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A review on global solar energy policy

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ABSTRACT

To overcome the negative impacts on the environment and other problems associated with fossil fuels have forced many countries to inquire into and change to environmental friendly alternatives that are renewable to sustain the increasing energy demand. Solar energy is one of the best renewable energy sources with least negative impacts on the environment. Different countries have formulated solar energy policies to reducing dependence on fossil fuel and increasing domestic energy production by solar energy. This paper discusses a review about the different solar energy policies implemented on the different countries of the world. According to the 2010 BP Statistical Energy Survey, the world cumulative installed solar energy capacity was 22928.9 MW in 2009, a change of 46.9% compared to 2008. Also this paper discussed the existing successful solar energy policies of few selected countries. Based on literatures, it has been found that FIT, RPS and incentives are the most beneficial energy policies implemented by many countries around the world. These policies provide significant motivation and interest for the development and use of renewable energy technologies. Also the status of solar energy policy for Malaysia is investigated and compared with that of the successful countries in the world.

Contents

Abbreviations: AEDB, Alternate Energy Development Board; ACT, Australian Capital Territory; BP, Before Present; BOS, Balance of System; BIPV, Bbuilding integrated PV systems; CAES, compressed air energy storage; CSP, concentrating solar power; CEB, Central Electricity Board; CDIC, Chinese Development and Innovation Committee; DG, distributed generation; EEG, Erneuerbare–Energien–Gesetz; FIT, feed-in tariff; GDP, gross domestic product; GHG, green house gas; HEE, health, environmental and economic; HOEP, hourly Ontario energy price; HOMER, hybrid optimization model for electric renewable; HRD, human resource development; IRR, internal rate of return of investment; ITC, investment tax credits; ISO, international organization for standardization; IEC, international electrotechnical commission; kWh, kilowatt-hour; MBD, million barrels per day; Mtoe, million tons of oil equivalents; MPPT, maximum power point tracking; MRET, mandatory renewable energy target; NIPV, non-integrated PV systems; NFPEs, non-financial public enterprises; NREP, national renewable energy policy; NEB, National Electricity Board; NDRC, National Development and Reform Committee; OPA, Ontario Power Authority; OPP, outline perspective plan; PV, photovoltaic; PER, renewable energy plan; PR, progress ratio; PTM, Pusat Tenaga Malaysia; PJ, petajoules; PCRET, Pakistan Council of Renewable Energy Technology; PTC, production tax credit; PURPA, Public Utility Regulatory Policies Act; RE, renewable energy; RESOP, Renewable Energy Standard Offer Program; RES, renewable energy source; RET, renewable energy technologies; RPS, renewable portfolio standard; RAT, reference average tariff; REL, renewable energy law; SREP, small renewable energy programme; SCORE, special committee on renewable energy; VAT, value added taxes; UKM, University Kebangsaan Malaysia; UM, University of Malaya; UPM, University Putra Malaysia; USM, University Sains Malaysia.

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1. Introduction

1.1. The energy policy

Energy policy is a strategy in which government decides to address the issues of energy development along with the development of the energy industry to sustain its growth; including energy production, distribution and consumption. The attributes of energy policy may include legislation, international treaties and incentives to investment. It plays a vital role to mitigate the impacts of global warming and crisis of energy availability [1,2].

1.2. Importance of solar energy

Solar energy is one of the cleanest energy resources that does not compromise or add to the global warming. The sun radiates more energy in one second then people have used since beginning of time. Solar energy is often called "alternative energy" to fossil fuel energy sources such as oil and coal.

Availability of cheap and abundant energy with minimum environmental and ecological hazards associated with its production and use is one of the important factors for desired improvement in the quality of life of the people. The growing scarcity of fossil fuels has raised global interest in the harnessing of solar energy [3–7]. Solar power is a type of energy with great future potential-even though at present it covers merely a minor portion of global energy demands (0.05% of the total primary energy supply); at the moment PV power generates less than 1% of total electricity supply. This is due to solar power still being considered the most expensive type of renewable energies. However, in remote regions of the earth it may very well constitute today's best solution for a decentralized energy supply [8,9]. According to the 2010 BP Statistical Energy Survey, the world cumulative installed solar energy capacity was 22928.9 MW in 2009, a change of 46.9% compared to 2008 [10].

1.3. Global energy consumption

World primary energy demand is projected in the Reference Scenario to expand by almost 60% from 2002 to 2030, an average annual increase of 1.7% per year. Demand will reach 16.5 billion tons of oil equivalents (toe) compared to 10.3 billion toes in 2002 which is shown in Table 1. On the other hand, fossil fuels will continue to dominate global energy use. They will account for around 85% of the increase in world primary demand over 2002–2030. And their share in total demand will increase slightly, from 80% in 2002 to 82% in 2030. The share of renewable energy sources will remain flat, at around 4%, while that of nuclear power will drop from 7% to 5% [11].

Oil will remain the single largest fuel in the global primary energy mix, even though its share will fall marginally, from 36% in 2002 to 35% in 2030. Demand for oil is projected to grow by 1.6% per year, from 77 MBD in 2002 to 90 MBD in 2010 and 121 MBD in 2030 [11].

1.4. Expected future of solar energy technology

Solar photovoltaic technology could harness the sun's energy to provide large-scale, domestically secure, and environmentally friendly electricity. In 2005, global solar markets reached US$ 11.8 billion, up 55% on 2004. Solar installations are expected to provide 15 GW in 2010 versus 2.7 GW in 2006. In April 2007, Photon Consulting forecast 2010 revenues from sales of solar energy equipment of US$ 90 billion, up from US$ 20 billion in 2006. Demand for silicon for solar cells is expected to increase from 41,000 tons in 2006 to 120,000 tons in 2010 and 400,000 tons in 2015 [12]. Table 2 shows the expected development and installation of solar photovoltaic electricity in the USA, Europe, Japan as well as worldwide until 2030.

1.5. Sources of GHGs and their effects

The most common GHG is carbon dioxide (CO_2) and two largest global sources of GHG are electricity and heat (32%) and transportation (17%). Service-sector companies' activities contribute to these sources through their electricity usage, heating, cooling and travelling. They may also contribute to other large global CO_2 emission sources such as land use change and forestry (24%) and manufacturing and construction (13%). Table 3 shows environmental impacts of the present energy system. Some degree of global warming is actually vital; otherwise this planet would be too cold to support life. However, the vast tonnage of CO_2 gas we have released into the atmosphere seems likely to upset the natural balance. Table 4 also shows world CO_2 emissions by region [14–17].

Table 1
World total final consumption (Mtoe) [11].

	1971	2002	2010	2030	2002–2030 (%)[a]
Coal	617	502	516	526	0.2
Oil	1893	3041	3610	5005	1.8
Gas	604	1150	1336	1758	1.5
Electricity	377	1139	1436	2263	2.5
Heat	68	237	254	294	0.8
Biomass and waste	641	999	1101	1290	0.9
Other renewable	0	8	13	41	6.2
Total	4200	7075	8267	11, 176	1.6

[a] Average annual growth rate.

Table 2
Development and installation of solar photovoltaic electricity in various countries [13].

Year	USA (MW)	Europe (MW)	Japan (MW)	Worldwide (MW)
2000	140	150	250	1000
2010	3000	3000	5000	14,000
2020	15,000	15,00	30,000	70,000
2030	25,000	30,000	72,000	140,000

Table 3
Environmental impacts of the present energy system [14].

Energy source	Inherent		Avoidable	
	Global	Local	Global	Local
Coal	CO_2	Mining	Acid rain	Air pollution
Oil	CO_2		Ocean pollution	Air pollution, local water resources
Gas	CO_2		Greenhouse gas due to leaking pipelines	
Hydropower		Aquatic ecosystem/competition with other water usage		Aquatic ecosystem/competition with other water usage
Nuclear	Non-proliferation	Accidents/political stability		Radioactive waste

Table 4
World carbon dioxide emissions by region, 1990–2025 [14].

Region	1990	2002	2010	2015	2020	2025
Mature market economics	10,465	11,877	13,080	13,745	14,392	15,183
North America	5769	6701	7674	8204	8759	9379
Western Europe	3413	3549	3674	3761	3812	3952
Mature market Asia	1284	1627	1731	1780	1822	1852
Transitional economics	4894	3124	3643	3937	4151	4386
Emerging economics	6101	9408	13,478	15,602	17,480	19,222
Asia	3890	6205	9306	10,863	12,263	13,540
Middle east	845	1361	1761	1975	2163	2352
Africa	655	854	1122	1283	1415	1524
Central and south America	711	988	1289	1280	1639	1806
Total world	21,460	24,209	30,201	33,284	36,023	38,790

1.6. Advantage of solar energy

Solar energy is obviously environmentally advantageous relative to any other energy source, and the linchpin of any serious sustainable development program. It does not deplete natural resources, does not cause CO_2 or other gaseous emission into air or generates liquid or solid waste products. Concerning sustainable development, the main direct or indirectly derived advantages of solar energy are the following [18–21]:

- No emissions of greenhouse (mainly CO_2, NO_x) or toxic gasses (SO_2, particulates);
- Reclamation of degraded land;
- Reduction of transmission lines from electricity grids;
- Improvement of quality of water resources;
- Increase of regional/national energy independence;
- Diversification and security of energy supply;
- Acceleration of rural electrification in developing countries.

As a result of concerns about climate change, increase the energy consumption rate, international agreements to reduce the GHGs emission and thinking about the availability of solar energy governments worldwide are beginning to establish national goals for the provision of electricity from renewable energy and hence try to set-up the various solar energy policies in various countries. In this paper the existing various solar policies are discussed briefly. There are many literatures that discussed mainly about the energy policies of a country. However, in this paper authors discussed and compared energy policies for 9 countries around the world. It is expected that it will be very useful for policy makers, energy producing industries, research organizations and Government for many parts of the world.

2. Review on solar energy policies for selected countries

A variety of policies like feed-in-tariff (FIT), portfolio standard (RPS), tax credits, pricing laws, production incentives, quota requirements, trading systems etc. have been developed and implemented to promote the use of renewable energy (RE) [22]. These strategies have main objective such as reducing the environmental impacts of the energy sector, reducing reliance on fossil fuels and encouraging new industrial development [23,24]. Yet the renewable portfolio standard (RPS) and the feed-in tariff (FIT) are the most popular. Though there exist a lot of debates surround their effectiveness, expecting a choice that has to be made between them. For this, it could be decided by the countries that which RE policy can be applicable in their own particular circumstances and objectives [23,25]. According to Ekins [26]"No optimal model has emerged, and probably none will do so in the contexts that is shaped by different histories and cultures".

2.1. Solar energy policy in North America

2.1.1. United States of America

In 2008 solar energy deployment increased at a record pace in the United States and throughout the world, according to industry reports. The Solar Energy Industries Association's, "2008 U.S solar Industry Year in Review", found that U.S. solar energy capacity increased by 17% in 2007, reaching the total equivalent of 8775 megawatts (MW). The Solar Energy Industry Association (SEIA) report tallies all types of solar energy, and in 2007 the United States installed 342 MW of solar photovoltaic (PV) electric power, 139 Thermal megawatts (MWTh) of silar water heating, 762 MWTh of pool heating, and 21 MWTh of solar space heating and cooling [27]. All renewable resources (solar, wind, geothermal, hydroelectric, biomass, and waste) provide 12% of the nation's electricity supply as of 2010. The DoE (Department of Energy) has established the goal of generating 10–15% of the nation's energy from solar sources by 2030 [28]. Solar power's contribution could grow upto 10% of the nation's power needs by 2025. The report, prepared by research and publishing firm Clean Edge and the nonprofit Co-op America, projects nearly 2% of the nation's electricity coming from concentrating solar power systems, while solar photovoltaic systems will provide more than 8% of the nation's electricity. Those figures correlate to nearly 50,000 MW of solar photovoltaic systems and more than 6600 MW of concentrating solar power [29].

2.1.1.1. Renewable portfolio standard. United States of America has adopted RPS mechanism in its 28 states; the maximum production energy is required by RPS from renewable energy such as solar, wind, geothermal and biomass. The majority of policy objectives aim to facilitate the diversification of electricity generation mixes, reduce state reliance on fossil fuels, increase renewable energy deployment, reduce carbon emissions, or various combinations thereof [30,31]. The majority of states with RPS policies allow utilities to exchange renewable energy certificates or renewable energy credits (RECs), to help utilities comply with their RE obligations.

Three assumptions were made about RPS policy program implementation. First, an RPS policy is only considered operational according to the effective date of policy implementation, not the adoption date. Second, any RPS policy that became effective in either November or December is not coded as effective until the following fiscal year. For instance, if a state effectively begins a RPS program in November 2003, the value of their RPS variable equals zero from 1998 to 2003, and one thereafter. Third, they do not code any voluntary or "goal" based RPS policies as a mandated standard.

They have to carefully assess the solar resource under worst conditions for renewable energy to totally meet its full potential in the US. Since, having added storage capacity in the form of CAES and thermal storage ensures that solar electricity production on the lowest radiation day, combined with the electricity production from the other renewable energy power plants, is sufficient to meet winter peak day load in 2100. To meet this hypothetical peak load, the solar power plant capacity is increased to the following: 4.72 TW of CAES–PV plants connected to 10.16 TW of supporting PV plants, 4.11 TW of CSP, and1.26 TW of distributed PV [32,33].

2.1.1.2. The formation incentives. It was first adopted as the Public Utility Regulatory Policies Act or PURPA in 1978. Like Denmark and many other developed nations, the U.S. crafted national policies to support energy alternatives and conservation in response to the rising cost of fossil energies throughout the 1970s. PURPA required utilities to purchase renewable electricity from qualified independent generators over long-term contracts. Unlike today's feed-in tariffs, which guarantee a premium for the renewable electricity delivered to the grid, PURPA payments were based upon the avoided cost of generating electricity from conventional sources. Approximately 12,000 MW was installed around the U.S. under PURPA from its implementation in 1981 until 1990. But the substantial drop in the price of oil and natural gas in the 1990s made these payments based on avoided cost too low for renewable energy projects to compete. Therefore, PURPA has resulted in only marginal amounts of renewable energy development since the early 1990s.

It was also in 1978 that the first investment tax credits (ITC) was established for renewable energy technologies. The Energy Tax Act of 1978 created residential tax credits for 30% of the first $2000 invested in a solar or wind system and 20% of the next $8000 invested; business tax credits for 15% of investment in a solar, wind and geothermal system; and an excise tax exemption for gasohol, which was later turned into a tax credit for ethanol. Tax credits had been available for the oil and natural gas industries but not for renewable energy, before this piece of legislation.

Over the last three decades, the renewable energy tax credits have undergone many changes, largely because of the shifting political climate in Washington, DC. In 1985, Congress was encouraged by the Reagan Administration to allow the residential solar and wind investment tax credits to expire for the first time.

2.1.1.3. Production tax credit. In 1992, a production tax credit (PTC) of 1.5 cent/kilowatt-hour (kWh) of electricity was created for large-scale wind projects. This tax credit was created partly in response to fraudulent developers who were installing turbines that did not function and taking advantage of the energy and investment tax credits, which were based on up-front capital costs [34]. The business ITC for solar was reduced to 10% from 1986 to 1988.The residential and business ITCs were raised to 30% and extended for 3 years in 2005, resulting in a doubling of installed PV capacity in the U.S. The 2007–2008 political seasons capped off the tumultuous 30-year ride for these tax credits. Congress finally passed a tax-extenders bill in October as part of a financial bail-out package for struggling Wall Street banks after a 2-year political stand-off over extending the credits before their expiration at the end of 2008. Today, the solar industry has an 8-year extension of the ITC. When looking at the brief history of renewable energy incentives in the U.S., it seems the only thing consistent about the tax credits has been in consistency.

This all-too-familiar issue has fuelled the debate over the effectiveness of relying on unstable short-term tax credits that are easily impacted by politics to incentivize renewable energy. Part of that debate revolves around the inequitable nature of the tax credits [35].

2.1.1.4. Target. Millions of Americans are enjoying the benefits of owning a solar hot water system or solar–electric. There were 83,000 solar–thermal and solar–electric systems installed around the U.S in 2007 [50]. Although state solar programs have played a key role in driving this growth, the 30% federal ITC has been the most important component. In recent report on the economic impact of the ITC, 8-year extension of the residential and business credits could result in over 6000 MW of annual solar PV and solar thermal installations by 2016. If Congress had failed to extend the ITC in 2008, Navigant projected that annual installations would have fallen to about 1500 MW by 2016.

2.1.2. Canada

Canada produces about 6% of global energy supplies and is the 5th largest producer of energy in the world [36]. The energy sector is an important part of Canada's economy in terms of investment, trade, income generation and employment. It produces of total energy (all sources) (397.5 megatons of oil equivalent (16,640 PJ). It is also the 8th largest consumer (269 megatons of oil equivalent (11,300 PJ)) [21,37].

Since the 1970s, Canada has formulated various strategic measures to accelerate the development of energy efficiency systems and renewable energy technologies [38] and has made significant progress. From 1990 to 2003, Canada's energy efficiency improved by an estimated 13%, or 883.3 petajoules (PJ), saving Canadians almost $13.4 billion in 2003 alone and reducing annual greenhouse gas emissions by 52.3 megatons [38].

2.1.2.1. Government incentives for photovoltaic. Government has an important role to play in reducing GHG emission trends. By using careful policy measures, government has the means to increase the uptake of PV, thereby spurring associated innovation and increasing economic competitiveness through economies of scale. By increasing reliance on distributed sources of renewable energy, particularly roof-mounted PV, governments of any size possess the power to reduce their regions' environmental impact through a reduction in GHG emissions from carbon use. Overall it can be seen that there are many reasons for which government has an interest in the expansion of distributed generation of renewable energy such as roof-mounted PV in their regions [39].

2.1.2.2. Feed-in tariffs. For renewable technologies, feed-in tariffs (FITs) have proven to be the most effective government incentive program. In fact, half of the world's PV installations are due to FITs [40]. FITs for PV are being utilized around the globe: in early 2009, 45 countries and 18 states/provinces/territories of Canada had FITs. Ontario's progressive FIT is predicted to increase the uptake of PV across the province; in particular, it will encourage rooftop PV deployment as a result of its sliding-scale pricing structure. The maximum potential if solar PV is deployed on every appropriate rooftop in the region, however, remains unknown because data concerning roof area in most regions simply does not exist. Understanding the rooftop solar PV potential is critical for utility planning, accommodating grid capacity, deploying financing schemes and formulating future adaptive policies.

Sustainable and renewable energy technologies (RETs) such as solar photovoltaic (PV) energy conversion are a solution to satisfying society's energy demands. As it is becoming clearer that energy policy needs to be informed by life cycle carbon emissions [41], many of the world's governments have produced policies intended to procure and improve the cost-effectiveness of RET projects by offering financial incentives (programs).

Ontario has made notable efforts towards expanding its RET sector. Although the 2009 and 2010 Federal budgets clearly indicate that the Canadian federal government is not directly investing or generating policy to support financial incentives for PV, it is providing funding for sustainable energy infrastructure to the provinces. In 2009, the Ontario Power Authority (OPA) launched the FIT program supported by the Green Energy and Green Economy Act 2009 [42] to procure RETs with small scale solar PVs receiving the highest tariff rate of 80.2 ¢/kWh [43,44]. In 2010, the Ontario government signed a $7 billion agreement between Samsung C&T Corporation and the Korea Power Electric Corporation (KPEC) which includes both solar PV and wind manufacturing facilities. Thus, the Ontario government is actively pursuing agreements with RET companies to stimulate manufacturing in Ontario.

The FIT initiative able to spark growth of the Ontario PV industry; the current subsidy structure does not guarantee grid parity and may lose many benefits associated with large-scale PV manufactured for Canada. While governments continue to prepare and establish energy policy to incentivize the growth of RETs, it is important to know that benefits arising from these initiatives are maximized for the society and the environment. The most aggressive growth has been seen in the thin-film PV production, which grew by 123% in 2008 to reach 0.89 GW.

In Ontario, Canada government has revenue streams for a large scale thin-film PV manufacturing plant. They estimated the revenue streams for the (i) taxation, (ii) sales of panels in Ontario, (iii) carbon offsets and (iv) saved health, environmental and economic costs associated with offsetting coal-fired energy generation for every year. Several assumptions were made to simplify the analysis and are justified appropriately. To account for variability and uncertainty that could occur with certain input values, a single variable sensitivity analysis was done to gain the effect of changes in major variables. It assumed that the market clear the entire 1 GW of panels produced each year in Ontario alone, excluding the effect of exports. Ontario has more than 30 GW of viable solar area potential on rooftops, and over 90 GW potential for ground based solar farms on marginal land in south-eastern Ontario alone making this a feasible assumption. Further analysis could consider more detailed market research in conjunction with multiple plant deployments. Currently, Ontario produces 28 TWh/year of energy from coal [45]. One GW of solar PVs functioning for an average of 3 'peak sun hours' per day for a year would produce1,095,750 MWh (~1.1 TWh) in Ontario. Currently, more than 25 years of cumulative deployment of 1 GW of PVs would be required to replace electricity production by coal plants. This means that greater deployment rates are necessary to replace coal and the cumulative market absorption of 1 GW per year of PV panels for 20 years. It is also clear that to eliminate all coal in the next 5 years in Ontario there needs to be aggressive investment in RETs [46].

Six general scenarios were considered for government investment in solar thin-film manufacturing as shown in Table 5. The options for investment were not limited to those, and it is possible for combinations or variations of those scenarios to be used as considered appropriate. The total cost of a 1 GW fabrication is $2.4 billion. The different scenarios consider ways in which the Ontario and Federal governments can invest in the 1 GW thin-film PV facilities.

Scenarios 1b, 1c and 5a are not desirable from a government stand point limited to an 8% internal rate of return of investment (IRR). In Scenario 5b, no loan default means the government invests nothing, but still has returns from the economic activity. In Scenario 6, the tax holiday has little investment or loss for the government, but again has a negligible impact on the capital required for the project from the company perspective. Scenario 3b is better than 3a as it helps the company more, with both governments easily able to recover the investment though economic activity. Scenario 1a, although aggressive, shows that it is possible for the government to give away the project while gaining a high return. Scenario 2 is more acceptable politically and commercially, but does not help the company decrease its upfront investment, though it reduces the

Table 5
Summary of the result for the six scenarios [47].

	Scenario 1		Scenario 2	Scenario 3	Scenario 4		Scenario 5		Scenario 6	
	1a Equal Fed + Prov	1b Prov only	1c Fed only	2 Equal Fed + Prov	3a 15% Prov	3b 15% Prov +15% Fed	4 Fed + Prov	5a Loan default 5thyr	5b No loan default	6 Fed +Prov
Prov. payback period (yr) IRR (%) years	6.40	11.38	N/A	2.32	2.96	2.96	9.24	11.38	N/A	N/A
5	−8%	−23%	N/A	18%	28%	28%	−19%	–	N/A	N/A
10	10%	−2%	N/A	26%	40%	40%	2%	−4%	N/A	N/A
15	14%	4%	N/A	28%	41%	41%	7%	5%	N/A	N/A
20	15%	6%	N/A	28%	41%	41%	9%	8%	N/A	N/A
Fed. Payback period (yr) IRR (%) Years	5.40	N/A	9.90	1.93	N/A	2.28	5.42	9.90	N/A	N/A
5	−3%	N/A	−20%	23%	N/A	41%	−3%	–	N/A	N/A
10	14%	N/A	0%	31%	N/A	50%	14%	0%	N/A	N/A
15	17%	N/A	6%	32%	N/A	51%	17%	8%	N/A	N/A
20	18%	N/A	8%	33%	N/A	51%	18%	11%	N/A	N/A

lead time towards regaining revenue through sales. Lastly, Scenario 4, where the government publicly owns the project, even though it has a lot lower returns due to the fact that the provincial government needs to fund the operating costs as well and is giving the panels away at cost, it is still able to see reasonable returns and may even get assistance from the federal government.

As the scenarios where the governments are not making direct financial investments in the plant the IRR cannot be calculated, but it is instructive to consider the cash flows in those scenarios compared to the more traditional 'investment' scenarios. It has been noted that the change in cash flow for Scenario 2 is where the company pays the government for the plant and the change in Scenario 5a shows a company defaulting on the loan guarantee such that the government has to bear the burden.

2.1.2.3. Subsidies. Government of Canada is improving and adapting the manufacturing and processing sector with new polices for taxation; energy; trade; labor; intellectual property rights protection; regulations; infrastructure and research, development and commercialization to enhance the foundation of sustainable long term economic growth. Ontario offers a skilled and diverse workforce, a socialized healthcare system, government commitment to innovation and economic growth, internationally competitive wage and tax rates and globally competitive labor costs and benefits [47]. The proven technology of thin-film PV combined with the financial and manufacturing stability of Ontario, Canada; augur well for government investment in PV manufacturing. The choice of entering this market is the consideration between creating domestic economic activity and subsidizing economic activity in other countries via imports as the FIT will stimulate demand.

The economic benefits were quantified for various levels of support of the PV manufacturing plant in Ontario from simple loan guarantees and tax holidays to more aggressive 100% subsidies. The results showed that it is in the financial best interest of both the Ontario and Canadian federal governments to implement aggressive policy to support PV manufacturing. Such policy would provide substantial economic, environmental and social benefits [48].

2.2. Solar energy policy in European countries

2.2.1. Germany

Germany is the world market leader for solar PV systems installation with an estimated cumulative installed capacity of 3.8 GW at the end of 2007 [49]. BMU [50] states about 14% of German electricity was generated from renewable sources at the end of 2007. However, solar PV has still a very small share of about 4% of total electricity generated from renewable sources. Other technologies have taken place on top of it with their share from wind around 45%, bio-energy around 27%, and hydropower around 24%. Out of all solar PV systems installed in Germany so far, about 99% are connected to the grids and only 1% is off grid type [51].

The economic analysis showed that grid connected PV systems is still not economically feasible in Germany under the boundary conditions used in this study. But they would make profit if systems with longer life time of up to 40 years are available. Even the calculations carried out considering FIT schemes show that PV systems with shorter system life time (e.g. 25 years) are not economically feasible. The breakeven analysis show that the systems would have been at breakeven as of today if the module price was as low as 0.72 €/Wp or the base year electricity price was as high as 0.29 €/kWh. In this year the module price will be around 1.52 €/Wp and the base year wholesale electricity price is projected to be around 0.13 €/kWh. It has been calculated that the learning investment for PV systems between year 2009 and breakeven year 2021 will be around 29.4 billion Euros. This loss will be covered by the installations after this year and a win point is expected to occur in 2032–2033 [51].

2.2.1.1. Feed-in tariffs. The document establishes the FITs' mechanism in the country with a contract duration time of 20 years and a constant remuneration for the produced energy. Different values of FITs are established for the different types and the different rated powers of the generation system.

In order to stimulate a stronger price reduction, an amendment of the Erneuerbare–Energien–Gesetz (EEG) was decided in late 2008. A digression rate of FITs' values for new PV systems was decided [52]. Table 6 summarizes the FITs' values and digression rates for 2009, 2010 and 2011 in Germany.

Furthermore, the digression rate was adapted to the market growth. If the growth of the PV market (new installations) in a year is higher or lower than the defined growth corridor, the digression rate will be increased or decreased by 1% for the next year. For 2009 the corridor was set between 1000 and 1500 MW, as shown in Table 7.

The rates were guaranteed for an operating period of 20 years. For small systems (<30 kW) installed in 2009 the producers have the possibility to auto-consume the electricity they produce. In this case, they receive a premium FIT of 0.2501 €/kWh for 2009 (instead of 0.4301) for the self-consumed PV electricity. If one includes the savings on electricity delivery costs (approximately 0.22 €/kWh [54], this way of operating the PV system may become attractive as every kW PV power is worth 0.47 €/kWh.

Table 6
FITs' values and digression rate for electricity generated from PV systems in Germany [53].

FIT	Rooftop								Ground-mounted installations	
	≤30 kW		>30 kW		>100 kW		>1000 kW		All sizes	
	Digression rate (%)	€/kWh	Digression rate (%)	€/kWh	Digression rate (%)	€/kWh	Digression rate (%)	€/kWh	Digression rate (%)	€/kWh
2009	8	0.4301	8	0.4091	10	0.3958	25	0.33	10	0.3194
2010	8	0.3957	8	0.3768	10	0.3562	10	0.2970	10	0.2875
2011	9	0.3601	9	0.3425	9	0.3242	9	0.2703	9	0.2616

Table 7
Upper and lower limits of the growth corridor of the PV market from 2009 to 2011 [53].

Growth corridor	Digression	2009	2010	2011
Upper limit in MWp	Above: +1%	1500	1700	1900
Lower limit in MWp	Below: −1%	1000	1100	1200

2.2.1.2. Incentives. Additional supports are beneficial in credit terms and tax incentives. They depend on whether the PV installations are done privately or by a commercial investor. Commercial systems are VAT (value-added taxes) exempt (VAT is 19% in Germany). Furthermore, investment grants exist in different German regions.

2.2.2. Spain

Solar energy is likely to play a key role in the future energy scene and Spain will most likely become one of the leading countries in terms of its implementation, expertise and development of new technologies. In Spain 2008 has been a very critical year due to the fact that a new regulatory framework has been established by the government, in order to introduce new rules, to rationalize the extraordinary increase of the PV market that the previous framework created, due to the very favorable FIT [53].

In Spain until September 2008, the legal framework for RES support was the Real Decreto (Royal Decree) 436/2004. This support system was based on the possibility of the producer to choose whether to sell the produced electricity with a fixed tariff (expressed as a percentage of the reference average tariff (RAT)) or whether to sell it in the free market taking favor of the sales price. FITs were supplied for an undefined number of years with a reduction after 25 years.

2.2.2.1. Feed-in tariffs. FITs for electricity generated from PV systems in Spain, according to the Real Decreto 436/2004, are represented in Table 8.

Solar PV has been deployed in so-called "solar farms." This implies very large-scale installations, in many cases between 10 and 30 MW, including tracking systems in many cases. The new regulatory framework established in the Royal Decree 1578/2008, implies changes in two main lines. On one hand, there is a reduction of the FITs' value to the order of 30% with better values for PV installation in roofs and facades. On the other hand, and in order to control the impact of the FITs in the national economic situation, a quota of 500 MW in 2009 and similarly for the next three years has been established. This will imply a strong reduction in the Spanish market, compared to the extraordinary increase of 2008. New FITs' value for PV systems in Spain is outlined in Table 9. Tariffs and caps are adjusted quarterly according to the demand in previous quarters, as explained in Table 6. Additional support applied to PV systems is tax incentives. Law 35/2006 establishes a tax rebate of 6% (2008), 4% (2009) and 2% (2010) from the annual benefits of the PV system [53].

The annual digression rate is capped at 10%. Annual caps are adjusted in inverse proportion to digression.

2.2.2.2. Target. In 2007, the target that the national renewable energy plan had established for the year 2010 was surpassed. The target for 2010 was 400 MW and at the end of 2007 the installed capacity was 680 MW. A limit date of 30 September 2008 was established to include projects in the old FIT scheme. This means that the projects on line after that date will be under a new and quite less favorable FIT system. This situation has highlighted the fact that in 2008 the market in Spain was the biggest worldwide and the country finished 2008 with an installed capacity of over 3500 MW, of which 2700 MW has been installed in that year.

The recently published Spanish Renewable Energy Plan 2005–2010 which states that solar thermal installed capacity by 2010 should reach 500MW. The current portfolio of projects under development as well as the solar thermal power plants under construction already exceeds the PER (renewable energy plan) goal. In order to evaluate the socio-economic impacts that would be generated when accomplishing the PER's solar thermal installed capacity objective, the increase in the demand of goods and services as well as the employment generated have been quantified [55,56].

2.2.3. France

Globally, France stands at the fifth place for the production of PV electric energy producer. In 2009, the French electricity giant EDF announced that it will build the country's largest solar manufactur-

Table 8
FITs for electricity generated from PV systems in Spain according to the Real Decreto 436/04 [53].

PV systems	
Kind of installation	FIT (€/kWh)
Rated power ≤ 100 kWp—first 25years	575% of RAT
Rated power > 100 kWp—first 25years	460% of RAT
Rated power ≤ 100 kWp—following years	300% of RAT
Rated power over 100 kWp—following years	240% of RAT

Table 9
Adjustment of tariffs and caps according to the demand in previous quarter [53].

Percentage of the CAP referred to the previous quarter CAP	Adjustment
≥75%	Rates decrease by a maximum of 2.5%, and the cap is increased by the same amount
≤50%	Rates increase by a maximum of 2.5%, and the cap is decreased by the same amount
50–75%	Incentive levels and caps remain the same

ing plant with an initial annual capacity of more than 100 Megawatt Peak (MWp). At the end of last year, France pledged to multiply its solar power use by 400 in the coming 12 years. This is part of a larger plan to double the share of energy from renewable to 23% by 2020 to meet its EU obligations and to compete with Germany which is regarded as the giant in EU countries [57,58].

2.2.3.1. Feed-in tariffs (FIT). FIT is one of the main measures adopted for PV in France. This mechanism has been issued in July 2006. It involves the obligation on the part of a utility to purchase electricity generated by renewable energy producers in its service area paying a tariff determined by Public authorities and guaranteed for a specific time period. A FIT's value represents the full price received by an independent producer for any kWh of electric energy produced by a RES-based system, including a premium above or additional to the market price, but excluding tax rebates or other production subsidies paid by the government. FITs have been the primary mechanism used for supporting RES development in both Europe and the USA. At present, they are being applied in 20 EU member countries.

In France, the legal framework for this measure is the Ministry of Industry. FITs are composed from a basic tariff, for non-integrated PV systems (NIPV) and a bonus in the case of building integrated PV systems (BIPV). Table 10 summarizes the FITs' values for PV installations in 2009.

These tariffs will remain in effect until 2012 when they will be revised as part of the normal review process. The PV cumulative installed capacity is expected to increase from 1100 MW in 2012 to 5400 MW in 2020. In 2008, 105 MW were installed, but only 46 MW were connected to the grid due to long administrative procedures [58].

2.2.3.2. Incentive. There are some other additional supports. For instance, (green loans) and tax incentives are beneficial in credit terms. For PV systems <3 kWp the government grants a tax credit of 50% on material costs at the main residence, (maximum €8000 for singles and €16,000 for couples, valid until the end of 2012). For PV systems >3 kWp, tax credit is not cumulative with FIT. Other financial incentives are a reduced VAT of 5.5% (if the equipped host building is more than two years old) and accelerated investment depreciation for companies.

2.3. Solar energy policy in Asian countries

2.3.1. China

China has had double-digit rates of economic growth for much of the past two decades. This growth has had huge implications for energy consumption and environmental impact [59]. One of the environmental problems associated with energy consumption is carbon emissions. Though, China's carbon emissions are low on a per capita basis, China is already ranked the world's second largest producer of carbon emission, behind only America [60,61]. It is reported that 75 percent of China's pollution is due to the burning of Coal as a source of primary energy and this accounts for the dominant share of China's total consumption. Though this share has declined recently, it is still too high relative to other countries [62]. With the rapid rise of the energy price, the application of solar energy is accelerating, and the great environmental and economic benefits have been brought by using the PV. Some policies were formulated in China by the central government and operated in the whole nation. Hundreds of manufactories have produced millions of PV equipments in the last 5 years [63].

The potential of solar energy in china is very high. Recently, it has been found that the special considerations on solar power have effectively decreased the cost of PV power generation. For instance, in 2007, electricity tariff from PV generation was 4 Yuan (US Cent 58.9)/kWh. In 2008, Sun tech Power Co., Ltd, the biggest Chinese solar cell producers, declared that it can reduce the PV power price to 1 Yuan (US$ 0.15)/kWh by 2012. Moreover, in 2009 the PV concession demonstration project has propelled the PV generation to reduce to 0.69 Yuan (US$ Cent 0.1)/kWh. The continuous pressure for carbon reduction has tempted China to determine its future energy policies. It is optimism that PV installed capacity will be rapid growth with the solar energy supportive policies [64].

2.3.1.1. Renewable energy law. In 2005, the National People's Congress has passed The Renewable Energy Law [55]. This law has marked a new stage of renewable energy development program in China. Since the introduction of REL, a number of supporting regulations and guide-lines have been put into place to implement it.

The NDRC (National Development and Reform Committee) published "Guidelines for Using the Public Fund for Renewable Energy Development in 2006." These guidelines list three priorities. One is support for renewable electricity generation (including wind, solar, and ocean). The other two priorities are research on energy sources able to replace oil, and support for the use of renewable energy by the heating- and-cooling systems of buildings. They decided that the public fund can be used in two forms. First, it can be issued as a grant. Recipients of such grants use the funds for renewable energy research and development. Second, it can be used to subsidize loan interest. Eligible renewable projects may obtain public funds to pay part of its loan interest.

Chinese government formulates a series of policies and regulations to encourage renewable energy utilization. These policies include: (I) all PV electric power should be purchased by Power Company, and which should provide enough grid-connect service. (II) The electrovalence is established more than conventional price in order to encourage the development of solar energy, the benefits of investor should be ensured. (III) The central government gives some allowances to the renewable resources industry. (IV) The central government encourages the renewable resources DG (distributed generation) in order to improve the electric power serves of no electric power supply region, and the early investment and medium-term maintenance are afforded by central government. (V) Although the end user uses the electric power from PV generation, but the electrovalence of end user is same compared with the end user who uses the conventional electric power? As mentioned above, the central government of China regards the development of PV in order to improve the unreasonable energy structure.

In order to improve the inopportune energy structure and sustainable development the Chinese central government has established some policies and laws, in this regard the following measures were especially recommended:

(i) The applications of solar energy are promoted by the e policy of central government and local governments, the allowance of government is important to increase the competitive power of PV production. And the Chinese central and local government should increase the research fund of PV to grasp the pivotal technology, such as circuit topology and MPPT (maximum power point tracking) control method and grid-connect. Moreover, the tax should be reduction or exemption by government, which will motivate the enthusiasm of entrepreneurs, and which will increase the PV market through government policy initiatives. The advantage of investors should be ensured by government policies. Certainly, the government fund should be launched in the vast power supply project in order to improve the energy structure in the foreseeable future. For example the large desert grid-connect power plant must be established. The ordinary investor and corporation cannot supply the vast fund

Table 10
FITs in 2009 for electricity generated from PV systems in France [58].

2009	Continental France		Overseas regions and Corsica
FIT			
Granting period		20 years	
Roof top and ground mounted	0.32823 €/kWh		0.43764 €/kWh
BIPV		0.60176 €/kWh	
Industrial/commercial buildings application (new tariff)		0.45 €/kWh	
Other information	Tariff annually revised on inflation for new and existing FIT contracts		

in the desert grid-connect power plant domain. The devotion of government is obligatory.

(ii) Abundant fund and personnel should be launched into the interrelated research of PV, and the universities and graduate schools should be encouraged to research in solar energy. The cooperation between corporation and university should be enhanced in order to improve the research level. The student is trained by universities in order to supply enough persons with ability to cooperation. Certainly, international cooperation should be encouraged to improve the domestic technology by central government and local governments.

(iii) The PV industry chain should be established in order to enhance the economy benefit of Chinese PV industry. Especially, the lack of silicon material and pivotal technology should be settled in future. The PV market should be enlarged in order to digest large numbers of PV product. The attestation and detect organization lacks the contact with the international organization, and the criterion of whole industry should be established.

In the future, central government of china should recognize the pertinence of solar energy utilization, prioritize it accordingly and increase investment [20]. Meanwhile, the local government should develop a medium and long-term plan of solar energy utilization, especially focused on systems operation and maintenance.

The high cost of PV power generation is the biggest barrier. Energy policy supports are necessary to reduce the cost of PV power generation in order to enable the solar power generation to advance on a large scale. As the good energy policies can effectively decrease the cost of power generation. China needs the substantial program as well as the policy to build environments that encourage the solar energy, so as to advance its rich solar energy resource and to use it's the great production capacity [64].

2.3.2. Pakistan

In Pakistan, potential for almost all types of renewable energies exist such as solar (PV and thermal), wind, biogas, hydro, biomass/waste, geothermal, tidal etc. [66].

Exploitation of these resources can enhance diversity in Pakistani energy supply market, secure long-term sustainable energy supplies, cut down import dependency and also reduce atmospheric emissions [67].

Therefore, the conditions to harness solar energy are not only excellent but also sustainable. Although in addition to other partly working departments, two fully fledged departments, PCRET and AEDB are dedicated to the acceleration of renewable energy technologies [57] development. Yet, the reported cumulative numbers of dissemination of most of the RETs are very low, particularly harnessing solar energy for agricultural applications [68].

2.3.2.1. Alternative energy development board. Pakistan has average potential of solar global insolation 5–7 kWh/m^2/day,over more than 95% of its area with persistence factor of 85% [66]. A daily average of global irradiation falling on horizontal surface is about 200–250 W/m^2. It is approximately 6840–8280 MJ/m^2 in a year. In Pakistan, Baluchistan, Sindh and Punjab provinces are affluent in solar energy [69]. The Government of Pakistan had 18 PV systems with a composite output of 440 kW installed in various parts of the country in 1990s. Due to lack of technical knowledge about operation and maintenance, these systems were no longer in operation. Under such conditions PCRET (Pakistan Council of Renewable Energy Technologies) started ensuring development and sustainability of solar and other renewable energy projects in the country. AEDB (Alternative Energy Development Board) joined such efforts in 2003. But unfortunately both of governmental organizations are so weak in financial and technical manpower resources to imagine any breakthrough in near future. More than 20 manufacturers, suppliers, etc. in private sector are active in solar energy business in the country. AEDB electrified approximately 3000 households with total PV power generation of 200 kW in districts of Rawalpindi (Punjab), Tharparkar (Sindh), Turbat/Kalat (Balochistan), Kohat (NWFP), and D.G. Khanetc, while providing 80W panel with lighting system to each household. PCRET electrified more than 500 schools, mosques, houses through PV power with total generation capacity of more than 80 kW. In private sector, the PV installations in the country are approximately in the range of 500 kW. In solar thermal side, solar cookers (box and concentrated type), solar dryers/desalination units, solar water heaters, etc. have been designed, developed and are in limited use but their contribution in energy provision is negligibly small. So the total installation appears to be much less than 1000 kW in PV and 10,000 kW solar thermal units in the country. Main constraints to widespread utilization of solar PV technologies are

- High initial cost of PV system
- Inadequate renewable energy policy (in fact the government has not properly realized the need of RET)
- Unawareness in local communities
- Inadequate availability of technical knowledge.

In National Renewable Energy Policy (NREP), announced in 2002, besides other policy matters, the following targets were set by the committee working on it [68].

1. Renewable energy resources will acquire 3% share in primary commercial energy supply by 2010.
2. Every year 2% of the annual development budget will be allocated for the development of renewable technologies in the country.
3. All localities anticipated to be connected with national grid in next 30 years are to be reserved for renewable energy source.

In future PV stand alone micro projects are being planned in the country instead of initiating any mega/macro PV project on commercial scale to overcome the energy crisis of the country through available solar resource.

2.3.2.2. Suggestions. Following suggestions are given for development, dissemination and better and efficient use of renewable energy technologies in the country [70]:

- Being enriched of nature gifted renewable energy resources; Pakistan must generate 10% of its energy demand through renewable energy technologies at least by 2014. To achieve such objectives, Government of Pakistan must have to formulate such laws and policies which also encourage private investors (local and foreign) to invest for the establishment of power/energy generating units. Tax rebate and financial leasing through banks or institutions must have to be opted as part of national renewable energy policies.
- RET large and commercial scale projects have not yet been initiated in spite of the fact that government institutions are working in renewable energy fields for the last more than two decades. Such projects remained in documents with planning wings but implementation is still not seen. Low powered generating units cannot meet energy demands of 160 million people, 95% of whom are not in position to afford cost of even micro/mini systems. So commercial and grid connected RET projects are suggested to start with immediate effect.
- Quality of installation and technology used must be improved. ISO/IEC (International organization for standardization/International electrotechnical commission) international standards must be followed for designing and erection of systems. Security standards are being ignored as no. of casualties especially of children have been reported. So adoption and implementation of international standards is suggested.
- Honesty and dedication to national interests is being superceded by personal benefits of the responsible authorities which must be countered through effective control and monitoring measures at government level. This is one of the main hurdles for dissemination of technology in the country. Mere demand of finances and release of funds for RET projects is insufficient to bring technological revolution. So formulation of effective monitoring and evaluation system at government level is suggested.
- Human resource development (HRD) in the field of renewable energy technologies must be emphasized. Such objectives can be achieved through introduction of RET courses at university level for graduation/post graduation purposes and also provision of attractive salary package to RET scientists and engineers. So far such incentives have not been taken at government level in spite of the fact that its importance was realized two/three decades before.
- Manufacturing of RET plants must be initiated in the country through transfer of technology from advanced countries. Apparently there is no ban on transfer of such technologies at international level but it is just a lack of planning, co-ordination and collaboration with other countries at government level. So transfer of RET technologies must be done on top priority.

Energy efficient, low cost and reliable systems are introduced in the country. Government department must have quality control checks through certification process. At present, such practice is not being exercised, hence causing damage to the reputation and use of RET products in the country. So establishment of certification labs for RET products at government level is suggested.

2.4. Solar energy policy of Australia

The renewable energy target announced in August 2009 builds on the mandatory renewable energy target [71] program of 2001 which aimed to encourage 9500 GWh of electricity generation from renewable energy sources by 2010 [57,72]. There is an estimated 115 MW of installed photovoltaic (PV) power in Australia (July 2009), contributing an estimated 0.1–0.2% of total electricity production despite the hot, dry, and sunny climate that would make it ideal for utilization. This unreached grid parity is mainly due to the higher cost per kW than other power sources because of the cost of solar panels. To assist renewable energy commercialization in Australia feed-in-tariffs and mandatory renewable energy targets are designed [73].

2.4.1. Feed-in tariffs

In Australia, several states and territories have investigated FITs, although at this time only Queensland and South Australia have existing schemes [74,75]. Queensland's Solar Bonus Scheme pays small electricity customers (defined as customers that consume less than100 MWh yr^{-1}) AU$ 0.44 kWh^{-1} [76] from photovoltaic systems less than10 kVA for single phase and 30 kVA for 3 phase systems until 2028 [77]. South Australia has an identical scheme although the small electricity customer must consume less than160 $MWhyr^{-1}$. The Victorian Government will introduce a premium FITs in 2009 that will pay AU$0.60 kWh^{-1} [76] for PV systems that are no larger than 2 kW. The Australian Capital Territory [78] has passed FITs legislation, which is expected to be implemented by the end of 2008. The ACT scheme pays 3.88 times the domestic electricity price for photovoltaic systems that are equal to or less than10 kVA, 3.104 times for systems greater than 10 kVA up to 30 kVA, and 2.91 times for systems larger than 30 kVA [79]. WA (Western Australia) has no FITs to date, although the newly elected government has indicated in-principal support for a WA FITs scheme [74].

2.4.2. Subsidies

Solar PV technology is still 3–4 times the cost of gas-fired electricity [80]. Consequently, despite significant government support programs, recent projections estimate solar PV growing at an annual rate of only 15 MW (medium case) up to 2020 [81]. Utility scale solar thermal technology is also at a developmental stage, albeit closer to commercialization with a 10 MW demonstration plant planned in Queensland for 2010. As a stand-alone technology, large-scale solar thermal remains an expensive proposition thereby limiting commercial diffusion to subsidized programs such as the Solar Flagships program which earmarks AU$1.6 billion over 6-years to support construction and demonstration of large-scale solar power stations, with an ultimate target of 1000 MW [82].

2.4.3. Target

Australia is at the cross-roads in terms of how to meet its future energy requirements in an increasingly 'carbon-constrained' multilateral policy environment [83]. At current levels of generation, a shortfall in available electricity is expected within the decade [84]. Federal policy is beginning to change with the publication of the Garnaut report and Carbon Pollution Reduction Scheme White Paper, announcement of an Emissions Trading Scheme to commence in 2010 and announcement of a national mandatory renewable energy target of 20% share of electricity supply in Australia by 2020 [85].

2.4.4. GHGs emission reduction

Australia has one of the highest per-capita greenhouse gas emissions levels in the industrialized world [86]. In part, this is due to its large domestic reserves of coal, which have kept electricity prices low and attracted energy-intensive industry. Currently, coal-fired power provides more than 75% of domestic electricity generation [87]. However, in recent years concerns over climate change have prompted Australian policymakers to seek mechanisms to increase

Table 11
Summary of solar energy policy of different countries.

Country	Principle support (FIT/RPS)	Investment support (e.g. subsidies)	Financing/public loan	Target implementation	Legislation (e.g. GHGs emission)	R&D support	Strength (highlight)
USA	RPS	Yes	Yes	Yes (25% of supply, 2025)	Yes (25%, 2025)	Yes	Investment and production tax credit
Canada	FIT	Yes	Yes	Yes (12 GW, 2016)	Regulatory framework in 2008	Yes	Production incentive of 1 cent/kWh for the first 10 years
Germany	FIT	Yes	Yes	Yes (30 GW, 2010)	Yes (20%, 2020)	Yes	Electricity feed-in tariff
Spain	FIT	Yes	Yes	Yes (500 MW, 2010)	–	–	–
France	FIT	Yes	Yes	–	–	–	–
China	–	Yes	Yes	Yes (total capacity 30 GW,2020)	–	–	Locally made components
Pakistan	–	Yes	Yes	–	–	–	–

the proportion of emissions-free renewable energy. As a result, in 2001 Australia became the first nation to introduce a national renewable energy market using tradable certificates [88].

The Labor Party had also announced its commitment to a long term emissions reduction target of 60% (compared with year 2000 levels) by 2050 as part of their campaign. These policies will gradually begin to level the playing field between wind and other renewable energy and coal power, which holds a 77% share of Australia's electricity generation.

All country's solar energy policy has been represented in Table 11.

2.5. Solar energy policy of Malaysia

Currently Malaysia has a total of 20,493 MW installed capacity and the energy reserve margin of Peninsular Malaysia stands at 47%. With an average of 4% annual growth, it is estimated that the maximum demand of electricity will be at 23,099 MW in 2020, which is nearly twice the current demand. At present, every 1% growth in gross domestic product (GDP) is accompanied by a growth in energy demand (and associated greenhouse gas emissions) of 1.2–1.5%. With increasing industrialization, electricity consumption has increased from 19,932 GWh in 1990 to 87,164 GWh in 2007, an increase of 337%. In fact, the period from 1990 to 2000 marked the period of rapid economic growth where demand for electricity recorded double digit growth [89–91]

The Malaysia Federal Government and the Non-Financial Public Enterprises (NFPEs) have invested a substantial amount of allocation to continue providing an adequate, reliable and reasonably priced supply of electricity to the people. For example, a total of RM27.9 billion (US$7.75 billion) was spent in the electricity supply sector under the 8th Malaysia Plan to undertake electricity sector programs in generation, transmission, distribution as well as rural electrification. The amount is expected to increase to RM30 billion (US$8.33 billion) under the 9th Malaysia Plan. With these investments and coupled with strong policy measures, the electricity coverage in Malaysia is expected to increase to 95.1% in 2010 from 89.5% in 2000, with the rural electrification rate in Peninsular Malaysia currently at 99% [90,92,93]. Fig. 1 shows the total energy demand in Malaysia.

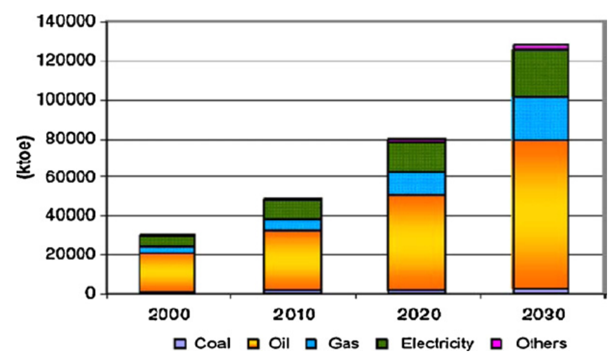

Fig. 1. Total energy demand (ktoe).
Source: Preliminary Energy Outlook, PTM [89].

2.5.1. Energy policies and outlook

For the past 60 years, Malaysia government has formulated quite a number of energy-related policies to ensure sustainability and security in energy supply, with the very first policy dated back to 1949 when the Central Electricity Board [94,95] was first formed, before it was changed to National Electricity Board (NEB) in 1965. But over the last three decades, pragmatic energy policies have facilitated a more environment-friendly energy development path. The first policy that really impacted the industry was the Petroleum Development Act 1974, vested on PETRONAS, the state-owned oil and Gas Company, the exclusive rights to explore, develop and produce petroleum resources in Malaysia, followed by the National Petroleum policy 1975 to regulate downstream oil and gas industry via the Petroleum Regulations 1974. The more significant policy, the National Energy Policy was actually introduced in 1979 with three primary objectives; supply, utilization and environmental. The first objective is to ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous energy resources both non-renewable and renewable energy resources using the least cost options and diversification of supply sources both from within and outside the country. The second objective is to promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption, and the last objective is aimed to minimize the negative impacts of energy through efficient energy utilization. After that, the National Depletion Policy 1980 and a year later, the Four-Fuel Diversification Strategy 1981 were implemented, with the former to prolong lifespan of the country's oil reserves for future security and stability of oil supply and the latter to pursue balanced utilization of oil, gas, hydro and coal.

The five-fuel policy has targeted to contribute 5% of the country energy mix with RE by year 2005 and mitigate 70 million tons of CO_2 over a span of 20 years [96]. Parallel to this goal is the Small Renewable Energy Program (SREP) which was launched in May 2001 under the initiative of the Special Committee on Renewable Energy (SCORE) to support the government's strategy to intensify the development and utilization of RE as the fifth fuel resource in power

Table 12
Renewable energy potential in Malaysia [89].

Renewable energy	Potential (MW)
Hydropower	22,000
Solar PV	6,500
Biomass/biogas (oil palm mill waste)	1,300
Mini-hydro	500
Municipal solid waste	400
Wind	Low wind speed

generation, which is also stipulated in the objectives of the Third Outline Perspective Plan (OPP) for 2001–2010 and the 8th Malaysia Plan (2001–2005) (8 MP). The primary focus of SREP is to facilitate the expeditious implementation of grid-connected RE resource-based small power plants [89,97–99]. In the 9th Malaysian Plan (2006–2010), the emphasis on energy efficiency is intensified to address the nation's energy challenge in line with the sustainable development agenda.

This was further emphasized in the 9th Malaysia Plan where efforts in the utilization of RE resources and efficient use of energy were further promoted. The establishment of the Ministry of Energy, Green Technology and Water to replace the Ministry of Energy, Communications and Multimedia earlier this year reflects Malaysia's seriousness in driving the message that 'clean and green' is the way forward towards creating an economy that is based on sustainable solutions. The launch of the new National Green Technology Policy in April 2009 by the current Prime Minister, Datuk Seri NajibTunRazak, that follows shall provide guidance and create new opportunities for businesses and industries to bring a positive impact to the economic growth. The National Green Technology Policy is built on four pillars: (1) seek to attain energy independence and promote efficient utilization (2) Conserve and minimize the impact on the environment; (3) Enhance the national economic development through the use of technology; and (4) improve the quality of life for all. It will also be the basis for all Malaysians to enjoy an improved quality of life, in line with the national policies, including the National Outline Perspective Plan, where the growth objectives for the nation will continue to be balanced with environmental consideration. While fossil fuels are expected to remain the dominant source of energy for decades to come, RE such as wind, solar, biomass, biofuel and geothermal heat are expected to double between now to year 2030, although their share in the energy mix is most likely still be around 5.9% of the total energy demand by 2030 [100–102].

Table 12 summarizes the rough estimation of the RE potential in Malaysia in the long run. Hydropower and solar PV are without the RE with highest potential due to Malaysia's geographical terrain with many large rivers suitable for dam projects and its tropical climate with plenty of sunlight.

However, regarding the utilization of solar power, Malaysia is not in a very different situation when comparing to other neighboring countries [103]. In fact, Malaysia has a grand vision of being a developed country by 2020, by focusing to achieve betterment in various social, environmental and economic parameters. It also includes elimination of subsidies for nonrenewable energy sources and instead providing some initial handholding for renewable energy sources should help among other things in rural electrification, environmental betterment and sustainable development. Needless to say that solar being the second major renewable energy source after biomass, would get a big boost. In this case, the policy for developing countries [104] for instance is always available as a mechanism to enhance the utilization of RE, which include solar, apart from the local National Energy Policy drafted since the 5th Malaysia Plan [105].

2.5.2. Involvement of research institutions and universities

The research institutes that are involved in renewable energy include SIRIM Berhad, the government research agency. Meanwhile, academic studies from the universities have helped in exploring new energy sources and their possibilities of utilization. In fact, energy conservation, energy efficiency and renewable energy are the topics of interest for most public universities, especially the four research-oriented universities: University of Malaya (UM) on energy conservation in industries and alternative fuels, Universiti Putra Malaysia (UPM) on solar energy and biomass, Universiti Sains Malaysia [106] on solar energy, PVs and rural energy planning, and Universiti Kebangsaan Malaysia (UKM) on solar energy and fluidized bed combustion [21].

2.5.3. Increase in energy research and development (R&D)

Presently, solar energy applications mostly oriented towards domestic hot water systems, water pumping, drying of agricultural produce. The tropical climatic conditions in Malaysia are favorable for the development of solar energy due to abundant sunshine with the average daily solar insolation of 5.5 kW/m^2, equivalent to15 MJ/m^2. PV-generated electricity, whether standalone or grid connected, is electricity generated at point of use. So, 1 MW of PV generated electricity is equivalent in fuel saving to about 4 MW of conventional electricity once generation and transmission losses of the conventional system are factored in. It may be quite feasible to set a target of about 10 MW of grid connected photovoltaic system for Malaysia.

For instance, Monier Malaysia, a local company which specializes in energy efficient roofing solutions, has seen systematic growth of demand for its solar product, launched last year when oil prices peaked. Globally, the overall solar photovoltaic industry generated revenues of more than US$100 billion in 2008. Malaysia managed to tap approximately US$4 billion worth of investment over the past three years and created 11,000 jobs, and the market is far from saturated

The RE policy provides the rules and funds to make RE an important component of the country's energy mix, overcome technological barriers, address existing market failures, create a level playing field for these technologies and drive down costs. But while the role of public policy is clearly important, it is not enough. The government must take the lead and find ways to generate public will in supporting the sustainable energy agenda. So far, the arguments in favor of supporting RE have been overwhelmingly environmental [89,105].

For any green technology industry to succeed, the right support mechanisms must be in place to create the market. One of the key stumbling blocks is the prohibitive pricing of RE that gives households and businesses little incentive to adopt the technology.

2.5.4. Subsidies

Now Malaysians have become used to cheap energy, with PETRONAS which currently subsidizing approximately 60% of the natural gas sold to utilities. Every type of energy can be benefited from assistance in its start-up phase, and RE should be no exception. There is still massive support for conventional energy sources in the forms of subsidies and export credits. If RE were to be competent economically, it is important to point out that RE receives the same treatment as fossil fuels. Otherwise, such subsidies should be removed or made transparent in order to create a level playing field. This can be partly overcome through a mandatory feed-in tariff, which has shown positive results in some countries. Under the scheme, which might be part of the RE policy, electricity utilities must buy renewable electricity at above-market rates set by the government. The higher price helps overcome the cost disadvantages of RE sources. Recently, PTM has proposed that consumers who use electricity beyond a certain minimum point are required to contribute 2% of their bill towards a RE fund, which will then be used to equalize the price between non-renewable and renewable sources of energy. The scheme could change the mindset of consumers as it is based on the "polluter-pays" principle [89].

In order to level the playing field for RE, the subsidies for conventional energy should be gradually removed or transferred to RE otherwise the same subsidies should be given to RE for the time being. Removal of subsidies does not always worsen the economy but rather boost it due to efficient use of energy.

The reforms of subsides can be done over a certain period of time to reduce the political barrier and sometimes with compensating measures. For example, if the subsidies are removed, offset mechanism should be introduced by giving other financial incentives to increase the use of RE such as tax exemption for the utilities that suffer from increase of production cost, and also social security for consumers which will suffer from increase of consumer price.

Timing matters for subsidy reform because sudden shock can deteriorate domestic economics. Thus energy price reform should be announced in advance so that utilities can shift from conventional energy sources to RE source besides giving incentives for RE [21,107].

2.5.5. Rational for subsidy in Malaysia

The role of the subsidies is very controversial. Following is the suggested justification of subsidies in Malaysia.

- Increase of energy price due to the removal of energy subsides hinder the foreign direct investments.
- Poor cannot afford the increased price and benefits and welfare gained can be higher than long-term costs in providing subsides.

Despite the detrimental effect of subsides, it is politically difficult to remove them partly because its short term costs that energy removal would entail [21].

3. Conclusion

Solar energy is one of the most promising renewable. It is very consistent and is not significantly vulnerable to changes in seasonal weather patterns. Solar energy can be exploited through the solar thermal and solar photovoltaic (PV) routes for various applications. Power generated by solar energy is not just relatively simpler but is also much more environmental friendly compared to power generation using non-renewable sources like the fossil fuels and coals. Considering that energy usage worldwide has been increasing throughout the years, switching to solar energy can be a viable move.

From the study, it is obvious that almost all countries that utilize solar energy for power generation have policies specific to solar energy. Some of the success stories include solar energy utilization in USA, Canada, Germany, Spain, Australia, China, and France. For these countries, the existence of solar energy policies managed to increase solar power generation significantly. In general, most countries policies include tax exemption, subsidies, Feed-in Tariff, formation incentives, renewable portfolio standards and others. Globally, policy analyses have increasingly focused on the effects of negative externalities on environmental quality, human health, economic development, or institutional objectives such as emissions growth management.

In order to promote and ensure the rapid, effective and smooth development of renewable energy, the Malaysian government has formulated a series of policies on renewable energy development, including laws, regulations, economic encouragement, technical research and development, industrialized support and renewable energy model projects, etc. These policies provide significant motivation and interest for the development and use of renewable energy technologies. However, Malaysia's renewable energy development policy has a few limitations, such as lack of coordination and consistence in policy framework; less encouragement in lower level, lack of regional policies innovation; unhealthy and incomplete financing and investment system; inadequate investment in technical research and development of renewable energies.

Regarding the particular solar energy policy Malaysia became a full member of the International Energy Agency Photovoltaic Power System Program (IEAPVPS) on 23rd October 2008. The PV market in Malaysia is still extremely small as compared to other developed countries. The grid-connected PV market began in 2006 and this is attributed by capital subsidies available under the Malaysian Building Integrated Photovoltaic (MBIPV) Project]. By 2011, the Malaysian government is planning to implement a new Renewable Energy Policy which will further drive the PV industry development. It is forecast that renewable energies in Malaysia will take fundamental role in the years to come as country prepares to substitute fossil fuel towards novel fuel sources which are truly clean, renewable and safe.

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