International Energy Agency

RENEWABLE ENERGY

MARKETS AND PROSPECTS BY REGION

INFORMATION PAPER

SIMON MÜLLER, ADA MARMION
AND MILOU BEEREPOOT

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This information paper was drafted by the Renewable Energy Division. It is one of three information papers that complement the IEA publication Deploying Renewables 2011: Best and Future Policy Practice, *providing more detailed data and information. This paper is published under the authority of the Energy Markets and Security (EMS) Directorate and may not reflect the views of individual IEA member countries.*
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INTERNATIONAL ENERGY AGENCY

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Context

This information paper accompanies the IEA publication *Deploying Renewables 2011: Best and Future Policy Practice* (IEA, 2011a). It provides more detailed data and analysis on the markets, policies and prospects for a number of renewable energy (RE) technologies and is intended to complement the main publication. Two other information papers are also available. One focuses on the markets, policies and prospects of by technology (Brown, Müller and Dobrotková, 2011), and the other analyses policies for deploying renewables (Müller, Brown and Ölz, 2011).

Introduction

The IEA Global Renewable Energy Markets and Policies Program (GREMPP) tracks market and policy developments in 56 countries. For the current publication, these countries have been divided into six regional groups, according to OECD membership and common economic and geographical factors (Table 1.1).

This information paper provides an in-depth account of:

- the recent market developments,
- policy developments in each of the six regional groups,[1]
- IEA projections, and
- an analysis of the mid-term potential of renewable energy technologies in these regions.

The first part of this document briefly outlines the role that the focus countries play in the renewable energy sector. This analysis is done for all countries together compared to the rest of the world as well as among the focus regions. This general information is intended to put subsequent discussions of each individual region into perspective.

Table 1.1 Regional grouping of GREMPP countries

Region acronym	Description	Members
ASEAN-6	Subset of member countries of Association of Southeast Asian Nations	Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam
BRICS	Five large emerging economies	Brazil, Russia, India, China, South Africa
MENA-7	Selection of countries from the Middle East and North Africa region	Algeria, Egypt, Israel[2], Morocco, Saudi Arabia, Tunisia, United Arab Emirates
OECD-30	All member countries of the OECD-30 as of late 2009	Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
LA-2	Two Latin American countries	Argentina, Chile[3]
SSA-6	Selection of Sub-Saharan African countries	Botswana, Ghana, Kenya, Nigeria, Senegal, Tanzania

Source: Unless otherwise indicated, all material for figures and tables derives from IEA data and analysis.

A dedicated analysis of the 2030 renewable energy (RE) potential for all 56 focus countries from across the six regional groups was carried out for this publication (IEE [Institute of Energy Economics], 2010). Caution is warranted when interpreting the data on potentials. Due to the lack of a globally consistent resource data set, estimates used for the analyses come from several different data sources and, therefore, may use different methodologies between countries and technologies. Moreover, they do not incorporate the same spatial resolution, which can result in significant underestimation, especially in case of wind resources. As a result, there is a high degree of uncertainty attached to the potential estimates.

[1] Please note that the information on policies dates from mid 2011. For more recent data and more details per country, please consult the IEA's online database (IEA, 2011b).

[2] Israel joined the OECD on 7 September 2010.

[3] Chile joined the OECD on 7 May 2010.

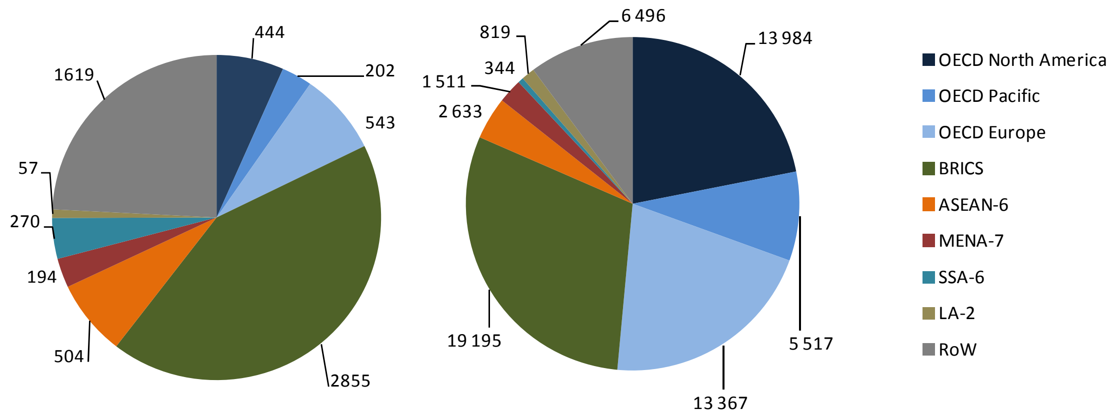
The assessment of potentials is based on a computation of the possible build-out of RE technologies until 2030, taking into account integration and sustainability constraints. Economic factors and competition between RE technologies are not accounted for.

The current paper also includes an analysis based on the import/export and GDP grouping of countries. Countries were assigned to the exporters group only if they were net exporters of all fuels used in a given energy sector (electricity, heat, transport). This rigorous approach can sometimes lead to counter intuitive results. However, a less stringent criterion would require *ad hoc* judgments. Therefore the current approach was chosen.

GDP and population data

In 2008, all focus countries accounted for 75.8% of the world's population and 89.8% of global gross domestic product (GDP) (Figure 1.1).

Figure 1.1 Population in million (left) and GDP in billion USD (right) by region, 2008



Note: GDP is expressed in year 2000 USD and in purchasing power parities. RoW stands for rest of world.

Key Point: GREMPP countries account for 76% of global population and 90% of global GDP.

Global market trends and the role of focus regions

In 2009, all 56 focus countries together accounted for

- 89.8% of global electricity output,
- 88.1% of all road transport energy consumption, and
- 83.3% of global energy consumption for heat.

Regarding renewable energy, focus countries accounted for

- 86.3% of global renewable electricity production,
- 99.7% of biogasoline and 95.7% of biodiesel consumption, as well as
- 75.5% of energy consumption for heat from renewable energy sources.

The focus regions show large differences in the size of their electricity, heat and transport fuel markets. Differences are also evident in the overall generation and consumption trends. These trends will be discussed next.

Renewable electricity

In the distribution of renewable electricity production among regions, the OECD-30 and BRICS provide 81% of the global renewable electricity production (Figure 1.2). The OECD-30 and BRICS produce the same amount of hydro power. With regard to non-hydro generation from renewable energy technologies, the OECD-30 remains clearly in the lead (14.5% in the OECD-30 versus. 2.2% in the BRICS). The ASEAN-6 group ranks third with a share of 2.7% of renewable electricity production. The comparably large amount of hydro generation puts Argentina and Chile at the fourth position with 2% of global production. MENA-7 and SSA-6 both contribute only 0.5%.

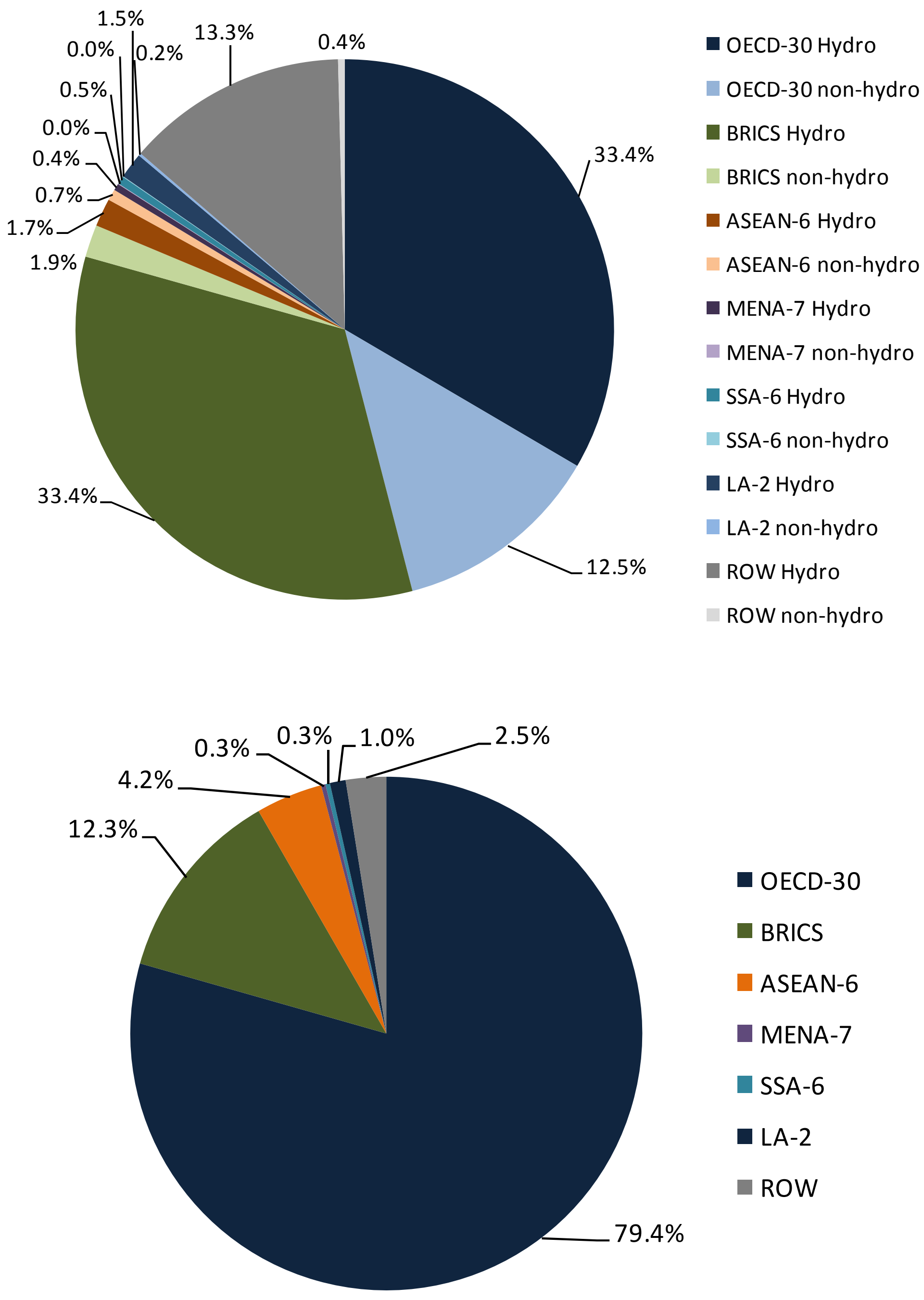
Viewing only the generation from non-hydro renewable energy technologies, the OECD-30 is responsible for 79.4% of global generation.

With respect to the overall electricity sector (*i.e.* including fossil and nuclear energies), the OECD-30 accounts for 51% of global production, down from 64% in 1990 (Figure 1.3). The decline in the share of the OECD-30 has been due to a rapid increase in generation in BRICS countries; while average growth was only 1.6% per year in the OECD-30, the BRICS grew at 5.2%. The majority of this increase involved fossil (mainly coal) generation in China. The other focus regions showed an even more dynamic increase (6.5%), however, from a much lower base.

The differences in growth rates should be considered when assessing the development of renewables in the different regions. Although demand increase can be an opportunity for RE technologies deployment, meeting very dynamic growth rates makes affordability a key issue, because large-capacity volumes need to be financed. In addition, less developed energy sectors historically tend to have large shares of hydro generation (for example the SSA-6 region). Normally, hydro cannot support recent demand increases at a sufficiently quick pace, because many of the suitable sites have already been developed. As a result, the overall share of renewables actually decreased in a number of focus regions over the last ten years.

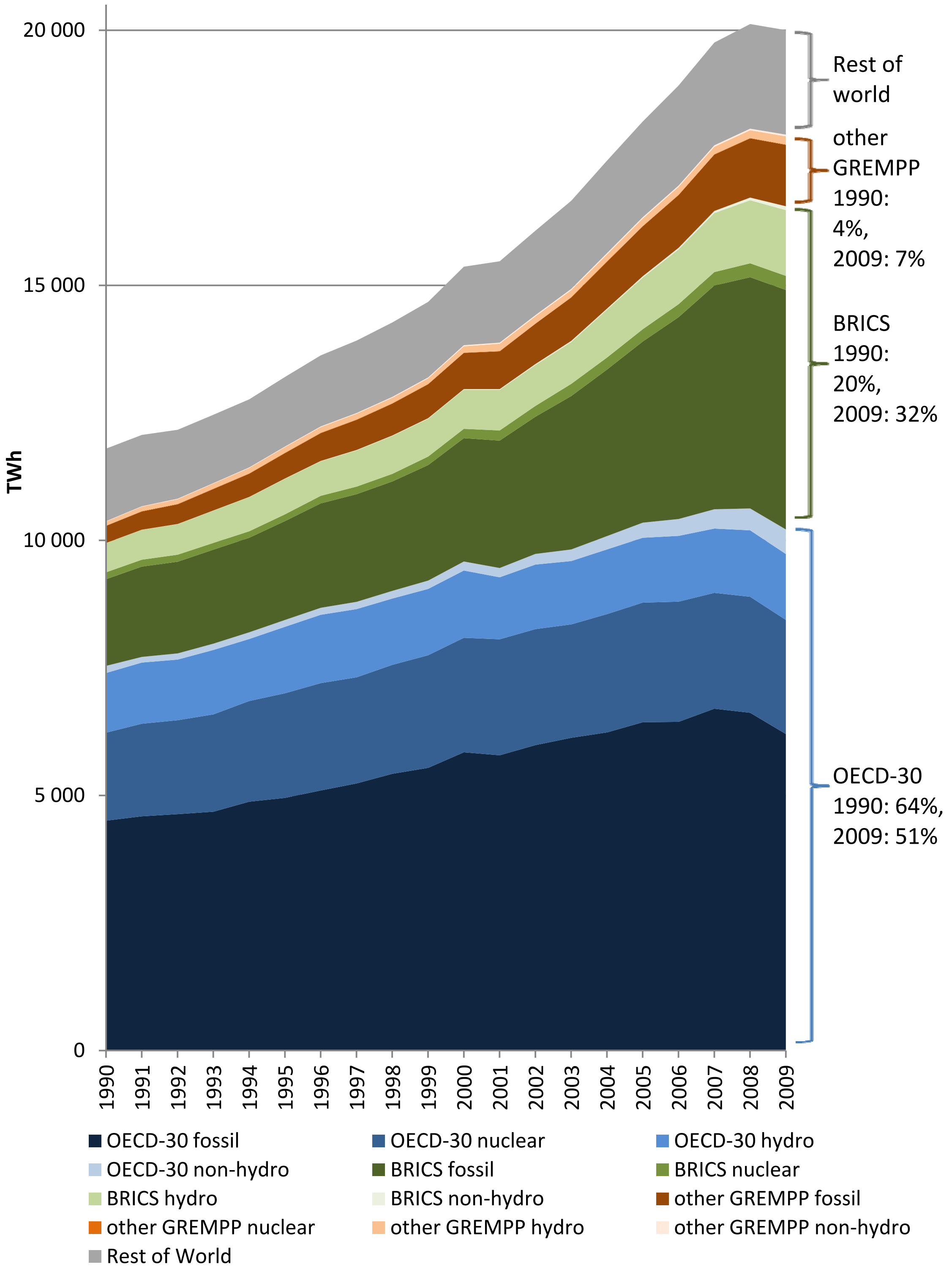
Moderate demand increases in large and more developed economies can be matched more readily by deployment of RE technologies, in particular as far as non-hydro technologies are concerned.

Figure 1.2 Segmentation of renewable electricity production by focus region, with (top) and without (bottom) hydro power, 2009



Key point: **The OECD-30 and BRICS dominate global hydro power generation. The OECD-30 accounts for 80% of all non-hydro renewable electricity.**

Figure 1.3 Contribution of focus countries to global electricity generation, 1990-2009



Key point: **The OECD-30 region is still the largest producer of electricity. Its share is declining mainly due to a strong increase in the BRICS region.**

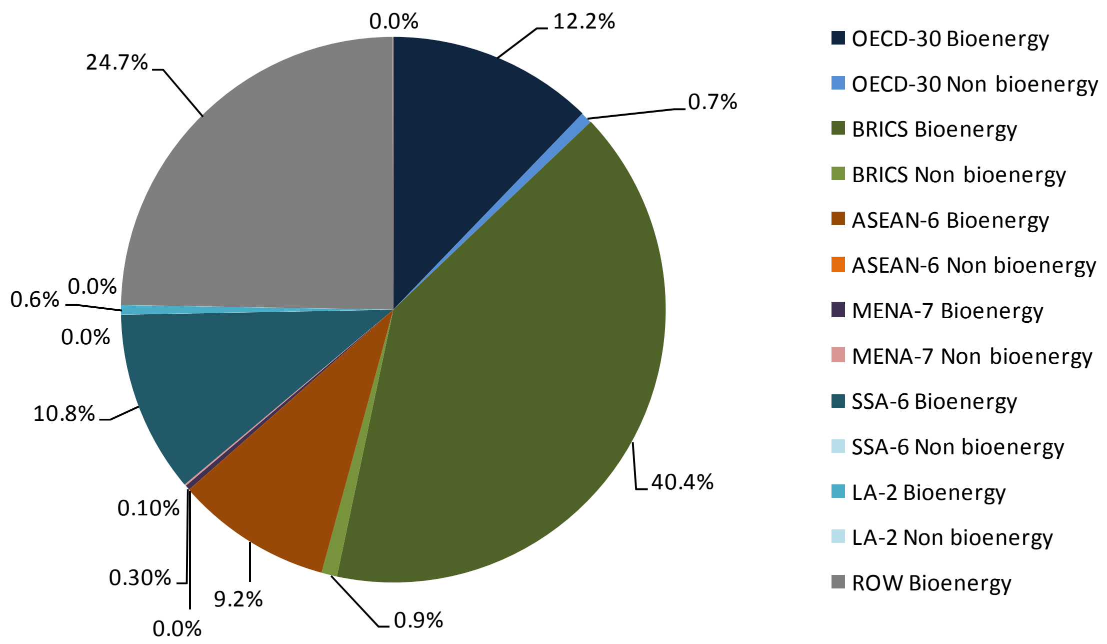
Renewable heat

The dominance of OECD-30 and BRICS in the renewable heat sector is less pronounced than for transport and electricity (Figure 1.4). The two main reasons for this are: 1) a more direct link between heat demand with population for cooking and hot water and 2) widespread use of traditional biomass in less developed countries. When considering the utilisation of biomass and waste as well as non-biomass renewables, the BRICS account for the largest share with 41.3%, followed by the OECD-30 (12.9%), SSA-6 (10.8%) and ASEAN-6 (9.2%). MENA-7 countries and the LA-2 region contribute 0.4% and 0.6%, respectively.

Non-biomass renewables contributed only very small amounts. Shares above 0.1% were attained only in the BRICS (0.9%) and in the OECD-30 (0.7%). This amount is due mainly to solar water heaters in China, as well as geothermal heat in the OECD-30. It is also noteworthy that, in the MENA-7 region, non-biomass renewables contribute 25% of renewable energy consumption for heat. This share is due mainly to the large market penetration of solar water heaters in Israel.

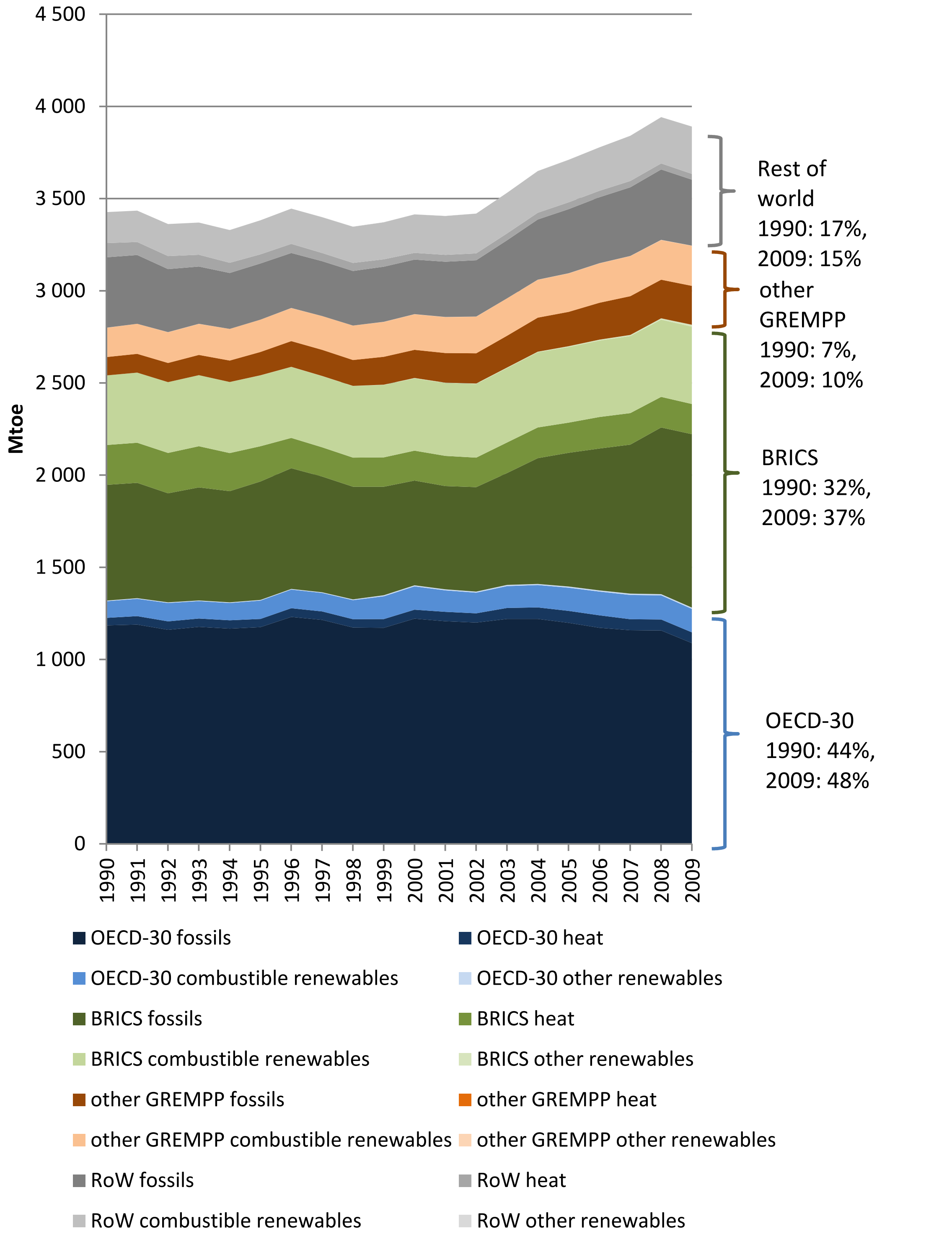
Regarding the total final consumption of all fuels for heat, the dominance of OECD-30 and BRICS on the global scale is also less pronounced (Figure 1.5). This finding reflects the fact that heat plays an important role independent of economic development and that more developed countries tend to produce and consume heat more efficiently.

Figure 1.4 Segmentation of bioenergy and non-bioenergy energy consumption for heat by focus region, 2009



Key point: Energy consumption from biomass and non-biomass renewable sources is more equally spread among regions.

Figure 1.5 Contribution of focus countries to total final consumption for heat, 1990-2009



Note: Heat refers to commercial heat. Commercial heat is produced from renewable and non-renewable sources ; RoW stands for rest of world.

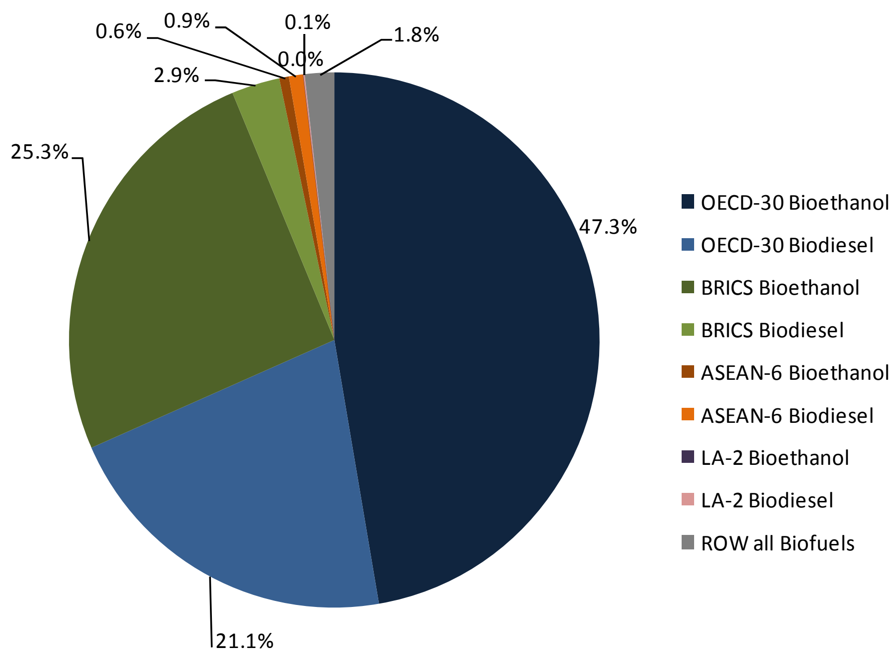
Key point: Energy consumption for heat is more equally spread among regions than electricity and transport fuel consumption.

Renewable transport

The OECD-30 alone accounted for two-thirds of global biofuels production and consumption. The main center of ethanol production and consumption is in the United States, while Europe produces and consumes mainly biodiesel (Figure 1.6). The OECD-30 is the only region with a net import of biofuels. The BRICS, in particular Brazil, are the second largest producer and consumer. Brazil dwarfs all other BRICS countries in both production and consumption. The remaining markets in other focus regions and the rest of the world account for merely 6% of total production and for 3.3% of consumption. Brazil has been a pioneer in the development of biofuels. The country had a biofuels share of 20% in 1990. This share declined to a minimum of 12.5% in 2001 and stood at 22.8% in 2009.

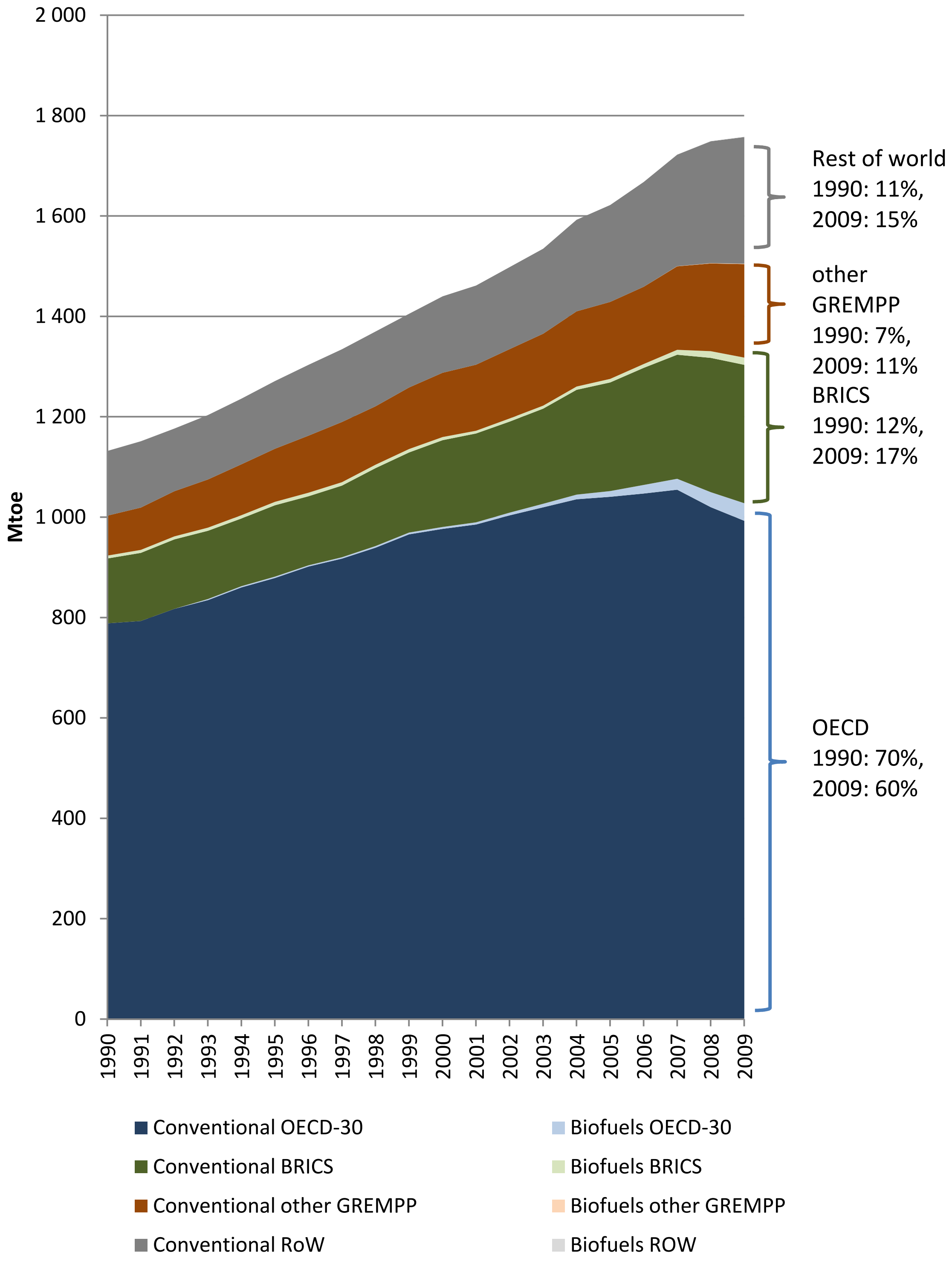
Compared to total final consumption for road transport, the total amount of biofuels consumption is small (Figure 1.7). In 2009, all biofuels together had a share of 3.0% in global road transport consumption. The BRICS had a higher share of 5.0% in 2009 (4.3% in 1990 and 3.5% in 2000).

Figure 1.6 Segmentation of biofuels production by focus region, 2009



Key point: **The OECD-30 and BRICS dominate global biofuels production.**

Figure 1.7 Contribution of focus countries to global road transport energy demand, 1990-2009



Key point: **The OECD-30 region is still the largest consumer for road transport. Its share is declining, mainly due a strong increase in the BRICS and the other focus regions.**

Focus on the OECD-30

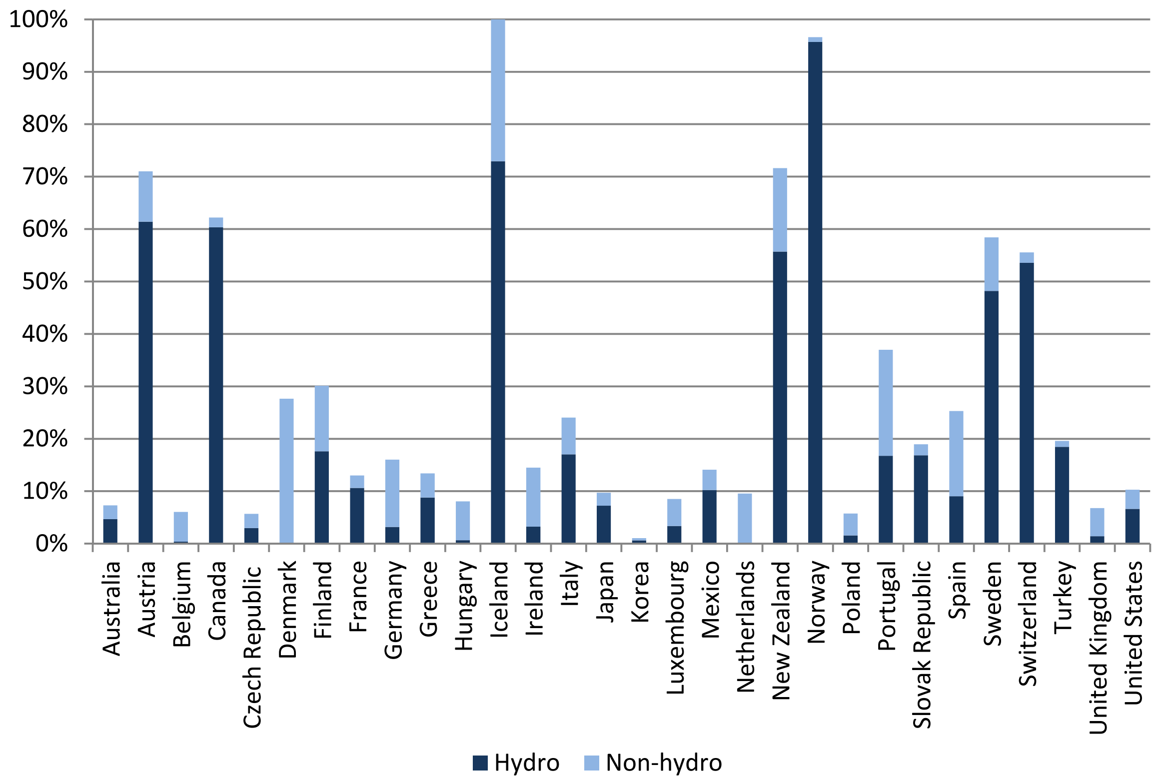
Renewable electricity

Current market status

In 2009, the electricity generated from renewable energy sources (RES-E) in OECD-30 countries amounted to 1 775 TWh. That year, renewables accounted for 17.3% of the electricity produced in the region. This share has risen from its 2005 level (15.1%); *i.e.* renewables have grown faster than overall electricity generation. The total generation, *i.e.* including non-renewable energy sources, grew by 2.7% from 2005 to 2008 but fell again in 2009 (by 3.8% compared to 2008 levels, slightly below the level of 2005). This reduction in total generation is a direct consequence of the global economic downturn, which markedly reduced energy demand. At the same time, renewable electricity production has seen robust growth at a compound annual growth rate (CAGR) of 3.16% since 2005.

Hydro power still dominates the OECD-30 RES-E portfolio with a share of 72.7%. This number has decreased since 2005, when it stood at 81.0%. Note that this decline is not due to weather-induced variability in output, which hydro generation is frequently subject to, but instead was caused by significant increases in non-hydro generation.

Figure 2.1 Renewable electricity share in the electricity mix in OECD-30 member countries, 2009

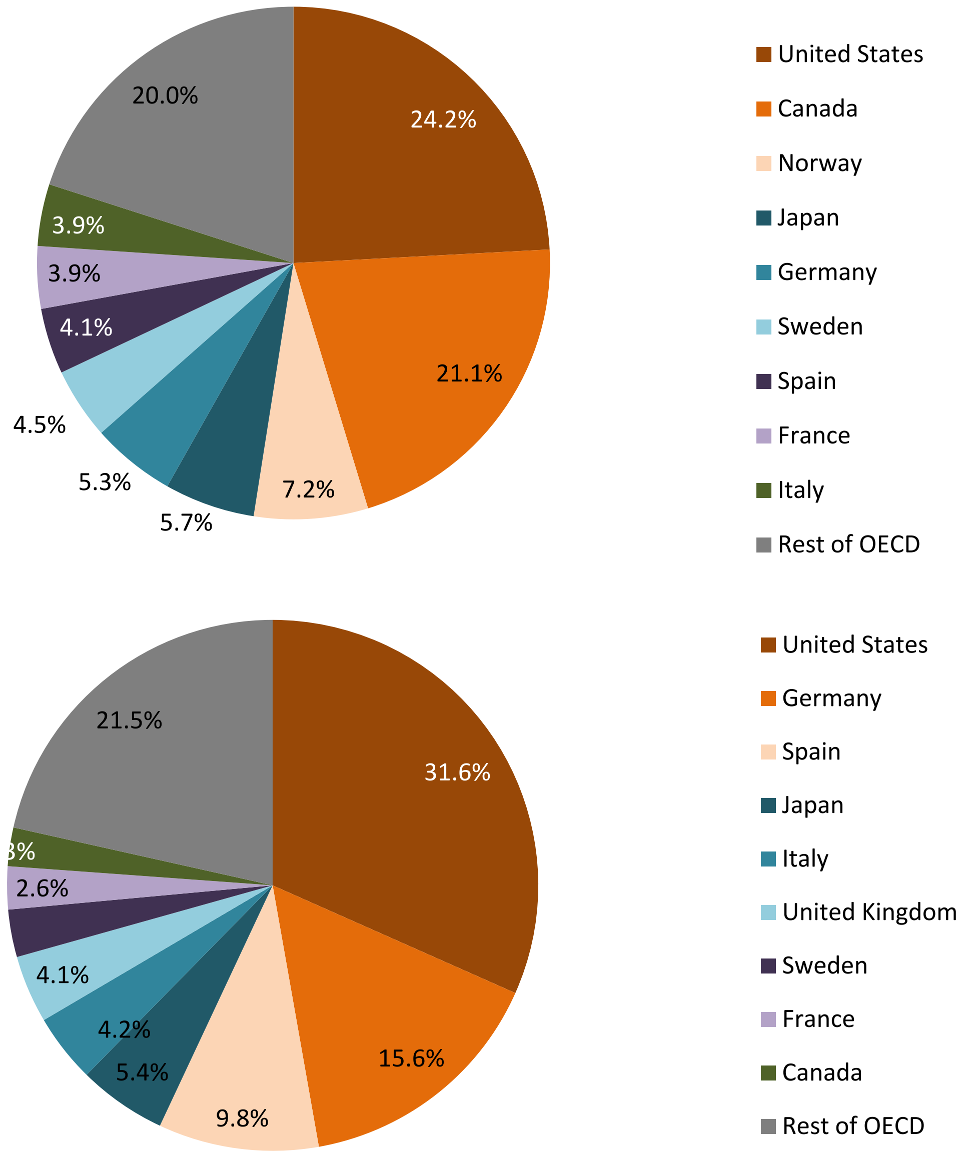


Key point: Hydro power still dominates the OECD-30 RES-E portfolio, but non-hydro sources also have significant shares in some OECD-30 countries.

Wind energy generation has more than doubled since 2005 (138% increase) and now is the second largest contributor with a share of 12.6%. The share of biomass, renewable municipal waste, biogas and liquid biofuels increased only marginally to 11.2% in 2009 (from 10.3% in 2005). Geothermal electricity has contributed at a stable level of around 2.4% since 2005. The most dynamic development occurred for solar photovoltaics (PV). Its contribution reached the 1% level for the first time in 2009 after a fivefold increase since 2005 (CAGR of 52%). Since 2005, overall generation from non-hydro RES has increased by 62.6% in OECD-30 countries as a whole.

Large differences are evident in the percent share of renewable electricity in the overall generation mix (Figure 2.1). Although Iceland and Norway are almost 100% reliant on renewables, a large group of countries such as Korea (1% share) and the Czech Republic (6% share) have a low penetration.

Figure 2.2 Renewable electricity share by country, 2009 (all RES top, non-hydro RES bottom)



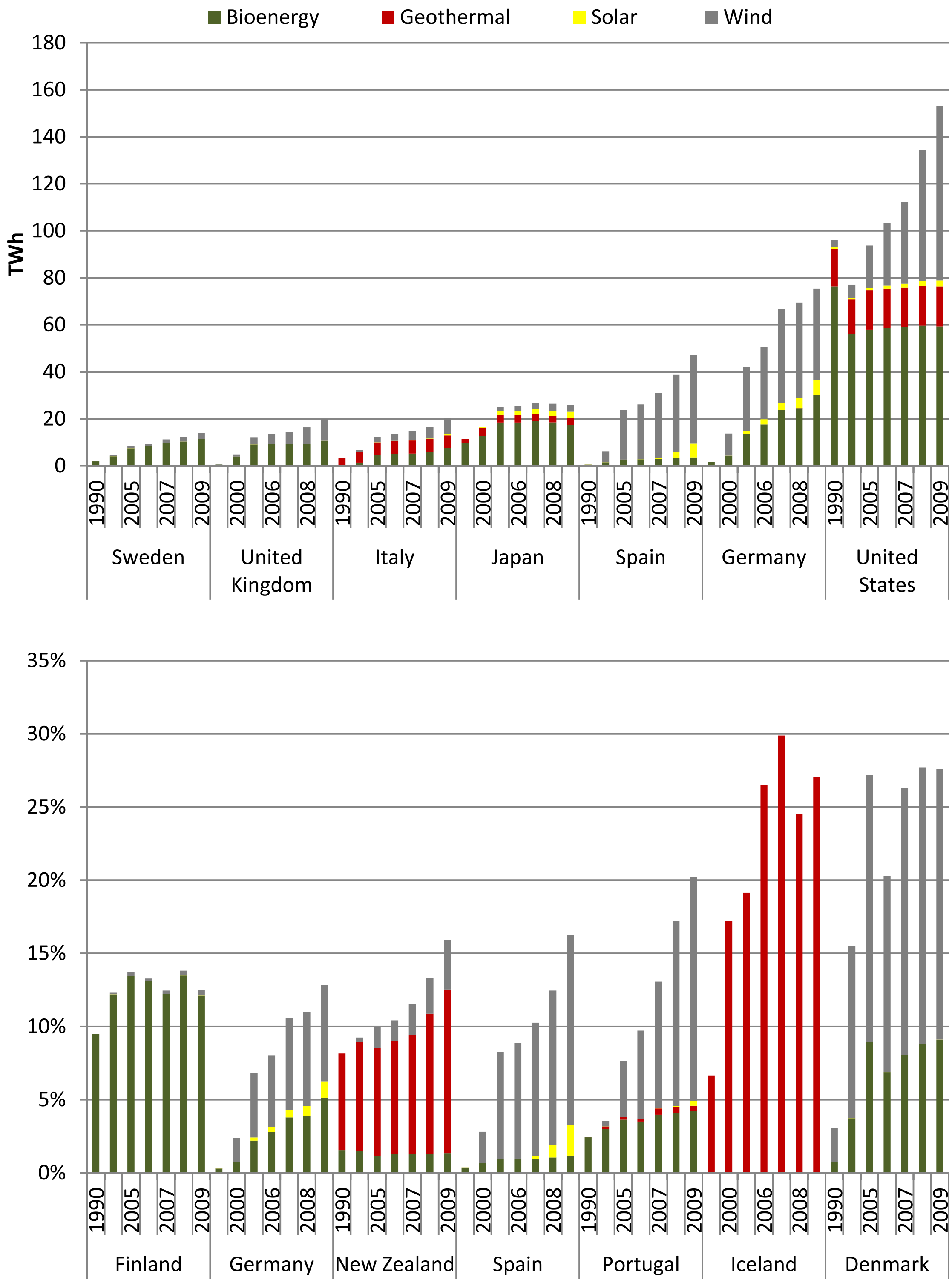
Key point: Among OECD-30 countries, the United States has a dominant share of both total production of all renewable electricity and of non-hydro renewables.

In a depiction of total OECD-30 renewable electricity generation, segmented by country and including hydro power, the United States, Canada and Norway are the largest contributors in absolute terms (Figure 2.2 [top]). Factoring hydro out of the calculation leaves the United States at the top position, but Germany comes in second and Spain third, with their large penetration of non-hydro renewables (Figure 2.2 [bottom]).

An analysis of the evolution of RE technologies over time in the largest markets (Figure 2.3 [top]) and in the countries with the highest penetration of RE technologies (Figure 2.3 [bottom]), indicates that wind power was responsible for the majority of the increase in generation.

Germany, Spain and Portugal saw the steepest increase in penetration. Iceland and New Zealand stick out as the only two OECD-30 countries that developed their abundant geothermal resource and therefore where geothermal electricity plays an important role in the power sector mix.

Figure 2.3 OECD-30 countries with highest absolute generation from (top) and share of (bottom) non-hydro renewables; 1990, 2000-09



Key point: Wind power was responsible for the majority of the increase in non-hydro renewable generation in OECD-30 countries. Biomass was responsible for large increases in Germany, the United Kingdom and Sweden.

Current policy environment

The most important support policies for renewable electricity in OECD-30 countries are feed-in tariffs (FIT), and the combination of quota systems with tradable green certificates (TGCs). Tax incentives, investment subsidies and special loan programs commonly complement these main policy instruments, or are the main instrument in a few countries, *e.g.* in the United States. In addition, to this set of standard support instruments, recent policies also tackle issues such as repowering[4] and system integration of renewable energy technologies.

Out of the 30 OECD-30 countries, 22 currently have a FIT in place. Even in countries relying mainly on TGCs, FITs are becoming increasingly popular to support small-scale generation, especially from solar PV. The United Kingdom and Italy, two countries that rely mostly on TGCs, both introduced FITs for small renewable generation recently (IEA, 2010b). In Italy, all sizes of PV plants are supported by a FIT premium. In the United States, seven states have adopted a FIT,[5] and Japan is considering extending its current FIT scheme. Although FITs were originally designed to be the only remuneration for the producer, five OECD-30 countries now have a scheme containing FIT premiums. Premiums are additional payments, supplementing revenues from selling electricity on the market.[6]

A number of OECD-30 countries support RES-E through TGCs. Poland and Sweden use TGCs exclusively. Great Britain, Italy, Japan, Norway and the United States (on the state level) use TGCs as the main support instrument, but also have FITs in place for the support of small producers or rely on tax incentives and grants for support. In Belgium, several TGC schemes are in place (depending on the region), with some certificates having a fixed price. An important innovation since 2007 in Italy and Great Britain was the introduction of banding.[7] Banding is important to ensure effective TGC support of technologies that are in an early stage of market deployment.

With the adoption of the directive on promotion of the use of energy from renewable sources (EU, 2009), all member countries of the European Union now have binding targets for the overall share of renewable energy in gross final consumption. The global European Union target of 20% is assigned to member states based on the current level of penetration and economic strength (Box 2.1).

The United Kingdom and Germany have started to address the issue of grid integration with targeted policies. The German law on grid expansion[8] (enacted in 2009) speeds-up the administrative process for selected new lines. In addition, the law includes a cost-sharing mechanism for underground cables: if a transmission system operator (TSO) chooses this expensive (and socially more accepted option), additional costs are shouldered by all TSOs. The federal government supplements the facilitation of grid expansion by policies incentivising electricity consumption at the site of production. Total remuneration is higher, due to savings in the electricity bill, if producers consume electricity locally rather than feeding it to the grid. This incentive can also be seen as a first step towards providing incentives for storage.

[4] Repowering refers to the replacement of older model wind turbines with new models.

[5] These states are California, Hawaii, Minnesota, Oregon, South Carolina, Vermont and Washington (DSIRE, 2010).

[6] Premiums either are fixed (Czech Republic, Slovak Republic and Spain) or vary according to market prices (Denmark and Netherlands). Varying premiums guarantee fixed or more stable revenues for producers. In addition, premiums can be the only available FIT option (Denmark, Netherlands and Slovak Republic) or producers can choose if they want to obtain a premium or a fixed rate (Spain and Czech Republic).

[7] This concept means that the same amount of RES-E is worth a different number of certificates depending on what technology produces it. For example, producers get more certificates per kWh produced from solar PV than for a kWh produced from wind power.

[8] Energieleitungsausbaugesetz (EnLAG).

Box 2.1 The European Union's directive on promotion of the use of energy from renewable sources

The directive on promotion of the use of energy from renewable sources (EU, 2009) requires member states of the European Union to reach an overall target of 20% RES of gross final energy consumption (today is 8.5%) with a sub-target of 10% renewables in transport by 2020. The overall target is divided among member states (Table 1.2). To facilitate compliance, the directive requires member states to submit to the European Commission National Renewable Action Plans (NREAPs). The NREAPs provide a detailed description of policy measures adopted by the member states to achieve their renewables targets in electricity, heating and cooling and transport by 2020.

According to the NREAPs, a total of 1.211 TWh (of which 1.160 TWh come from OECD-EU) of electricity from renewables would be generated by 2020. In terms of installed capacity in the 27 countries of the European Union, the plans foresee a total installed capacity of 491 GW (of which 469 GW in OECD-30-EU countries). Wind energy is expected to dominate the expansion in RES-E generation. Wind power is expected to supply 478 TWh, and solar PV 82 TWh in OECD-30-EU countries.

Table 2.1 Share of renewable energy in gross final energy consumption (%)

Country	2006	2007	2008	2020
EU (27 countries)	8.9	9.7	10.3	20
Belgium	2.7	3	3.3	13
Bulgaria	9.3	9.1	9.4	16
Czech Republic	6.4	7.3	7.2	13
Denmark	16.8	18.1	18.8	30
Germany	7	9.1	9.1	18
Estonia	16.1	17.1	19.1	25
Ireland	3	3.4	3.8	16
Greece	7.2	8.1	8	18
Spain	9.1	9.6	10.7	20
France	9.6	10.2	11	23
Italy	5.3	5.2	6.8	17
Cyprus	2.5	3.1	4.1	13
Latvia	31.3	29.7	29.9	40
Lithuania	14.7	14.2	15.3	23
Luxembourg	0.9	2	2.1	11
Hungary	5.1	6	6.6	13
Malta	0.1	0.2	0.2	10
Netherlands	2.5	3	3.2	14
Austria	24.8	26.6	28.5	34
Poland	7.4	7.4	7.9	15
Portugal	20.5	22.2	23.2	31
Romania	17.5	18.7	20.4	24
Slovenia	15.5	15.6	15.1	25
Slovakia	6.2	7.4	8.4	14
Finland	29.2	28.9	30.5	38
Sweden	42.7	44.2	44.4	49
United Kingdom	1.5	1.7	2.2	15

Source: EU (2009).

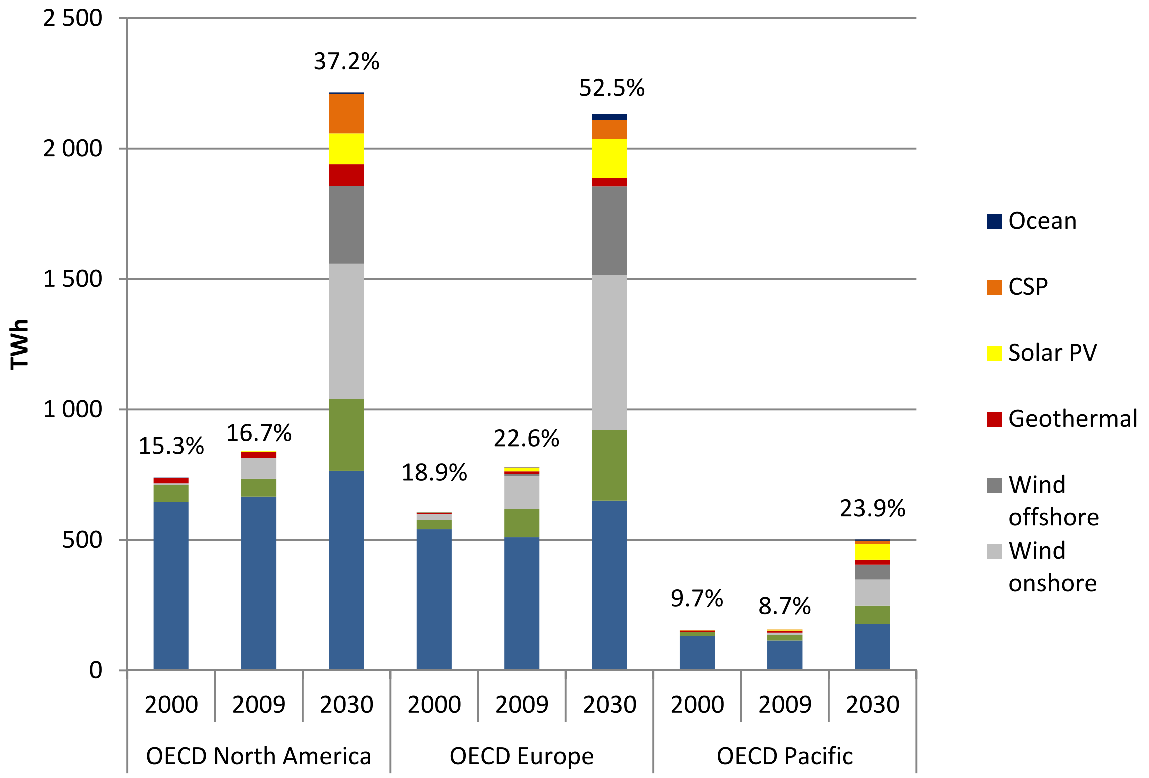
Sites that are already taken by old renewable installations can generate more electricity if equipped with modern technology. Retrofitting existing hydro plants with new generators is, therefore, a way to increase generation. France is currently considering political action in this direction. Denmark and Germany are providing higher incentives for repowering of wind turbines, *i.e.* replacing older models with newer, larger ones.[9]

A number of policies were enacted to interlink the development of electricity generation with building construction and solar heating. Ireland's 2008 building regulations require a minimum capacity of RES-E and RES-H installations per square meter for new dwellings, while Greece mandates the installation of RES-H devices in order to be eligible to receive FIT funding for rooftop solar PV installations (IEA, 2011db).

IEA projections and mid-term potential

In the *World Energy Outlook 2010* 450 Scenario, which projects a carbon-constrained energy mix, RES-E generation in the OECD-30 member countries reaches 38% by 2030, of which non-hydro renewables make up 65% (IEA, 2010a). Wind and hydro generation are the largest renewable electricity technology, with 13.5% and 13.2% of the electricity mix, respectively. However, non-hydro renewables show the most rapid growth over the projection period to 2030 (Figure 2.4).

Figure 2.4 *WEO* 2010 450 Scenario projections for renewable electricity in major OECD-30 regions



Note: Percentages indicate share of renewables in the total electricity production.

Key point: Power generation from RE sources is projected to more than double until 2030.

[9] Apart from general technical improvements, larger turbines access better wind resources.

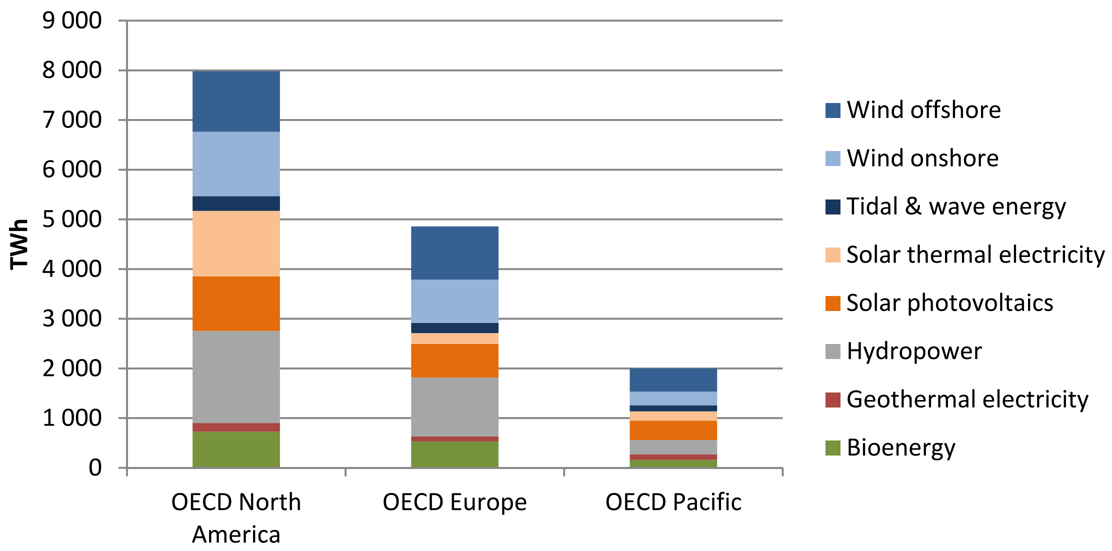
Bioenergy based electricity (which encompasses solid biomass, renewable municipal waste and biogas technologies) is the third largest contributor, with a 5.1% share of projected production. This set of technologies is already at a quite mature state today and therefore experiences far lower growth rates than wind, solar PV and concentrated solar power (CSP). Although CSP sees the most rapid growth from 2008 to 2030, its final generation in OECD-30 countries (239 TWh) is below that of solar PV (328 TWh). Marine technologies do not reach a significant share in overall generation (0.3% in 2030), pointing towards the additional need to further develop this suite of technologies (IEA, 2010a).

The following points may be made about 2030 mid-term potential for the three main OECD-30 sub-regions (Figure 2.5).

For **North America**, the cumulative potential across all technologies is at approximately 8 000 TWh. This potential compares to an electricity output of 5 030 TWh in 2009, so the potential from renewables is 1.6 times today's consumption. Comparing the potential to the *WEO* 2030 projections, the potential is about 1.3 times larger than total generation. The region has a very well-diversified portfolio of renewable resources, with roughly an equal split among offshore wind (15% of total potential), onshore wind (16%), CSP (17%), PV (14%) and hydro (23%). Bioenergy contributes 9% to the total potential, geothermal 2%, and tidal and wave 4%.

In the OECD-30 **Europe** region, the total electricity potential amounts to 4 900 TWh; this potential is 1.4 times of today's consumption and 1.2 times the projected 2030 electricity consumption. Europe has only a small potential for CSP (4%), while wind makes up 40% (onshore 18%, offshore 22%). Hydropower contributes 24% and bioenergy 11%. Solar PV has a generation potential of 680 TWh (14%).

Figure 2.5 Renewable electricity potentials for 2030 in major OECD-30 sub-regions



Source: IEA analysis based on data from IEE (2010).

Key point: The OECD North America has the largest and most diversified potential.

The total potential for renewable electricity in the **Pacific** region is smaller than in the other two regions, reflecting the smaller size of the region in terms of population and, in some countries, a less favourable resource endowment. The total potential is 2000 TWh, which is 1.26 times the 2009 consumption and only 0.95 times the projected 2030 consumption. The largest contribution to the potential is wind energy (23% offshore, 14% onshore), followed by solar (CSP and PV contribute 29% jointly), hydro power (9%) and bioenergy with 8%.

Measuring potential against population in 2008 shows a different picture: in North America, the per capita potential is 17.97 MWh/capita; in the Pacific region, it is 9.90 MWh/capita; and in Europe, it is 8.94 MWh/capita. However, it is important to note that the Pacific region is geographically disconnected and structurally diverse, so that the simple benchmarking of total potential versus population misses some important aspects: Australia and New Zealand have a very low population density and excellent resources, while Japan has a very high population density and a less favourable resource environment.

Energy security / GDP analysis

Table 2.2 Import/export categorisation for fossil fuels in the electricity sector and per capita GDP among the OECD-30 countries

	High GDP	Low GDP
Importer	Portugal, Italy, Ireland, Turkey, Luxembourg, Korea, Japan, Denmark, Spain, Austria, Finland, Slovak Republic, Hungary, Greece, Belgium, Netherlands, Germany, United Kingdom, Mexico, France, Czech Republic, Sweden, United States, Switzerland, Poland, Norway, Australia, Iceland	-
Exporter	New Zealand, Canada	-

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all the OECD-30 countries come under the high GDP category, and in 2000, all were importers of power generation fuels, except New Zealand and Canada (Table 2.2). The observed market evolution over the past years is in line with the prediction from GDP/energy dependency clustering. The majority of OECD-30 countries had a strong incentive to develop renewables in the power sector to enhance their security of supply. In addition, the favourable economic situation has made environmental policies more affordable.

For the **OECD-30-EU** group, countries have both binding emission targets and also mandatory shares of renewable energy in their supply portfolio in 2020. The European Union's strategy on renewables deliberately targets their development also for the sake of developing new markets and establishing technological leadership.

For the four European OECD-30 countries that are not members of the European Union, there is a split between Iceland and Norway on the one hand, and Turkey and Switzerland on the other. The first two countries have already achieved almost complete decarbonisation of their electricity sector, due to the abundance of cheap hydro and geothermal resources. Turkey has recently published a national energy document that outlines a comprehensive energy strategy until 2030. A law containing the corresponding support policies was enacted in late 2010, foreseeing 30% of the electricity to come from renewable sources in 2023. In Switzerland, the revised national energy concept (*EnergieSchweiz* 2011-2020) foresees a doubling in the share of renewables in the Swiss energy system until 2020. The demand increase in electricity will be covered exclusively by renewables.

North America is a key region for renewables in the OECD-30, as well as the largest source of uncertainty regarding the prospects for renewables. First, the size of the **United States** and its energy system make it a very important market for renewables, as was shown in the market overview above. In addition, the United States is also one country where the policy environment faces large uncertainties. The policy approach in the United States to deploying renewables has been flawed with instability for years. This instability reflects diverging opinions regarding the country's energy future among policy makers. The United States could become self-sufficient, at least in the power sector, by systematically developing its fossil resource base, especially unconventional gas and coal. Energy security targets could, therefore, be met even without massively scaling up renewables. However, climate change concerns and the prospects for green growth also drive policy making. This factor is reflected in a number of federal- and state-level policies, and documented by the success of deploying wind power in the United States, at least in some years.

Mexico is rapidly becoming more dependent on imports to cover its energy demand. This trend has gone along with a continuous increase in hydro power capacity[10] and the development of some biomass. Very recently, Mexico has engaged in wind power deployment, installing an estimated 316 MW in 2010, more than doubling its installed capacity (GWEC, 2010). Canada is fully self-sufficient in its power generation, with a 60% penetration of hydro power. Deployment has been slow over the past years, with renewables growing only at 0.25% (compared to a CAGR of the North America region of 1.46%).

As for the **OECD-30-Pacific** region, the situation is somewhat split between Japan and Korea, which are both highly dependent on imports, and New Zealand and Australia, which are not as dependent, or only mildly so. Korea and Japan have been relying strongly on nuclear power to meet energy security targets in the power sector, while developing their renewables industry with a view to exporting. The prospects for domestic renewables deployment in the two East Asian countries may have changed due to the nuclear catastrophe at the Fukushima Nuclear Power Station in March 2011.

New Zealand has very good wind resources, which makes the technology competitive in the absence of economic support. The government target is to generate 95% of electricity from renewable sources by 2035; this target is clearly due to the country's favourable resource base and its aim to maximise fossil export revenues. This renewable target will be achieved mainly by wind and geothermal energy. In Australia, the newly elected government has made climate change a priority. Australia's recent effectiveness in deploying solar energy underlines its growing interest in and commitment towards renewables.

Renewable heat

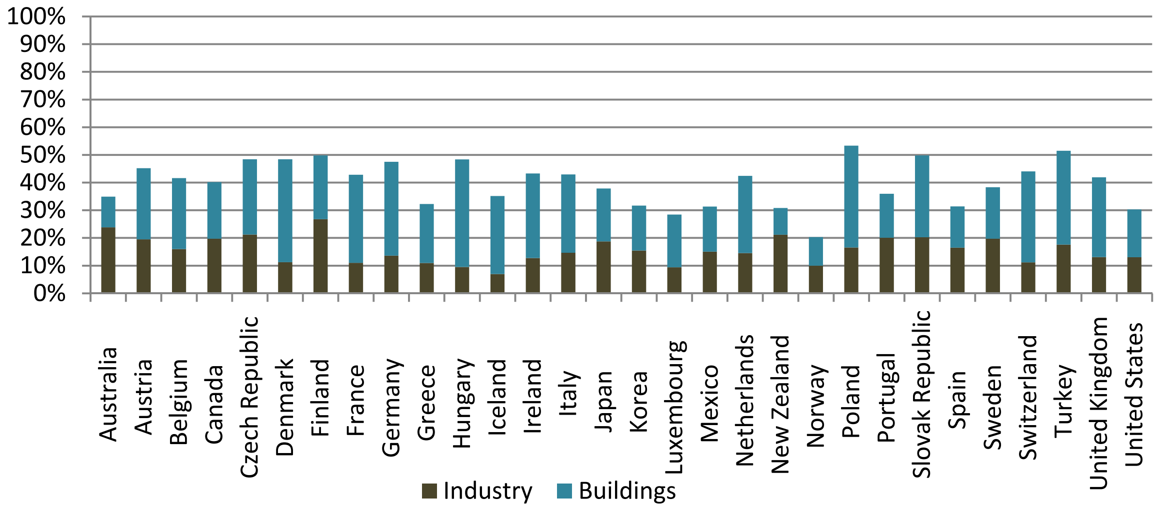
Current market status

Nearly all OECD-30 countries show considerable shares of final energy consumption for heat, independent of climatic conditions (Figure 2.6). Many countries face relatively high heat demands due to considerable space heating demand. A number of countries with warmer climates, such as Australia and Mexico, still show high shares of final energy used for heat as a result of the climate-independent need for heat in industrial processes and the relatively climate-independent demand for domestic hot water and cooking. Norway and Iceland are the only OECD-30 countries to show higher shares of final energy consumption for power as compared to heat. Both countries produce large shares of renewable electricity by hydro energy and/or geothermal energy and to some extent use power for (*e.g.* domestic hot water) heat demand; this is true also for France with electricity from nuclear power stations. Because of the overall

[10] Electricity output of hydropower was comparably low, presumably due to weather conditions.

high shares of final energy used for heat, renewable heat can make a substantial contribution to meeting climate change and energy security objectives.

Figure 2.6 Share of heat in total final energy consumption in OECD-30, 2009

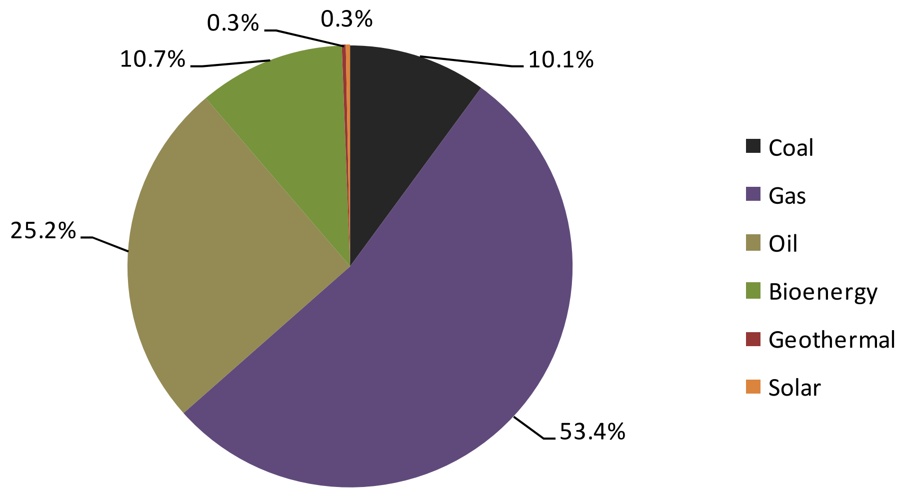


Key point: Nearly all OECD-30 countries show considerable shares of final energy consumption for heat, independent of climatic conditions.

In 2009, the total final consumption for heat was 1 282 million tonnes of oil equivalent (Mtoe). This number has decreased by 8.6% since 2000, when it stood at 1 402 Mtoe. Renewables had a share of 10.5% in 2009, up from 9% in 2000.

In OECD-30, the fuel mix used for heat shows a dominance on fossil fuels, with approximately 53.4% of heat fuelled by gas. This share has risen since 2000, when it stood at 49.9%. One-quarter of energy consumption for heat was covered by oil and approximately 10% by coal (Figure 2.7).

Figure 2.7 Fuel mix of final energy consumption for heat in OECD-30, 2009

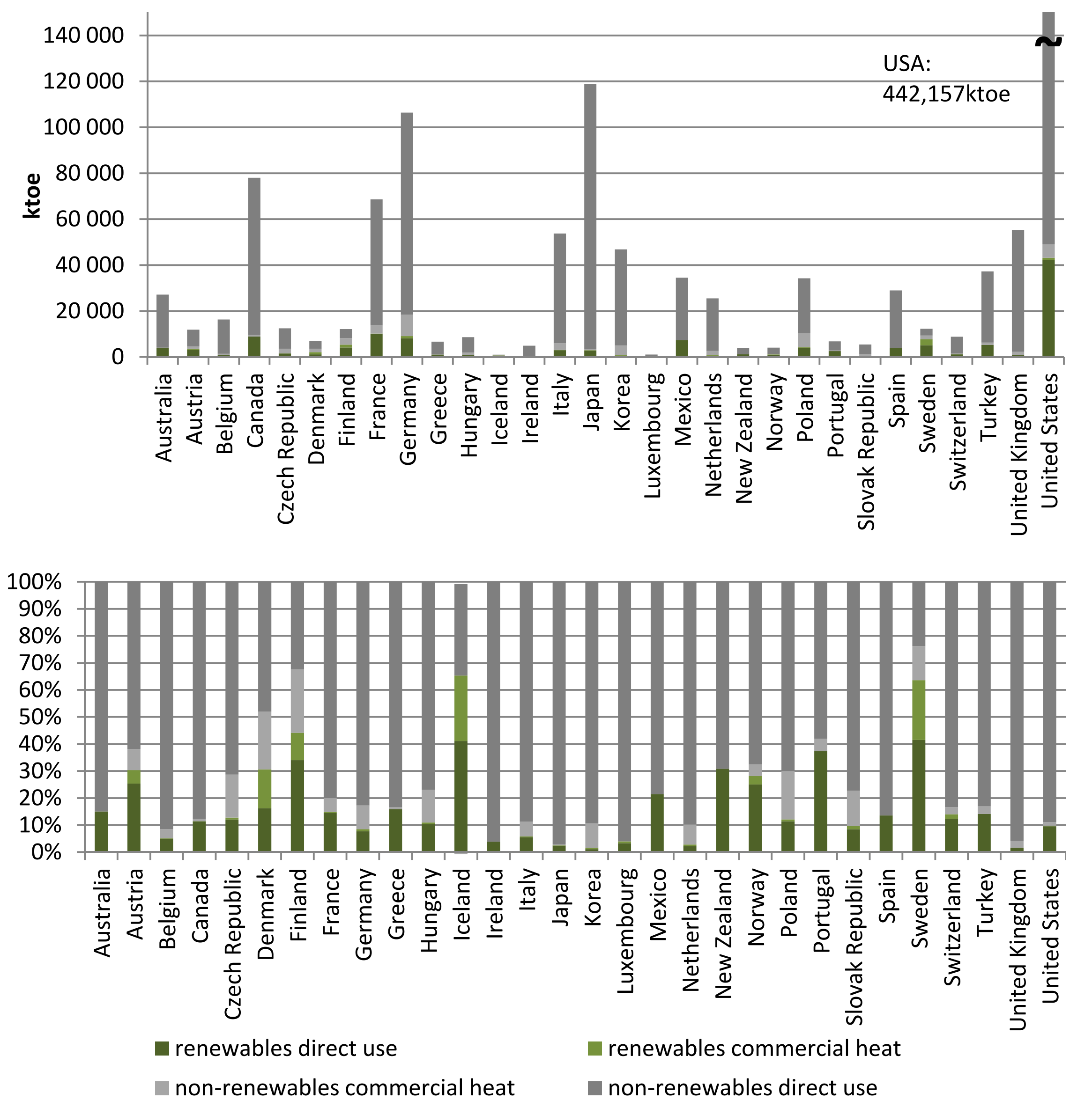


Key point: Gas and, to a lesser extent, oil dominate the OECD-30 final consumption for heat.

The high dependency on foreign gas for heat can cause concern for security of supply, as was demonstrated in January 2009, when 18 European countries reported major cut-offs of their gas supplies from Russia, as a result of a Russian dispute with Ukraine.

Bioenergy, including some non-renewable waste, contributed 10.7% to the mix. Geothermal heat and solar thermal heat provide 0.3% of final energy consumption for heat. A number of OECD-30 countries have extensive district heating networks: 5% of the heat comes from commercial heat, which is sold and distributed by district heating networks.

Figure 2.8 Renewable heat production in ktoe (top) and as a share (bottom) of final energy consumption for heat in 2009[11]



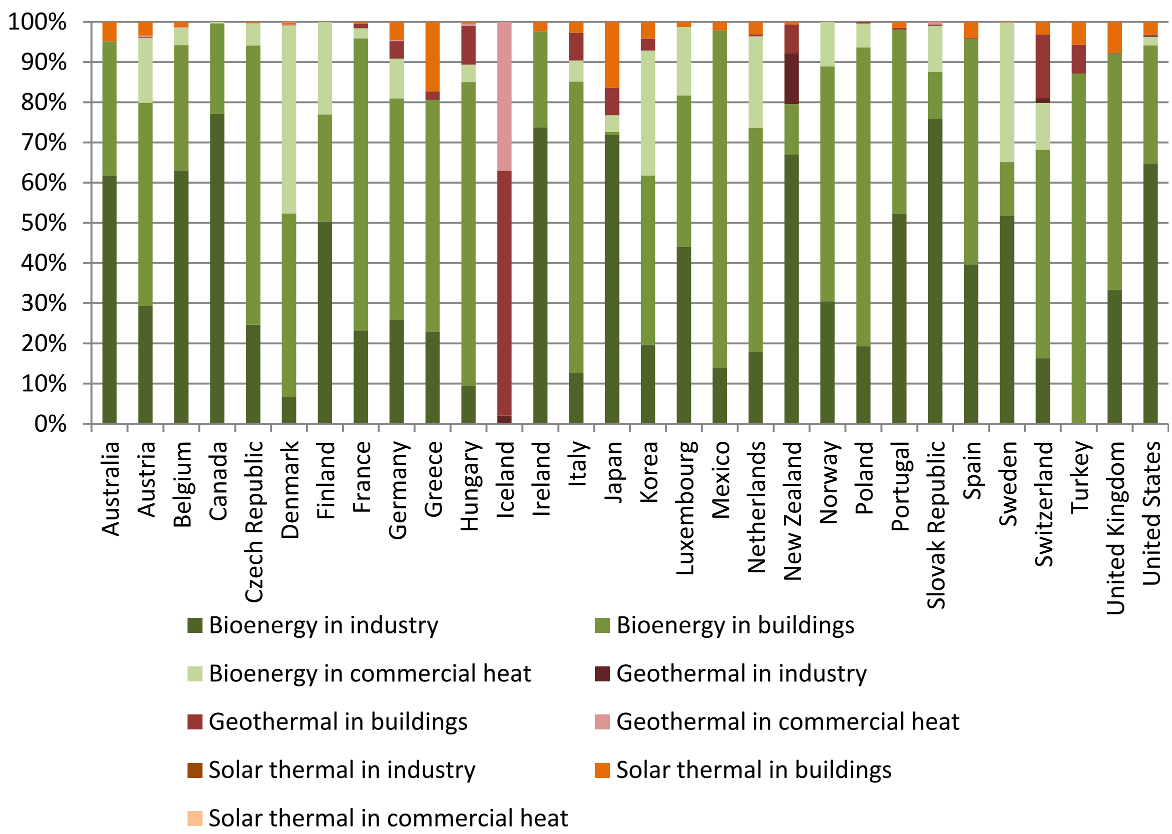
Key point: **In OECD-30 countries, shares of renewable energy in final energy consumption used for heat show large variations.**

[11] Bioenergy in commercial heat not included; geothermal data include heat produced by ground source heat pumps.

Shares of renewable energy in final energy consumption used for heat show large variations among OECD-30 countries (Figure 2.8). Bioenergy (combustible renewables and renewable waste) dominates renewable energy used for heat: 94% of renewable heat comes from bioenergy in OECD-30 countries in 2009. In a number of OECD-30 countries reporting high shares of biomass directly used in the residential sector, this biomass presumably consists, to a considerable extent, of biomass used in conventional wood stoves and open fireplaces, with relatively low efficiencies and high particulate matter emissions.

Relevant shares of solar thermal, low-temperature heat, used mainly for domestic hot water, are visible in Austria, Australia, Greece and Turkey. Iceland, known for its vast geothermal resources, supplies more than 60% of its heat demand by means of geothermal heat.

Figure 2.9 Technology mix of renewable heat in OECD-30 countries, 2009



Key point: Bioenergy is the most important source of renewable heat in the OECD-30.

The evolution of renewable heat in the production of commercial heat (heat that is sold and distributed by district heating networks) highlights the positive effects of efforts in Austria, Denmark, Finland and Sweden in increasing the uptake of modern renewable heating technologies (Figure 2.9). Austria, Denmark, Finland and Sweden show a remarkable increase of renewable heat as a share of commercial heat during the period 1995 to 2009. In 2009, Austria reported a high share of bioenergy used in combined heat and power (CHP) and heat-only plants. Denmark indicates a high share of bioenergy, including renewable municipal waste (MSW), for commercial heat and reports geothermal energy in its district heat. Denmark is the only country to report solar thermal energy supply to commercial heat. Finland's commercial renewable heat is dominated by use of bioenergy, similar to Sweden, whereas in Norway renewable MSW is taking the greatest share in renewable commercial heat. Iceland is known for its high share of geothermal heat used in district heating networks. The share of renewable commercial heat in Iceland has remained constant for decades and can only marginally increase due to the existing high share.

The significant increases in renewable commercial heat in the last two decades as reported in Austria, Denmark, Finland and Sweden seem to show a correlation between these increases and policies introduced for CO_2 reduction in general, or encouragement of renewable heat specifically. Sweden introduced taxation of fossil fuels in heat production in 1991. The gradual evolvement of a carbon tax set to nearly 30 EUR/ton CO_2 in the early 1990s towards a 101 EUR/ton CO_2 (IEA, 2008a) spurred a significant move from fossil fuels to biomass. Before the 1990s, mainly coal or oil was used in Swedish district heating, which is the common heating system in all Swedish cities. In 2007, the renewable share in Swedish commercial heat consisted of 44% from biomass (mainly waste from forests and forest industries), 9% from renewable MSW and 2% from solar thermal and heat pumps (Ericsson and Svenningsson, 2009). Denmark and Finland have had carbon taxes in place since the 1990s, whereas in Austria, a long tradition of subsidies, in combination with high dependency on oil and high oil prices, seems to have triggered an increase of renewable heat in commercial heat (Kalt and Kranz, 2009).

Current policy environment

To date, direct capital cost subsidies for the purchase of a renewable heating system are the most widely adopted financial mechanism in OECD-30 in support of renewable energy technologies. More recent innovative policies include renewable obligations, such as a solar obligation in Spain, renewable heat obligations in new buildings in parts of the United Kingdom and Germany, and a yet-to-be-introduced renewable heat feed-in tariff in the United Kingdom. To date, direct capital cost subsidies and tax incentives or soft loans for the purchase of a renewable heating system are the most widely adopted financial mechanism in the European Union for the support of renewable heat (Connor *et al.,* 2009).

In March 2011, the Government of the United Kingdom released the Renewable Heat Incentive (RHI), an innovative and ambitious renewable heat strategy combining different policy instruments. A feed-in tariff, ranging over a 20-year period, will be allocated to the industrial and commercial sectors, public not-for-profit organisations, and communities for heat produced from biomass, ground source heat pumps, solar thermal and biomethane. Domestic users of renewable heaters will be entitled to a renewable energy premium payment (REP) under the form of a cash subsidy. As previously stated, pricing policies are rare in the heat sector, and the RHI approach, which includes both producers and consumers, and individual and non-household beneficiaries, is a first of its type. Close attention will be devoted in the coming years to the efficiency and effectiveness of such a policy framework.

Energy regulations for buildings are gradually being harmonised in the OECD-30-EU countries as a result of the Energy Performance of Buildings Directive (EPBD).[12] The recast of the EPBD, adopted in early 2010, requires European Union member states to aim for all new buildings to be nearly zero energy buildings by 2020. The EPBD recast also aims to increase attention for existing buildings. Although not specifically targeted at increasing renewable energy, the requirements for reducing primary energy in buildings in this European legislation could prove to be an incentive for renewable heat in the near future.

[12] The EPBD was first launched in 2003 as the EU Directive 2002/91/EC, whereas in May 2010, a recast was adopted, known as Directive 2010/30/EU.

CO_2 taxes have been introduced in Sweden, Finland, Norway and Denmark since the 1990s and are believed to have considerably influenced renewable heat deployment.

Box 2.2 Recent developments: Obligations and heat feed-in tariff

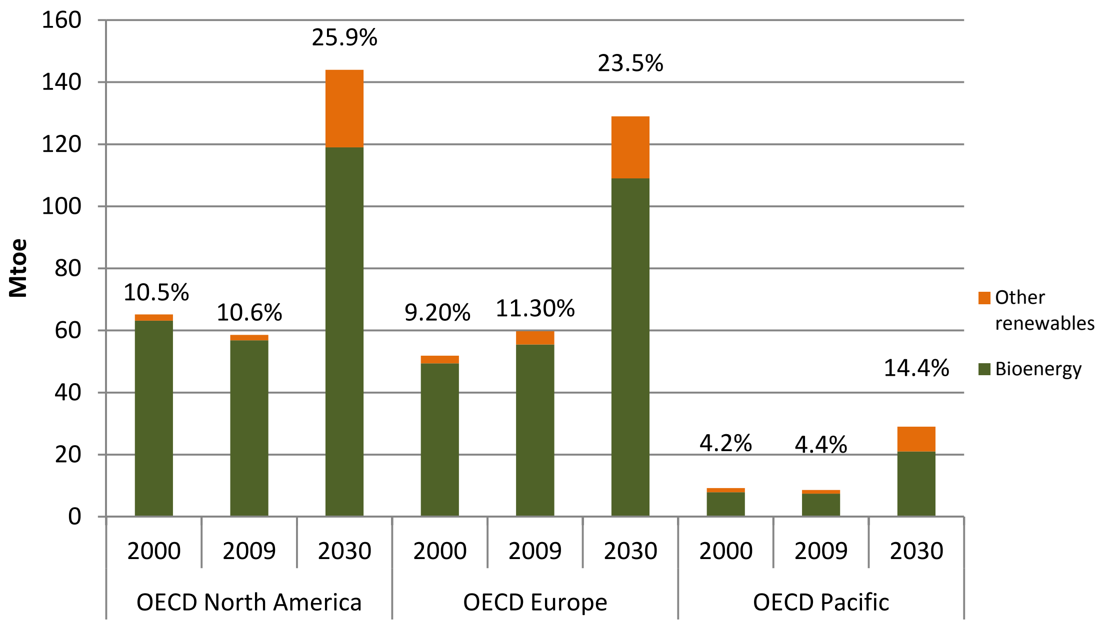
Recent renewable heat policies tend to favour regulatory approaches as well as using experience in successful renewable electricity policies for the renewable heat market. In 2000, Barcelona introduced a solar obligation, and its success resulted in the Spanish government developing a national solar obligation policy in 2006. Because a solar obligation incentivises one specific technology, such a policy should be introduced only in cases where there is no competition with other renewable technologies for the same purpose. Weaknesses of the solar obligation include the need to check compliance and the lack of an incentive for surpassing the required level of the obligation. Other regulatory approaches consist of requiring a share of a building's heating demand to be generated by renewable energy, such as in the London "Merton rule" and the German 2009 building regulations. This type of obligation allows for competition among renewable (heating) technologies but still lacks an incentive for surpassing the required renewable share in heating demand, which in the case of the Merton rule consists of a modest 10% renewables. When applied to new buildings only, the deployment effect may be limited, as in OECD-30 countries where annual construction rates are on average about 1% of the total building stock. In both examples of regulatory instruments, policies focus on the building level, which can disfavour medium- and large-scale options that are most relevant at the scale of a building district.

The United Kingdom aims to introduce a Renewable Heat Incentive by April 2011, which will be the first initiative for a feed-in tariff type of policy for the heat market (DECC, 2011). In Germany, the introduction of a renewable heat feed-in tariff policy has been explored but pushed aside in favour of an obligation type policy (Bürger *et al.,* 2008). Ideally, a renewable heat feed-in tariff scheme, as with such systems for renewable electricity, should allocate and distribute the additional costs of renewable heating technology among all heating fuel consumers according to the "polluter-pays" principle. Complications of introducing to the renewable heat market a feed-in tariff scheme that is similar to those used for renewable electricity arise from some key differences in delivery of heat as compared to electricity (Bürger *et al.,* 2008). The more heterogeneous delivery of heat and of fuels used for heat production means that there is a far more diverse group of companies supplying the market. Failure to include any companies supplying heat energy in the mechanism when assigning costs will effectively result in those companies gaining an economic advantage over their competitors. A key problem in a renewable heating feed-in tariff scheme is that of assessment of generated heat output. The cost of heat metering relative to any available subsidy is likely to continue to be a disincentive for smaller generators, suggesting that an alternative is needed. There is an additional factor that makes metering for small scale production problematic. There is generally no "grid" to which excess domestic heat can be delivered to. Installing a meter may therefore create an incentive for overproduction of heat, i.e. "heat production with open windows".

IEA projections and mid-term potential

In the *World Energy Outlook 2010* 450 Scenario, which projects a carbon-constrained energy mix, renewable heat (measured as a share of total final consumption for heat) in the OECD-30 member countries reaches 23% by 2030, of which bioenergy makes up 82.5% (Figure 2.10). Although still contributing in absolute numbers, other technologies (solar and geothermal) grow faster than bioenergy.

Figure 2.10 *WEO* 2010 450 Scenario projections for renewable heat in major OECD-30 regions



Note: Percentages indicate share of direct use of renewables in total final consumption for heat.

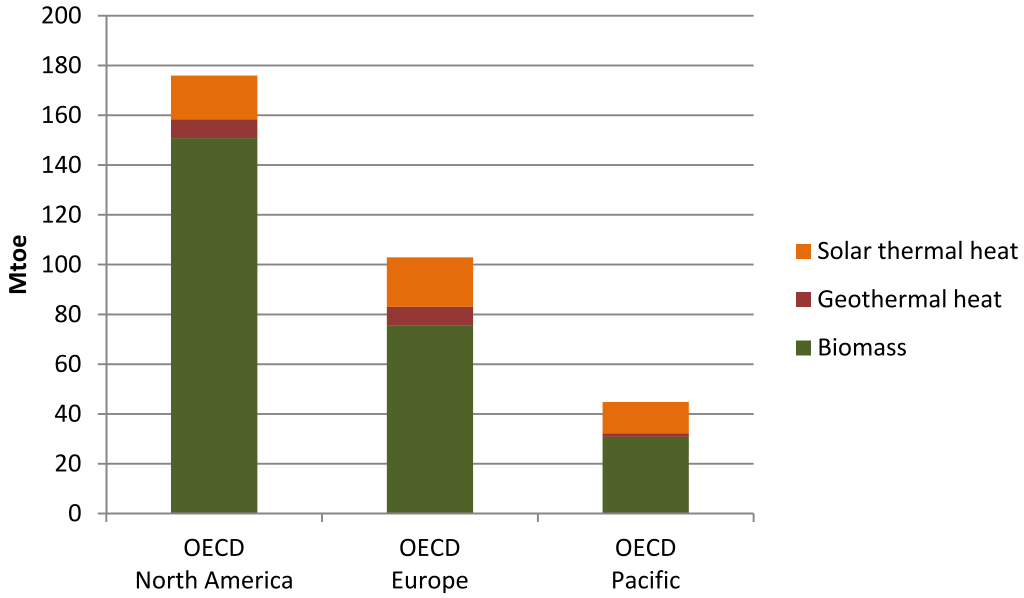
Key point: **OECD-30 regions are projected to have 25.9% (North America), 23.5% (Europe) and 14.4% (Pacific) of renewable heat in total final consumption for heat.**

The 2030 potential for heat production includes heat from the transformation sector that is not included in the *WEO* projections (Figure 2.11). Compared to the electricity sector, the differences between potential and projected values are smaller. In the OECD-30, the overall mid-term technical renewable heat potentials show large differences per country, with some of them being able to supply nearly all their heat demand by 2030 with renewable energy.[13] However, a number of countries do not reach more than a 5% share by that time**.** The varying mid-term technical renewable heat potentials are the result of a combination of restricted availability of renewable heat resources and limited transportability of heat, varying levels of heat demand and renewable heat production over the season, and limited policy efforts to increase the uptake of renewable heat thus far.

The limited mid-term technical renewable heat potential in some OECD-30 countries might be relieved by looking for technological options that have not been considered in this study, such as introducing biogas in a natural gas grid, (ground source) heat pumps, underground thermal energy storage (UTES), cogeneration of heat in CSP plants or using renewable power for heat.

[13] Under the condition of introducing a strong policy framework that will allow for its full exploitation.

Figure 2.11 Renewable heat potentials for 2030 in major OECD-30 regions



Source: IEA analysis based on data from IEE (2010).

Key point: Biomass dominates the potential for renewable heat applications.

Energy security / GDP analysis

Policies to encourage the development and deployment of RES-H technologies have been neglected compared with those supporting renewable electricity or biofuels for transport. Analysis of the effectiveness of policies incentivising renewable heating technologies demonstrated limited effectiveness rates in assessing the ratio of annual additional growth relative to additional realisable potential until 2020 (IEA, 2008b).

To date, direct capital cost subsidies for the purchase of a renewable heating system are the most widely adopted financial mechanism in OECD-30 for the support of renewable heat, even though they are probably most effective in the prototype and demonstration phase.

An advantage of these financial incentive schemes is the low transaction cost relative to other schemes, especially if an administration used to handling subsidy schemes is already operational. An advantage of direct capital cost subsidies is that they appeal to consumers who are used to paying for their heating/hot water installation as a one–time, up-front investment. Capital cost subsidies may be successful for encouragement of renewable technologies that are in the prototype and demonstration phase (IEA, 2008b). However, it also seems that capital cost subsidies are used much longer for renewable heating technology, even where technologies are reaching maturity. For example, in the case of domestic solar thermal technology, which is known as a relatively mature technology these days, capital cost subsidies seem to exist on a stop-and-go basis throughout a period of decades until today.[14] The stop-and-go nature of capital cost subsidies, as well as of tax incentives and soft loans, reveals one of their weaknesses: subsidy schemes usually depend directly on the public budget, or reduce government income (tax reductions), and therefore alter with a changing political agenda. Another disadvantage of subsidies or tax incentives is the absent guarantee of producing renewable heat, because the

[14] For example, in the Netherlands, capital cost subsidy for solar thermal systems had first been introduced in 1988 and was adjusted in 1992, 1995, 1997 and 2000 and stopped in 2003, whereupon a subsidy scheme was reintroduced in 2009.

incentive is usually provided up-front, without checking compliance of (properly) installing the equipment. However, in Austria and Germany, a long tradition of stable subsidies is reported to have triggered the increase of renewable heat, most notably solar thermal systems (Kalt and Kranz, 2009).

An explanation for the persistence of these financial incentive schemes might come from the perceived lack of alternative policies available, because the heat market is rather different from the electricity market. Allocating and distributing the additional costs of renewable heating technology among all heating fuel consumers according to the "polluter-pays" principle, such as used in feed-in tariff schemes for renewable electricity, might appear to be more complicated in the heat market (Box 2.2).

Renewable heat policies in the OECD-30 thus far concentrate on the building sector; because nearly half of final energy for heat is consumed in the industry sector, attention to renewable heat could be addressed in this sector as well.

Energy regulations for buildings can be an effective instrument to target heat demand in new buildings and can be used to introduce incentives for renewable heat. However, a key challenge exists in approaching the difficult market of heat use in existing buildings. The existing building stock will dominate the OECD-30 building sector as a result of the long life spans of buildings and the limited need for new building development due to stabilising or decreasing populations. In the market of existing buildings, a spilt-incentive problem often exists: tenants might not be in the position to alter heating installations without permission of the building owner, whereas the building owner does not benefit from the energy savings of improved installations. Moreover, in the existing building stock, renewable heat deployment potential can sometimes be restricted due to technical limitations.

A number of OECD-30 countries in colder climates have a well-established heat market with a strong gas industry and extensive gas networks. In these countries, the competitiveness of renewable heating technologies will not only be influenced by competition with fossil fuel prices, but can also be determined by strong vested interests of current industries that counteract developments in renewable heat.[15] Countries with an extensive gas infrastructure that, in some cases, benefit from national gas resources, might face more difficulties in realising a transition towards renewable heat, as compared to countries without such infrastructure and with a dependency on oil or expensive electrical heating. A transition path in some countries of the first type could possibly consist of bending the negative aspects of this commitment to gas into a positive concept, *e.g.* by looking for the introduction of biogas in the natural gas grid or by looking for hybrid technologies that combine gas as a backup fuel for an intermittent renewable heat technology.[16]

The success of past heat policies in countries such as Austria and Sweden might have been correlated, to a large extent, with dependency on oil in the national heat market and the absence of extensive (gas) infrastructures. At the same time, countries that link their gas prices with oil prices, while having a high dependency on gas for heating, faced a strong incentive towards renewable heat at the time that oil prices were peaking in 2008. However, if this linkage between gas and oil prices is broken, *e.g.* because of an expected gas glut, gas prices can fall and the cost-effectiveness of RES-H will be influenced negatively.

[15] Countries with an extensive gas infrastructure will have a strong industry that will be able to invest in improving gas technology to meet new (building) standards.

[16] For example, in the Netherlands, the hybrid technology of a gas-condensing boiler with heat pump technology is expected to rapidly gain ground in the near future, incentivised by strengthened energy regulations for buildings.

Table 2.3 Import/export categorisation for fossil fuels for heat and per capita GDP among the OECD-30 countries

	High GDP	Low GDP
Importer	Luxembourg, Japan, Belgium, Korea, Spain, Ireland, Switzerland, Italy, Slovak Republic, France, Greece, Germany, Portugal, Austria, Hungary, Turkey, Czech Republic, Finland, Sweden, Iceland, Poland, United States, New Zealand, Denmark, Mexico, Norway, Netherlands, United Kingdom, Australia	-
Exporter	Canada	-

In terms of the country cluster analysis, all OECD-30 countries fall into the high GDP category, while only Canada is classified as an energy exporter as far as this sector is concerned (Table 2.3). However, some sharp differences exist in the amount of renewable heat in the mix. A number of factors influence this. Resource availability is important. Countries with a strong tradition of producing forestry-based products (such as timber and paper) continue to have a high proportion of bioenergy in their mix, and have been able to build on this basis. Countries with high geothermal potential have exploited it. Overall energy policy is also an important factor, with renewable heat being fostered by carbon taxes in countries such as Sweden and Denmark. Austria, which is heavily reliant on imported gas, has taken a very proactive role, and is a leader in both solar water heating and biomass heating technologies. The energy infrastructure in place is a further important factor. Countries with strong heat distribution network have a readier means of taking advantage of renewable heat opportunities than those countries without such a network, and perhaps in the longer term, biological and thermal production of biogas will enable enhanced penetration of renewable energy into countries that benefit from a strong gas grid.

Renewable transport

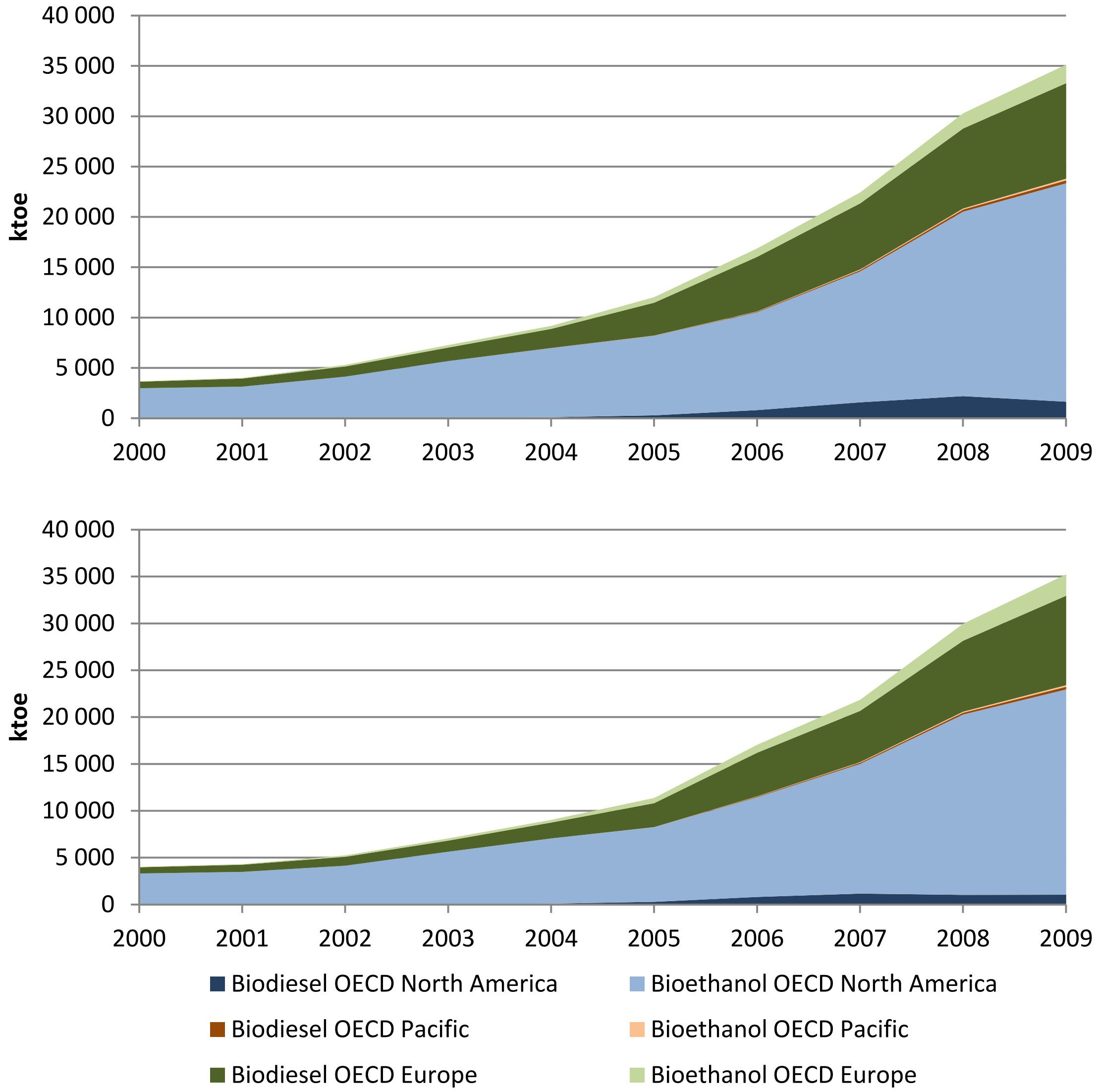
Current market status

In OECD-30 countries, the use of biofuels for transport, including bioethanol and biodiesel, increased by a factor of 8.7 between 2000 and 2009, and 3.1 between 2005 and 2009, and reached 35.2 Mtoe/year in 2009. As a result, the percentage of road transport fuel needs supplied by biofuels increased from 0.4% in 2000, to 1.1% in 2005 and to 3.4% in 2009.

Within the OECD-30, consumption of biofuels was dominated by the United States, where in 2009, over 63.9% of the total was consumed (22.1 Mtoe/year, increasing by a factor of 2.7 since 2005) (Figure 2.12). This amount represents 4.4% of total road transport fuel consumption. Consumption also continued to rise significantly in OECD-30 countries that are part of the European Union, reaching 11.7 Mtoe, or 33.2% of the total (an increase by a factor of 3.8 since 2005). Consumption is also now increasing sharply from a low base in the other OECD-30 countries, particularly because of large increases in Korea, Australia and Canada.

Biofuels are an internationally traded commodity, so production and utilisation are to some extent geographically decoupled. Within the OECD-30, the production of biofuels for fuel use increased by a factor of 2.9 between 2005 and 2009, reaching 35.1 Mtoe/year. Overall, the trends followed those for consumption as shown in Figure 5.19. The United States was the largest producer (22.1 Mtoe/y). Together, Germany and France are responsible for about two-thirds of total production in the European Union (3.8 and 3.5 Mtoe/y, respectively).

Figure 2.12 Production (top) and consumption (bottom) of biofuels in main OECD-30 markets, 2009

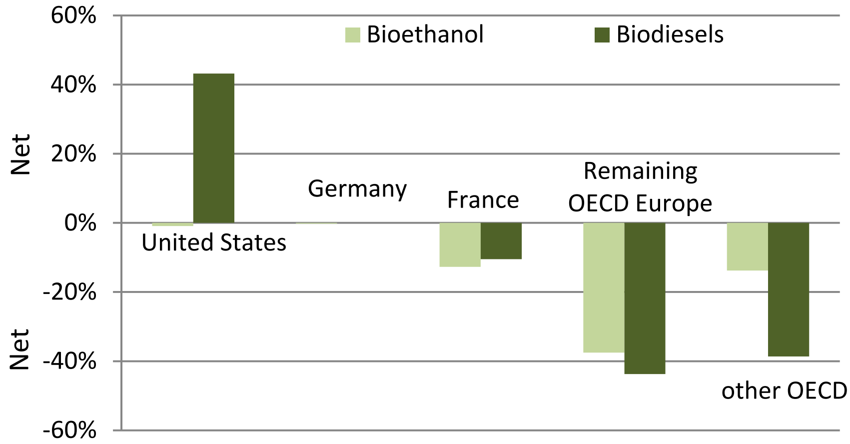


Key point: North America is a centre of bioethanol production and consumption; in the European Union, the focus is on biodiesel.

Although production and consumption within the OECD-30 countries are more or less in balance, trading of biofuels within and outside the OECD-30 is an increasingly important feature of the market, as reflected by differences between production and consumption at the national level. Trade is especially prominent among OECD-30 members, but also with non-OECD-30 members, such as Brazil, Indonesia and earlier, with Malaysia. The reasons include production cost differences and higher market values within the OECD-30 countries. In ten countries, consumption exceeded production by over 30% in 2008, as shown in Figure 2.13. The United Kingdom, France, Poland and Spain had the biggest shortfalls in absolute terms; Germany, the United States, Sweden and Denmark were the largest net exporters.

The types of biofuel produced and used differ markedly between the United States and the European Union, as shown in Figure 2.14. In the United States, only 4.6% of the biofuel used is biodiesel, with the market dominated by ethanol. By contrast, in the European Union, 77.3% of the biofuel used is biodiesel. In all OECD-30 countries, the proportion of biodiesel is 29.7%, with the market in Korea entirely based on biodiesel, and that in Canada dominated by ethanol.

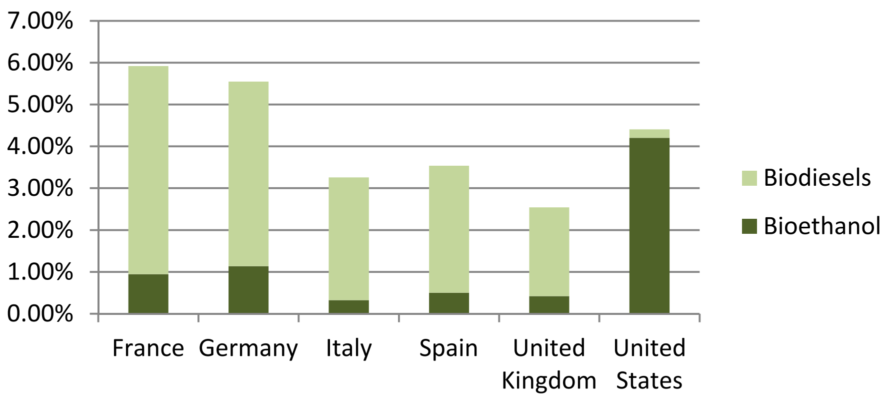
Figure 2.13 Net exports of biofuels as shares of domestic production in main OECD-30 markets, 2009



Key point: **With the exception of Germany, the OECD countries in the EU are net importers of biofuels; the United States is an exporter of bioethanol.**

Although biofuel production and use have been growing steadily since 2000 in each of the sub-regions, more detailed analysis of the pattern of biodiesel production within the European Union shows that, between 2007 and 2008, a significant drop in production occurred in some countries, notably Germany, but also the United Kingdom, Austria, Greece, Portugal and the Czech Republic. Overcapacity in Germany led to a number of plants being taken out of production. This action was reportedly due to low-cost biodiesel from the United States being imported into Europe, taking advantage of the so-called "splash-and-dash" practice, which allowed fuel imported into the United States to gain a tax excise credit before being exported to the European Union. However, with decreasing feedstock prices and the introduction in March 2009 of an anti-dumping import duty on biodiesel from the United States, overall production levels in the European Union continued to increase, notably driven by France, Italy and Poland.

Figure 2.14 Consumption of biofuels in main OECD-30 markets, 2009



Key Point: **In the United States, the market is dominated by ethanol; by contrast in the European Union, the dominant fuel is biodiesel.**

Current policy environment

United States

In the United States, the Renewable Fuel Standard was created under the Energy Policy Act of 2005, and established the first renewable fuel volume mandate in the United States, driven largely by energy security concerns. This standard requires 7.5 billion gallons of renewable fuel to be blended into gasoline by 2012.

The Energy Independence and Security Act of 2007 extends the Renewable Fuel Standard, requiring 9 billion gallons (34 billion litres) of renewable fuels to be consumed by 2008, rising progressively to 36 billion gallons (136 billion litres) by 2022. The Act places an obligation on all producers of gasoline for use in the United States, including refiners, importers and blenders to meet this requirement. These obligated parties can comply with the annual renewable fuel standard through the purchase of renewable identification numbers (RINs)[17] if they cannot or do not wish to blend renewable fuels into gasoline.

In response to concerns about the greenhouse gas balance and other sustainability issues surrounding biofuels, the Act specifies that 21 billion gallons of the 2022 target must be provided by "advanced biofuels",[18] defined as fuels that emit 50% less greenhouse gases than the gasoline or diesel fuel that it replaces, on a life-cycle basis. Fuel requirements are assessed according to a defined life-cycle assessment methodology. This methodology does not take into account indirect land-use change impacts. The following fuels meet or exceed the respective required minimum greenhouse gas reduction standards:

- corn-based ethanol plants using new efficient technologies;
- soy-based biodiesel;
- biodiesel made from waste grease, oils, and fats;
- sugarcane-based ethanol.

Fuels derived from cellulosic materials are expected to meet and significantly exceed the minimum greenhouse gas reduction standard.

The Standard also sets minimum volumes that must be supplied by advanced biofuels, biodiesel and as ethanol from cellulosic raw materials, and the United States Environmental Protection Agency (EPA) has published a schedule showing the volumes of each fuel category for each year up to 2022.[19]

The volume that needs to be produced from cellulosic sources for 2011 has been revised downwards, because production volumes are still low, and the volumes have been set as follows:

- total renewable fuel: 13.95 billion gallons;
- advanced biofuels: 1.35 billion gallons;
- biomass-based diesel: 0.80 billion gallons;
- cellulosic ethanol: 6.6 million gallons.

These volumes will make the overall proportion of transport fuel from renewable sources about 8% of total use.

[17] Under the RFS, a RIN is assigned to every gallon of renewable fuel produced or imported into the United States. RINs represent the amount of biofuel actually blended into motor vehicle fuel.

[18] Advanced biofuels in RFS nomenclature refers to biofuels providing more than 50% GHG emission savings.

[19] www.epa.gov/otaq/renewablefuels/420f10007.pdf.

Ethanol blending in the United States is supported by a blending tax credit of USD 0.45 per gallon, paid to the fuel blenders. This support was due to expire at the end of 2010, but has now been extended until the end of 2011, along with further support of USD 0.10 per gallon, which can be obtained by small producers. There is also a USD 0.54 per gallon import tariff for ethanol, designed to protect producers in the United States; this, too, has been extended until the end of 2011.

European Union

By 2000, a number of countries within the European Union had introduced biofuels targets and blending mandates to encourage the growth of biofuels. These measures were driven by environmental and energy security concerns, as well as the need to promote economic development and job creation within the rural sector. The increase in biofuels was backed by a 2003 European Directive that requires 5.75% of the transport sector's energy to come from biofuels by 2010.

These country-based targets were extended and co-ordinated across the European Union via the Renewable Energy Directive (RED). This Directive requires that 20% of all energy consumed in the European Union should come from renewable sources by 2020, and also contains a specific provision requiring that 10% of all transport energy demand should come from renewable sources by that date.

During the discussion and finalisation of the RED, concerns over the sustainability of biofuels, the greenhouse gas balances and other environmental and social impacts, grew. In particular, high-profile discussions took place about the link between food prices and bioenergy development, and about emissions associated with direct and indirect land-use change. These discussions led to a number of national reviews of biofuel sustainability and development of sustainability criteria (for example, the "Cramer Review" in the Netherlands).[20] In 2008, the United Kingdom reviewed the evidence about the indirect land-use impacts of biofuel production (the "Gallagher Review").[21] This review led to reductions in the rate of increase of biofuels required under the Renewable Transport Fuel Obligation (RTFO).

In the light of these concerns, the Directive was modified during the drafting stage. It now requires that, from the end of 2010, biofuels will only count towards the 10% target if they generate greenhouse gas savings of at least 35% compared to fossil fuels. The savings level rises to 50% in 2017 and 60% in 2018. These levels might be challenging for some of the fuels currently in use: for example, those produced from soybeans and palm oil.

To encourage the development of the most sustainable fuels, the contribution to national targets made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material is considered to be twice that made by other biofuels.

The Directive also puts restrictions on the type of land that can be used to produce biofuels, excluding conversion of areas of high biodiversity, forests or wetlands to biofuels production. The Directive also requires the European Commission to report on:

- the steps taken with respect to the land use and sustainability criteria in countries that are a significant source of raw materials for biofuels,
- the impact of biofuels production on social sustainability and the availability of foodstuffs at affordable prices. These reports must consider land rights and labour conditions.

[20] See www.senternovem.nl/mmfiles/CramerFinalReport_tcm24-280147.pdf.

[21] See www.renewablefuelsagency.gov.uk/reportsandpublications/reviewoftheindirecteffectsofbiofuels.

The Directive also required the Commission to submit a report, reviewing the impact of indirect land-use change on greenhouse gas emissions and ways in which such impacts can be minimised. The report was made available in December 2010, but concludes that a number of remaining deficiencies and uncertainties are associated with the modelling of indirect land-use effects. The Commission will continue to conduct work in this area to ensure that policy decisions are based on the best available science and to meet its future reporting obligations on this matter. The Commission is finalising its consideration of policy options, which include:

- taking no action for the time being, while continuing to monitor impacts;
- increasing the minimum greenhouse-gas-saving threshold for biofuels;
- introducing additional sustainability requirements on certain categories of biofuels;
- attributing a quantity of greenhouse gas emissions to biofuels that reflects the estimated indirect land-use impact.

The Commission will present its conclusions, together with a legislative proposal for amending the Renewable Energy Directive and the Fuel Quality Directive as necessary no later than July 2011.

Each country in the European Union has produced a National Action Plan (NAP), which shows how they will meet their obligations under the RED. The emphasis on biodiesel within European Union countries is expected to continue. By 2020, the plans call for 21.250 Mtoe/y of biodiesel and 7.121 Mtoe/y of bioethanol. Trade will play an important role in meeting the national plans with 26% of biodiesel and 25% of the bioethanol being imported.[22]

The two most common instruments used by member states to promote biofuels are tax reductions and biofuel obligations.

- 20 NAPs include provision for biofuels obligations.
- 24 NAPs also provide for tax exemptions (Bulgaria, Finland and the Netherlands are the exceptions).

While maintaining tax exemptions, many member states have reduced their value. Analysis by the Commission[23] indicates that the highest biofuel market shares are usually achieved by those member states that have obligations in place, combined with tax incentives (Germany, Slovakia and France). If no obligations are in place, greater tax incentives are required to reach substantial biofuel market shares. Sweden and Hungary are the only member states that achieved a biofuel market share above 3% without any obligations, and they are the two countries with the highest tax reductions.

Australia

New South Wales in Australia established a blending mandate for ethanol and biodiesel in gasoline in 2007, with the level currently set at E4 and B2.[24] The ethanol level was due to rise to 6% in 2011, but this rise has been suspended because of a lack of local production capacity. In addition, Queensland has established an ethanol mandate of 5% in all unleaded regular petroleum, which was also delayed from 1 January 2011 to autumn 2011, and Victoria and Western Australia have established 5% biofuels targets by 2010.

[22] www.ecn.nl/docs/library/report/2010/e10069_summary.pdf.

[23] http://ec.europa.eu/energy/renewables/reports/doc/sec_2011_0130.pdf.

[24] Ex and By are abbreviations widely used to denote a blend containing x% of ethanol or y% of biodiesel, respectively.

Canada

In September 2010, the Government of Canada announced the finalisation of Federal Renewable Fuel Regulations, requiring an average of 5% renewable content in gasoline across Canada. This Renewable Fuel Mandate came into effect on 15 December 2010. In addition, a mandate for 2% renewable fuel content in diesel fuel and heating distillate oil will be implemented by the end of 2012. This nation-wide mandates builds on earlier regulation that applied in a number of Canadian provinces.

Japan

Japan's biofuels strategy puts emphasis on the production of biofuels from cellulosic materials and other non-food feedstocks. Supply and use of biofuel are so far limited, with an E3 limit applied to ethanol/gasoline blends. A reduction in gasoline tax is provided for E3 fuels. The Biomass Nippon Strategy envisages the production of 50,000 kl of biofuels from molasses and off-specification rice, and a further 10,000 kl from demolition timber by 2011, with a long-term goal of producing 6 billion litres of biofuels per year (10% of domestic consumption) from cellulosic materials and crops by 2020.

Korea

The national energy plan for Korea establishes targets for biodiesel, rising from a B2 level to the B3 level by 2012.

New Zealand

In February 2007, the Government of New Zealand announced a Biofuels Sales Obligation, requiring biofuels to be introduced into the New Zealand fuels market. The Biofuel Bill was passed through Parliament on 3 September 2008. The Biofuels Sales Obligation, which was to take effect on 1 October 2008, requires all oil companies to supply biofuels as a fixed percentage of their total sales. Under the Obligation, biofuels would have to make up 0.5% of oil companies' sales in the first year of the scheme, with obligation levels rising by 0.5% increments to 2.5% in 2012.

The Bill contains sustainability principles to make sure biofuels contributing to the Obligation will emit significantly less greenhouse gas over their life-cycle than fossil fuels, avoid negative impacts on food production, and not reduce indigenous biodiversity or adversely affect land with high conservation values. Decisions about which type of biofuel is supplied, how much of it is blended with fossil fuels and where it comes from were to be up to the industry.

However, on 17 December 2008, the Parliament approved a repeal bill, revoking the biofuel obligation. It was determined that the biofuel industry in New Zealand was not yet large enough for the obligation to be met from domestic sources, and would need to rely on imports.

In May 2009, a biofuels grants scheme was established. The Biodiesel Grants Scheme is designed to provide support for New Zealand's biodiesel manufacturing industry, offer comparable treatment with bioethanol for biodiesel and diversify the New Zealand fuel market. It also aims to encourage the adoption of environmentally responsible fuels that reduce greenhouse gas emissions.

A grant of up to NZD 42.5 cents per litre for biodiesel or biodiesel content of a biodiesel blend will be available to biodiesel producers. Biodiesel producers must meet certain criteria including (in summary):

- the biodiesel must be manufactured in New Zealand and meet New Zealand engine fuel specifications;
- the biodiesel must be sold as a blend up to B20 or sold for the purpose of blending up to B20; and
- the biodiesel cannot be sold for export.

Norway

Norway has a blending mandate for 3.5% biofuels, and a proposed target of 5% for 2011. The government considers the alignment of Norway's biofuel mandate within the European Union mandate.

Switzerland

Switzerland has no specific targets or mandates for biofuels, but there is a tax exemption for biofuels, which entered into force on 1 July 2008. To qualify for exemption, biofuels must deliver a 40% reduction in CO_2 emissions as compared to gasoline on a life-cycle basis, not otherwise adversely affect the environment (including biodiversity and rain forest). Workers involved in harvesting the raw materials must enjoy International Labour Organization (ILO) labour conditions.

IEA projections and mid-term potential

The IEA *World Energy Outlook* scenarios all project significant rises in the use of biofuels for transport. The overall level of utilisation rises from the current 31 Mtoe/y to over 201 in the 450 scenarios (Figure 2.15). North America (mostly United States) remains by far the largest market. Biofuels in transport reach a share of 16.1% in North America, 12.8% in Europe and 7.1% in the Pacific region. A regional assessment of potentials is not provided due to large uncertainties.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all the OECD-30 countries come under the high GDP category, and in 2000 all were importers of transport fuels, except the United Kingdom and Norway (Table 2.5). The United Kingdom recognizes that it too will become a significant importer of transport fuels in the near future and is taking steps to improve its energy security, including the adaptation of biofuels as part of its overall energy policy.

As would be expected, given the strong energy security driver and ability to afford some extra costs associated with biofuels, most countries within the OECD-30 have some biofuels policy in place, including Norway, despite its energy-exporting status. Most countries have introduced some form of blending mandates or tax exemptions to reach specified targets. One exception is Iceland, although steps are being taken there to develop biodiesel production from indigenous resources (fats).[25] Another exception is Turkey, where no plans are in place to support biofuels use within the Renewable Energy Law, and tax advantages for biofuels have been removed.[26] In

[25] www.nordicenergysolutions.org/solutions/bio-energy/fuel-for-transport/biodiesel-production-in-iceland.

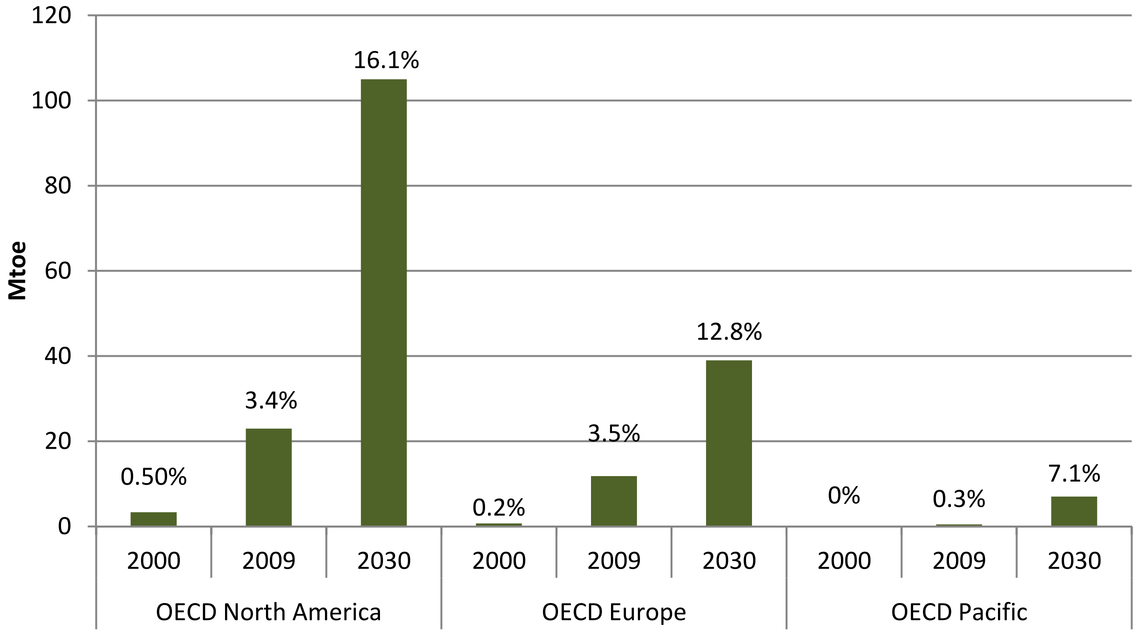
[26] www.thebioenergysite.com/articles/731/turkey-biofuels-annual-report-2010.

the short term, biofuels use is anticipated to grow as the mandates are fulfilled. However, the continuing debates about the sustainability of biofuels and its impact on food prices, coupled with constraints on bleeding levels (blending walls), are likely to make policy makers nervous about rapid expansion, so much higher penetration levels may well have to wait until advanced technologies are ready for deployment.

Table 2.4 Import/export categorisation for fossil fuels in the transport sector and per capita GDP among the OECD-30 countries

	High GDP	Low GDP
Importer	Luxembourg, Belgium, Ireland, Switzerland, Portugal, Sweden, Iceland, Japan, Spain, Finland, Korea, Slovak Republic, Greece, France, Germany, Poland, Netherlands, Italy, Czech Republic, Turkey, Austria, Hungary, New Zealand, United States, Mexico, Australia, Denmark	-
Exporter	Norway, United Kingdom	-

Figure 2.15 Biofuels in transport projections for the OECD region in the *WEO* 450 Scenario, 2030



Note: Percentages indicate share of biofuels in total transport.

Key point: Biofuels are projected to increase in all OECD regions until 2030.

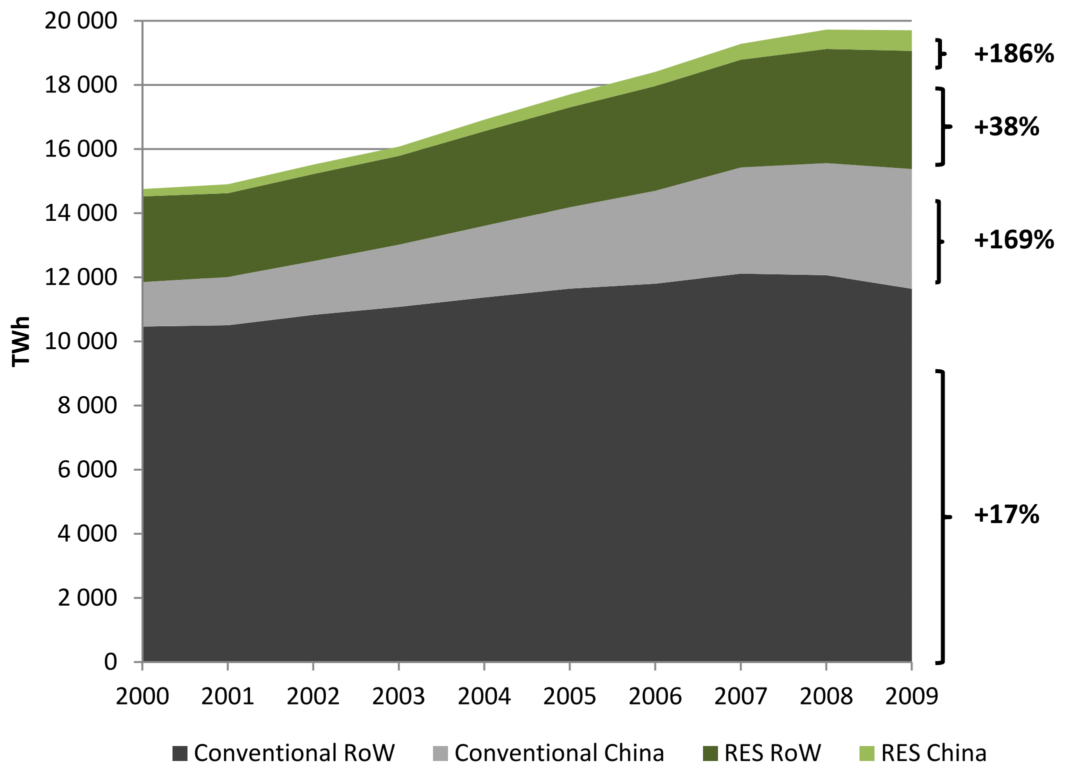
Focus on the BRICS

Renewable electricity

Current market status

In 2009, the total electricity output of the BRICS countries was 6 337 TWh. This amount corresponds to 31.6% of the global total. Total electricity generation grew by 87% since the year 2000; *i.e.* it is about twice as high today than in 2000. More importantly, the BRICS accounted for 65% of the global increase in electricity demand. The electricity sector in China grew at an average rate of 11.6% per year, accounting for 51% of the global demand increase. This percentage underlines the key role that China plays for the global electricity markets (Figure 3.1).

Figure 3.1 Development of renewable (RES) and non-renewable electricity generation in China and rest of the world (RoW), 2000-09



Key point: China drove more than half of the increase in global electricity demand since 2009.

Figure 3.1 underlines the ambivalent role that China plays in deploying renewables. On the one hand, growth in renewables outpaced that of conventional generation (186% increase versus 169%). However, renewables are starting from a low base in China. So, in absolute terms, China is adding massive amounts of conventional generation, in particular coal.

The share of renewables shows a clear split among countries in the group that have significant shares of renewables (Brazil, China and India) and those that have almost none (South Africa and Russia) (Figure 3.2).

Given the BRICS strong growth in demand (7.2% annual average from 2000 to 2009), it is remarkable that the share of renewables in the mix has remained fairly constant (21.5% in 2009, compared to 23.1% in 2000). This constant share is due to the development in China and India. The share of renewables in China increased from 16.3% in 2000 to 17.3% in 2009. India also increased the penetration of renewables from 13.8% in 2000 to 14.1% in 2009.

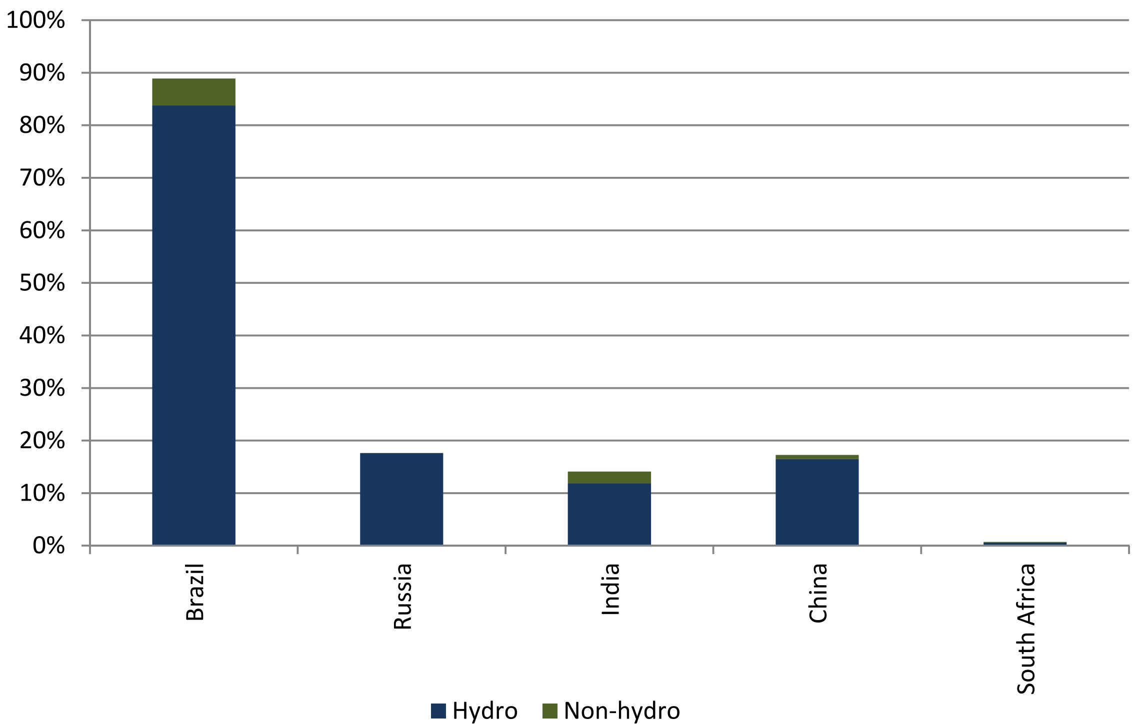
Hydro dominates the renewables mix in all the BRICS, with shares above 94% in the renewable portfolio in all countries but India (84.3%) and South Africa (82.2%) (Figure 3.2). The reduction of hydro in the renewable mix in India was due to an increase in non-hydro generation, along with a decrease in absolute hydro output (Figure 3.3).

As far as the deployment of non-hydro RE technologies is concerned, Brazil achieved a strong increase in biomass-fired electricity production, while India and, sometime later, China deployed wind power on a larger scale (Figure 3.3 bottom).

Current policy environment

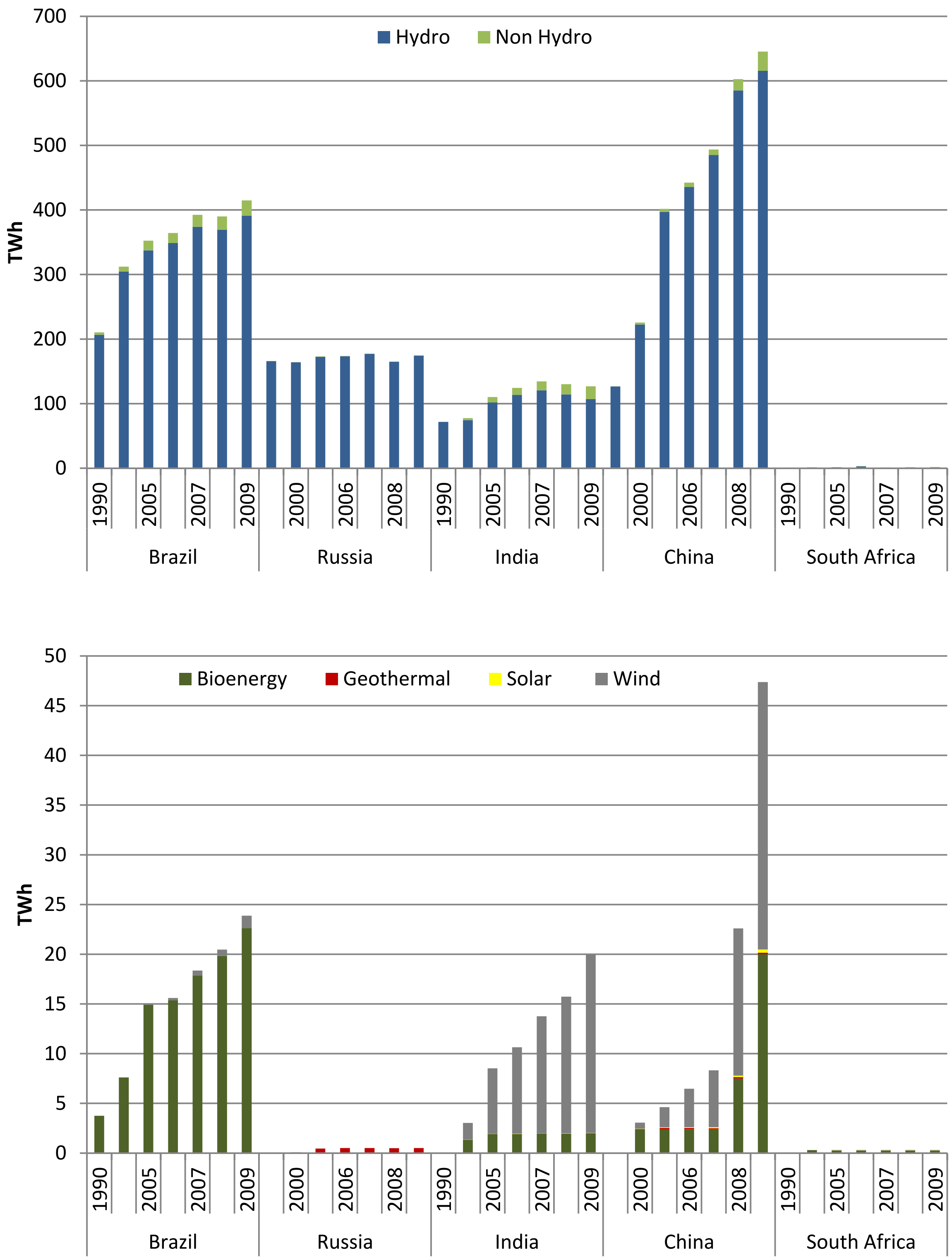
The main financial incentives for grid-connected renewable energy have evolved in recent years in the BRICS (except Russia). New or revised RES-E policies and incentives have fostered the observed market growth in the three more dynamic BRICS. By contrast, Russia and South Africa have experienced stagnant market evolution to date(Figure 3.3). In Russia's case, this trend is due to an absence of substantial policy developments since 2005. Although South Africa introduced a renewable energy feed-in tariff in 2009, which was reviewed downwards in 2011, regulatory uncertainty regarding grid access and power purchase agreements has meant that the incentive support has not translated into substantial market growth.

Figure 3.2 Renewable electricity share in the electricity mix in BRICS countries, 2009



Key point: Hydropower dominates the BRICS renewables portfolio.

Figure 3.3 Renewable electricity share by BRICS country, 2009 (all RES top, non-hydro RES bottom)



Key point: **China and Brazil show a dynamic increase in hydro generation. In Brazil, non-hydro deployment was dominated by biomass. In India and China, wind power led the expansion of non-hydro RE technologies.**

Brazil has moved beyond feed-in tariff incentive support for wind, biomass and small hydro projects (used under the Programme of Incentives for Alternative Electricity Sources (PROINFA) scheme, introduced in 2002-2003) and has adopted tenders (reverse auctions) with 20-year power purchase agreements (PPAs) for these technologies. Brazil is thus applying its previous experience gained through tenders for conventional thermal capacity to renewable energy. After a dedicated wind auction in December 2009, which awarded 1.8 GW of new wind projects as "reserve"/ backup grid capacity, Brazil has, in 2010, conducted further auctions for wind, biomass and small hydro as "alternative" baseload capacity to match future demand with supply, reinforcing the latest 10-year energy strategy's vision that no new thermal capacity will be commissioned after 2013. The winning tariff bids for wind in the 2010 auctions are significantly lower (by 42% on average), at USD 74.4 per MWh than the tariffs under the earlier PROINFA scheme (BNEF, 2010a).

At the national level, China has started to apply a generation-based tender system, which it had first adopted in 2005 to spur onshore wind deployment, to its first offshore wind development round of 2010. In contrast, for onshore wind projects, China's central regulatory body (the National Development and Reform Commission) replaced the tender system, which had granted individual on-grid prices that varied significantly, with a fixed feed-in tariff, differentiated by regional wind resource, in mid-2009. Similarly, for biomass projects with relatively consistent investment costs across the country, China introduced a fixed national feed-in tariff in mid-2010 to replace the previous premium over the local benchmark power tariff (which is the one for desulphurised coal generation), which varied significantly among regions. Incentives to spur domestic demand for solar power, primarily solar PV, were only introduced in 2009 with an emphasis on building-integrated PV systems, on the one hand, and a "Golden Sun" concession tender-based programme for 500 MW of large-scale grid-connected PV plants and off-grid stand-alone PV systems. However, the implementation of the PV support schemes has been patchy due to the insufficient tariffs and grid connection challenges.

In April 2011, China released the 12th five-year plan, which shows major interest in renewable technology quality improvement and in-depth enhancement of the industrial chain for China to stand as manufacturing leader in renewable energy appliances. The 2011-2015 Plan also sets additional installation targets to 2015 such as 120 GW of hydro, 70 GW of wind, 7.2 GW of biomass and 5 GW of solar power plants (NDRC, 2011).

An increasing number of Chinese provincial governments also offer additional incentives for renewable energy deployment, predominantly for onshore wind and solar PV, which are generally higher than the centrally determined tariffs.

Since 2006, India has introduced a myriad of support schemes for renewable energy projects. Renewable energy Portfolio Obligations (RPOs) on utilities and generation-based preferential tariffs, *i.e.* feed-in tariffs, were first implemented for wind at the level of individual states.[27] In 2008, the central government introduced national production incentives, which are additional to state-level support, for solar (PV and thermal electric/CSP) and large-scale grid-connected wind.

In 2009, the Government of India launched the Solar Mission, targeting the installation of 20 GW of solar power (PV and thermal electric/CSP) by 2022. In November 2010, in the first phase of the Mission, 1 815 GW of solar PV and 3 211 GW of thermal capacity were tendered under the Mission's framework (25-year PPA), and mechanisms to support the deployment of off-grid, decentralised, rooftop and small-scale solar applications came into force in 2011. Annual solar tariffs included in the Solar Mission for the years 2009-10 have been adjusted by the Central

[27] As of April 2010, 18 states had either implemented or had drafted RPO requirements (Arora *et al*., 2010).

Electricity Regulatory Commission for the years 2011-12 and register a decrease of about 14.5% for solar PV and less than 2% for solar thermal.

As an alternative to the renewable energy feed-in tariffs, India's central electricity regulatory commission announced the implementation from 2011 of a tradable green certificate (TGC) system for grid-connected plants. The system will have periodically set floor and ceiling TGC prices and solar-specific RECs issued for compliance with the solar RPO, with standard TGCs for all other eligible renewable energy technologies. Eventually, several Indian states have taken substantive steps forward in setting up local renewable energy strategies, such as Rajasthan targeting 3 GW of solar capacity by 2017 and enforcing fiscal incentives and a land bank to support solar sector take-off.

South Africa introduced a feed-in tariff system (REFIT) in 2009 for all grid-connected RE technologies. As of mid-2010, no project had yet been approved under the REFIT programme due mostly to regulatory delays in finalising PPA terms and project selection criteria, as well as uncertainty about the exact volumes that the single buyer would be required to contract.

In March 2011, 2009 tariffs were adjusted downwards, substantially modifying the level of support attributed to some renewable sources, especially landfill gas, CSP without storage and >1 MW ground-mounted solar PV. The national energy regulator, NERSA, adjusted the REFIT so as to align with important drops in the nominal cost of debt, the real cost of debt before tax and the inflation rate over the past two years. Implications of this adjustment will affect investors' assessment of commercial viability and expected rates of returns in renewable electricity generation projects.

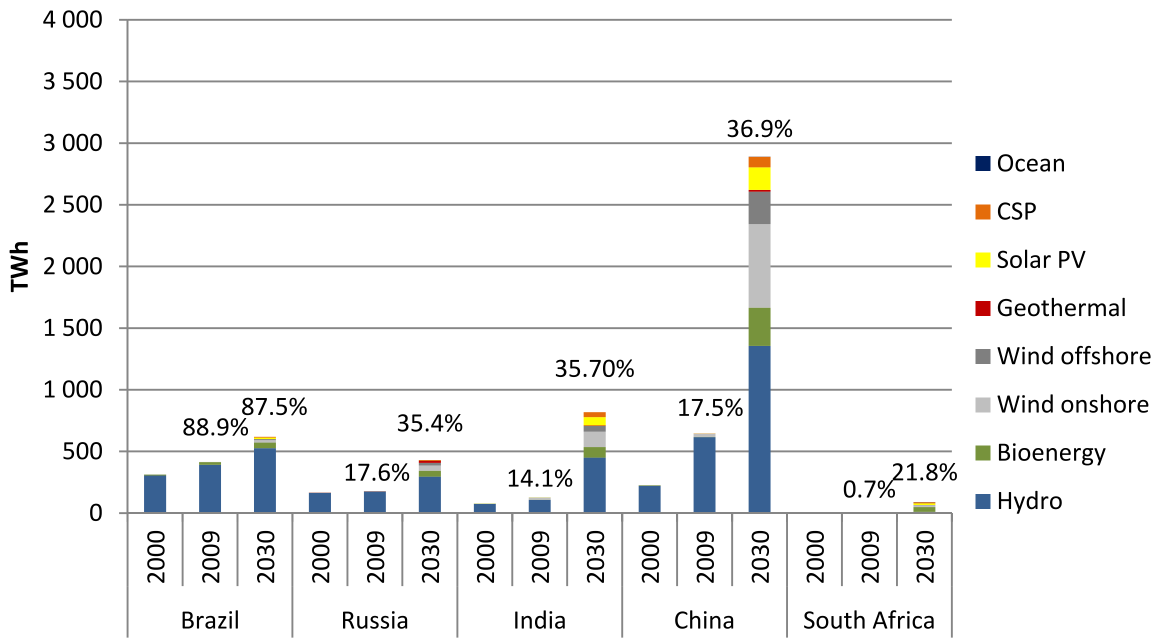
Moreover, in April 2011, the Department of Energy published the Integrated Resource Plan for Electricity 2010-2030. The plan introduces a significant ramping-up of the target market penetration to 2030, with hydro, wind and solar PV expected to be the leading technologies in the future renewable electricity mix. Major attention is also dedicated to ambitious grid expansion commitments so as to meet South Africa's fast-growing electricity demand, and shift away from the country's dependence on coal. Ambitious and long-term targets may address early criticisms levelled against the REFIT programme, which stated that the renewable energy targets were set too low to encourage the development of a local renewable energy technology supply industry (Edkins, Marquard and Winkler, 2010).

IEA projections and mid-term potential

In the *World Energy Outlook 2010* 450 Scenario, which projects a carbon-constrained energy mix, RES-E generation in BRICS countries reaches 40% by 2030, of which non-hydro renewables make up 34% (IEA, 2010a) (Figure 3.4). Hydro and wind generation are the largest renewable electricity technology, with 21.6% and 10.3% of the electricity mix, respectively. However, non-hydro renewables show the most rapid growth over the projection period to 2030, with their total generation increasing 25-fold compared to a doubling for hydro. Biomass-fired electricity (which encompasses solid biomass, renewable municipal waste and biogas technologies) is the third largest contributor, with a 4.4% share of projected production.

The total potential in all BRICS countries amounts to 14 470 TWh (Figure 3.5). This total is about 1.4 times the projected 2030 demand of 10 605 TWh. Solar technologies have a high potential, particularly in China and India. In these countries, the combined CSP and solar PV potential make up 32% and 42% of total potential, respectively. Hydro power is significant in Brazil (40% of national potential), Russia (37%), China (30%) and India (24%).

Figure 3.4 *WEO 2010* 450 Scenario projections for renewable electricity in BRICS countries



Note: Percentages indicate share of renewables in the electricity production.

Key point: BRICS regions are projected to have a share of renewables in the electricity production in the range of 87.5% (Brazil) and 21.8% (South Africa).

Wind power has a large potential, particularly in China with about 2 000 TWh in combined onshore and offshore generation. This amount corresponds to 28% of the country's RES potential in 2030. Wind is also a major resource in South Africa (28%), India (20%), Brazil (16%) and Russia (12%). Bioenergy dominates the potential in Russia (43%) and also has a significant share in Brazil (18%) and India (14%), while contributing 9% to China's potential.

Energy security / GDP analysis

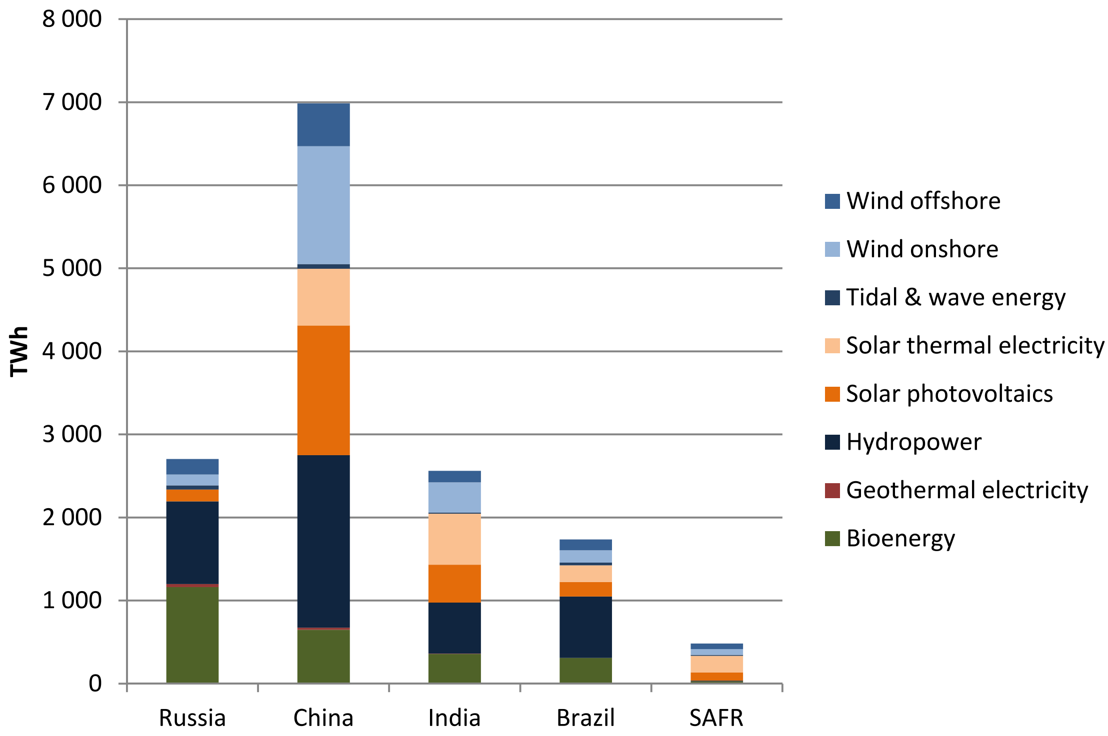
The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all the studied countries are in clusters with low GDP (Table 5.6). India, Brazil and China are import dependent as far as their power sector requirements are concerned. South Africa and the Russian Federation were net exporters in 2000.

Table 3.1 Import/export categorisation for fossil fuels in the electricity sector and per capita GDP among the BRICS countries

	High GDP	Low GDP
Importer	-	India, Brazil, China
Exporter	-	South Africa, Russia

The observed market and policy developments partially reflect the differences in import dependency among the BRICS. The importing countries have put in place policies to encourage the deployment of renewables on a large scale. Brazil is among the global leaders in biofuels production and hydro power. It has now also begun to engage in the mass deployment of wind power. India has systematically developed its wind energy sector with large deployment volumes, and the Indian company Suzlon is becoming a major player on a global scale. China has overtaken India with respect to wind power deployment and is now the largest wind market in the world, just a few years after entering the scale-up phase. Chinese wind manufacturers have become important market players, putting incumbent European and American manufacturers increasingly under pressure.

Figure 3.5 2030 renewable electricity potentials in BRICS countries



Source: IEA analysis based on data from IEE (2010).

Key point: China has the largest and most diversified renewable electricity potential.

The deployment drivers in these countries can be expected to keep up the momentum in renewables deployment. In the face of massive demand growth, especially China is becoming more and more dependent on energy imports for the power sector.

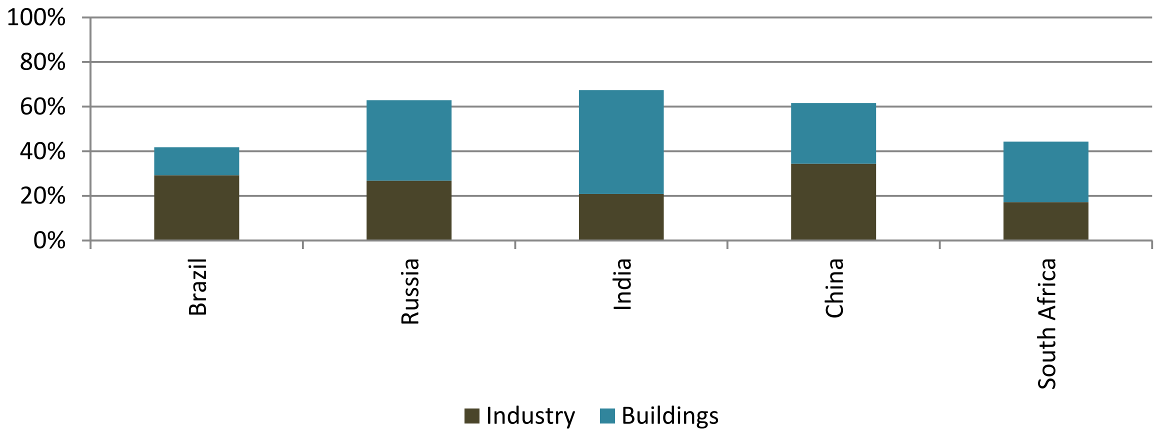
The situation has been different in Russia and South Africa. Energy security concerns are of negligible importance in both countries. However, South Africa is beginning to put an emphasis on climate protection in its projected development of the power sector. Today, the country relies almost exclusively on coal for power generation. In the run-up to the 2011 United Nations Framework Convention on Climate Change (UNFCCC) negotiations in Durban, South Africa, the country has announced a 18 GW build-out of renewable energy sources until 2030. However, these capacity additions will only account for 42% of the total projected increase in that time. As for Russia, no signs indicate that the country will develop its renewable resources apart from hydro in the short and medium term.

Renewable heat

Current market status

Renewable heat is relevant in all BRICS countries, because all countries show considerable shares of final energy used for heat (Figure 3.6). Russia and China face relative high heat demands due to considerable space heating demand. Warm climate countries such as Brazil, India and South Africa show relatively high final energy demand for heat, as a result of heat demand for industrial process heat and domestic hot water, on the one hand, and the use of traditional biomass at very low combustion efficiencies, on the other.

Figure 3.6 Share of heat in total final energy consumption in BRICS, 2009



Key point: BRICS countries show considerable shares of final energy consumption used for heat.

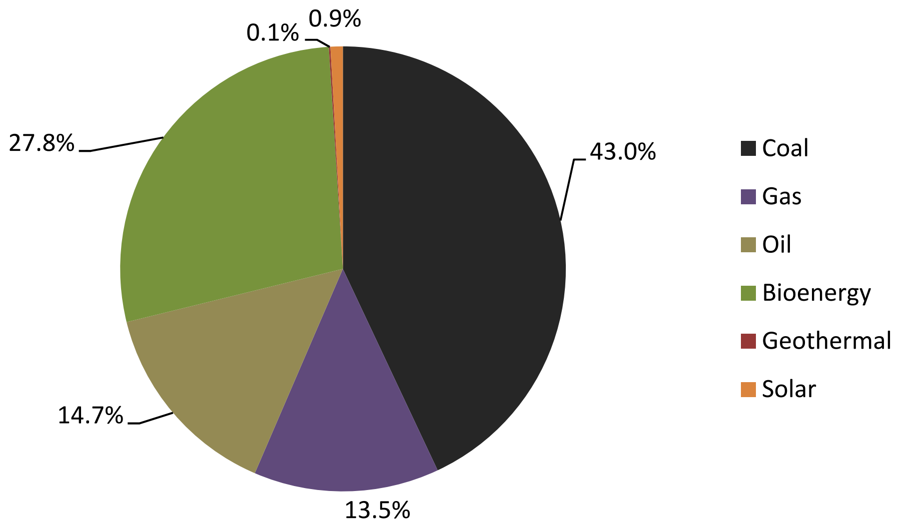
In 2009, the total final consumption for heat was 1 537 Mtoe. This amount corresponds to an increase of 35% since 2000. In the BRICS countries, the fuel mix used for heat is dominated by fossil fuels, particularly coal (43%), followed by gas and oil (13.5% and 14.7%, respectively) (Figure 3.7). Bioenergy had a share of 27.8%. Geothermal (0.1%) and solar (0.9%) provided only small shares. Total renewables had a share of 28.3%.[28] This share has gone down from 2000 levels, when it stood at 35.12%. This decrease was due to the slow growth of renewables compared to total consumption for heat. However, it should be noted that this decrease is most likely due to a decline in the use of traditional biomass as a result of economic growth.

Shares of renewable energy in final energy consumption for heat show large variations per country within the BRICS (Figure 3.8).

The share of renewable heat in final energy for heat is limited to just 1.15% in Russia, with no geothermal or solar heat reported and combustible renewables showing small figures. India may seem to show considerable shares of renewable heat, all consisting of bioenergy, but 83% of this bioenergy is used in the residential and commercial building sector, and as expected, consisting of large shares of traditional biomass. Residential use of bioenergy in non-OECD-30 countries is associated with cooking at very low efficiencies, often with unsustainable management of biomass resources and causing high particulate matter emissions, which have a serious impact on health.

[28] Statistical differences arise due to the fact that the bioenergy category contains small amounts of non-renewable waste.

Figure 3.7 Fuel mix of final energy consumption for heat in BRICS, 2009



Key point: In BRICS countries, coal, oil and gas dominate final energy consumption for heat, although renewables, mainly Bioenergy, are also an important contributor.

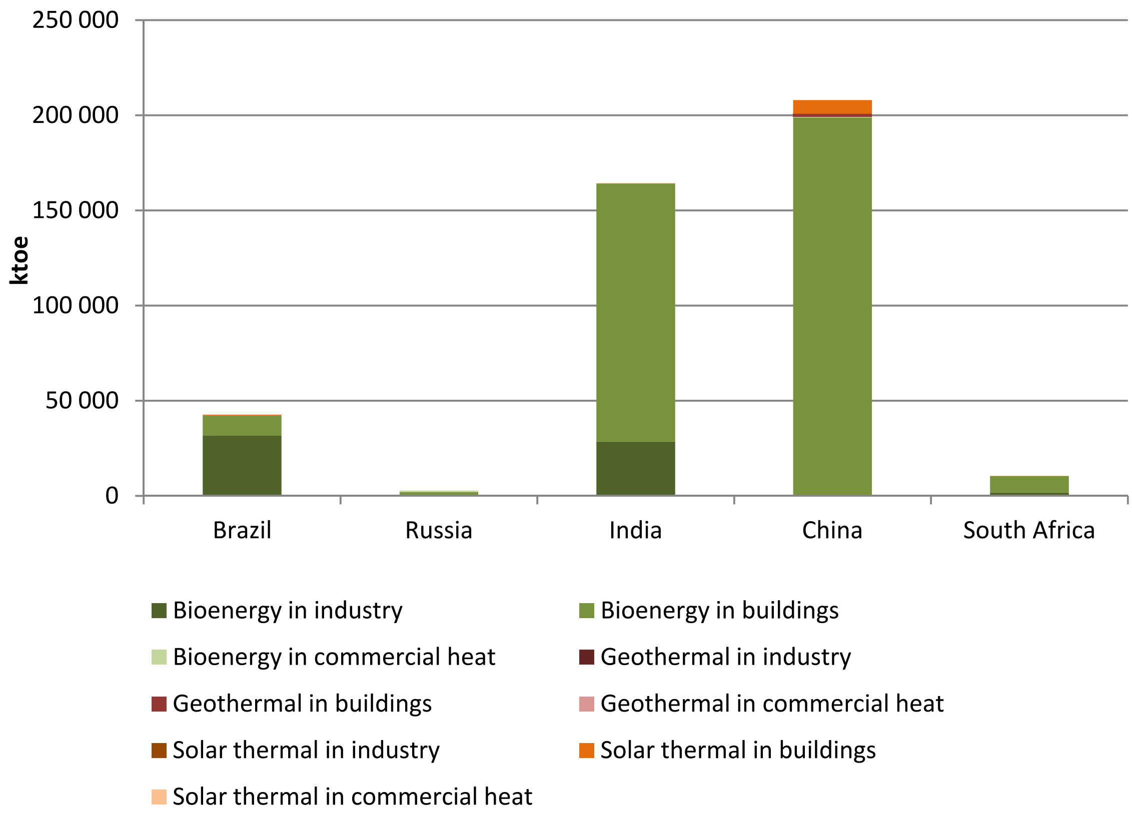
In China, solar thermal collectors are a common technology for domestic hot water production. Even though, in relative shares, the contribution of solar thermal low-temperature heat does not show significant quantities, on a worldwide scale, 101.5 GWth, or 58.9%, of the total worldwide collector installations was reported to come from China by the end of 2009 (Weiss *et al.,* 2011). China is also reported to be the largest contributor to worldwide geothermal direct heat use. A recent survey of worldwide geothermal direct heat use, including ground source heat pumps, mentions Chinese geothermal heat capacity to be close to 9 GWth by the end of 2009 (Lund *et al.,* 2010). In Brazil, bioenergy for heat plays an important role, covering 53% of total consumption. In South Africa, coal (54%) and oil (11%) dominate the mix; bioenergy contributes 34%.

Current policy environment

Renewable heat policies reported mainly focus on solar water heaters. China, South Africa and India have outlined (medium-term) targets for increased deployment of solar thermal energy in their national energy policy frameworks, mainly for domestic hot water production in the building sector.

The National Development and Reform Commission (NDRC) of China issued its Medium and Long Term Development Plan for Renewable Energy (2007), stating targets and calling for the percentage of renewable energy to rise to 10% of total energy consumption by 2010 and 15% by 2020. Part of the Development Plan for Renewable Energy is the aim to deploy 300 million m^2 of coverage of solar water heaters by 2020. Some six Chinese provinces introduced solar thermal obligations for new buildings, starting in 2007. The moderate prices for solar water heaters in China, where basic models start at around CNY 1 500 (USD 190), allow for a strong uptake of solar collectors, even without financial incentives. Further deployment of solar thermal is also included in the 2011-2015 Five-Year Plan, with major emphasis on technology deployment in rural areas.

Figure 3.8 Renewable total final consumption for heat, including traditional biomass in BRICS, 2009



Key point: In BRICS countries, renewable energy in final energy consumption used for heat shows large variations.

In 2008, India released its first National Action Plan on Climate Change (NAPCC), outlining existing and future policies and programmes directed at climate change mitigation and adaptation. The plan outlines eight "national missions" running up to 2017, with a strong emphasis placed on solar energy in the National Solar Mission. The Indian Solar Mission is a large-scale solar energy programme that will run from 2010 to 2022, with specific targets for both solar photovoltaic power and solar thermal, low-temperature heat. The Solar Roadmap establishes specific installed capacity targets for three different periods, where solar thermal energy is expected to increase from 7 million m^2 at the end of 2013 to 20 million m^2 by the end of 2022. India offers subsidized loans to domestic users and community users, and capital cost subsidies to commercial organisations. Some Indian states offer capital costs subsidies for solar water heaters in situations where the benefits of the national incentive scheme are not available.

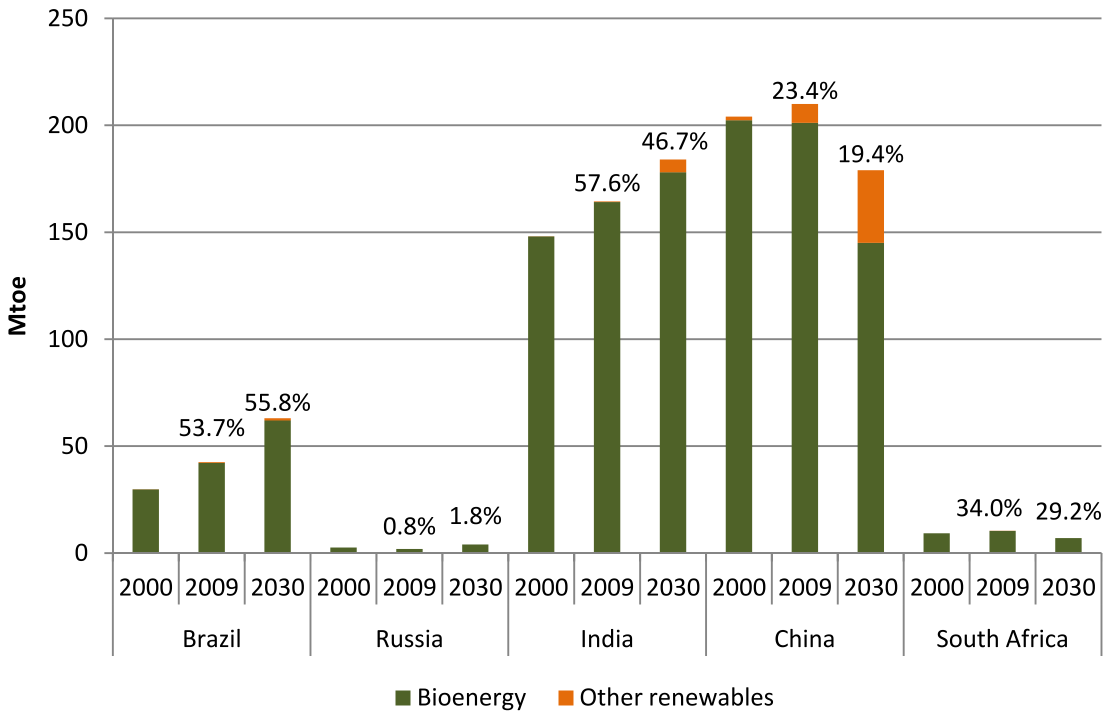
In South Africa, a capital cost subsidy for solar water heaters was introduced in 2008 as part of the overall 2013 renewable energy targets. In early 2010, the South African solar thermal rebates were doubled, to a level where it reduces payback periods for installation costs to less than five years. Drivers for solar water heater policy in South Africa are partially coming from the aspiration to reduce power blackouts, as the currently dominating electrical water heaters contribute to peak power demands. The government is aiming for deployment of a million solar water heaters over the next five years to prevent further increases of the 4.2 million electric water heaters currently installed throughout the country.

Brazil's 2008 National Climate Change Plan (PNMC), which focuses on reducing greenhouse gas emissions from deforestation, establishes a goal to stimulate the use of solar water heaters and to investigate how to facilitate energy production from solid waste in the residential sector. Although no national policy incentives for renewable heat are in place, solar thermal production increased as a result of 12 municipalities, among them Sao Paulo, introducing mandatory building codes that require installation of solar water heaters in new buildings. In Brazil, solar water heaters can compete with electricity and gas, having payback times of one to four years, which is also supported by the fact that solar thermal manufacturers benefit from a tax exemption for their industry.

IEA projections and mid-term potential

In the *World Energy Outlook 2010* 450 Scenario, which projects a carbon-constrained energy mix, renewable heat (measured as a share in total final consumption for heat) in the BRICS countries reaches 26.1% by 2030, of which bioenergy makes up 90.1% (Figure 3.9).

Figure 3.9 *WEO 2010* 450 Scenario projections for renewable heat in BRICS countries



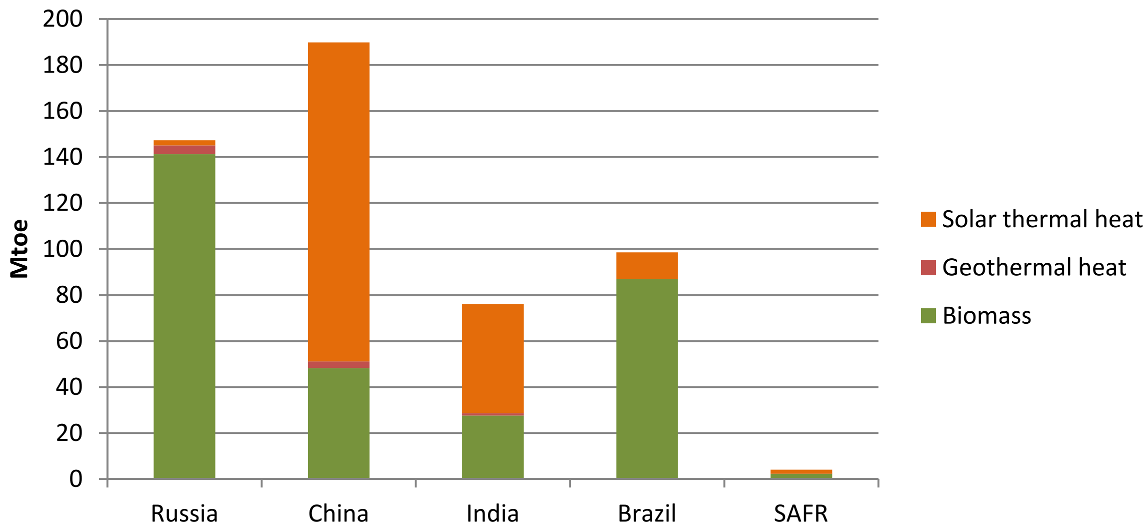
Note: Percentages indicate share of direct use of renewables in total final consumption for heat.

Key point: In BRICS countries, renewables are projected to cover a total of 1675 Mtoe for heat-related consumption. This amount corresponds to a share of 26.1% of the total. Bioenergy dominates the contribution from renewables.

Figure 3.10 shows the 2030 potential for heat production. Note that this amount includes heat from the transformation sector that are not included in the *WEO* projections. Compared to the electricity sector, the differences between potential and projected values are smaller.

In the BRICS, the overall mid-term technical renewable heat potentials show considerable differences per country, with Brazil being able to supply nearly all its heat demand by 2030 with renewable heat, whereas South Africa and China have the potential to reach a 20% share by that time (Figure 5.32). The varying mid-term technical renewable heat potentials are, to some extent, the result of restricted availability of renewable heat resources. For example, solar resources are obviously more abundantly available in South Africa, India and China as compared to Russia. Brazil and Russia have ample disposal of bioenergy resources, allowing them to realize both on-grid combined heat and power (CHP) installations, and off-grid heating installations to be supplied with biomass. Deep geothermal heat only shows up in Russia, where deep geothermal resources are reported in the Kuril-Kamchatka, Dagestan and Drasnodar Krai regions. The abundant bioenergy resources in Russia, by themselves, allow the country to fulfil its projected heat demand by 2030 for some 70% by renewable heat.

Figure 3.10 2030 renewable heat potentials in BRICS countries



Source: IEA analysis based on data from IEE (2010).

Key point: Solar potentials are large in China and India; biomass dominates in Russia and Brazil.

Energy security / GDP analysis

The key challenge in opening up the market for renewable heat in the BRICS countries consists of raising the awareness that heat demand is responsible for an important part of final energy demand, and is thus an important issue in realising CO_2 emissions reduction, energy security and fuel diversification.

In countries with limited space heating demand, energy infrastructure addressed at space heating demand is often absent. As a result, the climate-independent demand for domestic hot water is often satisfied with electric water heaters. Rising affluence is often related with rising demand for services such as domestic hot water, and thus imposes additional peak demands on electricity grids that are often already overburdened by regular power demands. Renewable heat technology, such as solar hot water heaters, can help tackle this threat to grid stability.

Both Russia and China show high heating demands among the BRICs countries and are well experienced with central heat (combined with power) plants and district heating systems. Wherever sufficient biomass resources or even geothermal resources are available, these district heating networks can relatively easily be supplied by renewable heat. Russia and China have technological capabilities that parallel most developed countries, thus allowing these countries to also look for other, more challenging, technology options that could contribute to renewable district heat. For example, China is exploring the possibilities of enhanced geothermal systems that, when technologically more mature, could supply both power and heat in a wide range of locations. Enhanced geothermal systems and combined heat and power plants could supply existing district heating systems with renewable (geothermal) heat.

In terms of the country cluster analysis, all OECD-30 countries fall into the low GDP category, and only the Russian Federation is classified as an energy exporter as far as this sector is concerned (Table 3.2). The performance largely matches with what might be expected, with Russia having the least well-developed renewable heat market and few initiatives to promote the sector. This situation is true despite the fact that Russia is rich in biomass resources, has a high heat demand for space heating, and has widespread heat distribution networks. The other countries all have initiatives in place that aim to stimulate the renewable heat market, particularly those associated with solar water heating.

Table 3.2 Import/export categorisation for fossil fuels for heat and per capita GDP among the BRICS countries

	High GDP	Low GDP
Importer	-	Brazil, India, South Africa, China
Exporter	-	Russia

Renewable transport

Current market status

Among the BRICS countries, the production and use of biofuels continues to be dominated by Brazil. Between 2000 and 2009, consumption in Brazil rose from 6.1 Mtoe/yr to 13.2 Mtoe/yr, representing an increase from 14.3% to 22.9% of total road transport energy use. Most of the consumption relates to bioethanol, but there has also been some growth in biodiesel use (Figure 3.11).

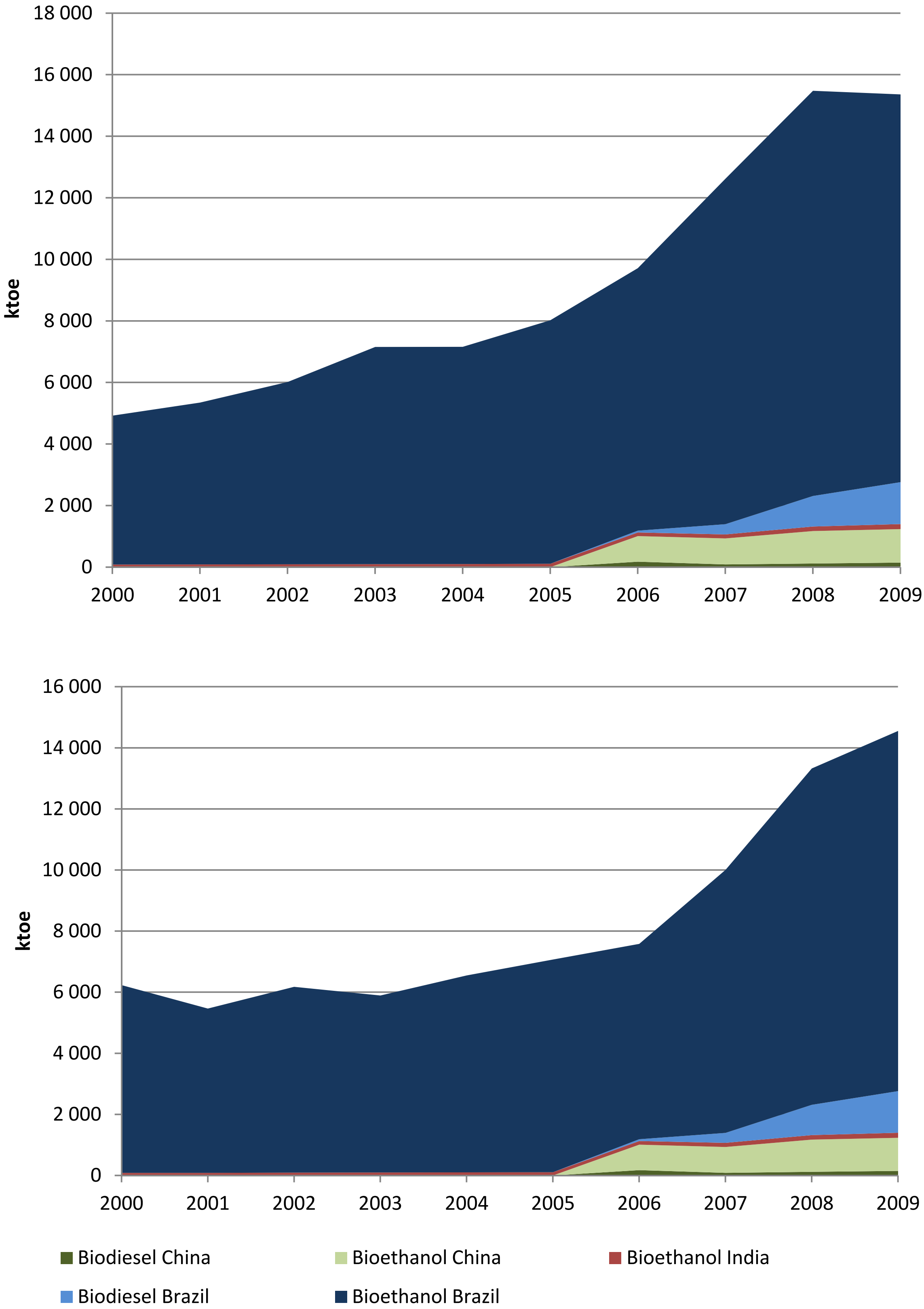
Biofuels use has also grown rapidly in China in the last few years, reaching 1.2 Mtoe/yr in 2009, which is 1% of road transport energy use, with 88% of the biofuel being bioethanol and the remainder biodiesel. Biofuel use has continued to grow steadily in India, reaching 163.9 ktoe/yr in 2009, which is 0.36% of road transport fuel demand, all bioethanol. There is no recorded use of biofuels in either Russia or South Africa.

Current policy environment

Brazil

Brazil is the largest producer and user of biofuels. Its national ethanol programme was launched in the 1970s. Use of bioethanol is facilitated by the widespread availability of flex-fuel vehicles, which can run on any combination of ethanol and gasoline, allowing consumers to choose which fuel they purchase based on price and performance. Use of ethanol is driven by a mandatory ethanol-blending regime, coupled with tax reductions for pure ethanol. The blending mandatory blend level is set at 25% (although it was reduced to 20% for a three-month period in early 2010 to reduce pressure in the sugar market). An obligation to blend 5% of biodiesel into diesel fuels came into effect in January 2010.

Figure 3.11 Production (top) and consumption (bottom) of biofuels in the BRICS, 2009



Key point: **Brazilian bioethanol dominates the biofuels production and consumption of the BRICS.**

China

In China, biofuels are included within the medium- and long-term plan for renewable energy, which calls for 50 million tpy of biofuels. The plan emphasises the need to focus on biofuels that do not threaten food security, so emphasis is placed on developing non-food biofuels and using land less amenable to crop cultivation to raise specific biofuel crops, such as Tung trees and sorghum. Plants that manufacture both ethanol and biodiesel have received support from the government, and R&D on production from indigenous sources continues. China also has R&D efforts under way to develop advanced biofuels from lignocellulosic ethanol, with the first pilot plants now operating (IEA, 2011c). Most fuel ethanol is produced by state-run enterprises and blended and marketed through the state-run petroleum companies. Ethanol blends, usually E10, have been introduced in a number of regions, including the provinces of Heilongjiang, Jilin, Liaoning, Henan, and Anhui, as well as selected cities in Hubei, Hebei, Shandong, Jiangsu, and Guangxi provinces. By the end of 2010, ethanol gasoline is expected to be used in all provinces except for Tibet, Qinghai, Gansu, Ningxia, and Shanxi provinces/autonomous regions.

The 2011-2015 Five-Year Plan targets the generation of seven million tons of biomass liquid fuels production capacity by 2015 and also includes a new consumer tax exemption for the consumption of pure biodiesel from waste animal and plant oil.

India

In October 2007, the Union Council of Ministers of India made a series of announcements in relation to ethanol production, which included the establishment of a mandatory 5% blend of ethanol with petrol. India's states were given the option to increase this level to 10%. In 2009, the policy was updated through a National Policy on Biofuels, which sets an indicative target of a minimum 20% bioethanol and biodiesel share across the country by 2017. The policy also removes all central taxes on biodiesel and according declared goods' status to biofuels, which would ensure a uniform 4% sales tax on the product across states. Biodiesel production will be taken up from non-edible oil seeds in waste, degraded and marginal lands. The focus would be on indigenous production of biodiesel feedstock; import is not permitted of free fatty acid (FFA)-based oil, such as palm, etc.

South Africa

In South Africa, an Industrial Biofuels Strategy was approved in December 2007, based on using sugar cane, sugar beet, sunflower, soybeans and canola. A national target for 2% of ethanol in petrol was established, equivalent to some 400 million litres per year. The consumption of ethanol is encouraged by a 100% fuel levy exemption for bioethanol and 50% for biodiesel. However, the target has been pushed back to 2013, and will not be enforced until the industry can secure the necessary supply.

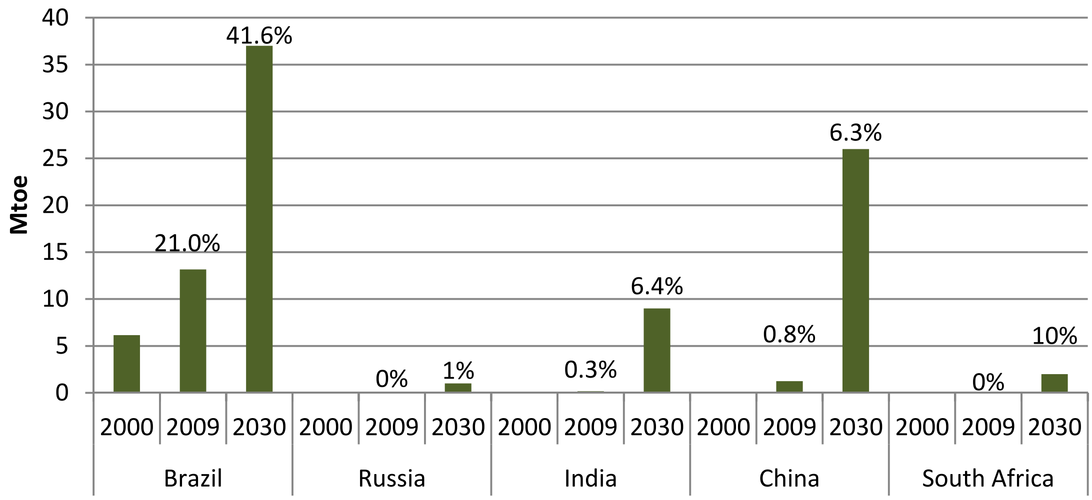
Russia

No policies are in place in Russia to encourage the use of biofuels.

IEA projections and mid-term potential

The IEA *World Energy Outlook* scenarios all project significant rises in the use of biofuels for transport. The overall level of utilisation rises from 243 Mtoe/y in 2009 to over 625 Mtoe/y by 2030 in the 450 Scenario. As Figure 3.12 indicates, Brazil remains by far the largest market, but China gains in importance. However, the penetration of biofuels in Brazil (41.6%) exceeds biofuels penetration in China (6.3%) by far. A regional assessment of the 2030 potential for biofuels is not provided due to the large uncertainties.

Figure 3.12 Biofuels in transport projections for BRICS countries in the *WEO* 450 Scenario, 2030



Note: percentages represent the share of biofuels in total transport.

Key point: Biofuels shares are projected to increase mostly in Brazil, India and China.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all the BRICS countries come under the low GDP category, and in 2000, all were importers of transport fuels, except the Russian Federation (Table 3.3).

Table 3.3 Import/export categorisation for fossil fuels in the transport sector and per capita GDP among the BRICS countries

	High GDP	Low GDP
Importer	-	South Africa, India, China, Brazil
Exporter	-	Russia

As would be expected, given the strong energy security driver and the ability to afford some extra costs, all the importing countries have biofuels policies either in place or under development. It is also clear that the policies of these countries stress the need for biofuels to rely on indigenous production, while also focusing on crops and production methods that are less likely to interfere with the availability or price of food.

Brazil is a global pioneer in the usage of biofuels, which is driven by the country's strong interest in energy security. However, all of the BRICS countries have significant biofuel potential, and it would be valuable to explore a balanced package of policies encouraging biofuel production and consumption, which meet sustainability criteria, such as those being developed by the Global Bioenergy Partnership (GBEP) initiative. This package of policies would involve, in particular, the use of wastes and residues and other feedstocks that do not compete with food use or rely on using productive land. In the longer term, a significant potential will arise for producing advanced biofuels from feedstocks produced in these countries, and although China is actively involved in researching and demonstration activities, widespread deployment in the region will probably await the early commercialisation of these technologies in the OECD-30 area, where the technologies can be proven and de-risked at scale.

Focus on MENA-7

Renewable electricity

Current market status

In 2009, total electricity generation in the MENA-7 countries was 581 TWh. From 2000 to 2009, generation grew by an average of 6.3% per year. Renewable energy sources accounted for 3.5% of the total. A split exists between Morocco and Egypt, on the one hand, which have higher renewables penetration (14% and 10%, respectively) and the other countries, on the other hand, where renewables contribute 0%-1%.

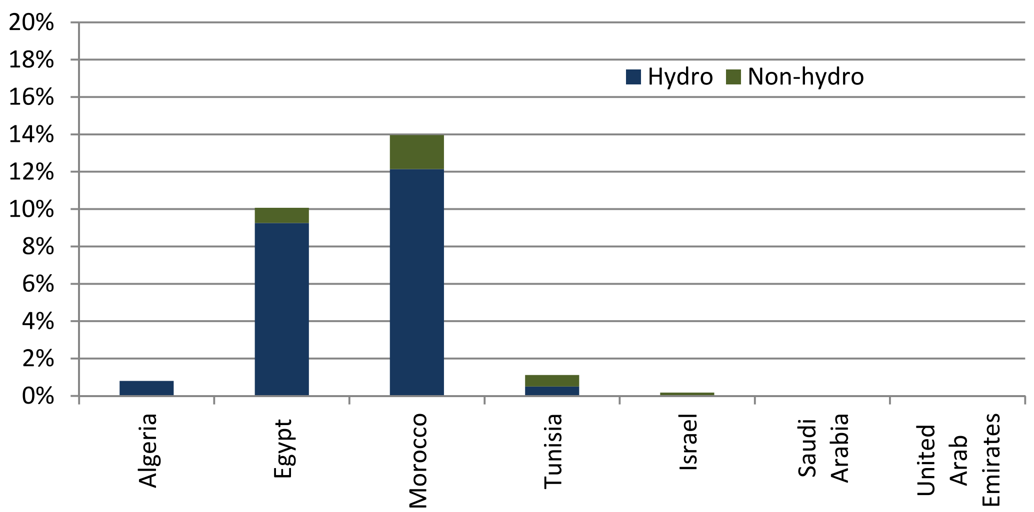
Two main trends characterise the development of renewables in the region. First, total power generation is growing faster than renewables (CAGR, 2000-2009, 6.3% versus 1.95%). Second, non-hydro renewables have an increasing share in the renewables portfolio.

Renewables make up only for a small share of total generation (Figure 4.1). Their low percentage growth compared to the growth in overall generation corresponds to a massive dominance of conventional sources in power sector expansion in recent years. Non-renewable generation increased by 248 TWh since 2000 (almost a doubling), while renewables grew by only 3 TWh.

Hydro power is growing more slowly than other renewables. The contribution from hydro is dominated by Egypt's Aswan Dam, which was inaugurated in 1971. The dam's power plant has a rated capacity of 2 100 MW, and delivers about 13-14 TWh per year. The additional hydro power output since the year 2000 comes mainly from Morocco (adding about 2 TWh) and, to a lesser extent, from Algeria (adding about 0.3 TWh).

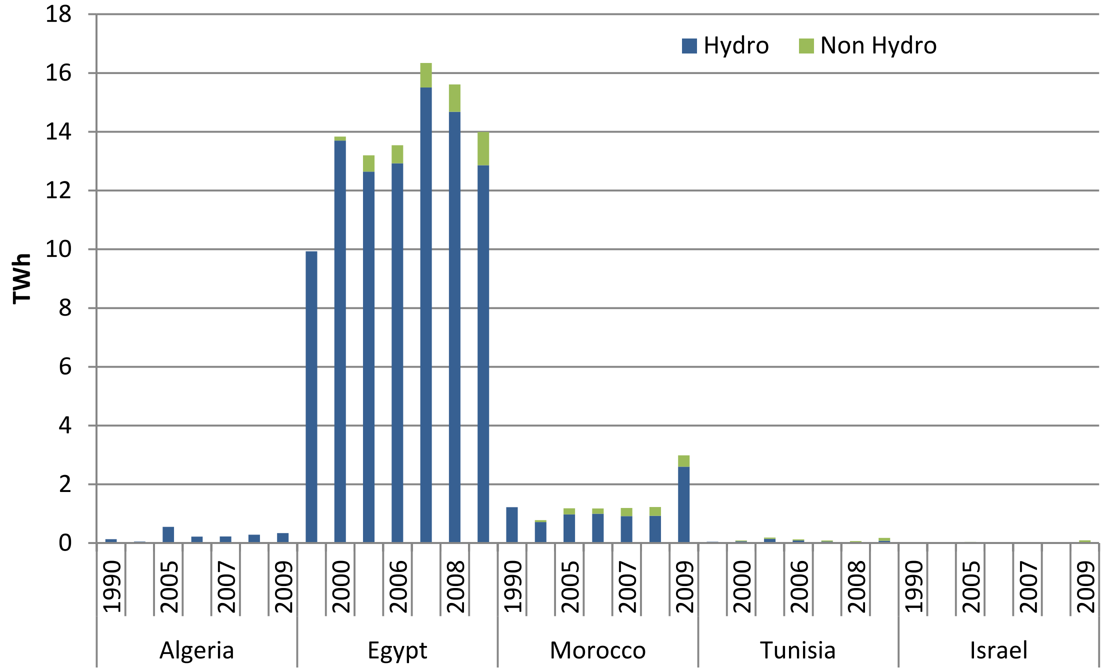
Non-hydro renewables grew at an average rate of 25.2% since 2000, however from a very low base. The development of non-hydro resources was concentrated in Egypt, Morocco, Tunisia and Israel. As of 2009, none of the other countries reported any non-hydro generation (Figure 5.36).

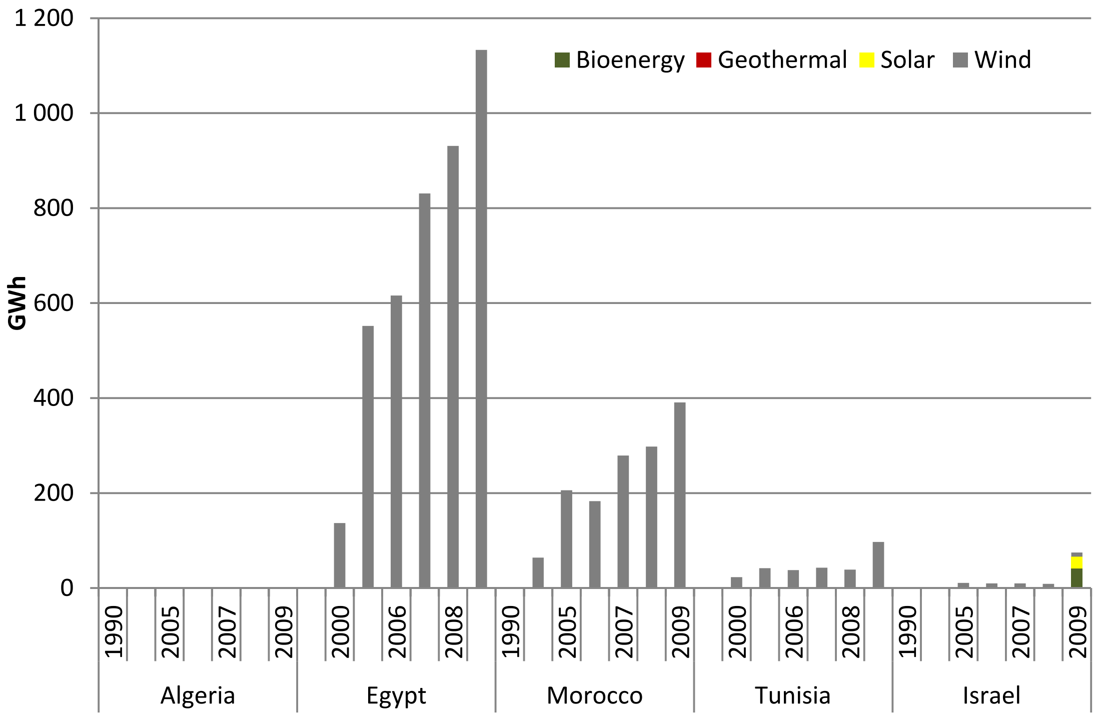
Figure 4.1 Renewable electricity share in the electricity mix in MENA-7 countries, 2009



Key point: Hydro power still dominates the MENA-7 RES-E portfolio, but non-hydro sources also have significant shares in some MENA-7 countries.

Figure 4.2 Renewable electricity generation in MENA-7 countries, 2009 (all RES top, non-hydro RES bottom)





Key point: **Hydro power in Egypt dominates the MENA-7 renewables production. Wind power expansion in Egypt and Morocco were the source of increase in non-hydro generation.**

Current policy environment

All North African MENA-7 countries have introduced financial support mechanisms for renewable electricity (RES-E), as has Israel, although the two other Middle Eastern countries (Saudi Arabia and United Arab Emirates) have not yet done so.

However, in practice, the financial incentives have not encouraged much RES-E market deployment to date. The generally very low or absent effectiveness of these policy instruments is mainly due to lacking actual policy implementation, compounded by the decision makers' low political will. But still: up to now, most of the non-hydro RES-E development in the region has followed a pattern of *ad hoc* funding from international donors or Clean Development Mechanisms (CDM) revenue streams (UNEP Risoe, 2010), although MENA-7 countries make use of the latter option much less than countries such as China or India.

However, since 2009, the MENA-7, and especially North African, policy landscape has been undergoing rapid changes, spurred by the large-scale ambitious policy initiatives aiming at greater RES-E market integration among the Southern Mediterranean countries and Europe, in the shape of the Mediterranean Solar Plan (MSP) and the DESERTEC Industrial Initiative (DII), besides multilateral support for clean technology diffusion, *e.g.* the World Bank-managed Clean Technology Fund's "CSP scale-up in MENA-7" programme. The expected investment volumes resulting from these multi-billion projects and programmes have helped push the North African countries to make their policy frameworks more accommodating for RES-E investments. Particularly non-economic measures encouraging RE deployment are increasingly being implemented across the region.

Although not specifically linked to RES-E deployment, the strengthening of network interconnections among the MENA-7 countries, and between North Africa and Southern Europe, currently being discussed, will facilitate the integration of variable renewables and the envisaged large-scale RES-E exports.

Algeria

In institutional terms, dedicated renewable energy actors have been established over the past two decades, including the Renewable Energy Development Centre (CDER) and New Energy Algeria (NEAL), whose objective is to foster renewables and, in the case of NEAL, develop them at an industrial scale. The resource capabilities of these newer institutional players are impressive and growing, with strong research on resource potential mapping. However, they face opposition from entrenched interests and traditional thinking among the management within the conventional oil and gas sectors, which continue to mistrust the economic value of renewables.

With the aim of diversifying its energy mix in the face of growing domestic electricity demand coupled with rising gas exports, Algeria passed a 2002 law, permitting electricity production from renewable energy and cogeneration. In 2004, the country introduced a feed-in premium (FIP) system for solar PV, hybrid solar (CSP) combined cycle plants, municipal waste, hydro power, and CHP. The designed support mechanism pays a premium in addition to the market price for every kWh produced or consumed. The latter case is especially relevant for auto-production. The premium is set as a factor between 0.8 and 3 of the current market price depending on the RE technology.

Calls for tender are meant to operationalise the FIP system by setting specific quantities that are eligible for FIP price support. However, although targets and the policy framework are in place, actual implementation remains absent, and no calls for tender have been announced since 2004.

No information is available on funding or spending of the National Energy Management Fund, created in 1999, which, besides its main objective of furthering energy efficiency, is also supposed to provide resources for renewable energy demonstration projects.

A national rural electrification programme incorporates the use of appropriate RES-E technologies for rural and peri-urban electrification purposes. Several larger-scale projects deploying mini PV systems, wind/diesel hybrid systems and small wind turbines for water pumping have been executed in the past decade, both from state revenues and through bilateral development cooperation (OME, 2008). No dedicated funding mechanisms exist for stimulating off-grid RE technology applications.

In contrast to other North African countries, Algeria has not, as of mid-2010, accelerated its RE policy support to entice international investors.

Egypt

To date, no national financial support mechanism is in place for RES-E generation. However, RES-E plants have guaranteed grid access and priority dispatch. The planned competitive bidding procedure (see below) should guarantee a "one-stop shop" process, helping to streamline currently highly complex administrative procedures. The National Renewable Energy Authority (NREA) was established in 1986 under the control of the Ministry of Electricity and Energy (MOEE). NREA faces a possible conflict of interest in that it is, on the one hand, responsible for setting the institutional framework for RE technology and for granting RE project authorisations, while being, on the other hand, a RE project developer in its own right.

Fiscal support comes through a decrease of import duties for RE technology equipment from 5% down to 2%. Most existing non-hydro RES-E projects, mainly wind farms, have benefited from the financial support of international donors, mostly multilateral and bilateral financial institutions, and development agencies, as well as CDM revenue streams. However, the focus of international development cooperation is now shifting away from supporting RES-E generation plant capacity and instead helping to fund the necessary grid infrastructure upgrade and extension, which is currently curtailing further development. This infrastructure upgrade is a crucial step for the large-scale deployment of variable renewables, such as wind, because the best wind resources are located along the Red Sea coast, far from the demand centres along the Nile River and the greater Cairo metropolitan area.

As of mid-2010, Egypt has drafted a new electricity act, currently in consultation with stakeholders, which supports large-scale market penetration of RES-E through greater private sector involvement. It guarantees third-party grid access and priority despatch. The planned incentive support will be introduced in two phases: the first phase consists of international competitive tendering for large-scale wind projects with guaranteed long-term power purchase agreements (PPAs), reducing investor's financial risk. With benchmark prices thus established, a second phase will seek to introduce a feed-in tariff (FIT), at first primarily for small- and medium-sized wind projects. The new electricity law will allow producers and consumers to enter into direct bilateral contracts for the trading of power. IPPs will be able to generate power on a build-own-operate (BOO) basis, provided that they have entered into a bilateral agreement with an end-user.

Israel

To reach its targets of 5% RES-E generation by 2014 and 10% by 2020, Israel introduced FIT support in early 2009. However, as of mid-2010, price support had been implemented only for small and medium-scale solar PV and wind installations. The FITs for residential and industrial customers are coupled with 20-year purchase obligations, providing investment security, although the capacity caps of 50 MW for small-scale PV and 30 MW for small-scale wind may drive up project risks and hamper deployment.

Financial incentives for large-scale CSP and PV plants (with a capacity up to 500 MW), whose generation is expected to account for over 70% of the targeted RES-E generation by 2020, were scheduled to be published in 2009, but have been delayed. In the meantime, large solar demonstration projects, co-financed with the European Investment Bank, are proceeding in the Negev Desert, with a total of 250 MW CSP capacity and 15-30 MW solar PV. These projects form part of a development plan to build 10 large CSP plants in the Negev between 2010 and 2020.

Morocco

As of mid-2010, no national price support scheme exists for RES-E projects, although the 2007 energy efficiency and renewable energy law did include provisions for an incentive mechanism to support energy efficiency and renewable energy deployment. Until 2010, auto-production was possible up to 10 MW, with the excess production fed into the national grid. The purchase tariff was defined by a PPA signed between the operators and the National Electricity Office (ONE), which occupies a near-monopoly position as the electricity sector’s single buyer, national transmission operator, and the country’s largest generator. However, the low purchase price to date, usually as low as 0.6 times the regulated wholesale power price (contrary to a FIT), has deterred industrial consumers and independent power producers (IPPs).

Since 2009, the Government of the Kingdom of Morocco has accelerated its RE promotion efforts to increase its attractiveness to investors. These efforts are also driven by increasing energy security concerns, because the country’s electricity imports (primarily from Spain) have quadrupled from 2005 to 2007. A new renewable energy law was passed in December 2009, setting regulations for RES-E commercialisation and establishing a deployment roadmap, including targets for achieving its 2015 (pushed back from 2012) targets. It also expands the maximum limit for industrial self-generation to 50 MW, with the excess purchased by ONE at a negotiated tariff. The new law established guaranteed third-party grid access and the possibility of exporting RES-E to other countries, *e.g.* through the existing Morocco-Spain interconnection. Public sector procurement of renewable energy and expansion of the RE investment portfolios of public organisations is encouraged.

A renewable energy and energy efficiency fund was established in 2009, and endowed with USD 1 billion from Saudi Arabia, the United Arab Emirates and the country’s Hassan II Fund for Economic and Social Development. The exact modalities and procedural mechanisms for the use of this fund have not yet been determined. However, the fund’s resources will help leverage public-private partnerships for the development of the five large-scale projects within the 2 GW solar programme to 2020 announced in late 2009. The programme has seen important progress throughout 2010, and a dedicated agency to implement the plan was founded in January 2010 (Moroccan Agency for Solar Energy). The tax incentives in place mean that RE equipment, including solar water heaters (SWHs), benefit from a reduced value-added tax of 14%, instead of 20%, and a 2.5% reduction of custom duties. These incentives, by themselves, have not fostered RES-E market growth, although they facilitate the import of foreign RE technology equipment and components.

Rural electrification has been steadily growing, mainly with decentralized PV for households in the most remote areas. The projects have been funded by ONE and the French Development Agency (AFD).

Tunisia

Currently, financial support for RES-E installation comprises direct financial incentives and tax incentives. The former are mainly provided by the National Fund for Energy Conservation (FNME) at a level that depends on the RE technology type. The latter (VAT reductions and custom duty exemptions) benefit both RE and energy efficiency equipment. According to the USD 2.2 billion Tunisian Solar Plan (PST) launched in 2009, the country will implement 40 projects between 2010 and 2016 under public-private partnership arrangements (29 are planned to be carried out by private sector companies; the rest are to be implemented by the public sector, five of which by the government-owned power and gas utility STEG [*Société Tunisienne de l'Electricité et du Gaz*]). To enhance the sector's institutional capacity to fulfill the ambitious Tunisian Solar Plan (PST), a dedicated PST management unit, as well as a renewable energy division within STEG, will be created. In terms of RES-E, the programme targets solar (PV and CSP) and wind generation, including export-geared projects. Besides about 25% national public sector financing, expected funding from multilateral development cooperation (*e.g.* the World Bank, Global Environment Facility), bilateral cooperation and CDM revenues are anticipated to help leverage private investment *e.g.* within the remit of the MSP and DII. Although the country enjoys very high electrification rates (99.5) the new PST will deploy RE technologies in several dedicated rural energisation projects for rural households and farms, employing solar home systems, micro wind turbines and solar PV-driven water pumping systems. Although the target of the PST is ambitious, it remains to be seen if the reality on the ground will match this articulation of political will.

Saudi Arabia

Despite not having an official RES-E target or policy instruments in place as of mid-2010, several semi-official announcements from government sources and Saudi Aramco oil company executives have been issued recently, suggesting a possible RES-E target of 7-10% peak electricity generation by 2020, equivalent to about 5 GW RES-E capacity, mostly solar energy. The aim is to dedicate some of this RES-E production for export. The national regulator, the Electricity and Cogeneration Authority (ECRA), appears to be keen to finalise a transparent and predictable regulatory RES-E framework by 2011 in order to kick-start investment in the sector. According to ECRA, the financial incentives are likely to be based on a tender, whereby the lowest auction price will determine the FIT for the subsequent three years (Shamseddine, 2010).

To help accelerate cost reductions in solar energy technology applications, including solar PV, CSP and solar-powered desalination, the kingdom is expanding its focus on renewable energy R&D with the recently announced creation of a large-scale civilian nuclear and renewable energy research complex. Saudi Arabia's intensified and more strategic interest in solar energy, departing from isolated project developments in past decades, may be influenced by the UAE's, and especially Abu Dhabi's, concerted renewable energy vision and activities (see below).

United Arab Emirates

To date, Abu Dhabi is the only emirate in the federation of the United Arab Emirates to have introduced a RES-E target, although no incentive mechanisms are in place to help achieve the target.[29] The announcement in early 2009 to enact a domestic RES-E goal, albeit not very ambitious compared to other MENA-7 countries, appears to have been influenced by the emirate leadership's strong interest in establishing Abu Dhabi as a global R&D and manufacturing hub for RE technologies, especially for solar energy. The government-owned Masdar Initiative was

[29] But a feed-in-scheme for rooftop PV is likely to be adopted in 2011.

established in 2006 as a regional economic development programme to foster clean energy technology development and diffusion. One of the Initiative's pillars is the Masdar City project, which aims to be the world's largest carbon-neutral urban development with 90 000 residents and commuters when it is completed in 2020 (the scheduled completion date has been pushed back from 2016). This project will serve as a test-bed and showcase for the R&D activities on solar energy, especially PV, being pursued by the Masdar Initiative, both domestically and overseas. However, large-scale demonstration projects may not suffice to achieve the 7% target, which requires an estimated installed capacity of at least 2 GW of solar and wind energy. The Government of Abu Dhabi needs to demonstrate its commitment to achieving the policy target and that domestic demand for RES-E is sufficiently high by introducing financial incentives for RES-E generation. These incentives will help attract the necessary investment by foreign RE companies in Abu Dhabi.

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. The MENA-7 belongs to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for MENA-7 cannot be isolated and are, therefore, not shown.

The total renewable electricity potential in the MENA-7 region amounts to 1 552 TWh in 2030; *i.e.* the potential is 2.67 times the total generation in 2009 (Figure 4.3). Saudi Arabia and Egypt show a large potential as a result of their large electricity systems. The potential calculation accounts for the size of national energy systems. Therefore the potential in less populous countries such as Algeria is comparably small. However, also in Algeria, a significant potential exists for solar generation that could be exported.

Taking the total of all MENA-7 countries, CSP contributes 37.5% to the total potential (thanks to its favourable system integration properties), and solar PV stands at 19.5%. Onshore and offshore wind each contributes 15%. Hydro power and bioenergy both contribute about 5% to the total.

If the constraint on power systems is relaxed, the total potential is much higher. The long-term technical potential for solar PV and CSP technologies is many times larger than global total primary energy demand (Figure 4.4). This potential will most likely never be exploited to its full scale: the world will probably never need so much energy.

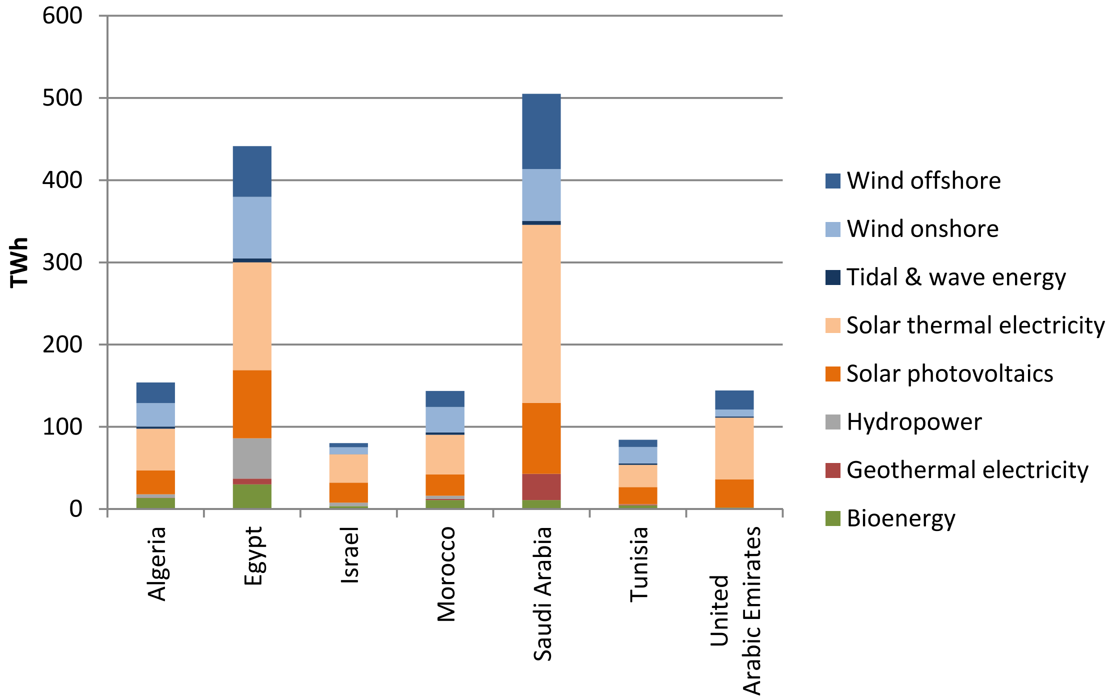
Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that MENA-7 countries are very diverse regarding their underlying driver structure (Table 4.1). Israel, Morocco and Tunisia all are importers, with Israel having a high GDP, and Morocco and Tunisia having a low GDP. The UAE and Saudi Arabia are exporters with a high GDP, while Egypt and Algeria are low GDP exporters.

Table 4.1 Import/export catergorisation for fossil fuels in the electricity sector and per capita GDP among MENA-7 countries

	High GDP	Low GDP
Importer	Israel	Morocco, Tunisia
Exporter	United Arab Emirates, Saudi Arabia	Egypt, Algeria

Figure 4.3 2030 renewable electricity potentials in MENA-7 countries



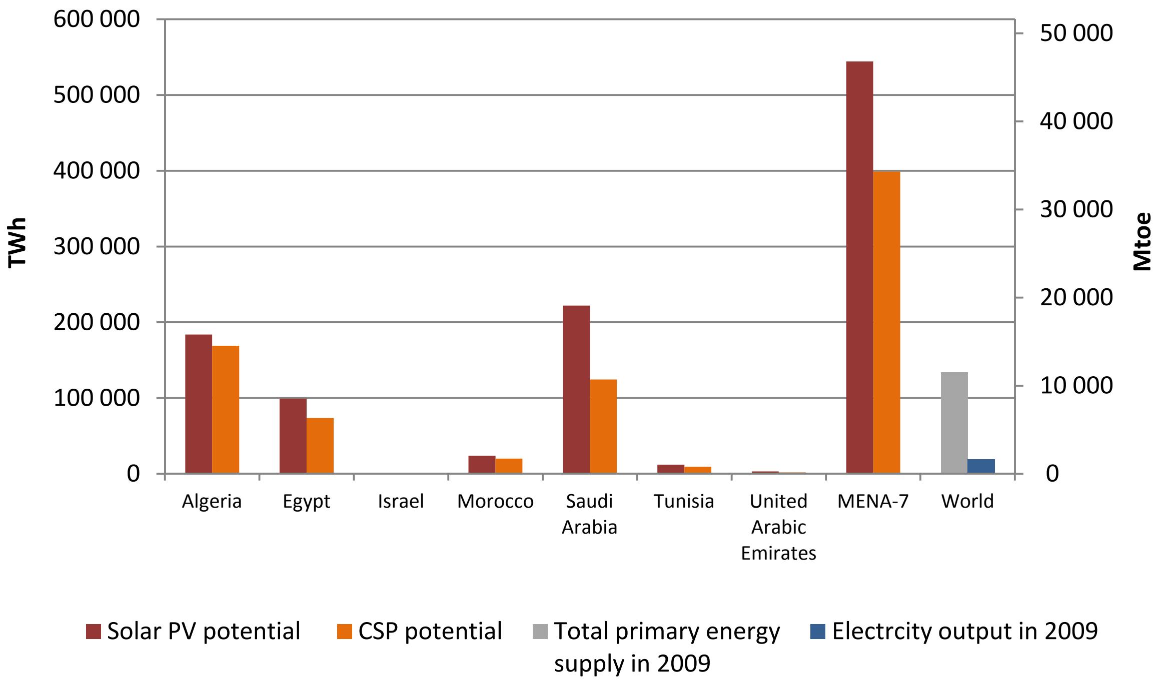
Source: IEA analysis based on data from IEE (2010).

Key point: Egypt and Saudi Arabia show the largest potential because of their comparably large power sectors. Solar and wind energy show the largest potential in the MENA-7 countries.

Past policy and market developments are in line with expectations for all MENA-7 countries with the exception of Israel and Egypt. Egypt, a low GDP exporting country, has seen the strongest deployment of non-hydro renewables in the past years. In addition, it is the country with the largest contribution from hydro power. Although Egypt is an exporter of oil and gas, resource depletion, especially oil resources, is an increasing problem in the country. This problem is compounded by surging power demand increase, with blackouts becoming more and more frequent in summer months. Egypt has developed its wind resources with strong support from international financial institutions. Also the wind resources close to the Red Sea are exceptionally good, further lowering the additional costs of wind power deployment.

Israel, on the hand, shows surprisingly little deployment of renewables in the power sector. Although the country is totally dependent on energy imports for power generation and is economically strong, deployment of renewables has been practically absent in the power sector. A possible reason for this is that Israel disposes only of solar resources in a large quantity. The country's small arable land area is not suitable for economically producing biomass feedstock. In addition, wind resources are moderate. Solar energy has been harvested on a large scale for heat (see heat section) since the 1970s. Also research and development in the field of solar energy has been promoted in the country. Mass deployment was not initiated by the government, however. This may be due to the country's small size. The potential Israeli market may simply be too small to realise economies of scale. However, with solar PV moving quickly down its learning curve and CSP being commercialised in Spain and the United States, it is very possible that a rapid scale-up of solar energy may occur in Israel in the coming years.

Figure 4.4 Long-term technical potential of CSP and solar PV in MENA-7 countries



Source: IEA analysis based on data from IEE (2010).

Key point: In MENA-7 countries, the long-term technical potential of CSP and solar PV each dwarfs global primary energy demand.

As for Algeria, the country exports a multiple of its own gas consumption, the main fuel in the power sector. Algeria has not made a particular effort to develop its solar and wind resources. Although this lack of effort has been changing slowly in recent years, a mass acceleration of renewables would most likely require external economic incentives for the country. The European Union could play a key role in this respect. Linking gas imports into the European Union with the deployment of renewable energy in exporting countries could be an innovative approach to achieve this goal.

The situation in Morocco and Tunisia lies within clustering expectations. They have made an effort to develop clean energy in a cost-effective manner. Morocco has seen the largest increase in wind penetration and also an increase in hydro power output over the past years. Tunisia also deployed some wind power. Energy efficiency has also been a government priority in Tunisia.

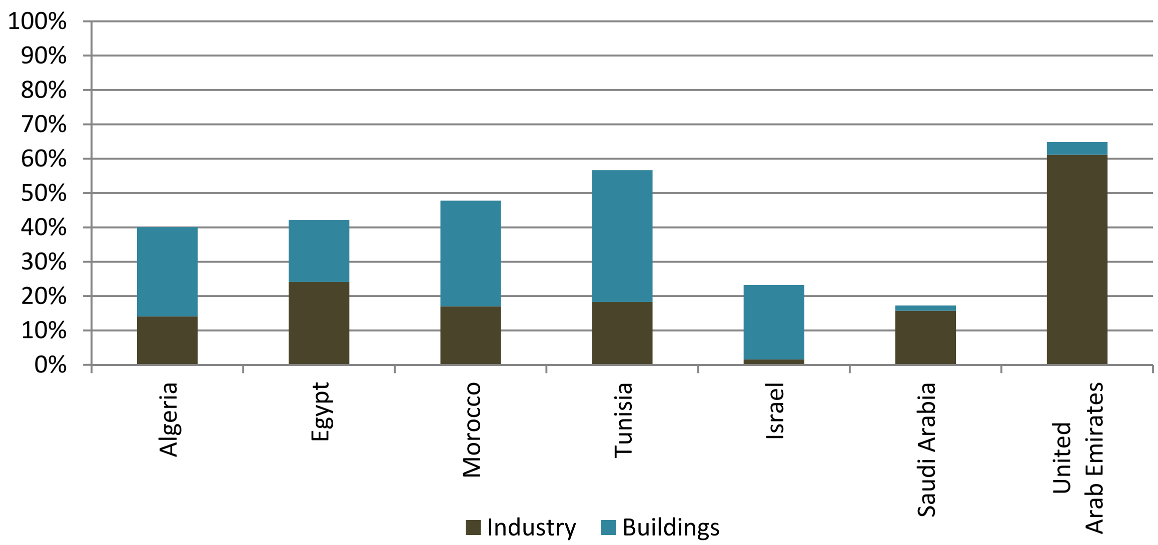
Renewables deployment was practically absent in Saudi Arabia, the world's largest exporter of crude oil, and the United Arab Emirates. With increasing wealth in these countries and the prospect of resource depletion in the long term, both countries have taken first steps towards renewables, with the UEA showing comparably more ambition. The country now hosts the International Renewable Energy Agency (IRENA), and the state-owned power company Masdar engages in the deployment of renewables, especially in the model city Masdar, which is intended to become completely supplied by renewable sources. Recent developments in Saudi Arabia (see above) also point to a developing interest in renewables.

Renewable heat

Current market status

Final energy used for heat differs per country in MENA-7 due to the combination of a Mediterranean climate along the coast line of North Africa, where space heating demand in winter (October to March) is common, and a desert climate inland and in the Middle East, where space heating demand is absent (Figure 4.5). In the Northern African countries, where population is concentrated along the Mediterranean coast, heating demand consists of space heating demand in the period from October to March and domestic hot water demand and industrial heat demand throughout the year. Industrial heat demand consists to a large extent of heat demand for food production, especially for heating greenhouses during the winter season. In the regions with a desert climate, especially all of Saudi Arabia and the United Arab Emirates, space heating demand is nearly absent, although a small share of domestic hot water and considerable shares of industrial heat demand still exist.

Figure 4.5 Share of heat in total final energy consumption in MENA-7, 2009



Key point: With the exception of Saudi Arabia, MENA-7 countries show significant shares of final energy consumption used for heat.

The Mediterranean and desert climate conditions in MENA-7 result in a considerable (latent) cooling demand, which is expected to rise parallel to economic development (Box 4.1). Active cooling installations penetration rates are already rising to considerably high shares in countries such as Israel, United Arab Emirates and Saudi Arabia. The climate conditions of a country such as Egypt could lead to a penetration of 95% of active cooling installations, whereas the level today remains under a 10% share (Table 4.2). Demand for cooling coincided with the availability of renewable heat, *i.e.* when it is hot outside. This situation can be used to create synergies. The use of renewable heat for cooling by means of sorption chillers for small-scale applications is still an experimental technology and, therefore, could not be included in the potentials analysis. When technology development is more advanced, small-scale sorption chillers could be valuable in preventing increases in peak demand in the electricity grid (by electric active cooling installations).

Box 4.1 Cooling demand in MENA-7

Although energy demand for electrical cooling appliances is still relatively low in the Northern African countries, this demand is expected to increase with rising affluence. Israel already has high penetration rates of active cooling appliances, resulting in active cooling energy use accounting for approximately 12% of the annual energy consumption (5 TWh) and approximately 25% of peak morning electricity demand (2.5 GWe). At the same time, active cooling is accounting for almost all the increase in the electricity demand (Hassid, 2009). As a result of the difference in human tolerance for heat and cold, cooling is generally considered a latent (energy) demand that will be fulfilled once sufficient capital is available. Rising affluence in developing countries with high numbers of annual cooling degree days can cause rapidly growing energy demand caused by higher penetration rates of air conditioning systems. Another factor possibly influencing increase in air conditioning in the longer term is climate change.

Modelling results demonstrate a rise in penetration of air conditioning systems in Northern Africa from currently low percentages to 28% by 2030, on the basis of an expected growth rate of GDP of 4% per year (Mc Neil, and Letschert, 2007). Air-conditioning systems in the Middle East are expected to rise from a current penetration of about ca. 30% to a penetration level of 53% by 2030. In the same modelling exercise, energy consumption of air conditioner systems is predicted for the Northern African region to increase from 2 TWh in 2005 to 20 TWh in 2030 in the base case scenario, while energy consumption is expected to increase to 15 TWh in 2030 in the case of a high efficiency scenario. For the Middle East region, energy consumption of air conditioning is expected to rise from 29 TWh in 2005 to 116 TWh by 2030 in the base case scenario, while a rise to 62 TWh is predicted in the high efficiency scenario (McNeil, and Letschert, 2007). These projections are based on expected GDP growth only; they do not incorporate the effect of climate change effects. The expectation is that, as a result of a scenario without strong policy effort to mitigate climate change, countries with a considerable heat demand will expect fewer heating degree days and a higher number of cooling degree days, which will cause a trade-off. For Saudi Arabia and the United Arab Emirates, this trade-off will have limited effect as a result of presently limited or absent heating demand. This observation implies that energy demand will rise as a result of increasing cooling degree days. However, in the case of successful stabilisation at 450 ppm, the global net effect of climate change on heating and cooling is expected to result in a relatively small increase in worldwide energy demand.

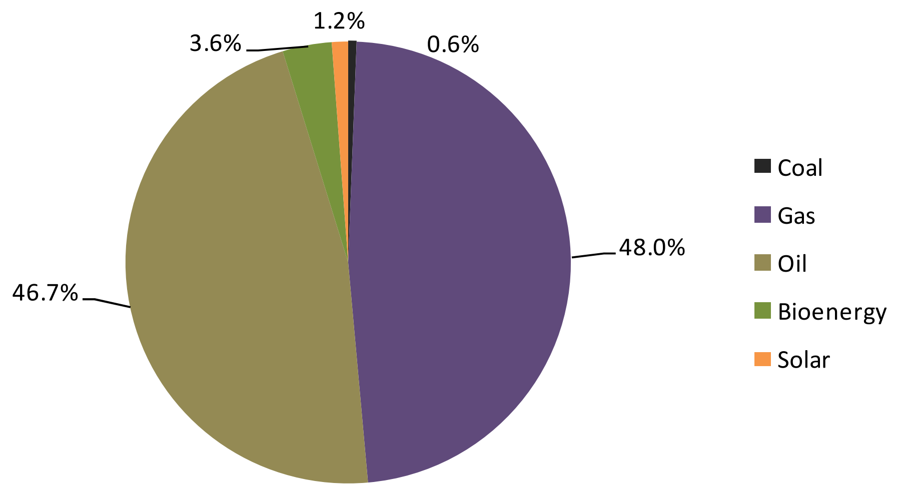
The total consumption for heat usage amounted to 87.6 Mtoe in 2009. This number has increased by 47% since 2000, when it stood at 60 Mtoe. In the MENA-7 region, the fuel mix used for heat shows a dominance of oil and gas with a 46.7% share of oil and 48.0% share of gas used for heat. Renewable heat contributes to a 4.8% share in total final energy consumption for heat, with 3.6% coming from bioenergy (Figure 4.6). Geothermal heat and solar thermal heat provide 1.2% of final energy consumption for heat. The MENA-7 region is very heterogeneous with respect to the energy mix for heat. Algeria, Egypt and (to a lesser extent) Tunisia use large shares of domestically produced gas and some oil, whereas Morocco and Israel largely depend on imports. Saudi Arabia's fuel mix consists of a 100% use of oil, whereas the United Arab Emirates predominantly uses domestically produced gas. Israel shows a considerable share of solar thermal in the fuel mix for heat, while Tunisia uses about 26% of combustible renewables to produce heat.

Table 4.2 Heating and cooling degree days, climate maximum saturation for residential air-conditioning systems and penetration data in MENA-7 countries

MENA-7 country	Annual heating degree days (country average)[1]	Annual cooling degree days (country average)[2]	Climate maximum penetration aircondition	Penetration aircondition (year of survey)
Algeria	1177	1154	n/a	n/a
Egypt	400	1836	95%	3,4% (2003)
Morocco	772	910	n/a	n/a
Tunisia	892	1184	n/a	n/a
Israel	756	1244	n/a	Ca. 60-70% (2010)
United Arab Emirates	4	3294	100%	Ca. 30% (2010)
Saudi Arabia	311	3136	100%	Ca. 30% (2010)
Reference:				
Canada	4493 (avg.)	263 (avg.)	42%	41.7% (2003)

Note: First column denotes heating degree days (18°C - mean outdoor temp) over 365 days, second column denotes cooling degree days (mean outdoor temp. – 18°C) over 365 days, third column denotes maximum saturation for air conditioning systems given the climate conditions.

Figure 4.6 Fuel mix of final energy consumption for heat in MENA-7, 2009



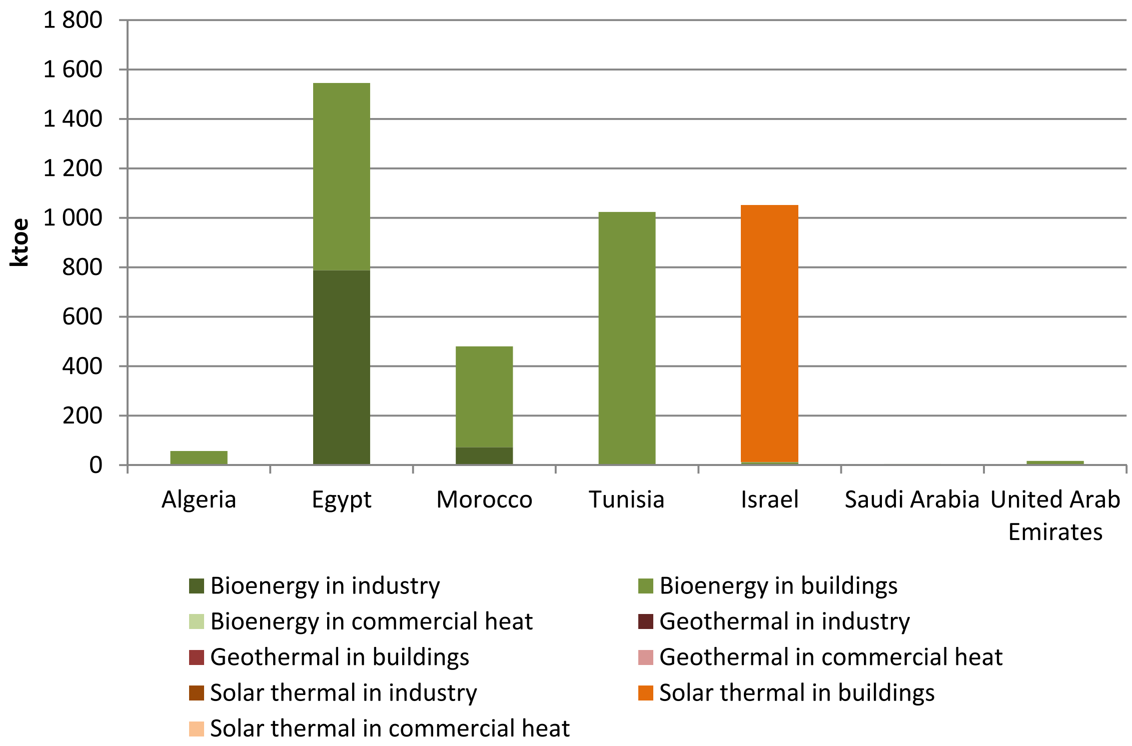
Key point: In the MENA-7 region, oil and gas dominate final energy use for heat.

Current levels of *modern* renewable heat in the MENA-7 region represent an overall small or insignificant share in total final energy use for heat despite its resources, especially in terms of solar insulation. Small shares of modern bioenergy heat production in the industry sector are reported in Egypt and Morocco. Residential use of bioenergy used for cooking has negligible shares in Algeria, Israel, Saudi Arabia and the United Arab Emirates, while noticeable shares of residential bioenergy use are reported in Morocco, Egypt and Tunisia. In non-OECD-30 countries, residential use of bioenergy is associated with cooking at very low efficiencies, often with unsustainable management of biomass resources and causing high particulate matter emissions, which have a serious impact on health.

Israel has installed large amounts of solar water heating (SWH) systems, already covering noticeable portions of final energy used for heat (see Figure 4.7).

Additional sources also indicate geothermal heat production in the MENA-7 countries. The reported geothermal heat in Algeria is coming from more than 200 springs that have been recorded in the northern part of the country, with low-temperature springs that are used mainly for balneological purposes, although a small amount of greenhouse heating also exists. In Israel, low-enthalpy geothermal resources have been utilised directly for fish farming, spas and greenhouses. The small contribution of direct geothermal heat utilization in Tunisia is reported to come from the low enthalpy resources in the southern part of the country and is utilized mostly for agricultural purposes (irrigation of oases and greenhouses).

Figure 4.7 Renewable total final consumption for heat, in ktoe, MENA-7, 2009



Note: Including traditional biomass.

Key point: **Israel has successfully deployed solar technologies in the heat sector, other MENA-7 countries rely on bioenergy for heat.**

Current policy environment

Policies encouraging the development and deployment of RES-H technologies have been modest or even neglected thus far in the MENA-7 countries. Renewable heat policy targets reported mainly focus on solar water heaters: targets for solar hot water production exist in Morocco and Tunisia.

In 1980, Israel made solar thermal systems obligatory in new residential buildings, with the aim of reducing the country's dependence on imported energy. Due to the solar obligation, solar thermal systems are now a mainstream technology in the water heater market without any financial support. The solar thermal obligation applies to all new buildings, except those used for industrial or trade purposes or as a hospital, and those buildings higher than 27 metres. The required daily heat output of the solar system differs according to the use of the building and on the kind of solar system installed. In Israel, solar thermal has reached the critical mass of market size necessary to create self-sustained growth without any subsidy. Today, Israel has over 1.3 million solar water heaters, producing an estimated 8% of Israel’s electricity consumption as a result of mandatory solar water heating installations (Estif, 2007). These days, more than 90% of Israel's solar thermal market is in the voluntary segment, such as installation on existing buildings, or systems bigger than required by law. Due to decreased prices, typical payback times are about three to four years (Estif, 2007).

In Tunisia, the PROSOL project has been particularly successful in incentivising the Tunisian solar thermal market. The PROSOL project was initiated by the national government in 2005 to revitalise the declining Tunisian SWH market as a result of the ending in 2001 of a Belgian/Global Environmental Facility (GEF)-financed stimulus program for solar thermal systems. The innovative component of PROSOL lies in its efforts to actively involve all the sector stakeholders and particularly the finance sector. By identifying new lending opportunities, banks have started building dedicated loan portfolios, thus helping to shift the solar thermal market from a cash-based to a credit-based market. The main feature of the PROSOL financing scheme (GTZ, 2009) is a loan mechanism for domestic customers to purchase solar thermal systems, paid back through the electricity bill. The loan mechanism includes:

- a capital cost subsidy provided by the Government of Tunisia, up to 100 Dinars (EUR 57) per m^2;
- discounted interest rates on the loans progressively phased out.

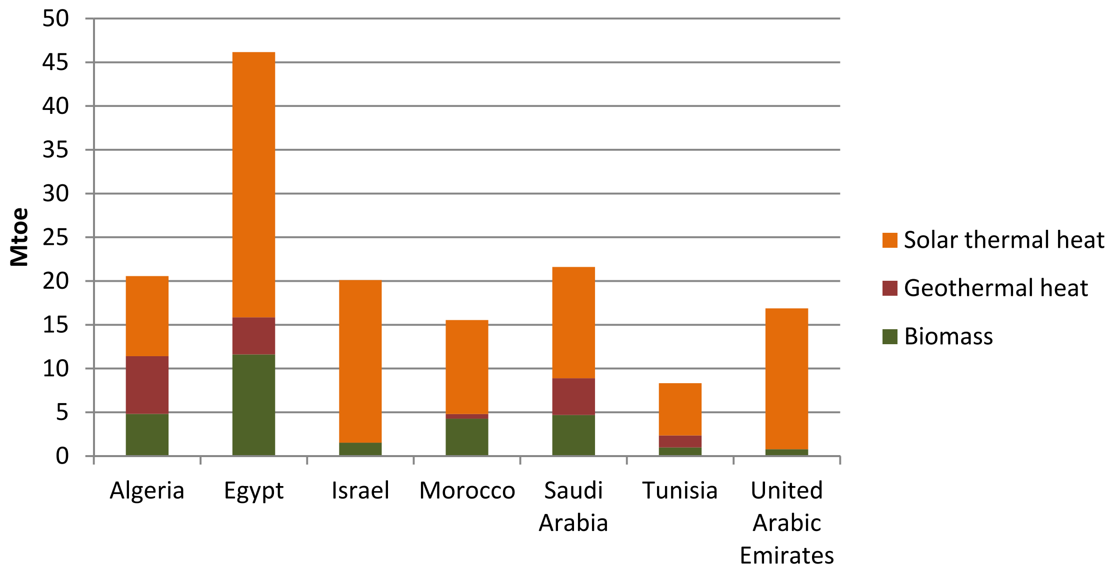
A series of accompanying measures have also been developed, consisting of supply-side promotion, quality control of the system set-up, an awareness-raising campaign, a capacity-building program and carbon finance. The National Agency for Energy Conservation (ANME) manages the overall program. Besides ANME, key partners consist of the state electricity utility STEG (*Société Tunisienne d’Electricité et du Gaz*), a commercial bank that provides prime loan condition under a bidding process (Attijari Bank), suppliers (including local manufacturers and importers), installers of solar thermal systems and the Renewable Energy Syndicate.

In Morocco, a reduced tax (falling from 20% to 14%) has been introduced for solar thermal systems in order to incentivise the national manufacturing of (components of) these systems (Ettaik, 2009).

IEA projections and mid-term potential

The IEA *World Energy Outlook* 2010 450 Scenario projects a number of countries on an aggregated level. The MENA-7 belongs to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for MENA-7 cannot be isolated and are, therefore, not shown.

Figure 4.8 2030 renewable heat potentials in MENA-7 countries, 2030



Source: IEA analysis based on data from IEE (2010).

Key point: Solar dominates the renewable heat potential in MENA-7 countries.

The total potential for renewable heat amounts to 12 830 ktoe in all MENA-7 countries. The potential is dominated by solar thermal, particularly in Israel and the United Arabic Emirates due to limited biomass resources (Figure 4.8).

In absolute numbers, Egypt shows the highest mid-term technical potential for solar thermal energy, which (considering its current low solar thermal penetration levels) would require a substantial effort in introducing policies to encourage solar thermal deployment. The renewable heat potential that is offered by solar thermal energy could be significantly enlarged by means of cogeneration of heat in concentrated solar power (CSP) plants. This option has not been considered in this study.

Deep geothermal hydrothermal resources of sufficiently high temperatures are reported in Algeria, Egypt and Saudi Arabia, showing noticeable mid-term technical RES-H heat potentials from these resources. Small potentials for deep geothermal heat are noticed in Tunisia and Morocco.

Energy security / GDP analysis

The key challenge yo opening up the market for renewable heat in the MENA-7 countries consists of raising the awareness that heat demand is responsible for an important part of final energy demand, and is thus an important issue in realising CO_2 emission reductions, energy security and fuel diversification.

Solar thermal heat offers enormous potential in the MENA-7 region for providing domestic hot water production and, to some extent, industrial process heat. Policy incentives, such as solar obligations, have proven to be very effective in Israel, and should be considered in all MENA-7 countries, given their vast solar resources. Innovative financial policies, such as the PROSOL scheme in Tunisia, aimed at shifting the solar thermal market from a cash-based to a credit-based market, could be effective in countries where private consumers suffer from a lack of capital that is needed in advance.

The Mediterranean and desert climate conditions in MENA-7 result in a considerable (latent) cooling demand, which is expected to rise parallel to economic development. Cooling demand occurs when (renewable) heat is available and could thus create synergy. However, the use of renewable heat for cooling by means of sorption chillers for small-scale applications is still experimental technology. Progress in technology development should be closely monitored by the MENA-7 countries, because the use of renewable heat for active cooling could be valuable in preventing increases in peak demand in the electricity grid (by electric active cooling installations).

The MENA-7 countries are spread across three of the four categories in the GDP/exporter status matrix (Table 4.3).

Table 4.3 Import/export catergorisation for fossil fuels for heat and per capita GDP among MENA-7 countries

	High GDP	Low GDP
Importer	Israel	Morocco, Tunisia, Egypt, Algeria
Exporter	United Arab Emirates, Saudi Arabia	-

As might be expected, Israel has been the most active promoter of solar water heating systems, while the United Arab Emirates and Saudi Arabia are not actively pursuing renewable heat policies, although each has a large potential for solar water heating. Morocco and Tunisia are also taking steps to encourage solar water heating, but Egypt and Algeria have not yet followed suit.

Renewable transport

Current market status

No use or production of either biodiesel or bioethanol is recorded up to 2009 in any of the MENA-7 focus countries.

Current policy environment

No record exists of any biofuels policies or mandates in any of the MENA-7 focus countries.

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario, projects a number of countries on an aggregated level. The MENA-7 belongs to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for MENA-7 cannot be isolated and are, therefore, not shown. A regional assessment of the 2030 potential for biofuels is not provided due to the large range of uncertainties.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that for road transport all four categories in the typology are represented in the region (Table 4.4).

Table 4.4 Import/export categorisation for fossil fuels in the transport sector and per capita GDP among MENA-7 countries

	High GDP	Low GDP
Importer	Israel	Morocco, Tunisia
Exporter	United Arab Emirates, Saudi Arabia	Egypt, Algeria

However, none of the countries is actively pursuing biofuels via policies or blending mandates. Although this is understandable for oil-exporting countries, it could be expected that Israel might find this an attractive option, and that Morocco and Tunisia might consider it worth exploring. Perhaps climatic conditions, in particular water shortages across the region, militate against biofuel consideration.

Focus on ASEAN-6

Renewable electricity

Current market status

In 2009, renewable electricity, mostly hydro and some geothermal, accounted for 15.2% of the total 596 TWh of electricity produced across the ASEAN-6. This share had gone down since 2000, when it stood at 17.7%. In the nine years from 2000 to 2009, total power generation grew at an average rate of 5.7% per year. This rate compares to an average growth of renewables of only 3.94%. Total generation grew at a faster rate than renewables.

This comparative difference is true, in particular, in Vietnam. Total generation in this country grew at an extreme rate of 13.5%, while renewables grew at only 8.36% (all hydro power). Consequently, the share of renewables went down from 54.8% in 2000 to 26.0% in the year 2009. Nevertheless, Vietnam remains the country with the highest share of renewables in the generation mix (Figure 5.1).

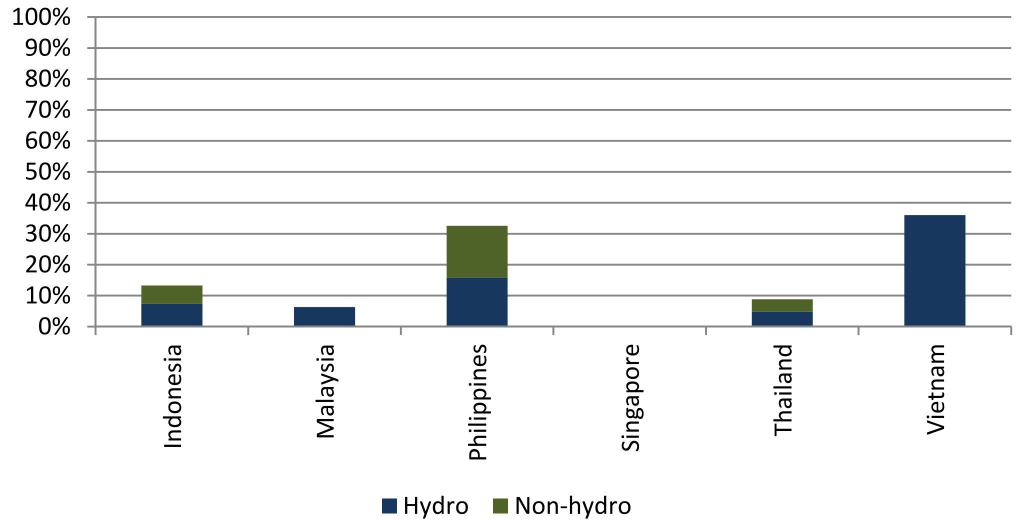
The Philippines come next with 32.6% of renewables in the generation mix. Geothermal contributed 16.7% to the mix and hydro 15.8%. Renewables showed hardly any growth in the Philippines (CAGR from 2000 to 2009 was at 0.4%), while total electricity generation grew at 3.5% on average. As a result, the share of renewables was higher in 2000 (42.9%) than in 2009.

The only country that showed an increase in the penetration of renewables is Thailand. Starting from a low base in 2000 (roughly one-tenth of total generation), renewables grew more quickly than total generation (6.1% versus 5.0%). Growth in the renewables sector was due to expansion in bioenergy power generation (Figure 5.2). The bioenergy sector was developed entirely within the past 20 years, with the most dynamic expansion since 2005.

In Indonesia, renewables output from hydro remained fairly stable. Geothermal grew by 5.8% per annum since 2000 and now contributes roughly one-third to renewables. The rest of renewables is hydro power. Thanks to the increase in geothermal generation, the share of renewables went down only mildly from 15.9% in 2000 to 13.3% in 2009, although the total electricity generation grew at a fast rate.

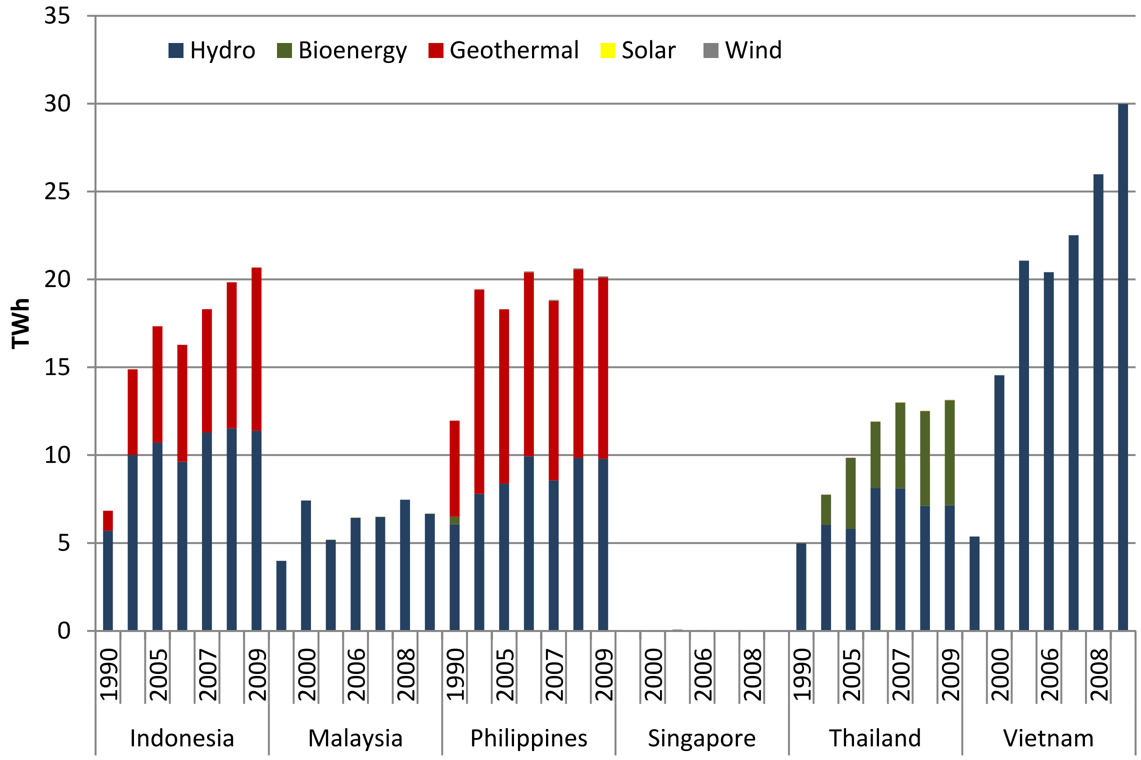
In summary, only Thailand was able to maintain its penetration of renewables over the last ten years, thanks to the development of its bioenergy sector. The other ASEAN-6 countries saw a drop in the contribution from renewables. However, it is important to note that hydro power had historically dominant shares in generation, especially in Vietnam, where more than half of the electricity came from hydro power in the year 2000.

Figure 5.1 Renewable electricity share in the electricity mix in ASEAN-6 countries, 2009



Key point: The Philippines and Vietnam show the largest penetration of renewables in ASEAN-6 countries.

Figure 5.2 Evolution of renewable generation in ASEAN-6 countries, 1990-2009



Key point: The increase in renewables generation was concentrated in Thailand (biomass), Indonesia (geothermal) and Vietnam (hydro).

Current policy environment

RE targets

Nearly all ASEAN-6 countries have adopted medium- and long-term targets for renewable energy. Indonesia, Singapore and Thailand have also announced CO_2 emissions reduction targets in support of the Copenhagen Accord. Interest in renewables varies considerably among the ASEAN-6 countries. Renewable energy targets for the medium and long term are much more ambitious in some countries than in others, with Thailand and Indonesia at the forefront (*cf.* market evolution in these countries).

Thailand has set the most ambitious target, aiming for a 20.3% share of renewable energy in final energy demand by 2022. Some countries, such as the Philippines, have targets that provide indications only to 2015; others, such as Indonesia, have targets to 2025. Malaysia, by implementing the 2011 Renewable Energy Feed-in Tariff, expects to install more than 4 000 MW of non-hydro renewable energies by 2030, about 12% of the total energy mix, while Indonesia, the Philippines and Thailand have sectoral targets for electricity and biofuels for transport.[30]

Economic support policies in the region

Several ASEAN-6 countries have recently introduced renewable energy feed-in tariffs (FITs); others are about to do so (Table 5.1).

In 2007, Thailand was the first to introduce a pricing policy with the Feed-in Premium for Renewable Power, switching from a contractual power purchase agreements for small renewable power producers. Premiums awarded to electricity producers on top of the fixed electricity tariff were adjusted upward in 2009. Solar technologies are entitled the highest premium, BHT 8.00/kWh (USD 0.27/kWh), compared to BTH 4.50/kWh (USD 0.15/kWh) for wind plants > 50kW.

Since 2010, the challenge of balancing solar PV deployment with sustainable market growth and cost control observed in OECD-30 markets (*e.g.* Spain, Czech Republic and Germany) has also been witnessed in Thailand. Although PV-installed capacity is expected to increase 15-fold over a 15-year period, from 35 MW in 2007 to 550 MW in 2020, a generous and uncapped feed-in premium, combined with a decline in PV system costs, led to an explosion of solar project applications with a cumulative capacity of 3.6 GW. Although power purchase agreements (PPA) have been signed for 1.6 GW of this capacity, 1 GW of the capacity relates to concentrating solar power / solar thermal projects rather than solar PV, and the country's potential for CSP is accepted to be low. This problem of speculative applications highlights the importance of introducing adequate penalties to dissuade speculators wishing to profit from the sale of PPA authorisations and foster actual project development (BNEF, 14 January 2011). To stem the flow of project applications and subsequent increase in consumer electricity tariffs, the Government of Thailand decreased the "adder" by 19% (from THB 8.00 per kWh to THB 6.5 per kWh) and suspended all project applications in June 2010 (Hirschman, 2011).

In July 2010, the Philippines Energy Regulatory Commission issued feed-in tariff rules, initiating a national pricing policy for electricity from renewable sources. Although tariff rates are still to be published, and as of May 2011, the feed-in tariff system has yet to be implemented, the regulation designed the upcoming tariff framework. Ranging over a 20-year period, the FIT is

[30] In general, longer time horizons (but including interim milestones) and sectoral contribution targets provide greater predictability for potential investors, and more confidence in the country's commitment to achieving its goals.

coupled with a priority access to transmission and distribution grids for eligible renewable energy plants. The FIT will be financed by a fixed and uniform charge on electricity consumers and be subject to annual degression rates.

In April 2011, Malaysia implemented a feed-in tariff package, including both generation targets to 2030 and annual installation caps per technology. Such a precaution may effectively avoid the recent overheating of renewable energy markets, especially for solar PV, as previously mentioned for Thailand. Although highest tariffs and additional bonuses are set up for solar PV, the technology annual degression rate is much higher than for other technologies (-8% for PV and -0.5% for biogas and biomass), stressing regulators' anticipation of the cost effect of rapid installation growth.

Indonesia reformed the existing fixed purchase tariff for electricity from geothermal sources in February 2011. From now on, the main utility PT Perusahaan Listrik Negara is assigned to purchase the whole electricity generation from geothermal sources at a guaranteed and fixed tariff of a maximum of ct USD 9.70/kWh.

To date, no economic support policy exists in Vietnam, although discussions are taking place in the Ministry of Industry and Trade for pricing support to renewable energies, such as wind.

Other financial incentives being applied include tax exemptions for certain renewable energy technologies in Malaysia, the Philippines and Indonesia; capital costs grants in Thailand; and R&D incentives in Singapore.

Table 5.1 Generation incentives for RES-E in the ASEAN-6 countries

	Tools	Duration	Budget source	Grid priority access
Indonesia	Benchmark price of electricity from geothermal source with compulsory purchase of all geothermal electricity by PL (2011)	30 years	Public budget	Yes
Malaysia	Feed-in tariff	16 years for biomass and biogas, 21 years for solar PV and small hydro	Electricity consumers, exemption for very small electricity consumers	Yes
Philippines	Feed-in tariff, not yet in force	20 years	Electricity consumers FIT-All Fund	Yes
Thailand	Fixed feed-in premium	20 years	Public budget (TBC)	-

Apart from the novel generation-based support, technology-specific support policies in the region tend to rely on financial and fiscal incentives rather than on pricing policies. In Indonesia, for instance, total investments in geothermal benefit from a 30% net tax deduction, while plant components are exempted from income duty.

In the Philippines, Indonesia and Malaysia, grants and fiscal incentives have been created to support bioenergy production. In Malaysia, with the Green technology Financing Scheme, and in Thailand, with the Revolving Fund, green energy project developers can apply for soft loans and preferential interest rates. The Government of Singapore allocates grants to research and development projects through the Clean Energy Research Programme.

Malaysia, Indonesia and Thailand have also introduced non-financial support mechanisms, including standard power purchase agreements (PPAs), preferential arrangements for small generators, and information support. These initiatives help independent power producers enter the market more easily and reduce barriers specific to non-liberalised energy markets. To date, however, these incentives have had limited success in fostering the expansion of renewable energy markets in many ASEAN-6 countries.

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. The ASEAN-6 belongs to this group of countries. Because developments throughout the entire *WEO* region are unlikely to be homogenous, projections for the ASEAN-6 cannot be isolated and are, therefore, not shown.

The total 2030 renewable energy potential for electricity in ASEAN-6 countries amounts to 1 495 TWh. This is roughly 2.5 times as much as the region consumed in 2009 (596 TWh). The composition and relative weight of individual renewable energy technologies are similar in all six countries, with wind, solar PV and hydro contributing significant shares. Geothermal electricity and heat are concentrated in Indonesia and the Philippines (Figure 5.3).

At the regional level, as well as in several individual ASEAN-6 countries, bioenergy and hydro power have the largest potential with 19% and 18%, respectively. However, the generation from hydropower in 2009 (64.9 TWh) already corresponds to about one-quarter of the potential. This is different for biomass. Here, 98% of the potential remains to be exploited.

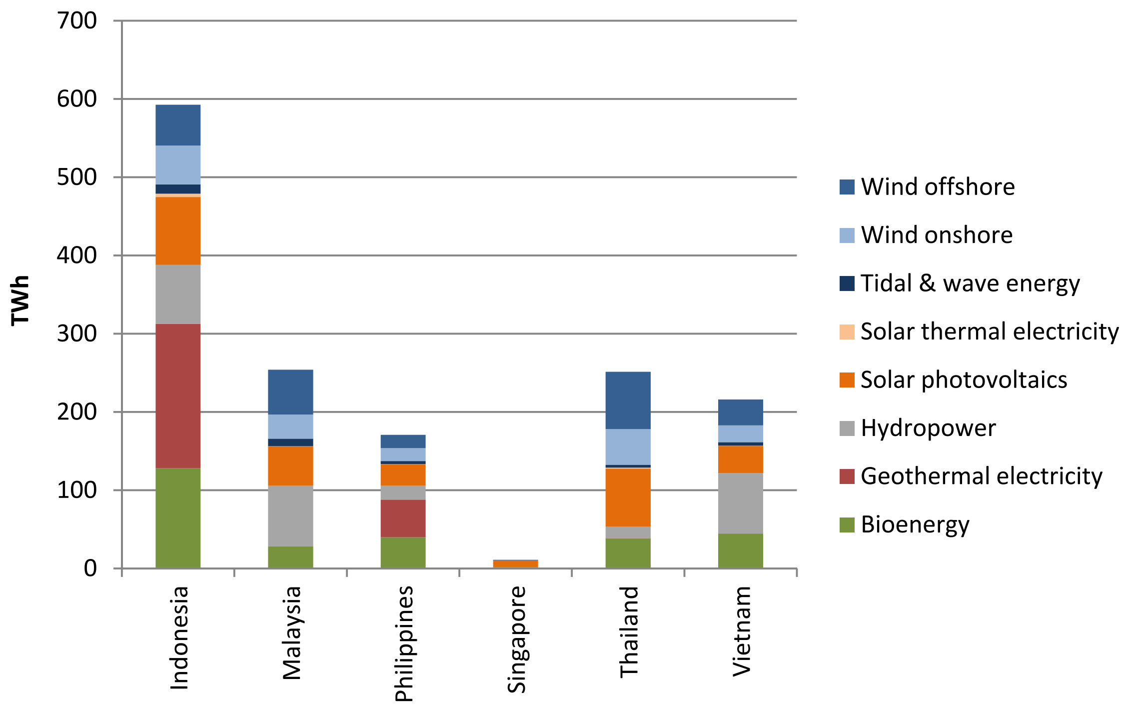
Similarly to biomass, wind energy is characterised by a large future potential in the ASEAN-6, especially in Indonesia, Thailand and Vietnam: more than 99% of the total realisable mid-term potential remains to be exploited.

Geothermal electricity generation using hydrothermal fluids[31] is already a proven RE technology option in two ASEAN-6 countries: Indonesia and the Philippines. Geothermal represents a considerable 12% of the overall ASEAN-6 RES-E potential. Innovative technologies, such as hot dry rock (also called enhanced geothermal systems) that uses hydraulic fracturing to “enhance” geothermal resources, are likely to be developed and deployed more beyond 2030.

Solar photovoltaics (PV) is a promising option. Although not a focus of this analysis and not quantified, the realisable potential for off-grid PV installations in the ASEAN-6 countries can be estimated to lie in the range of up to 20% of the on-grid PV potential by 2030.

[31] Hydrothermal refers to the circulation of hot water close to heat sources within the earth’s crust, often close to areas of volcanic activity.

Figure 5.3 2030 renewable electricity potentials in ASENA-6 countries



Source: IEA analysis based on data from IEE (2010).

Key point: All ASEAN-6 countries, with the exception of Singapore, show a significant and diverse renewable energy potential for electricity

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all ASEAN-6 countries depend on imports in their power sector, while only Singapore can be classified as a high GDP country (Table 5.2). The situation in all ASEAN-6 countries is characterized by an increase in electricity demand since the year 2000.

Table 5.2 Import/export categorisation for fossil fuels in the electricity sector and per capita GDP among ASEAN-6 countries

	High GDP	Low GDP
Importer	Singapore	Philippines, Vietnam, Thailand, Malaysia, Indonesia
Exporter	-	-

Vietnam has seen by far the strongest increase in electricity demand. From an energy security perspective, Vietnam's import dependency actually decreased, while its electricity generation increased by a factor of 8 from 1990 to 2009. These changes are due to two facts: the development of the country's gas resources (generation up from 6 GWh in 1990 to 36 141 GWh in 2009) and its hydro resources (up from 5 369 GWh in 1990 to 29 981 GWh). Vietnam relied on domestic resources to decrease dependence and chose hydro as a cost-competitive option to do so along with gas. With RE technologies moving further down their learning curves, Vietnam can also be expected to develop its currently untapped non-hydro resources.

It is somewhat surprising to see Indonesia, one of the world's largest exporters of coal, being in the import-dependent cluster. This categorisation is due to the fact that the country produces a large share of its electricity from oil products, *i.e.* diesel, and has insufficient refinery capacity. This fact implies that solar PV applications could be a cost-competitive alternative to satisfy a growing energy demand for off-grid applications. Not surprisingly, Indonesia recently passed legislation, but now facing the typical problems of a PV bubble (IEA, 2011a). In sum, strong drivers for RE technology deployment in off-grid applications remain, but the problematic experiences recently may hinder a healthy market development in the mid-term. Indonesia also succeeded in developing its cost-competitive geothermal resources to a certain degree.

Malaysia relies on domestic gas resources, along with imported coal, to cope with rising electricity demand, while phasing out the usage of oil products. Similar to Indonesia, the country is now turning to renewables, because renewables are becoming more competitive, while paying close attention to the cost-effectiveness of deployment. Power generation in the Philippines also grew based on partially imported coal and domestic gas. However, the country also has good geothermal resources that were exploited.

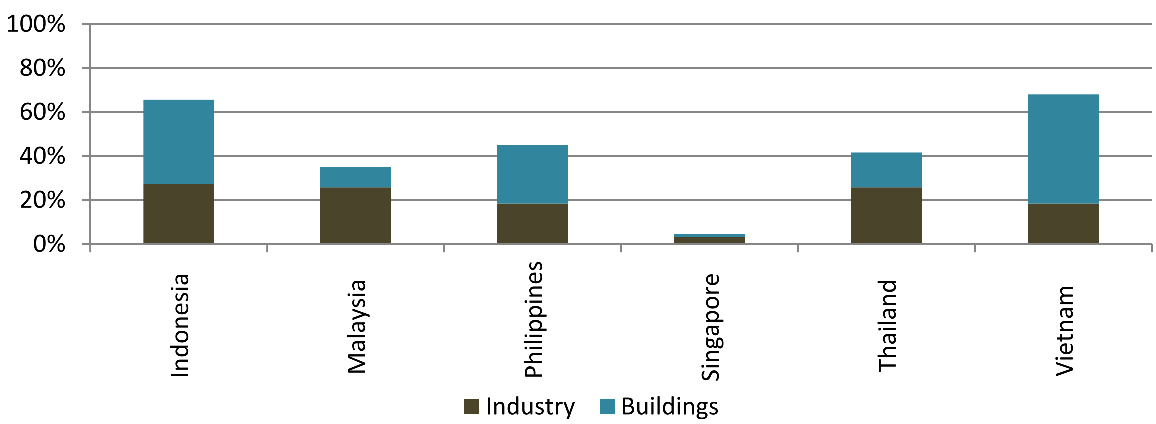
Singapore does not show any significant contribution from renewables, although it belongs to the country group of high GDP energy importers. The reason for this is simple: the country's very small size makes renewables deployment a challenge.

Renewable heat

Current market status

In ASEAN-6 countries, the total final consumption for heat applications was 190 Mtoe in 2009. This number has increased by 23% since 2000, when it stood at 154 Mtoe. Heat demand for space heating is nearly absent, and cultural preferences limit the demand for domestic hot water. However, substantial shares of traditional biomass used residentially at very low efficiencies make heat demand in this sector appear larger than it is. To phrase it differently, the amount of useful heat generated from relatively large inputs is comparably low. Industrial heat demand is responsible for a large share of final energy consumption used for heat (Figure 5.4).

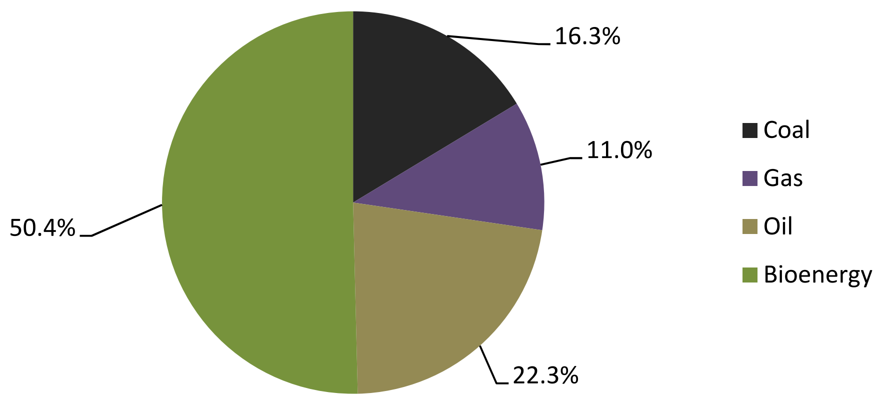
Figure 5.4 Share of heat in total final energy consumption in ASEAN-6 countries, 2009



Key point: The use of traditional biomass, especially in the building sector, leads to a very large share of input into heat production in total final energy consumption.

In ASEAN-6 countries, the fuel mix used for heat shows a 50.4% share of combustible renewables used for heat. This consists of large shares of traditional biomass used in very low efficiencies. Oil comes second to bioenergy with 22.3%, and coal and gas have shares of 16.3% and 9.3%, respectively (Figure 5.5). The share of renewables in heat-related final energy consumption has dropped since the year 2000, when it stood at 56.9%. Although consumption increased on average at 0.93% per year since 2000, the overall sector grew more quickly.

Figure 5.5 Fuel mix of final energy consumption for heat in ASEAN-6 countries, 2009



Key point: In ASEAN-6 countries, combustible renewables (mostly traditional biomass) contribute half to the fuel mix for heat.

Renewable heat production in ASEAN-6 countries is dominated by traditional biomass (Figure 5.6). As a result of its inefficient conversion, biomass dominates the picture of final energy use. One main usage of heat in the building sector in ASEAN-6 countries is for cooking. Cooking demand could be replaced by a fraction of the current amount (between five and eight times smaller), if more efficient technologies were used. Modern biomass applications already exist in the industry sector of Indonesia, Thailand and the Philippines for producing industrial process heat (as well as for on-site power generation).

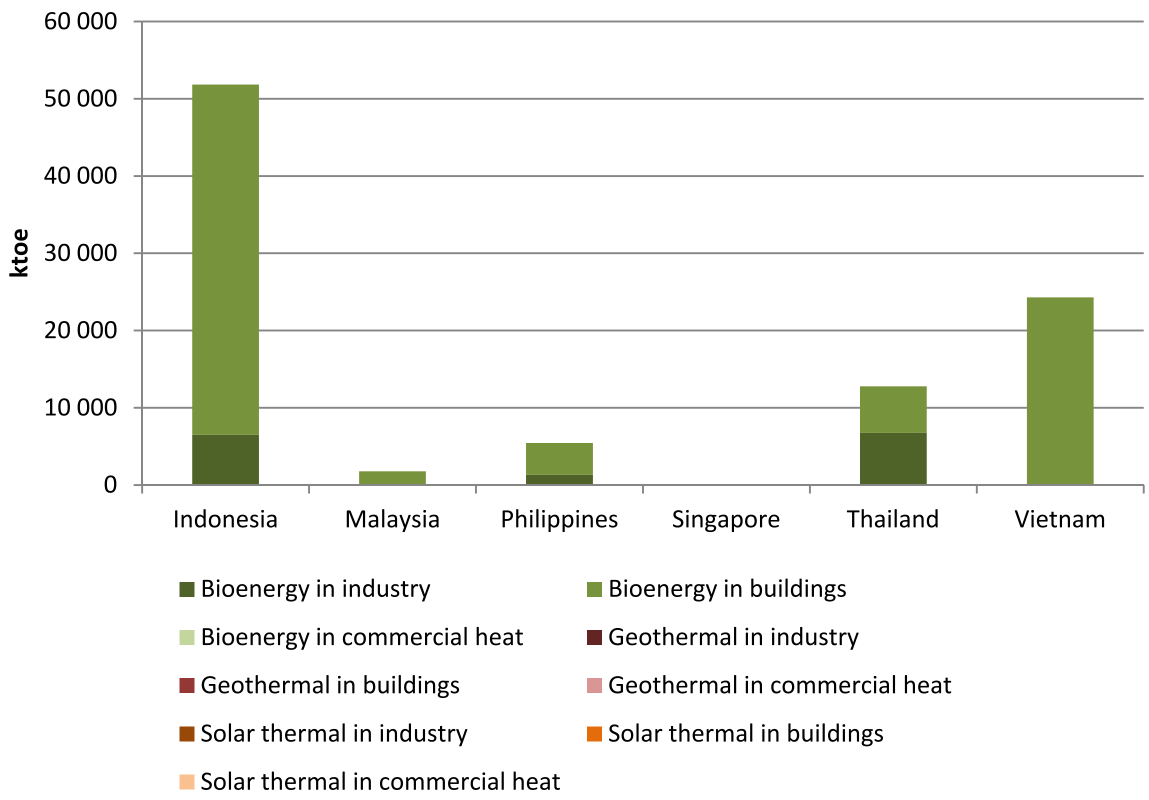
Geothermal heat and solar thermal heat do not contribute to the energy mix for heat in ASEAN-6. However, solar resources are available throughout the ASEAN-6 countries, and geothermal resources are abundantly available in Indonesia and the Philippines.

Current policy environment

So far, only a few policy initiatives encourage the use of renewable heat. Even though nearly all ASEAN-6 countries have adopted medium and long-term targets for renewable energy, and some introduced renewable energy feed-in-tariffs, these measures concentrate on renewable electricity. Thailand is the only country to introduce incentives for renewable heat, specifically targeting solar water heaters.

The current energy policy of the Government of Thailand contains targets for solar thermal energy use up to 2022. According to the Thai Renewable Energy Development Plan, heat produced by solar thermal energy should increase by 5 ktoe in additional production in 2011 (compared to 2007), with further increases programmed until 2022. In 2008, Thailand announced a solar thermal subsidy programme, which will continue to 2011. In 2008 and 2009, the program supported the installation of 4 000 m^2 and 3 000 m^2 of solar collector surface, respectively. The program target for 2011 is to install 10 000 m^2. The plan also targets the development of municipal solid waste, biomass and biogas.

Figure 5.6 Renewable heat production, including traditional biomass in ASEAN-6 countries, 2009



Key point: Traditional use of bioenergy in buildings dominates renewable heat production.

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. The ASEAN-6 belongs to this group of countries. Because developments throughout the entire *WEO* region are unlikely to be homogenous, projections for the ASEAN-6 cannot be isolated and are, therefore, not shown.

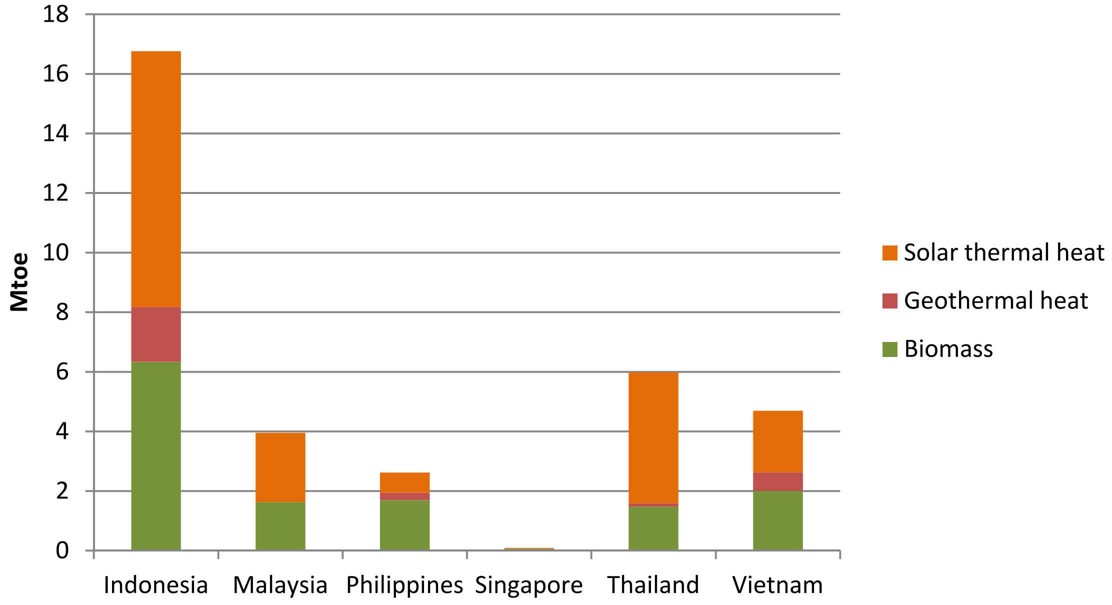
ASEAN-6 countries benefit from solar and bioenergy, Indonesia and the Pihilippines also from geothermal resources. In absolute numbers, heat from solar and bioenergy in Indonesia dominates the region's potential for renewable heat (Figure 5.7).

Note that the potential estimates are lower than current demand for bioenergy. This is due to stringent sustainability constraints on the potential calculation and the prospect of efficiency increases on the demand side.

Solar thermal, low-temperature heat can make a considerable contribution in absolute numbers in Indonesia, Thailand and Malaysia. Where potential for solar thermal is limited in domestic hot water applications for cultural reasons, solar thermal energy may have several niche applications, *e.g.* in solar ovens and/or crop dryers for reduction of post-harvest losses, thereby improving the quality of agricultural produce for high export prices.

Deep geothermal hydrothermal resources of sufficiently high temperatures are present in Indonesia, Vietnam and the Philippines. However, direct geothermal heat use is complicated by its location-bound character and thus shows modest potential.

Figure 5.7 2030 renewable electricity potentials in ASEAN-6 countries



Source: IEA analysis based on data from IEE (2010).

Key point: Solar thermal heat has a very large potential in most ASEAN-6 countries.

Energy security / GDP analysis

Heat demand is expected to be modest in ASEAN-6 countries, although the dominance of traditional biomass, used in very low efficiencies, disguises actual heat demand. A key challenge lies in raising the awareness that heat demand is responsible for part of final energy demand, and is thus a relevant issue in realising CO_2 emission reductions, energy security and fuel diversification.

Given the concerns for sustainable biomass use and health issues related to traditional biomass, increased efforts are needed to convert traditional biomass in domestic appliances to modern renewable energy use for domestic heat demand. Policies and development schemes that encourage and financially support the use of improved firewood-fuelled cooking stoves or biogas cooking stoves can address the widespread use of traditional biomass for cooking. Moreover, rising affluence is expected to result in fuel switching to fossil fuels for cooking. The development of a market of improved biomass cook stoves, or biogas cooking stoves in combination with sustainably produced biomass cooking fuels, could be an alternative to switching to fossil fuels. Maintenance issues and overcoming cultural cooking traditions are challenges in the encouragement of improved cooking stoves.

Although all countries in the region are substantial importers of energy for heat production, and also rely heavily on traditional biomass (except for Singapore), none are actively pursuing programmes to encourage renewable heat production, although a high potential exists for solar water heating and more modern applications of bioenergy technologies, along with geothermal in some countries (Table 5.3).

Table 5.3 Import/export catergorisation for fossil fuels for heat and per capita GDP among ASEAN-6 countries

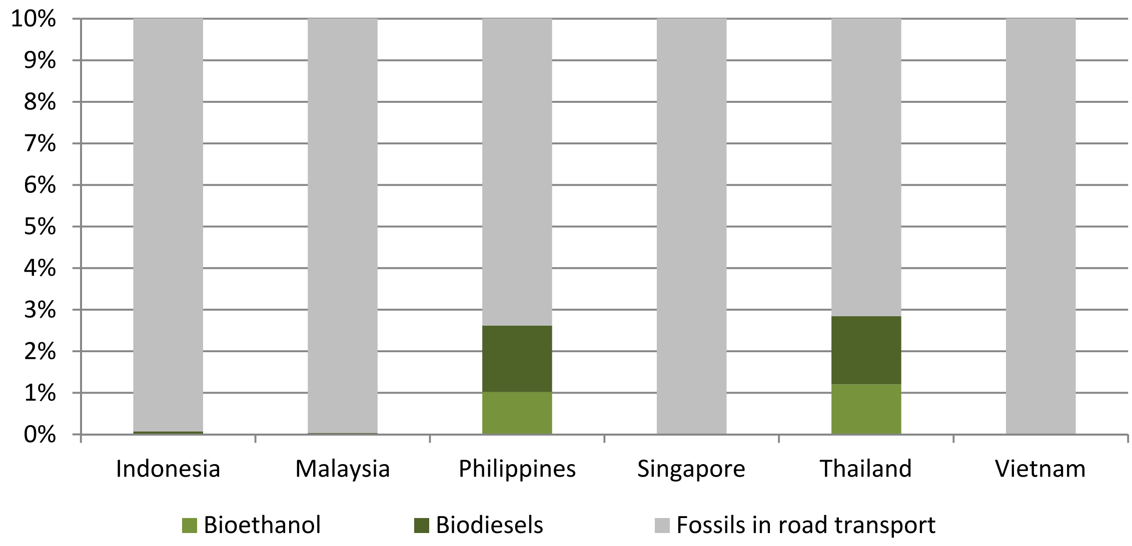
	High GDP	Low GDP
Importer	Singapore	Philippines, Thailand, Vietnam, Malaysia, Indonesia
Exporter	-	-

Renewable transport

Current market status

Biofuels for road transport are nearly absent in the ASEAN-6 countries, and currently only play a small role in the Philippines and Thailand (Figure 5.8).

Figure 5.8 Share of biofuels in road transport in ASEAN-6 countries, 2009

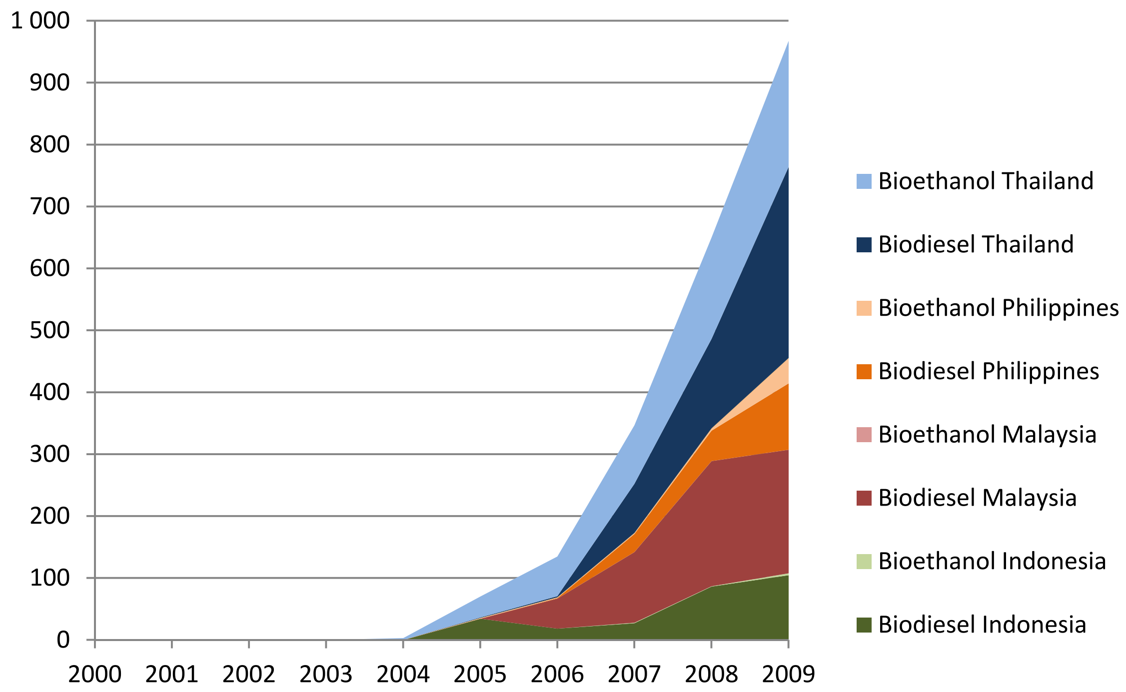


Key point: Biofuels for road transport currently only play a small role in the Philippines and Thailand.

However, all ASEAN-6 countries produce biofuels (Figure 5.9). The total production of biodiesel in the region reached 719.8 ktoe in 2009. Bioethanol had a smaller production of 247.7 ktoe in that year. These levels have greatly increased since 2000, when production was zero. First reports of biofuels production are from Vietnam in 2004, although the scale is small. Thailand has developed production of both bioethanol and biodiesel (accounting for over 60% of the region's production), and biodiesel production in Indonesia, Malaysia and Philippines is also significant. In early 2011, a large-scale advanced biofuels plant, producing hydrogenated vegetable oil via the Neste process, and located in Singapore, has come on-line. One of the first such plants in the world, it uses feedstocks from many parts of the Pacific region.

ASEAN-6 countries show great variation regarding their net export balances (as measured in percentage of production). Malaysia exports practically all of its production. This product is mainly biodiesel. Indonesia also exports very large shares of its production, while the Philippines relies on the import of biofuels to cover its demand (Figure 5.10).

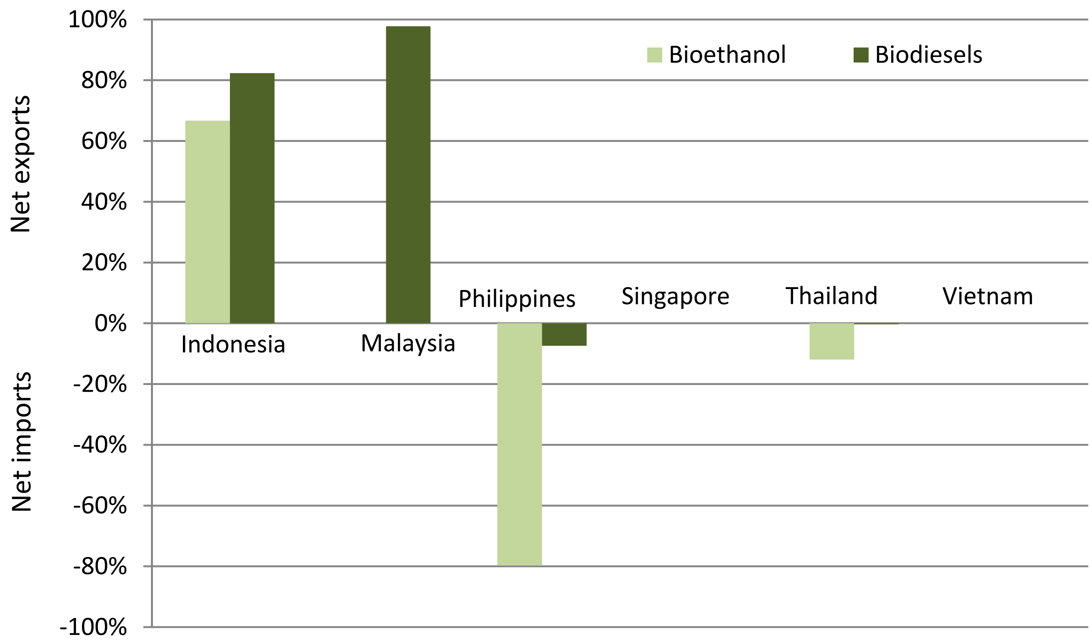
Figure 5.9 Production of biofuels in the ASEAN-6 countries, 2000-09



Note: Only countries that produce are shown.

Key point: Biofuels production ramped up rapidly in Thailand and Malaysia between 2004 and 2009.

Figure 5.10 Net exports of biofuels as a share of total production in ASEAN-6 countries, 2009



Key point: The Philippines imports slightly less bioethanol than it produces; Indonesia and Malaysia export almost their entire production.

Current policy environment

All the ASEAN-6 countries, except Singapore, have announced biofuels blending mandates. These mandates are:

- Thailand: B3 mandate today, rising to B5 in 2011. Future ethanol mandates are 3 Ml/day in 2011, rising to 6.2Ml/day by 2016, and 9.0 Ml/day in 2017.
- Indonesia: E3 in 2010, rising to E5 by 2015, E10 by 2020 and E15 by 2025, along with biodiesel targets rising from B2.5 in 2010, to B5 in 2015, B10 in 2020 and B20 in 2025.
- Malaysia: B5.
- Philippines: E5 rising to E10 by 2011, and B2 rising to B5 by 2011.
- Vietnam: 50 Ml biodiesel and 500 Ml ethanol by 2020

Specific financial and fiscal policies have been implemented in Indonesia and the Philippines to spur the deployment of biofuel production, domestic consumption and export. In the Philippines, the fuel component (local or imported) of biofuel production is exempted from income tax and import duty, while raw materials are exempted from value-added tax (VAT). Water effluents resulting from biofuel production are exempt from payment of wastewater charges.

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. The ASEAN-6 belongs to this group of countries. Because developments throughout the entire *WEO* region are unlikely to be homogenous, projections for the ASEAN-6 cannot be isolated and are, therefore, not shown. A regional assessment of the 2030 potential for biofuels is not provided due to the large uncertainties.

A rough estimate of the mid-term prospects of biofuels in the region can be obtained from the *2009 WEO* 450 projection for the ASEAN-6 region. This is projected to have a consumption of 14 Mtoe/year in 2030, which is roughly a ten-fold increase compared to current levels.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, puts Singapore alone in the energy importer/high GDP category (although it does have a large-scale refining capacity and is a major exporter of petroleum products) (Table 5.4). Singapore is the only country that has not so far put biofuels mandates in place, although the first commercial-scale advanced biofuels plant, which produces hydrogenated fuels from vegetable oil feedstocks, is also located there. All the other countries in the group have biofuels policies in place and are also active producers of fuel, with Indonesia and Malaysia also being major exporters.

Table 5.4 Import/export categorisation for fossil fuels in the transport sector and per capita GDP among ASEAN-6

	High GDP	Low GDP
Importer	Singapore	Vietnam, Philippines, Thailand, Indonesia
Exporter	-	Malaysia

Focus on Latin America

Renewable electricity

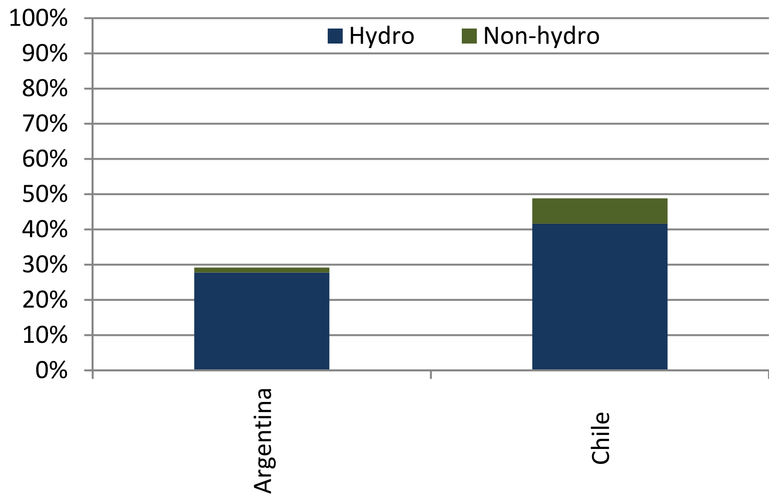
Current market status

Argentina and Chile produced 65.2 TWh of electricity from renewable sources in 2009. This corresponded to a share of 40.3% of total generation (182.6 TWh). Argentina's electricity generation is twice as high as Chile's (121.9 TWh versus 60.7 TWh). This difference mainly reflects the difference in population (Argentina 40.3 million, Chile 16.9 million). The total electricity generation has increased in both countries (CAGR 3.6% in Argentina and 4.7% in Chile, 2000-09).

Chile has a higher share of renewables than Argentina (48.8% versus 29.2%) and showed stronger growth in past years (CAGR of non-hydro renewables for 2000-2009: 18.6% versus 10.3%). However, the increase in total electricity consumption, combined with a decreasing output of hydro power, led to a decreasing share of renewables in the mix. It stood at 48.5% (Chile) and 33.1% (Argentina) in 2000.

Hydro dominates the renewables portfolio with a share of 95% in Argentina and 85.3% in Chile (Figure 6.1). The role of non-hydro renewables in Chile increased from 2000, when it had a share of only 4.8%. This was due to the increase in the utilisation of bioenergy (Figure 6.2).

Figure 6.1 Renewable electricity share in the electricity mix in Argentina and Chile, 2009



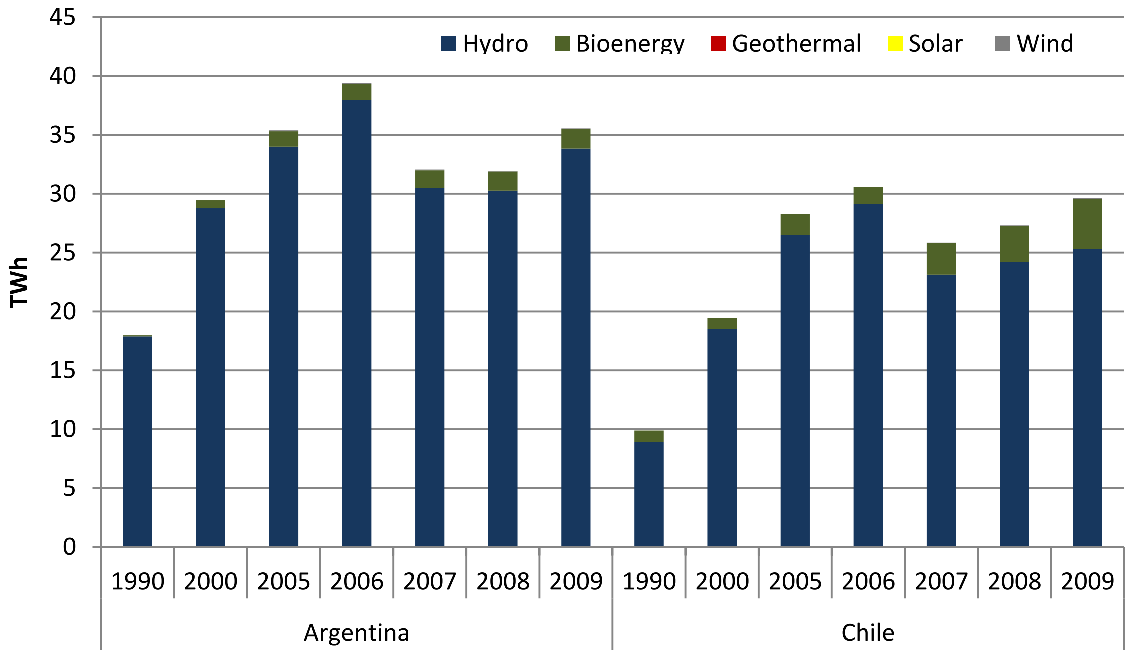
Key point: Hydro power dominates Argentina's and Chile's renewable portfolio. Chile has more significant penetration of non-hydro renewables.

Current policy environment

In Argentina, the development of wind and solar generation was first declared to be of national interest in 1998 in the country's national wind and solar promotion law. At the time, an additional payment per unit of renewable electricity was established at 40% above the market price. Some tax exemptions were also set for a period of 15 years from the law's promulgation. It became generally accepted that the national law on the promotion of renewable energies did not offer sufficient incentives and, therefore, needed to be expanded, leading to the Law on the

Promotion of Power Generation from Renewable Energy Sources being passed in late 2006. This legislation established an 8% target for renewable energy consumption by the end of 2016, and a trust fund was set up to allocate resources to pay a premium for electricity produced from renewable sources.

Figure 6.2 Electricity generation from renewable sources in Argentina and Chile, 1990-2009



Key point: Hydro power was responsible for the majority of renewable generation in Argentina and Chile.

In June 2010, Argentina's dominant and state-owned energy company Energía Argentina S.A. (ENARSA) announced the results of its 1 GW renewable energy tender (part of the GENREN procurement programme), the country's first large-scale renewables deployment scheme since the 2006 law. All RE technologies except large hydro were represented with minimum required capacity shares in the tender, although wind constituted half of the 1 GW required share. Although projects worth 1.4 GW of potential capacity were initially submitted, ENARSA awarded 15-year USD-denominated power purchase agreements (PPAs) to 32 projects totalling 895 MW. Wind projects seized 84% of this capacity (754 MW), with tariffs ranging between USD 120 per MWh and USD 135.20 per MWh.

However, the competitive bidding tender, which follows other Latin American countries, is an isolated effort to foster renewables growth without the backing of a comprehensive renewable energy policy framework or a clear strategic direction for Argentina's overall energy policy.

Moreover, the lack of streamlined administrative procedures and the continued application to renewable energy projects of regulations that pertain to fossil power plants, such as oil-drilling rules imposed on geothermal developers, present risks to the successful completion of the tender and to the medium-term outlook for renewables market growth in Argentina.

In adherence to the overall market orientation of Chile's energy sector, the government pursues the promotion of "non-conventional renewable energy" (NCRE) (wind, solar, geothermal, biomass, marine and small [<20 MW] hydro plants) without generation incentives. Nevertheless, policy makers are well aware of the barriers that stand in the way of NCRE sources becoming cost-competitive in the short to medium term (IEA, 2009). The policy framework that has been gradually implemented since 2004 reflects this understanding. Under the 2004 *Short Law I* for the electricity sector, NCRE were first exempted from paying toll charges for the trunk transmission system, and generators of all sizes (including often smaller-scale NCRE) were guaranteed access to all different electricity sub-markets. The *Short Law II*, passed in 2005, further reduced barriers to NCRE entrants into the market by establishing long-term supply contracts between generators and distributors, thus reducing the take-off risk for NCRE projects, which often have high capital costs yet low operating costs.

In the context of future electricity demand projected to grow by 5.4 % per year on average to 2030, Chile set Latin America's first renewable energy portfolio standard on utilities (above 200 MW installed capacity) to obtain 5% of their electricity supply from NCRE in 2010, with the target increasing to 10% by 2024. In May 2010, the newly inaugurated Chilean president announced the intention to double the required amount NCRE would contribute to the country's total generation from 10% to 20% by 2020. This announcement has not been translated into law.

NCRE targets are legally binding, with a penalty of USD 31-47/MWh[32] in case of non-compliance. It remains to be seen, however, how effective the law will prove. For the target to be achieved, about half of new grid-connected generating capacity should be NCRE.

Project developers in Chile benefit from a large variety of targeted support measures, mainly channelled through the Chilean Economic Development Agency (*Corporación de Fomento de LA-2 Producción* – CORFO), such as co-funding of pre-feasibility studies and grants for pre-investment studies. CORFO also assists the financing of NCRE projects, offering concessional loans with participation of local banks (IEA, 2009). The government instituted a Renewable Energy Centre (*Centro de Energías Renovables,* or CER). In addition, in 2009, they established a USD 400 million government fund that supports NCRE project financing through loan guarantees and risk-sharing for geothermal deep-drilling.

In 2009, the National Energy Commission (CNE) in Chile announced an international tender for a 500 kW solar PV and a 10 MW CSP plant in the north of the country. These projects would receive government grants from Chile's Economic Development Agency (CORFO). Moreover, since late 2010, the the Government of Chile has demonstrated its will to expand geothermal energy deployment by tendering no fewer than about 70 geothermal exploration concessions in 17 specialized areas through March 2011. Financial support will be guaranteed to project developers in the form of covering the risk of costly drilling operations that prove unsuccessful.

IEA projections and mid-term potential

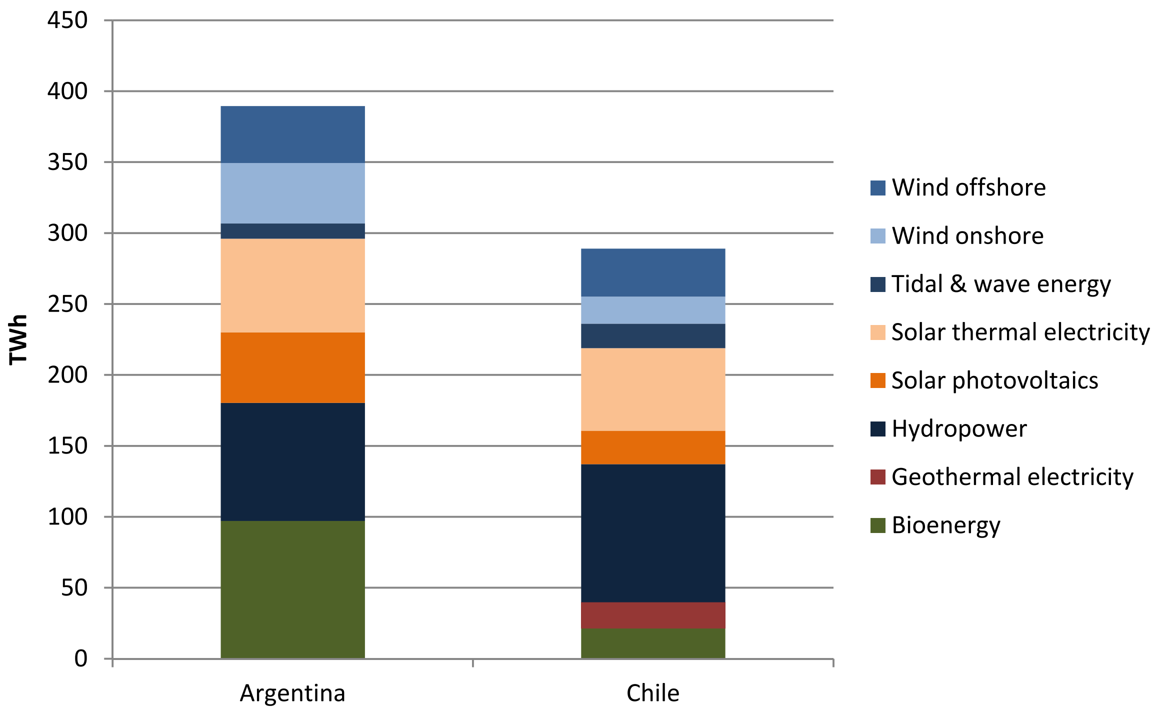
The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. Argentina and Chile belong to this group of countries. Unfortunately, the *WEO* region that contains Argentina and Chile also includes other countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for Argentina and Chile cannot be isolated and are, therefore, not shown.

The 2030 total mid-term potential for Argentina and Chile is 390 TWh in Argentina and 289 TWh in Chile (Figure 6.3). This amount corresponds to 3.2 (Argentine) and 4.8 (Chile) times the demand in 2009. The potential in both countries is well diversified.

[32] The penalty charges are set as fractions of the so-called UTM (*Unidad Tributaria Mensual*), a Chilean unit of account used for tax payments and penalties, which is adjusted for inflation. The charge amounts to UTM 0.4 for each non-supplied MWh and increases to 0.6 UTM/ MWh for repeated non-compliance (IEA, 2009).

In Argentina, bioenergy has the largest contribution to overall potential with 25%, followed by hydropower (21%) and the two solar technologies (30% total for CSP and PV). Onshore and offshore wind each contributes around 10%. The potential in Chile is concentrated more on hydro (34%) and CSP (20%). Wind has a total of 19%, with a larger offshore contribution. Solar photovoltaics, geothermal and bio energy each contributes about 6-8%. Due to its early stage in development, tidal and wave energy contributes only small shares to overall potential (3% in Argentina and 6% in Chile). Chile also has geothermal resources that make up 6% of the total potential.

Figure 6.3 2030 renewable electricity potentials for Argentina and Chile



Source: IEA analysis based on data from IEE (2010).

Key point: Argentina and Chile both have a large, diversified renewables potential.

Energy security / GDP analysis

Table 6.1 Import/export categorisation for fossil fuels in the electricity sector and per capita GDP in Argentina and Chile

	High GDP	Low GDP
Importer	Chile, Argentina	-
Exporter	-	-

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that Chile and Argentina depend on imports in their power sector, and both are classified as a high GDP country (Table 6.1).

Chile is much more dependent on imports than Argentina. Chile's coal mining has declined significantly compared to the 1990s. In the early 2000s, the decline in coal production was compensated by a massive ramp-up of generation from gas, mainly imported. In 2003, gas accounted for 35.4% of total output. At that time, net imports were 3.7 times domestic production. After 2004, generation from gas started declining in absolute terms. In 2009, gas contributed only 6.4% to the overall mix. The resulting gap in generation was partially compensated by combustible renewables and waste: their share in generation went up from 3.9% in 2003 to 7% in 2009. On the other hand, the contribution of oil products increased significantly. This trend hints at the operation of an increasing number of small generators. With Chile's import dependency remaining high, the growing cost-competitiveness of renewables could trigger a second wave of deployment, particularly wind.

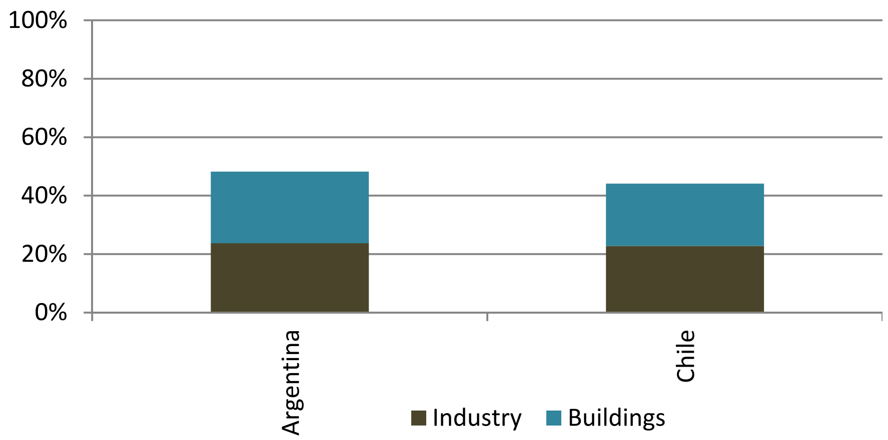
Argentina, which is much less dependent on imports than Chile, uses its domestic gas resources for generation, supplemented by hydro. However, recently, the increase in generation was outpaced by growing demand. Power outages were a consequence, along with a growing share of oil products in the mix.

Renewable heat

Current market status

Renewable heat is relevant in Argentina and Chile, although heat demand differs considerably from region to region within these countries. These differences are due to the widely dispersed land areas and the resulting diversity in climatic conditions. Southern regions in Argentina and Chile have a much higher space heating demand compared to northern regions. However, northern regions still face climate-independent industrial and domestic water-heating demand. The resulting average values show about 50% of total final consumption for heat (Figure 6.3). In absolute terms, the total final consumption for heat purposes was 25.5 Mtoe in Argentina and 9.9 Mtoe in Chile.

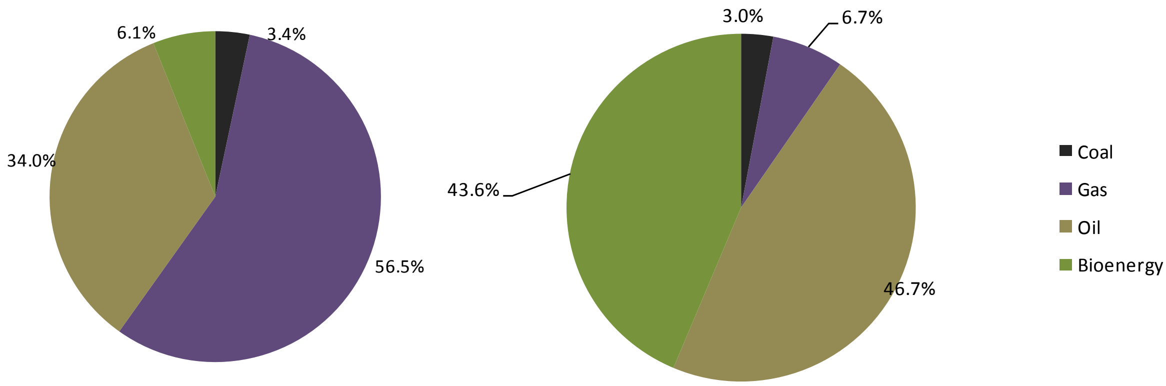
Figure 6.3 Share of heat in total final energy consumption in Argentina and Chile, 2009



Key point: Heat-related uses account for half of total final consumption in Argentina and Chile. There is an even split between usage in the buildings and industry sector.

In Argentina and Chile, the fuel mix used for heat shows a large difference between the two countries (Figure 6.4). Argentina uses large quantities of its own gas (56.5%) and oil (34%); Chile is largely dependent on imported oil (46.7%) but also uses large quantities of combustible renewables (43.6%) in both the industry and the buildings sector.

Figure 6.4 Fuel mix of final energy consumption for heat in Argentina (left) and Chile (right), 2009



Note: Bioenergy contains small contributions from non-renewable waste.

Key point: In Argentina and Chile, oil and gas dominate final energy use for heat. Especially in Chile, renewables also have a large share.

Since 2000, the share of renewables in heat-related total final consumption has remained stable in Chile (43.0%), but declined in Argentina (down from 11.5% in 2000 to 6.1% in 2009). The decline in Argentina is due to a decrease in absolute terms in the utilisation of biomass.

In Argentina and Chile, renewable heat is thus far mainly noticeable by means of substantial shares of biomass (Figure 6.5). In Chile, large shares of biomass are used in residential appliances, as fuel for cooking, producing domestic hot water and space heating. In Chile, residential use of biomass is commonly more efficient than traditional biomass usage, which has efficiencies of 10% to 15%. Typical stoves used in Chile for cooking have efficiencies on the order of 40% to 60%. In Chile, firewood is often preferred for cultural reasons, even in wealthier households. Chile also uses considerable amounts of modern biomass in the industrial sector.

Argentina reports a small share of modern biomass in industrial applications. In Argentina, residential usage of biomass is much smaller than in Chile. The absolute difference in Figure 6.5 is even more significant given that Argentina has a much larger population than Chile.

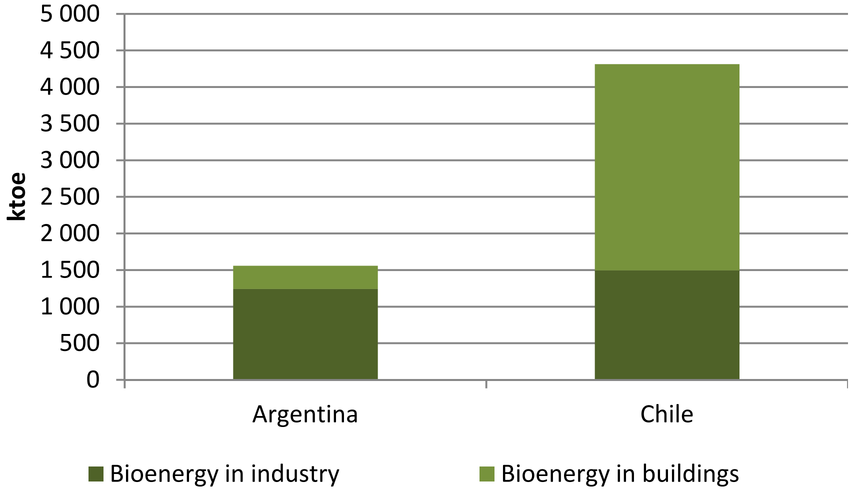
Current policy environment

Only a few policy initiatives supporting renewable heat in Argentina and Chile have been in place until recently.

In Argentina, the province of Buenos Aires has introduced a solar obligation, demanding the use of solar-powered water-heating systems in all public buildings and homes that do not have natural gas networks.

In July 2009, the Chilean Congress approved a bill providing tax credits for the installation of solar thermal collectors in new housing units. Houses valued up to UF73 2 000 (USD 80) will be credited with a 100% tax rebate for such installations; houses costing between UF 2 000 and UF 4 500 (USD 80 and USD 175) will receive a progressively smaller rebate. This support scheme seeks to boost market development, encourage the training of solar panel installers, and establish a certification system and technical standards. The tax incentive will last for five years only, in the expectation that once proposed objectives are achieved, private cost-effectiveness of installing this technology should ensure that the market is sustainable without publicly funded incentives.

Figure 6.5 Renewable final consumption for heat, including traditional biomass, 2009



Key point: All renewable heat in Argentina and Chile comes from bioenergy.

The Government of Chile has put in place a certification scheme for wood supply and introduced penalties on illegal felling. Recognising that there is a cultural affinity for wood use as an integral part of the energy mix, the Government of Chile has explicitly chosen to encourage a more sustainable use of wood for energy. Currently no plans are in place to incentivise fuel switching away from wood. Native forests are protected by law, and the government is planning to enact new laws to regulate the use of firewood. Despite the introduction of decontamination plans in some cities, measures to reduce emissions from wood use are less advanced compared with other decontamination measures. Proposals to limit emissions from residential firewood in cities with decontamination plans are currently under review.

IEA projections and mid-term potential

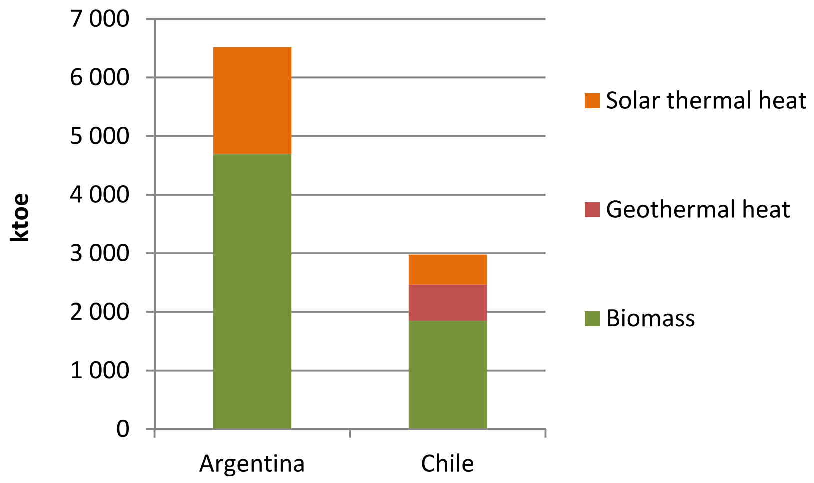
The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. Argentina and Chile belong to this group of countries. Unfortunately, the *WEO* region that contains Argentina and Chile also includes other countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for Argentina and Chile cannot be isolated and are, therefore, not shown. The 2030 mid-term potential for Argentina and Chile is shown in Figure 6.6.

Compared to 2009 levels, a very large potential exists for the development of the bioenergy sector for heat in Argentina. However, this is not the case in Chile. In fact, the potential, which takes into account stringent sustainability constraints and assumes some increase in efficiency of usage, is lower than the current consumption levels. Geothermal energy remains fully unexploited, according to IEA statistics, and this resource has considerable potential in Chile.

Solar thermal, low-temperature heat can make a considerable contribution in absolute numbers in Argentina. The percent contribution of solar thermal is equal for Chile and Argentina (Figure 6.6). Deep geothermal hydrothermal resources of sufficiently high temperatures[33] are reported in Chile. The deep geothermal energy potential in Argentina could not be assessed due to a lack of resource data.

[33] Ground source heat pumps are not considered in this analysis.

Figure 6.6 Renewable heat potential in Argentina and Chile, 2030



Source: IEA analysis based on data from IEE (2010).

Key point: Biomass dominates the renewable heat potential in Argentina and Chile. Both countries have potential for solar heat applications, and Chile also has the potential for geothermal.

Energy security / GDP analysis

Although both Argentina and Chile fall in the category most able and likely to pursue renewables policies, neither is yet actively pursuing renewable heat programmes (Table 6.2).

Table 6.2 Import/export categorisation for fossil fuels for heat and per capita GDP in Argentina and Chile

	High GDP	Low GDP
Importer	Chile, Argentina	-
Exporter	-	-

The main challenge for developing the market for renewable heat in Argentina and Chile is raising the awareness of the importance of heat in the overall energy system.

Especially in Chile, given its high dependence on biomass in the building sector, regulation is needed in the sector to address the forestry protection and health issues associated with biomass used in conventional stoves. The widespread residential usage of wood is a main cause of high levels of local air pollution in many cities in south-central Chile. Wood use has also led to deforestation around urban centres throughout the country. The introduction of stringent certification schemes for wood supply, therefore, needs to be a priority. This action should be complemented by effectively enforced penalties for illegal felling. A need also exists for further technological development and cost reduction, in particular, for more efficient stoves. Targeted incentives can help low-income households to purchase efficient stoves. Aiming at modern renewable energy use for domestic heat demand will strengthen the position of renewable heat in the Chilean fuel mix.

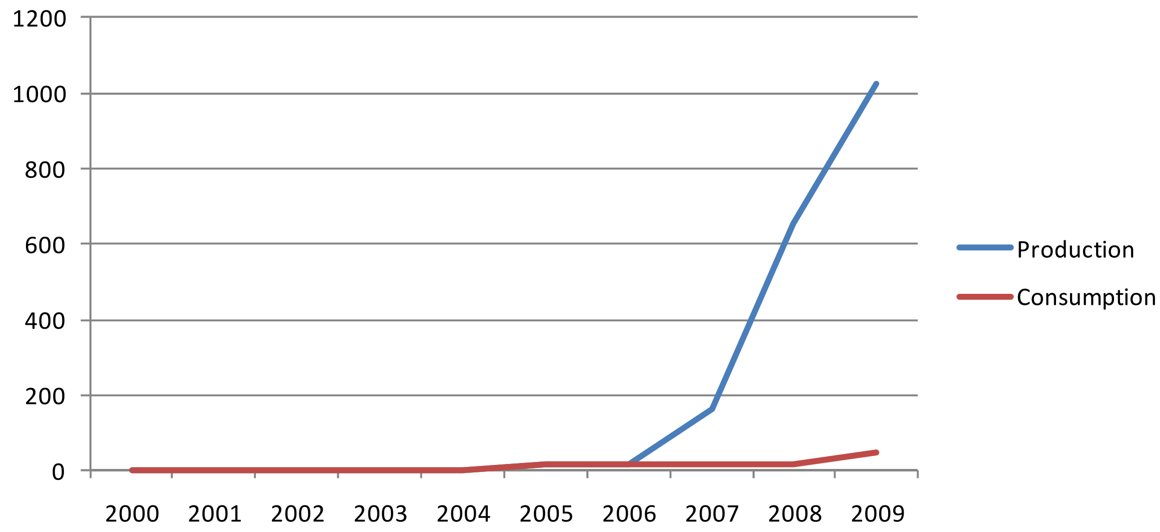
The recent interest in both Argentina and Chile to capitalize their nearly unexplored geothermal is an important step. Moreover, because geothermal energy may be used not only for power generation but also for heat production, this latter application could become an important and cost-effective part of developing geothermal energy resources.

Renewable transport

Current market status

Biofuel production and consumption in the two South American focus countries considered is concentrated in Argentina, with no recorded production or consumption of either biodiesel or bioethanol in Chile. In Argentina, all production and consumption relate to biodiesel, mainly produced from soybeans. The production has grown very rapidly since 2006 and reached 1 027 Ktoe/y in 2009; however, consumption is static at 47.46 Ktoe/y (0.39% of road transport fuel demand) (Figure 6.7). The surplus production is exported, principally to Europe.

Figure 6.7 Biodiesel consumption and production in Argentina



Current policy environment

Argentina has introduced a blending mandate for E5 from 2010. The law establishes criteria for plants to be licensed for biofuels production, including biofuel quality requirements and environmental impact assessment procedures. It also establishes criteria for beneficiaries of the benefits enacted by the law, focusing on supporting small and medium enterprises (SMEs), promoting agribusiness, and enhancing regional economies. This support should lead to a market of some 270 million litres of ethanol. Argentina also introduced a biodiesel B7 blending mandate in March 2011, stimulating a market of between 700 and 900 thousand tons of biodiesel.

Chile has introduced voluntary blending targets equivalent to E5 and B5.

Other South American and Caribbean countries have also introduced blending targets and mandates, including:

- Bolivia (E10 and B2.5; B20 by 2015),
- Colombia (E10, B10; 2012: B20 [planned]),
- Costa Rica (E7 and B20)
- Dominican Republic (E15 and B2 by 2015),
- Jamaica (E10; 2012: 11% renewable energy in transport; 2015: 12.5%; 2030: 20%),

- Paraguay (E24 and B1),
- Peru (E7.2 and B2; B5 by 2011),
- Uruguay (E5 and B5 by 2015),
- Venezuela (E10).

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. Argentina and Chile belong to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for Argentina and Chile cannot be isolated and are, therefore, not shown.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that both countries come under the high GDP category, and, in 2000, Chile was an importer of transport fuels, and Argentina an exporter (Table 6.3).

Table 6.3 Import/export categorisation for fossil fuels in the transport sector and per capita GDP in Argentina and Chile

	High GDP	Low GDP
Importer	Chile	-
Exporter	Argentina	-

Both countries have now introduced biofuels mandates, although use in Chile is still low and use in Argentina is just starting to develop, the major focus so far has been on exporting biodiesel to other markets. The opportunity for increased economic activity associated with biodiesel production form soy (where the oil is principally a by-product of the main production) is clearly an important driver, overriding the energy and climate change prerogatives.

Focus on Sub-Saharan Africa

Renewable electricity

Current market status

In 2009, the total generation (all sources) in the Sub-Saharan Africa (SSA-6) countries amounted to 43.5 TWh. This is a very small amount compared to the region's population of 235 million. The total generation means that the per capita generation was at 192.7 kWh per year, which is only 2.25% of the OECD-30 average (8 572 kWh/year) and 1.4% of the United States (13 547 kWh/year). In other words, the average per capita generation for a single person in the United States was 70 times higher than in Sub-Saharan Africa.

Electricity from renewable sources (RES-E) in the SSA-6 countries accounts for a substantial share of total electricity generation, 42.1% in 2009 (Figure 7.1). Hydro dominates the renewables portfolio in SSA-6 countries. It provided 91.2% of total renewable electricity in 2009. Geothermal made up 6.8% of the share (concentrated exclusively in Kenya), biomass contributed 1.9% and wind and solar energy contributed negligible shares.

Renewable generation has been growing at a slow pace since 2000 and before. The total share of renewables has dropped. Its share stood at 52.8% in 2000*, i.e.* 11 percentage points higher than in 2009. The reason for this decline is that renewable electricity did not grow as fast as total generation. While total generation grew by 3.8% per year (CAGR 2000-2009), renewable electricity grew by only 1.21%. From 2008 to 2009, a reduction of 4.1% occurred in total renewable generation due to a reduction in hydro generation, caused by severe droughts in the region (Figures 7.1 and 7.2).

Some diversity exists among the countries regarding the evolution of the renewables share.

Senegal had the highest growth rate, starting from a low base of 3.3% in the generation mix in 2000. This was due to hydro generation, which increased from zero to 0.29 TWh. Senegal now has a share of 10.2% of renewables in the mix (CAGR 22.9%).

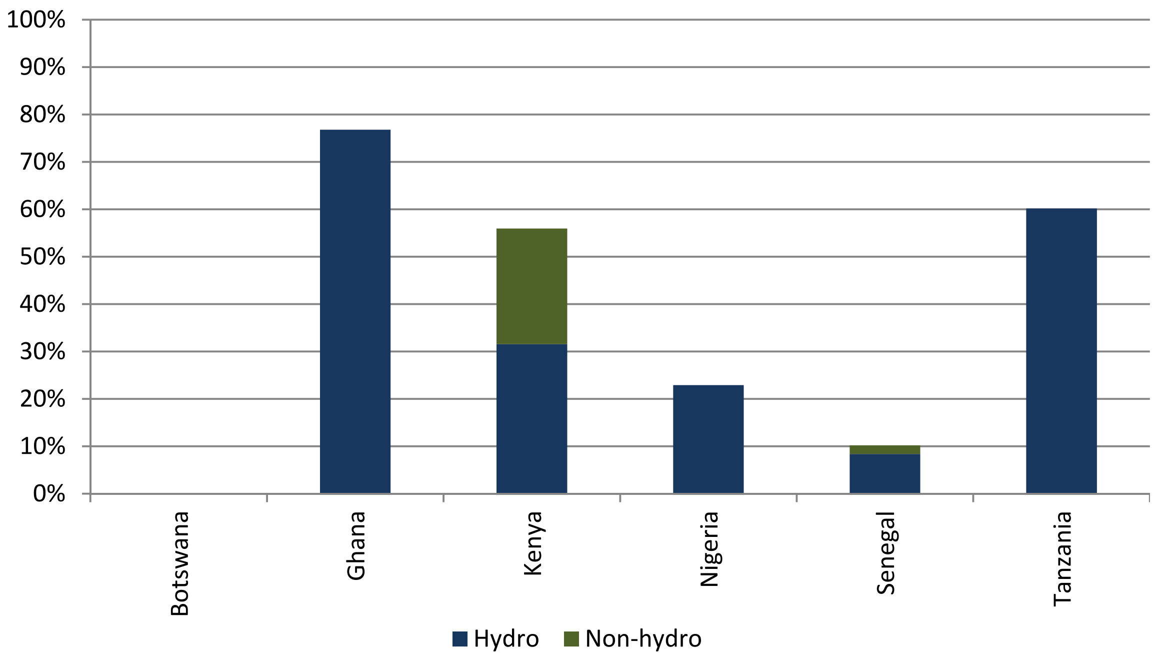
Kenya had the most dynamic evolution in absolute terms (from 2.0 TWh, corresponding to 48.17%, in 2000 to 3.8 TWh, corresponding to 56.0%, in 2009). This change was due to an increase in hydro power (2009 generation was 1.64 times the production of 2000). In addition, geothermal grew by a factor of 3.12 and generated 1.3 TWh, which corresponds to 10.5% of total generation (including fossils).

Ghana had a stagnating production of renewables from 2000 to 2009; relying 100% on hydro power for renewable generation. Because demand increased over the same period (CAGR 2.4% in Ghana), the contribution of renewables fell. A similar development took place in **Tanzania**. The country produces all of its renewable electricity from hydro power. Renewable generation grew at an average rate of 3.0%, while total generation grew at 7.2%.

Botswana did not have any renewable generation in the period of 2000 to 2009.

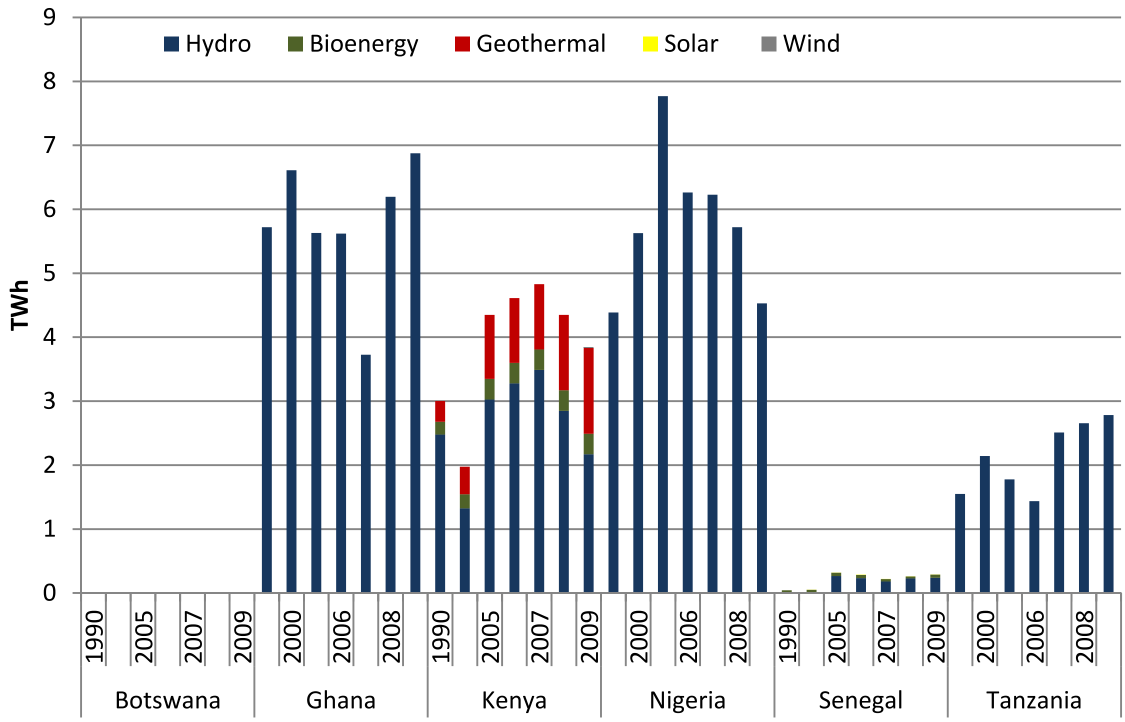
Nigeria is the only country in which the generation from renewables fell significantly between 2000 and 2009. It dropped from 5.6 TWh to 4.5 TWh. Nigeria produces renewable electricity only from hydro power. This decrease appears to be related to meteorological conditions (generation in 2008 was 5.7 TWh).

Figure 7.1 Renewable electricity share in the electricity mix in SSA-6 countries, 2009



Key point: Hydro power dominates the generation mix in Ghana and Tanzania; Kenya also has a significant non-hydro contribution, coming from geothermal.

Figure 7.2 Evolution of renewable electricity production in SSA-6 countries, 1990-2009



Key point: Hydro power shows large variability over time (presumably due to weather); Kenya is the only country that has succeeded in developing non-hydro resources (mostly geothermal).

Current policy environment

In all SSA-6 states except for Botswana, specific support policies, legislation or master plans have been dedicated to renewable energy deployment over the past ten years (Tables 7.1 and 7.2).

In Senegal, the government enforced a renewable energy-specific regulation, the Law on Renewable Energies and Biofuels, meant to secure safe and reliable energy access in sufficient quantity, quality and sustainability and at affordable price, to increase energy access and to reduce Senegal's vulnerability as a non-oil producer. Ghana and Botswana are expected to enforce similar frameworks by 2012.

Other states have relied on general energy acts to support renewable energy. In its 2006 Energy Act, Kenya first included renewable energy deployment targets, the creation of dedicated institutions (*e.g.* the Geothermal Development Company), and the design of tax holidays. In 2008, the government further expanded its support with the implementation of a feed-in-tariff policy, which was reviewed and completed in 2010 (Box 7.1). Although such a policy does not have the strength of a law, it is the only regulation of its type in the region and requires full attention. Kenya is a frontrunner with regards to renewable energy deployment, and its experience will allow experts to better understand how a feed-in-tariff can meet the specific needs of energy producers and consumers in the particular context of Sub-Saharan Africa.

Box 7.1 Kenya's 2010 renewable electricity feed-in tariff

Geothermal: Capacity ≥ 70 MW, USD 0.085/kWh (maximum).

Wind: Capacity from 0.5-100 MW, USD 0.12/kWh (maximum).

Biomass: Capacity from 0.5-100 MW, USD 0.08/kWh (maximum) for firm capacity and USD 0.06/kWh for non-firm capacity.

Small Hydro:

- Capacity from 0.5-0.99 MW: USD 0.12/kWh max for firm capacity and USD 0.10/kWh for non-firm capacity;
- Capacity from 1-5 MW: USD 0.10/kWh max for firm and USD 0.08/kWh for non-firm capacity;
- Capacity from 1-5 MW: USD 0.10/kWh max for firm and USD 0.08/kWh for non-firm capacity;
- Capacity from 5.1-10 MW: USD 0.08/kWh (maximum) for firm and USD 0.06/kWh for non-firm capacity.

Biogas: Capacity from 0.5-40 MW: USD 0.08/kWh (maximum) for firm and USD 0.06/kWh for non-firm capacity.

Solar: Capacity from 0.5-10 MW: USD 0.20/kWh (maximum) for firm and USD 0.10/kWh for non-firm capacity.

Renewable energy deployment targets and support mechanisms have also been included in electricity acts and market-unbundling processes. In Tanzania, the premium awarded to small-scale renewable electricity producers in the Standardize Small Power Purchase tariff was enforced and will be reviewed on a yearly basis under the 2010 Electricity Rules.

Eventually, an observable trend is the overlapping of renewable electricity concern and rural electrification targets. In all SSA-6 focus states, rural electrification programmes (REP) seek to expand existing grids, on the one hand, and kick-start renewable energy mini or off-grid systems, on the other hand.

Most programmes subsidise isolated solar appliances, appropriated for providing households in remote areas access to sustainable and affordable electricity. In Ghana, the Specific Strategy for

Remote Off-grid and Island Communities finances preliminary assessment studies and allocates grants to support solar PV installation cost. In Botswana, the Renewable Energy-based Rural Electrification Programme, funded by the Global Environmental Fund, supports initial investment in solar PV portable lights (GTZ, 2009).

Table 7.1 Renewable electricity targets in the SSA-6

Country	RES installed capacity	RES-E share of primary energy	RES-E share of electricity generation	Geothermal	Solar
Botswana					
Ghana			10% by 2020; 30% penetration of RE in rural electrification by 2020		
Kenya	Double by 2012 from 2009 baseline			4GW by 2030	
Nigeria	16 GW by 2015	20% by 2012	7% by 2025		1 million Solar Home Systems by 2016
Senegal		15% by 2025			
Tanzania					

Box 7.2 Regional cooperation in Africa in support of renewable electricity deployment

Four regional electricity pools (West, Central, Eastern and Southern Africa Power Pool) provide a structure for the Sub-Saharan Africa power market and address the challenges of secure and sustainable power supply and access. Several of these regional institutions recently adopted energy strategies including renewable electricity generation and distribution regional targets (AfDB, 2008).

The Monetary and Economic West African Union (UEMOA) implemented the **Regional Initiative for Sustainable Energy 2009-2020**. The plan targets universal electricity access by 2030, harmonised and cheaper regional electricity prices, and an increased share of renewable electricity from 36% in 2007 to 82% by 2030.

The **South African Power Pool Plan (SAPP) 2009** underlines how regional integration of electricity markets can generate electricity at a lower cost compared to those registered under national plans. The SAPP plan targets 57 000 MW of additional installed capacity by 2025 at an estimated USD 89 billion investment, about half the cost of cumulated national power strategies for the same amount of additional installed capacity.

Regional initiatives also apply to resources management. The **Nile Basin Initiative** (NBI), a partnership led by riparian states of the Nile River, targets sustainable management, generation and distribution of hydroelectricity throughout the region. Because Kenya and Tanzania import hydro power from Ethiopia and Uganda, respectively, regional cooperation can be a great factor in the expansion of grid-connected large-scale renewable power generation.

In 2003, Kenya, Ethiopia, Uganda, Tanzania, Eritrea and Djibouti, together with the United Nations Environment Programme (UNEP) and donor countries, created the **Agency for Geothermal Development in the African Rift (ARGeo)**. The ARGeo supports geothermal development activities, regional grid inter-connections and future multinational integrated geothermal power plants.

In Senegal, the program for the promotion of renewable energies, rural electrification and the promotion of sustainable supply in domestic fuel (PERACOD) seeks to expand the electrification rate from 16% in 2007 to 50% by 2012 and 60% by 2022. The programme also provides independent power producers (IPPs) and end-users with installation subsidies for isolated solar PV systems, and supports the deployment of solar lighting in remote villages.

Table 7.2 Renewable energy support policies in SSA-6 countries

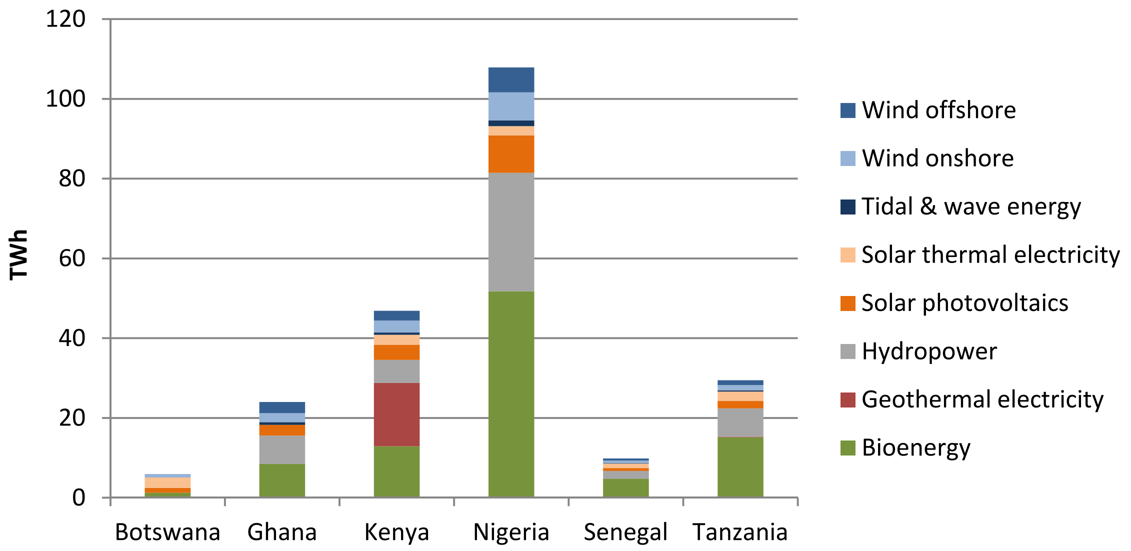
Countries	Feed-in tariff (FIT)	Standardised Power Purchase Agreement	Capital cost grants/subsidies	Fiscal incentives
Botswana	Expected feed-in tariff by March 2012[i]			
Ghana	New RE Law expected to include a FIT by end-2011		PV grants to electricity end-users	Total import duty exemption on RE equipment
Kenya	2008 FIT, modified and expanded in 2010, including geothermal, wind, solar, small-hydro, biomass, biogas			Investment Tax exemption
Nigeria				Short-term moratorium on import duties, Renewable Energy Master plan
Senegal				Total tax exemption for any RE-related device
Tanzania		For wind, hydro, PV and cogeneration below 10 MW	TEPAD Solar PV/kWh grant	PV equipment exemption from VAT and income duties

IEA projections and mid-term potential

The IEA *World Energy Outlook 2010* 450 Scenario projects a number of countries on an aggregated level. The SSA-6 countries belong to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for the SSA-6 countries cannot be isolated and are, therefore, not shown.

SSA-6 countries show diversified RE potential, with all showing comparably large biomass potential. Geothermal potential exists as well, in particular, in Kenya. Solar photovoltaics also show some potential across all countries. It is important to note that the small increases in electricity demand projected for SSA-6 countries constrain potential, as contributions from variable resource can only cover a certain percentage of demand. This explains the relatively high – and unexpected – dominance of bioenergy in the potential portfolio, as bioenergy generation is dispatchable.

Figure 7.3 2030 renewable electricity potentials in SSA-6 countries



Source: IEA analysis based on data from IEE (2010).

Key point: SSA-6 countries show diversified RE potential.

Energy security / GDP analysis

Table 7.3 Import/export categorisation for fossil fuels in the electricity sector and per capita GDP in Sub-Saharan Africa

	High GDP	Low GDP
Importer	-	Senegal, Kenya, United Republic of Tanzania, Ghana, Botswana, Nigeria
Exporter	-	-

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all SSA-6 countries depend on imports in their power sector, and all can be classified as low GDP countries (Table 7.3).

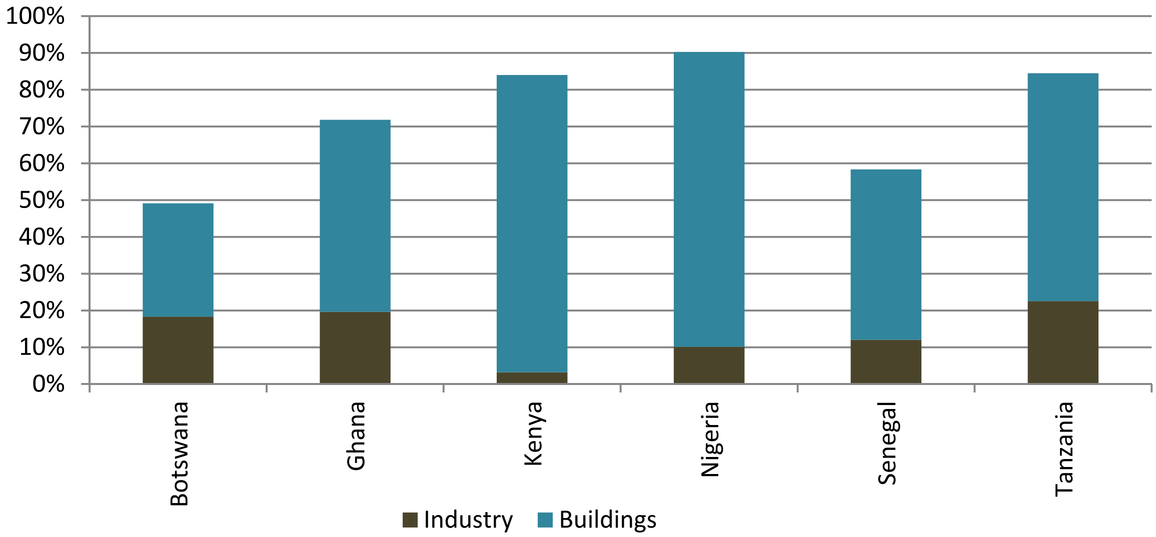
Consequently, most SSA-6 countries have developed cost-effective renewables: hydro power and, as far as resources permit it, geothermal. Kenya also managed to scale up biomass-based electricity generation. For the future, rural electrification, where RE technologies have become competitive, could provide the basis for growth in RE technology deployment.

Renewable heat

Current market status

Heat demand is limited in Sub-Saharan Africa as a consequence of nearly non-existent space heating demand and a limited share of industrial heat demand. Moreover, cultural preferences limit the demand for domestic hot water. The relatively high per capita energy use for heat in the SSA-6 countries results from substantial shares of traditional biomass use, particularly for cooking (Figure 7.4). In 2009, the total consumption related to heat amounted to 117.7 Mtoe. This amount is a 17% increase compared to 2000 levels. Low efficiencies make energy input much larger than actual heat demand.

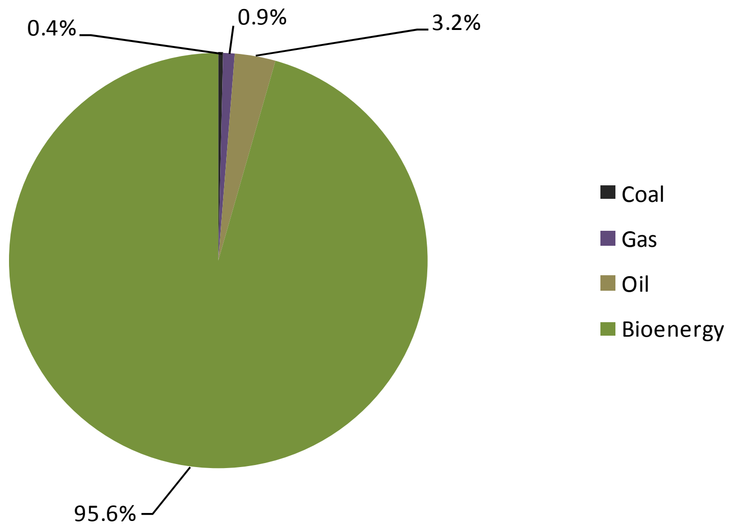
Figure 7.4 Share of heat in total final energy consumption in SSA-6 countries, 2009



Key point: The domestic use of traditional biomass dominates total final consumption in SSA-6 countries.

Combustible renewables are the dominant source of energy for heat (Figure 7.5). In 2009, they accounted for 95.6% of heat-related energy consumption. This share has remained stable since 2000. Some modern biomass usage exists in Nigeria's, Ghana's and Tanzania's energy sector.

Figure 7.5 Fuel mix of final energy consumption for heat in SSA-6, 2009



Key point: In the SSA-6 countries, combustible renewables dominate the fuel mix for heat, mainly consisting of traditional biomass use in the building sector.

Current policy environment

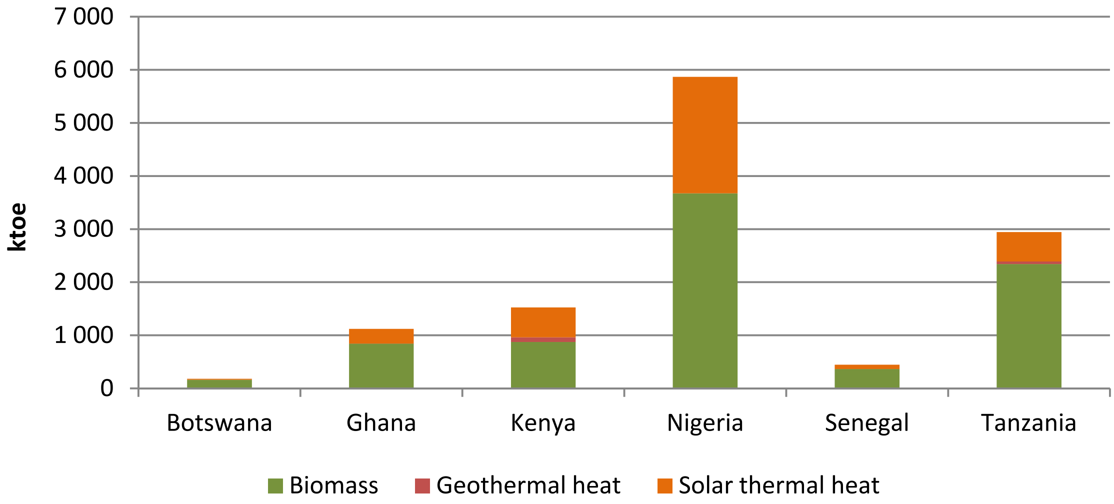
Tanzania is in the process of implementing a National Solar Programme under the World Solar Programme in order to promote the use of solar thermal applications for water heating and cooking. At present, further records on policies targeting the heat sector do not exist for SSA-6 countries.

IEA projections and mid-term potential

The IEA *World Energy Outlook* 2010 450 Scenario projects a number of countries on an aggregated level. The SSA-6 countries belong to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for the SSA-6 countries cannot be isolated and are, therefore, not shown.

There is significant potential for biomass for heat, in particular, in Nigeria and Tanzania, as well Ghana and Kenya. Significant solar potential exists in all countries, with the exception of Senegal and Botswana (Figure 4.6).

Figure 7.6 2030 renewable heat potentials in SSA-6 countries



Source: IEA analysis based on data from IEE (2010).

Key point: In SSA-6 countries, biomass and solar dominate the potential for renewable heat applications.

Energy security / GDP analysis

Heat demand is expected to be low in Sub-Saharan African countries, although the dominance of traditional biomass, used in very low efficiencies, disguises actual heat demand. The first key challenge lies in raising the awareness that heat demand is responsible for part of final energy demand, and thus is a relevant issue in realising CO_2 emission reductions, energy security and fuel diversification.

Given the concerns for sustainable biomass use and health issues related to traditional biomass, ncreased efforts are needed for converting traditional biomass in domestic appliances to modern renewable energy use for domestic heat demand. Policies and development schemes that encourage and financially support the use of improved firewood-fuelled cooking stoves or biogas cooking stoves can help to reduce the widespread use of traditional biomass for cooking.

Moreover, rising affluence is expected to result in fuel switching to fossil fuels for cooking. The development of a market of improved biomass cook stoves or biogas cooking stoves, in combination with sustainably produced biomass cooking fuels, could be an alternative to switching to fossil fuels. The key challenges in the encouragement of improved cooking stoves include maintenance issues and overcoming cultural cooking traditions.

All the countries in the SSA-6 region are fuel importers as far as the heat sector is concerned, and all are also in the low GDP category (Table 7.4).

Table 7.4 Import/export categorisation for fossil fuels for heat and per capita GDP in Sub-Saharan Africa

	High GDP	Low GDP
Importer	-	Senegal, Botswana, Ghana, Kenya, United Republic of Tanzania, Nigeria
Exporter	-	-

Although all the SSA-6 countries are reliant on imported fuels and experience pressure on the traditional use of their biomass resources, only Tanzania has an active programme in the solar water sector. Significant potential exists for more efficient biomass use, including in the industry sector, and for broader application of solar technologies for hot water and in industry (*e.g.* for drying), but these potential applications are so far being given only low priority.

Renewable transport

Current market status

Up to 2009, no record was available for the use or production of either biodiesel or bioethanol in any of the SSA-6 countries.

Current policy environment

Although consumption and production of biofuels in the Sub-Saharan African region are limited so far, a number of countries have developed biofuels targets and blending mandates.

Mozambique has an ambitious biofuel policy and action plan (developed with Brazilian assistance). The country intends to increase ethanol levels so as to achieve E10 levels by 2015, then increasing levels up to E20 by 2020, and to develop a parallel distribution network for E75 or E100 thereafter. Mozambique also plans to increase biodiesel consumption to B5 level by 2015, and to ramp this up to B20 level by 2020, developing a B100 infrastructure thereafter.

In 2007, Nigeria developed a comprehensive biofuel policy initiated by the country's National Petroleum Corporation (NNPC), and approved by the federal government. The policy articulates, among other things, a seeding programme that will import into the country for automotive fuels up to a 10% mixture of ethanol in premium motor spirit (E10) and 20% of biodiesel in petro-diesel (B20) by volume. However, the legal status of this policy is not yet clear.

Zambia has announced blending targets for E% and B10 by 2011, but it is not clear whether these targets are mandatory.

Kenya has announced a pilot E10 blending mandate in Kisumu province, along with a B5 target.

IEA projections and mid-term potential

The IEA *World Energy Outlook* 2010 450 Scenario projects a number of countries on an aggregated level. The SSA-6 countries belong to this group of countries. Because developments throughout this entire *WEO* region are unlikely to be homogenous, projections for the SSA-6 countries cannot be isolated and are, therefore, not shown. A regional assessment of the 2030 potential for biofuels is not provided due to the large uncertainties.

Energy security / GDP analysis

The clustering approach, which classifies countries according to their GDP and import dependency, indicates that all the SSA-6 countries are in the cluster with low GDP and are import dependent as far as their transport fuel requirements are concerned (Table 7.5).

Table 7.5 Import/export categorisation for fossil fuels in the transport sector and per capita GDP in Sub-Saharan Africa

	High GDP	Low GDP
Importer	-	Senegal, Botswana, Ghana, Kenya, United Republic of Tanzania, Nigeria
Exporter	-	-

Four countries have announced biofuels policies, although these policies are not yet seriously implemented, and, up to 2009, no record was available of biofuels within the transport fuels mix.

Several of these countries have very significant biofuel potential, given the climatic conditions. It would be interesting to explore integrating a balanced package of policies that encourage biofuel production and consumption, while meeting sustainability criteria, such as those developed by the Global Bioenergy Partnership (GBEP) initiative. Brazil is already working with Mozambique, and a number of other initiatives are under consideration, some within the technology transfer and capacity-building efforts being developed under the GBEP initiative.

Acronyms, Abbreviations and Units of Measure

Region definitions and focus countries

ASEAN-6	Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam.
BRICS	Brazil, Russia, India, China (People's Republic of China and Hong Kong), South Africa.
MENA-7	Algeria, Egypt, Israel, Morocco, Saudi Arabia, Tunisia, United Arab Emirates.
OECD-30	Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.
LA-2	Argentina, Chile.
SSA-6	Botswana, Ghana, Kenya, Nigeria, Senegal, Tanzania.

International bodies and fora

EU-27 member countries

Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom.

Clean Energy Ministerial (CEM) countries

Australia, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Norway, Russia, South Africa, Spain, United Arab Emirates, United Kingdom, United States.

Group of Twenty (G20)

Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Republic of Korea, Russia, Saudi Arabia, South Africa, Spain, Turkey, United Arab Emirates, United Kingdom, United States, European Union.

IEA member countries

Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, The Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

OECD member countries

Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Acronyms

CAGR	compound average growth rate
CCS	carbon capture and storage
CEM	Clean Energy Ministerial
CHP	combined heat and power
CSP	concentrating solar power
DNI	direct normal irradiance
DDGS	dried distillers grains with solubles
DSG	direct steam generation
EIA	Energy Information Administration
EU	European Union
EU ETS	European Union Greenhouse Gas Emission Trading Scheme
EU-OECD	OECD member countries which are also European Union member states
FIP	feed-in premium
FIT	feed-in tariff
FLH	full load hours
GDP	gross domestic product
GWEC	Global Wind Energy Council
IEA	International Energy Agency
IPP	independent power producer
ITC	investment tax credit
IEAPVPS	International Energy Agency Photovoltaic Power Systems Programme
IEABCC	International Energy Agency Biomass Combustion and Cofiring
IEASHC	International Energy Agency Solar Heating and Cooling Programme
LCA	life-cycle analysis
LCOE	levelised cost of electricity
LR	learning rate
MoU	Memorandum of Understanding
NPV	net present value
n/a	not applicable
OECD	Organisation for Economic Co-operation and Development
O&M	operation and maintenance
PII	Policy Impact Indicator
PPA	power purchase agreement
PTC	production tax credit
PV	photovoltaics
RAI	Remuneration Adequacy Indicator
R&D	research and development
RD&D	research, development and demonstration
RE	renewable energy
RES	renewable energy sources
RES-E	electricity generated from renewable energy sources

RES-H	heat produced from renewable energy sources
RES-T	transport fuels produced from renewable energy sources
RFS	renewable fuels standard
RPS	renewable portfolio standard
ROC	renewable obligation certificate
TCI	Total Cost Indicator
TFC	total final consumption
TGC	tradable green certificate
TPES	total primary energy supply
UNEP	United Nations Environment Programme
WACC	weighted average cost of capital
WEO	*World Energy Outlook*

Units of measure

GWh	gigawatt-hour, 1 kilowatt-hour equals 10^9 watt-hours
ha	hectare
Gt	Giga tonnes
J	joule
kb	kilobarrel
kW_h	kilowatt-hour, 1 kilowatt-hour equals 10^3 watt-hours
kW_p	kilowatt peak
kW_{th}	kilowatt thermal
l	litre
m^3	cubic metre
Ml	million litres
Mtoe	million tonnes of oil equivalent
MWh	megawatt hour, 1 megawatt-hour equals 10^6 watt-hours
PJ	petajoule, 1 petajoule equals 10^{15} joules
Ppm	parts per million
TJ	terajoule, 1 terajoule equals 10^{12} joules
toe	tonne of oil equivalent
TWh	terawatt-hour, 1 terawatt-hour equals 10^{12} watt-hours

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