓					✓
Predatory Practices by Incumbents		✓		✓	✓	✓	✓	✓		

distribution companies will charge "excessively high transmission costs and rates for wheeling power from renewable resources [38]." In Malaysia, regulators have set high import duties on solar and biomass systems which can increase total system costs by as much as 55 percent [39]. In Indonesia, forest laws intended to stop the expansion of palm oil plantations have (perhaps unintentionally) stunted the development of geothermal power sources [40].

Many of these barriers were confirmed in a wide-ranging 2007 survey of renewable electricity in Southeast Asia [4]. The study identified 19 non-technical barriers ranging from lack of awareness and grid access to inappropriate regulations and fossil fuel subsidies in every Southeast Asian country but Myanmar, which was excluded from its scope.

4. Effective public policies

The question therefore becomes—if government intervention is justified, which public policies can best overcome these barriers to promote renewable electricity in Southeast Asia? Government interventions to promote renewable energy technologies have generally fallen into two broad classifications: supply-push mechanisms focus primarily on "pushing" technologies into the market through direct subsidies, and demand-pull mechanisms focus primarily on "pulling" technologies into the market by creating demand for them. Common examples of supply-push strategies include: (a) conducting basic and applied research and development on energy technologies; (b) building large test or prototype facilities; (c) having the government procure large amounts of an experimental technology; and (d) investor tax credits that spur innovation on a given technology. Common examples of demand-pull strategies include: (a) creating markets for technologies through production tax credits; (b) establishing rate-based or purchase-based incentives such as higher rates of return or tariffs; (c) promoting technologies through training or information and awareness campaigns [41–43].

In practice, the most prominently used mechanisms in Europe and the United States have been renewable portfolio standards, green power programs, public research and development expenditures, systems benefits charges, investment tax credits, production tax credits, tendering, and feed-in tariffs. This section develops and analytical framework consisting of the following five criteria to evaluate these eight policies, drawn from interview respondents as well as scholarship on public policy for renewable energy: [44–47].

- **Efficacy** refers to the ability of a mechanism to achieve its target or accomplish its goals. Efficacy is connected in part to level of support offered by a policy as well as its continuity and ability to create financial security. In this study a policy was deemed efficacious if it has resulted in a substantial increase in the amount of renewable energy generation.
- **Cost effectiveness** refers to the ability for a mechanism to reach its target at the lowest societal cost. Cost effectiveness is often enhanced by setting incentives that decrease in value over time (i.e., a consumer gets $100 today for installing a solar panel but only $90 next year). In this study a policy was deemed cost effective if it kept electricity prices low for consumers.
- **Dynamic efficiency** refers to the ability for a policy to promote a diversification of renewable energy sources and technologies. It captures how much a policy encourages the adoption of a basket of renewable energy systems including the most expensive ones. The criterion does face a tension with cost effectiveness in the short term, but in the long-term dynamic efficiency tends to reduce costs as innovation and competition occur. In this study a policy was deemed dynamically efficient if it promoted all five sources of renewable electricity (wind, solar, geothermal, biomass/waste, and hydroelectric) at various sizes and configurations.
- **Equity** refers to the eligibility of a policy mechanism. Does a policy assist all small-scale electricity producers and homeowners or is it only eligible for a small consolidated group? In this study, a policy was equitable if it offered support for not only electricity companies and manufacturers but also end users and firms outside of the energy sector.
- **Fiscal Responsibility** refers to how much a policy costs government. A fiscally responsible policy would be self sustaining and not need continually disburse government revenue. In this study, a policy was fiscally responsible if it was paid for by consumer themselves instead of by the government.

The analytical framework shows that each of the policy mechanisms has different sets of strengths and weaknesses (See Tables 4 and 5). This section explores them in detail.

4.1. Renewable portfolio standards

Sometimes called "renewable energy standards," "sustainable energy portfolio standards," the "Mandatory Renewable Energy Target" in Australia, the "Renewables Obligation" in the United Kingdom, or the "Special Measures Law" in Japan, renewable portfolio standards (RPS) mandate that utilities use renewables to produce a specific amount of their electricity sales or generating capacity. The RPS in the state of California in the United States, for example, currently requires that major electric utilities meet 20 percent of their retail sales with renewables by 2010 and a goal of reaching 33 percent by 2020.

RPS policies initially developed in the mid 1990s as a response to the perceived dangers of the introduction of electricity restructuring, where regulators privatized and liberalized many electricity markets. Since renewable energy sources were not at that time price competitive, it was agreed that additional policies were required to monetize their positive benefits. RPS became a tool for encouraging renewable energy as support for other mechanisms, such as R&D expenditures and tax credits, were waning [48]. In the mid 1990s, the European Commission also tried to push member states of the European Union to implement quota based support mechanisms and openly favored them over price-based support instruments.

RPS policies satisfy the criterion of efficacy, cost effectiveness, and fiscal responsibility but tend not to promote dynamic efficiency and equity. While the price of renewable energy under an RPS will remain uncertain as it is set by the market, quotas can ensure a given quantity of renewable energy is delivered by a given date. Unlike instruments developed by public utility commissions with long and complex procedures (often followed by litigation), one respondent stated that "RPS policies are bureaucratically simple [49]." They avoid the administration or dissemination of funds by government agencies, as quotas enable customers to pay producers directly for renewable energy. And, unlike a onetime award for funds, no project is guaranteed a place in the market [50].

However, RPS schemes do not tend to promote dynamic efficiency or equity. Because they promote least cost development, one respondent warned that "RPS policies promote only the cheapest resources first [51]." Under the intense competition induced by an RPS to keep prices low, suppliers tend not to support higher cost renewable energy resources. RPS usually apply only to electric utilities, meaning they exclude smaller firms or homeowners. To date, the bulk of projects associated with RPS programs in the United States have been commercial scale wind farms. This means RPS tend to favor vertically integrated generating companies and

Table 4
Advantages and Disadvantages of Eight Renewable Energy Policy Mechanisms.

Mechanism	Advantages	Disadvantages
Renewable Portfolio Standards	Diversifies investment risk Creates continuous pressure for lower electricity prices Minimizes government intervention Provides flexibility when coupled with a Renewable Energy Credit market	Will not initially support higher cost renewable energy Does not support off-grid systems Renewable Energy Credit prices will perpetually fluctuate
Green Power Programs	Allows consumers in areas without plentiful renewable resources to support them Does not impose the cost of renewable energy on those that do not wish to pay for it	Voluntary nature means no guarantee that new projects get built Does not uniformly promote renewable energy projects Inflated costs of renewable energy may create little incentive to improve efficiency among providers
Research & Development	Easily controlled by government Provides support to specific technologies	Concentrates investment risk with no guarantee of success At risk to declining public and private budgets
System Benefit Funds	Socializes the cost of renewable energy Can be used to promote other policy goals	Narrow geographic focus Modest funding Regulatory uncertainty
Investment Tax Credit	Directly promotes R&D Distributes risk to private companies	Can send false price signals Benefits investors, not electricity customers Can inflate vendor prices May have no effect on behavior
Production Tax Credit	Wide in scope Socializes the costs of renewable energy	Can be insufficient to attract new investment Significant budget must be available Must be known by producers Producers must have significant income stream Exclusionary to individuals and small firms
Tendering System	Government can control level of renewable penetration Provides an incentive to keep costs low Distributes savings to consumers	Fixed price distorts the market Reduces investor margins and can hurt R&D Tends to hurt domestic manufacturing, as investors seek least cost international suppliers
Feed-In Tariffs	Provides stable investment stream to developers Suppliers receive payments immediately Puts pressure on lower equipment prices More consistent than many unclear RPS	Little incentive may exist to drive electricity rates down or to innovate without degression Initially inflates the cost of electricity until significant amounts of renewable energy are deployed

big electric utilities that can handle large-scale renewable energy investments and infrastructure. They also concentrate renewable energy development in areas with the best resources, exacerbating public opposition to projects in some cases and distributing the benefits from renewable energy unevenly. Because they set an actual quota as a goal, moreover, RPS can create an "unintentional ceiling on renewable energy development, with little incentive to go beyond the minimum rate set by the policy [52]." One recent study from the U.S. National Renewable Energy Laboratory on the effectiveness of policy mechanisms argued that RPSs have been completely *ineffective* at promoting small-scale, residential renewable energy systems [53].

Because quotas stipulate a certain quantity of renewable energy but not a certain price, respondents also cautioned that "prices for renewable power will always be changing" making them "impossible to predict [54]." Given that many investors will care more about price than quantity, such an impediment could be significant in the eyes of many banks, insurance companies, and investing firms. In the United Kingdom, their RPS (called the "Renewables Obligation") has failed to grow the renewable energy market as intended and has actually increased costs. The uncertainty of prices for renewable electricity under the scheme has passed regulatory risk to the private sector, who then place a premium on it, adding to the expense of renewable energy systems [55].

4.2. Green power programs

Green power programs, sometimes called "green power marketing," "voluntary green power markets," or "utility green pricing," enable consumers to voluntarily pay more to receive electricity from renewable resources. (When their local power provider is unable to actually deliver this electricity, many programs allow consumers to buy renewable energy credits). The customer—whether an individual, business, or institution—can join a program offered by a local electric utility or retail marketer to purchase renewable energy (in areas that it is provided) or credits (in areas that it is not).

Green power programs have become especially popular in Australia, Germany, Switzerland, and the United States. In Germany, more than one million households and commercial firms relied on green power programs to purchase 4.1 TWh of renewable electricity in 2008; in Australia, almost one million homes and 34,000 businesses purchased 1.8 TWh of green power; and in Switzerland more than 600,000 customers purchased 4.7 GWh [3]. In the United States, about 850,000 residential and commercial customers participated in these green power programs and purchased 18 TWh of electricity in 2007.

Green power programs satisfy the criteria efficacy, equity, and fiscal responsibility but violate those of cost effectiveness and dynamic efficiency. They have the advantage of allowing customers in places that do not have significant renewable resources to support the development of renewable energy technologies elsewhere. They also do not impose the costs of renewable energy on those that do not wish to pay for them.

Respondents indicated that these strengths, however, are offset by substantial weaknesses. Green power marketing schemes provide no guarantee that additional renewable energy capacity will be built. The most common experience with rapidly growing programs has been for sponsors to cap or limit it, not build more capacity. Even the most successful programs barely represent a significant fraction of energy use or electricity sales. For those programs run by electric utilities, participation rates rarely exceed 5 percent, and the most popular programs have never exceeded 20 percent [56]. The problem here, said one respondent, is that "since green power programs are not mandatory and have no mechanisms to force people to use renewable energy, many customers can rely on conventional sources and 'free ride' on those wishing to enroll

Table 5
Analytical Evaluation of Eight Renewable Energy Policy Mechanisms.

Criteria	Meets Criteria	Does not meet Criteria	Why?
Efficacy			
Renewable Portfolio Standards	✓		Has incentivized considerable investment in electricity markets
Green Power Programs	✓		Programs promote renewable energy as long as demand for the product exists.
R&D		✓	R&D programs are subject to changing budget and policy conditions
Systems Benefits Charges		✓	Only a small fraction has gone towards renewable energy
Investment Tax Credits		✓	ITCs have been subject to regulatory uncertainty and frequently expired
Production Tax Credits		✓	PTCs have been prone to frequent expirations and changes
Tendering		✓	Tendering systems have been prone to many bids that were later abandoned by their sponsors
Feed-In Tariffs	✓		Provide long-term guarantees to project developers
Cost Effectiveness			
Renewable Portfolio Standards	✓		The competitive nature of the market provides an incentive to keep production and generation costs down
Green Power Programs		✓	Consumers pay a premium over market rates for renewable energy
R&D		✓	Usually aimed at promoting feasible technologies but not necessarily cost effective ones
Systems Benefits Charges		✓	SBCs are usually dispersed in lump sums or with fixed costs, providing little incentive to innovate or lower prices.
Investment Tax Credits		✓	ITCs they create little incentive to keep costs down
Production Tax Credits	✓		PTCs provide money for production of electricity rather than investment, keeping prices down
Tendering	✓		The competitive bidding process keeps generation costs low
Feed-In Tariffs	✓		Use of degression places pressure to lower costs over time
Dynamic Efficiency			
Renewable Portfolio Standards		✓	Tends to promote low cost renewable energy resources such as wind and biogas at the expense of solar and less mature systems
Green Power Programs		✓	Producers have little incentive to innovate if they are already receiving inflated costs for renewable energy generation
R&D	✓		Participants can utilize the money for a wide range of projects and applications
Systems Benefits Charges	✓		Can funnel funds to support a broad array of technologies
Investment Tax Credits	✓		ITCs can be utilized to support less mature technologies
Production Tax Credits	✓		PTCs can be utilized to support less mature technologies
Tendering		✓	Tends to promote least cost renewable resources
Feed-In Tariffs	✓		Supports both mature and less mature technologies
Equity			
Renewable Portfolio Standards		✓	Usually applies only to electric utilities and power providers and not homeowners and businesses
Green Power Programs	✓		Programs typically are open to all electricity customers
R&D		✓	R&D funds are usually available only to large corporations and national laboratories
Systems Benefits Charges		✓	SBC funds are usually distributed to select companies and foundations
Investment Tax Credits		✓	ITCs favor wealthy investors with significant sources of capital
Production Tax Credits		✓	PTCs favor incumbent or wealthy firms with significant financial assets
Tendering		✓	Favors large firms that can undertake projects with slim margins
Feed-In Tariffs	✓		Eligible to large utilities and power providers as well as homeowners and businesses
Fiscal Responsibility			
Renewable Portfolio Standards	✓		Ratepayers pay producers directly without relying on government funds
Green Power Programs	✓		Customers directly subsidize renewable energy projects
R&D		✓	R&D funds require substantial government support
Systems Benefits Charges	✓		SBC funds are derived directly from ratepayers with no need for government investment
Investment Tax Credits		✓	ITCs require continuous government funding
Production Tax Credits		✓	PTCs require continuous government funding
Tendering	✓		Financing comes indirectly from consumers
Feed-In Tariffs	✓		FITs do not require government financial support

in them [57].'' Green power programs, because they try to avoid charging consumers too much, also tend to promote only the lowest cost renewable resources. Indeed, the programs in the United States have almost exclusively promoted large-scale wind farms, but not solar panels, small-scale wind turbines, or other alternatives. In Europe, voluntary markets for green power have been primarily based on cheap hydroelectric power produced and certified in Scandinavian countries and sold in central Europe.

Lastly, and perhaps ironic given the point above about keeping costs low, green power programs *do* tend to be more expensive than other policy mechanisms. This is because the programs need firms to certify credits, match buyers with sellers, track trades, and ensure no "double counting" occurs (i.e., that the same credit is not used more than once). In 2009, for example, the average purchase price for wind electricity from a green power program in the United States was 9.1 ¢/kWh [58] when the U.S. Department of Energy reports that the average cost of producing and transmitting that electricity was less than 7.0 ¢/kWh [59]. This implies an extra cost of about 2 ¢/kWh to manage a green power program.

4.3. Research and development (R&D) expenditures

Another way many governments promote renewables is by sponsoring research and development (R&D). Every country in the European Union and North America manages some sort of R&D program. In the United States, one of the largest spenders on energy R&D in absolute terms, more than 150 separate R&D programs are funded by the federal government [60]. Some countries spend more on individual technologies. In 2003 the U.S. government spent $139 million for R&D on photovoltaics, yet that same year Japan sent more than $200 million and Germany more than $750 million [61].

R&D strategies have the benefit of being extremely flexible and promoting dynamic efficiency. Policymakers can support any particular technology, and can easily control and monitor the distribution of research funds. In addition, the direct expenditures on R&D can create jobs and occasionally lead to patents and royalties owned by the government. However, R&D expenditures fail to satisfy any of the other criteria relating to efficacy, cost effectiveness, equity and fiscal responsibility.

Respondents expressed skepticism that R&D programs could truly yield meaningful benefits in Southeast Asia because "large projects funded by the government not only cost taxpayers money, they tend to encourage corruption and nepotism [62]." R&D efforts are susceptible to declining government budgets, and in Southeast Asia "many governments have enough trouble trying to provide basic services such as clean water and housing—the idea of a crack Burmese program for advanced solar cells or an intensive offshore wind turbine research program in Vietnam is almost laughable [63]." One commentator also argued that R&D funds tend not to be awarded to "a large number of small and innovative firms" but to a "small number of large corporate firms that already have a close relationship with the government," leaving little funds left for independent entrepreneurs [64].

4.4. Systems benefits charges

System benefit charges (SBCs) place a small tax on every kWh of electricity generated, and then collect and use those funds to pursue socially beneficial energy projects. Also called "public benefit funds," "system benefit funds," and "clean energy funds," SBCs originated in the 1990s at a time when electricity markets were undergoing restructuring.

At least 18 different SBC programs exist in the United States and other countries have utilized a variety of SBC arrangements. The United Kingdom has an "Energy Savings Trust" that operates as a private limited company that receives money from a charge on transmission and distribution services that it uses to invest in energy efficiency and renewables. Norway has a small "transmission tax" dedicated to funding clean energy projects. New Zealand created its "Energy Saver Fund" to support $18 million worth of investment in small-scale renewable energy and energy efficiency [65].

SBCs satisfy the criteria of dynamic efficiency and fiscal responsibility, but do not meet those of efficacy, cost effectiveness, and equity. In terms of fiscal responsibility, SBCs can produce millions of dollars of revenue each year drawn precisely from electricity consumers. The 18 funds in the U.S. are expected to generate almost $7 billion in energy investments from 1997 to 2017. SBCs also promote dynamic efficiency because they offer policymakers the flexibility of promoting a rich variety of technologies and options. One survey of the SBC programs in the United States found that they promoted large-scale wind farms and solar power plants; non-renewable forms of distributed generation; consumer financing for energy efficiency investments; support for green power programs; public education campaigns about energy; small grants for business development; local research and development on new technologies; and low income energy assistance and weatherization programs [66].

However, respondents indicated that they believed SBCs suffered notable drawbacks. First is that only a small fraction of the funds actually go to renewable energy projects. As one respondent put it, "if we were to create a series of SBCs in Southeast Asia, renewable energy would be the last thing on the list; first could come air pollution controls and retrofits at conventional power plants, pipeline repairs, and other needed maintenance followed by electrification programs and transmission enhancements [67]." SBC funds also are usually dispersed in lump sums per project (meaning they are based "not on performance but instead create an incentive for managers to spend exactly the amount they are given") and awarded not to energy users and small companies but "government affiliated research institutes [68]."

4.5. Investment tax credits

Investment tax credits (ITCs), like the name implies, give favorable tax treatment to those that decide to invest their money in renewable energy projects. ITCs provide a partial tax write-off to investors of a particular renewable energy technology. At least 30 countries offered ITCs for renewable energy in 2007. ITCs have often enabled businesses and homeowners to receive a 5–50 percent tax credit for purchases of eligible renewable resources [69].

ITCs satisfy the criterion of dynamic flexibility, but violate the remaining four of efficacy, cost effectiveness, equity, and fiscal responsibility. ITCs have the benefit of facilitating investment in a specific technology or a suite of technologies, and they do offer investors a guaranteed and predictable source of tax relief.

However, these benefits are offset by shortcomings. ITCs are available for investment in certain technologies without account to their performance, meaning that they often lead to investments poorly designed systems. This may draw companies into the renewable energy industry that, in the words of one respondent, "usually lack experience and know more about tax laws and finance than engineering and electricity [70]." There is a history of ITC-funded wind turbines being sited carelessly and densely in the United States, leading to more avian deaths and underperformance, and resulting in lines of ugly, motionless machines [71]. Respondents also indicated that ITCs usually favor commercial installations and can inflate costs. Many homeowners and manufacturers in Southeast Asia lack sufficient income to use the ITC efficiently, since they must have all of the capital up-front for investment and can only claim the credit when filing for taxes [72]. ITCs can also contribute to the volatility of renewable energy markets, as large expenditures can inflate prices for projects and capital equipment.

In India, the ITC spurred the largest wind power industry among all developing nations but because firms received large economic gains from installing (but not operating) turbines performance has been poor. Capacity factors have been lower than wind facilities elsewhere, and many wind turbines were reportedly not operational with little effort made by their developers to repair them [73].

To capture ITC rebates, some companies in the United States installed non-functioning wind turbines made of cardboard and took pictures of them at the end of the year. These dodgy businesspeople hoped the photos would prevent the Internal Revenue Service (the national tax collection agency in the U.S.) from disallowing the tax write offs in case of an audit. If the projects were actually audited, a rare occurrence given the backlog of the IRS at the time, developers then claimed the turbines had been photographed but merely removed for repair. Because the chance of being caught gaming the ITC system was so low, investments in wind energy became a sort of lottery with developers hoping the benefits of getting credit for fake systems outweighed the chances of getting caught [74]. Millions of dollars intended to spur renewable energy ended up supporting motionless pieces of cardboard.

4.6. Production tax credits

Production tax credits (PTCs), unlike ITCs, provide the investor or owner of a qualifying property with an annual tax credit based on the amount of electricity generated by the facility during the course of a year. The clear difference is that the PTC actually rewards performance and production of energy. In the United States the PTC has lowered risk premiums for manufacturing investment. The PTC has enhanced private R&D expenditures, encouraged transportation savings from increased domestic manufacturing of components, and reduced financing charges and fees. Researchers at the Lawrence Berkeley National Laboratory have calculated the benefits of the PTC over ten years at a cost savings of 22 percent for wind turbines, or a reduction of $380 per installed kW [75].

In a Southeast Asian context, respondents suggested that PTCs would satisfy the criteria of cost effectiveness and dynamic efficiency but not those of efficacy, equity, and fiscal responsibility. By focusing on production of actual electricity, the PTC would incentivize innovation and lower costs, as the cheaper electricity could be produced the more the PTC would contribute to profits. The PTC could also be designed to support a basket of technologies from wind turbines and landfill gas generators to geothermal plants and solar panels.

However, respondents argued that the PTC does have some serious disadvantages. Since the PTC can only be used against passive income, it does little to help interested parties (such as rural farmers, homeowners, small businesses) find the funds to invest in renewable energy [76]. Governments lose millions of dollars in foregone tax revenue every year from PTCs, and the mechanism favors firms with significant financial assets. One respondent called the PTC "a rich man's" mechanism because it must work through actors, such as integrated energy companies or corporations, with high tax liabilities that are able to gain tax benefits from large-scale investments [77]. One recent study confirmed that the PTC, while benefitting big energy conglomerates, has actually discouraged community-based projects and investments in small-scale residential systems [78].

An overall inconsistency with PTC expiration has also hampered its effectiveness in places such as the United States. There, the expiration of the PTC and resulting uncertainty slowed wind development, increased reliance on greater foreign manufacturing, and convinced some wind developers to shift to overseas markets. Wind installations in the U.S. are 15–25 percent more expensive than if the PTC had not been allowed to expire multiple times [79].

4.7. Tendering

In a tendering system (also called a bidding system), renewable energy investors, developers, and project owners are invited to apply to bid on a renewable energy contract. The bid that can meet the requirement at the lowest price is awarded a fixed price contract. Renewable electricity resulting from bids is sold at market prices, while the difference between the sale and purchase price is financed through a non-discriminatory levy on all electricity consumption. The tender system was first developed under the Non-Fossil Fuel Obligation (NFFO) in the United Kingdom in 1991, where calls for tenders in relation to energy supply from renewables were made at intermittent intervals. Each renewable technology was given a quota, and the provider with the lowest asking price was given the contract by the UK's 12 public electricity supply companies. A similar competitive bidding process was started in France in 1996.

The tendering system meets the criteria of cost effectiveness and fiscal responsibility. By allocating contracts on the basis of competitive bidding, providers have an incentive to cut costs to make their bids more attractive. The tendering system also charges consumers directly for renewable energy rather than relying on tax credits or research grants.

However, tendering systems do not meet the criteria of efficacy, dynamic efficiency, and equity. Tendering has tended to motivate providers to reduce margins to make their bid. Such lower margins can damage their investment capabilities and in extreme situations lead to bankruptcy. In the United Kingdom, less than one-third of contracted capacity under the NFFO was actually installed [80]. One respondent stated that "tendering would not be effective in Southeast Asia or anywhere else for that matter because it is such a stop-and-go approach to renewable energy, relying on periodic calls for bids that are sporadic and unpredictable [81]." Such erratic announcement of tenders can complicate investment decisions.

The price competition resulting from tendering usually favors large incumbent renewable energy developers and suppliers, often state-owned enterprises without profit motives, at the expense of independent providers and small firms. Such competition translates into higher risks and therefore higher overall costs [82]. Since the chance of winning bids in a competitive market is rather low, many investors and potential power providers simply decide not to participate. This limited number of bidders allows the tendering system to be easily gamed. For example, in some tendering schemes a small number of players have "gamed" bid prices to block out competitors (but never intended to actually complete projects). Similarly, state-owned enterprises can commit to unreasonably low prices to win contracts since their lack of profitability means that they can force taxpayers to subsidize eventual projects [83].

4.8. Feed-in tariffs

Similar to a tendering system, feed-in tariffs (FITs) set a fixed price for utility purchases of renewable energy. Unlike a tendering system, however, providers do not have to compete in an auction to guarantee the lowest price, and rates are usually set at a "premium" and above retail prices to incentivize investment in renewable energy. Germany implemented its Electricity Feed-In Law in 1991 and created a market for renewable electricity by guaranteeing a high price and thus recovery of generation costs. The tariff works the same way a pollution tax does for firms that pollute, but as a positive rather than negative asset [84]. FITs are sometimes called "fixed price policies," "standard offer contracts," "feed-in laws," "renewable energy payments," and "advanced renewable tariffs [85]."

Most FIT schemes share several core characteristics. They provide a fixed price contract, which can be an all inclusive rate or a fixed premium on top of existing market prices for electricity, over a long period of time (usually the reasonable life of a system, or 15–30 years). The costs of these higher tariffs are distributed to all electricity consumers. Contracts are designed to cover investment costs and a modest return of 5–6 percent, utilities are obligated to purchase the power produced from renewable resources even if they do not need it, and tariffs are paid irrespective of the owner's actual power consumption. FIT schemes generally mandate that network and transmission operators must provide those wishing to take advantage of the tariffs access to the grid, sometimes giving them priority access. The most effective FIT schemes decrease tariff prices each year (something known as "degression" or "stepped tariffs") to reduce costs, encourage innovation, and incentivize people to take advantage of the tariff sooner rather than later (e.g., if a solar panel was given 40 ¢/kWh in 2009 it may fall to 38 ¢/kWh in 2010). FITs are differentiated by type, project size, location, and resource quality. FITs set no restrictions on eligibility or capacity, meaning that large-scale investor owned utilities can take advantage of them alongside smaller businesses and individual homeowners.

FITs satisfy all five criteria from the analytical framework. They promote efficacy by giving investors a guaranteed price for renewable electricity which "spills over into better financing and interest rates and lessens the transaction costs involved with securing capital, as the availability of a long-term revenue stream means projects are not constrained by periodic solicitations or program expirations and renewals [86]." Unlike tendering systems (that set the price too low) and RPS policies (that leave the price to the market), FITs give investors a reasonable rate of return, meaning the mechanism enrolls not only power providers and utilities but also ordinary people and firms outside of the energy sector.

FITs are performance based (providers get paid only for the electricity they produce), and they tend to promote cost effectiveness by driving prices down in a variety of ways. One respondent put it this way:

> The accelerated penetration of renewable resources provoked by FITs lessens demand for fossil fuels and displaces expensive fossil fuel imports, lowering electricity prices. The certainty and better financing rates with FITs translate into lower operating costs. By creating a domestic renewable energy industry FITs result in cost savings associated with the localization of manufacturing. Degression places pressure on manufacturers to continually innovate to lower costs of each set of technology, and operators and investors also face pressure to improve performance to get a greater return on investment. The diversification of supply induced by FITs enhances energy security and minimizes the risk of interruptions and price spikes of any single fuel or technology [87].

Some of these benefits can even be quantified. According to data from the German Federal Ministry of Environment, despite forcing consumers to pay higher tariffs for renewable energy, FITs produce net gains. There the FIT has lowered the average market price of electricity, displaced inefficient and more polluting power plants, and reduced energy dependence and the costs of importing coal and other fossil fuels. When added together, the German FIT cost consumers and the government about €3.3 billion in tariffs and program costs but saved them €9.4 billion in 2006 [88]. One respondent noted that all of these benefits were captured by an initial increase on electricity bills by about €6 a month, or "the equivalent of a cup of coffee or a loaf of bread per family [89]."

FITs meet the criterion of diversification because they provide an incentive to build renewable energy "all over the country, in varying sizes and configurations, owned by a variety of people and institutions, even in low resource areas [90]." In Germany, the FIT has promoted wind energy in coastal regions, inland areas, and offshore; solar panels on roofs, integrated into buildings, and in open spaces; small and large hydroelectric stations in the mountains, highlands, near rivers, and on streams; geothermal facilities; landfill gas and sewage treatment plants; and biomass plants near agricultural lands and forest centers. FITs not only promote diversification of technologies and locations but also ownership. "Because of the investor security FITs create," one respondent commented, "they bring more investors into the market, not just big firms that are used to handling risk [91]." Another respondent noted that "FITs do not discriminate against small or large firms, making them ideal for Southeast Asia and unlike other mechanisms such as RPS that have been cockeyed in favor of big energy conglomerates [92]." More than 90 percent of the 430,000 solar panels installed under the German FIT scheme, for example, are owned by homeowners and cooperatives instead of electric utilities and independent power providers. One respondent argued that "such participation greatly reduces public opposition to renewable energy projects because members of the public stand so much to gain from them [93]."

FITs satisfy the final criteria of equity and fiscal responsibility because they are generally open to everyone, and also are not paid for by the government. By setting tariffs that everyone can take advantage of, "FITs capture not only the idealists that want to do something green and would probably invest in renewable energy anyways, they also widen the scope to people that don't care about being green but do care about making money, and they broaden participation from large energy firms down to the smallest household [94]." FITs are also not a subsidy from the government, as the higher costs from tariffs are spread across electricity customers.

5. Discussion and conclusion

Those wishing to promote renewable electricity sources in Southeast Asia can mandate their use through RPS policies or count on the goodwill of people to voluntarily purchase renewable energy credits through green power programs. They can fund R&D of a particular technology or create a miniscule tax on every kWh of electricity generated and use some of the funds to invest in renewable energy. They can give large companies and savvy homeowners tax credits to partially offset their expenditures on renewable energy equipment or performance. They can create a complex bidding and auction system for renewable energy contracts, or pay renewable energy producers premium rates through a FIT.

Almost all mechanisms try to create price incentives for renewable electricity, some more effectively than others, some more directly than others. Many entail disadvantages that serve to benefit particular firms, consultants, and stakeholders, often at the expense of other firms and to the exclusion of small-scale, independently owned distributed systems. Most do not promote dynamic efficiency and instead focus on the cheapest and most mature technologies. Only FITs satisfy all of the analytical criteria of efficacy, cost effectiveness, dynamic efficiency, equity, and fiscal responsibility.

What about when different policy mechanisms are compared not to an abstract analytical framework but to each other? While the bulk of the data collected for this study was qualitative, the author did ask one quantitative question of respondents: if they could choose only one single policy mechanism, which one would be most important? Fig. 5 shows that almost two-thirds of respondents chose a feed-in tariff, about 10 percent chose RPS, PTC, and R&D policies, and less than 3 percent chose other mechanisms.

What explains the popularity of the FIT among respondents? Perhaps one reason is that FITs can work for practically any country in Southeast Asia independent of its particular type of electricity market, economy, or resource base. Less developed countries in the region can set tariffs more in line with their particular needs. Countries with abundant wind and solar resources can tailor their FIT to them; those with geothermal or

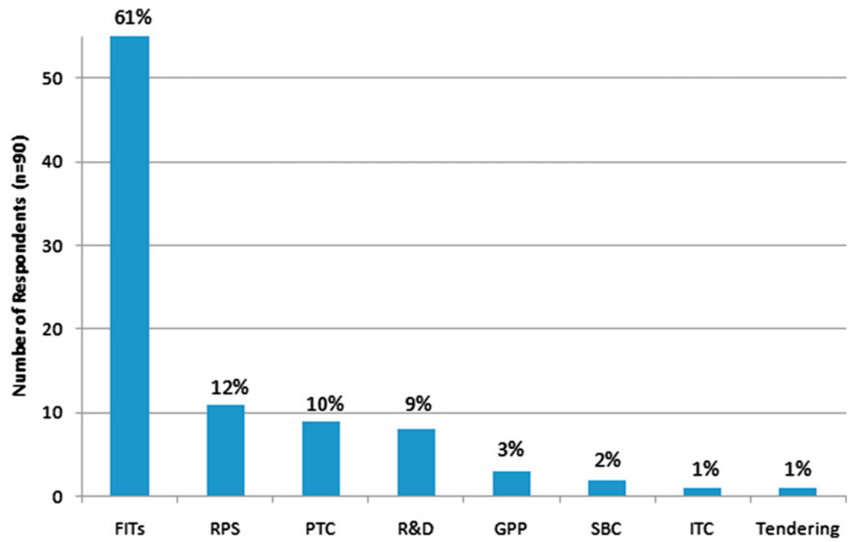

Fig. 5. Most Preferred Policy Mechanism Selected by Participants.

hydroelectric resources can do the same. FITs can also work in different types of electricity markets, giving state-owned enterprises access to the FIT in places such as Brunei or Myanmar and enhancing the access of private players and independent power providers in the restructured markets of Indonesia, Singapore, and Thailand.

Also, much of the literature recommended by participants suggests that FITs perform exceptionally when compared to other policy mechanisms. One recommended study from the International Energy Agency, for example, examined the effectiveness of renewable energy policies in 35 countries including members of the European Union and United States along with Brazil, Russia, India, China, and South Africa [95]. Together these countries account for 80 percent of total commercial renewable power generation around the world. The study noted that the group of four countries with highest effectiveness—Germany, Spain, Denmark, and Portugal—*all* used FITs to encourage wind and solar development. The study praised FITs for promoting high rates of investment stability, their simple framework with low administrative barriers and costs, and their tendency to have favorable grid access conditions. The study concluded that the average remuneration rates for FIT programs (9–11 ¢/kWh) were far more cost effective than any other mechanism (quota systems averaged 13–17 ¢/kWh). Other studies have compared FITs to alternative policies around the world and argued that they promote renewable electricity cheaper, [96,97] quicker, [98] and with lower production costs [99]. Several companies such as Suzlon Wind Energy and Dong Energy, among the world's biggest suppliers, have indicated they would not invest abroad without the certainty provided by FITs [100].

The results presented here also confirm those of other studies. One survey of representatives in the financial and renewable energy sectors (including infrastructure firms, commercial banks and investors, and multilateral and bilateral financing institutions) asked which kinds of policy frameworks were most effective at promoting renewable energy [101]. Eighty-one percent indicated FITs were the "most effective" yet just 10 percent said capital subsidies and grants and only 5 percent favored renewable portfolio standards. When asked to discuss the policy mechanisms that did not work, 58 percent said tradable certificates, 27 percent chose tendering, and 7 percent said capital subsidies, grants, and rebates. Another study surveyed 60 investment professionals from European and North American venture capital firms and private equity funds about their views on renewable energy policy mechanisms [114]. The study noted that investors in the sample strongly preferred FITs to be the most effective mechanism when compared to eleven other policies including carbon credits, tax credits, and reduction of fossil fuel subsidies. A final assessment of renewable energy policies in 17 countries measured the effectiveness of FITs against other mechanisms by looking at the amount of installed capacity per capita those policies incentivized from 1998 to 2004 [115]. That analysis concluded that FITs were the most effective since they supported almost 30 kW of capacity per capita whereas other mechanisms barely promoted 5 kW–10 kW per capita.

While FITs may be the best single tool to promote renewable electricity, however, a few caveats must be mentioned. FITs may be insufficient by themselves to catalyze growth in the Southeast Asian electricity sector. One study interviewed stakeholders from project development, capital provision, law, finance, investment banking, and electric utilities and found that far more important than the type of policy was how it was implemented. Respondents emphasized preference for policies that were easy to understand, transparent in terms of eligibility and compliance, and stable in duration and statute [102]. One respondent for this study termed this having "loud, long, and legal" policies: loud in the sense that they offer clear price signals and encourage public involvement; long in that they are consistent and predictable; and legal in that they are backed by strong political support and have penalties for noncompliance [103]. FITs may be most effective when combined with other complementary policies, such as the removal of subsidies for conventional energy sources, more accurate electricity prices, and the provision of energy efficiency programs [104]. Finally, some of the factors correlated with the acceptance of renewable energy may extend beyond regulation entirely, and include the level of awareness and type of values held by consumers and policymakers, structure of the electricity market, extent of political leadership, and the relative strength of existing energy and environmental lobbies [100]. As one respondent put it, "the issue of political will and social acceptability is one that may transcend any individual policy mechanism [105]."

Still, the evidence introduced in this study suggests that investors will not adopt renewable electricity resources on their own because of unpriced externalities, the distortionary effects of conventional energy subsidies, dilemmas of collective action, and a host of non-technical barriers. While policymakers have a rich number of options available to overcome these factors, the data presented here clearly shows that a FIT is the best option for Southeast Asian countries wishing to endorse renewable electricity supply.

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Appendix 1. Institutions Interviewed for the Study

Asia-Pacific Economic Cooperation (APEC) Secretariat
Asian Development Bank
Association of Southeast Asian Nations (ASEAN)
Central Research Institute of the Electric Power Industry
Cambodian Ministry of Industry, Mines, & Energy
Chatham House
Danish Energy Authority
Dong Energy
Economic Research Institute for Northeast Asia
Electricity Generating Authority of Thailand
Enercon
European Association for Renewable Energy
Fraunhofer-Institut für Solare Energiesysteme
General Electric Energy
German Federal Ministry for the Environment (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)
Global Wind Energy Council
Iberdrola
Indonesia Ministry of Energy and Natural Resources
Institute of Energy Economics (Japan)
Institute of Southeast Asian Studies
International Energy Agency
Laos Ministry of Energy and Mines
Laos National Committee for Energy
LM Glasfiber
Malaysia Energy Center
Nordic Hydropower
Philippines Department of Energy
Ramboll Wind Energy
Ratchaburi Electricity Generating Company
Renewable Energy and Energy Efficiency Partnership
Phoenix Solar
Sandia National Laboratories
Semiconductor Equipment and
Materials International
Singapore Ministry of the Environment
and Water Resources
Singapore Ministry of Trade and Industry
Solar-Fabrik AG
SunPower (Malaysia)
United Nations Environment Programme
University of Barcelona, Spain
University of Birmingham
Vestas
World Bank Group
World Future Council

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