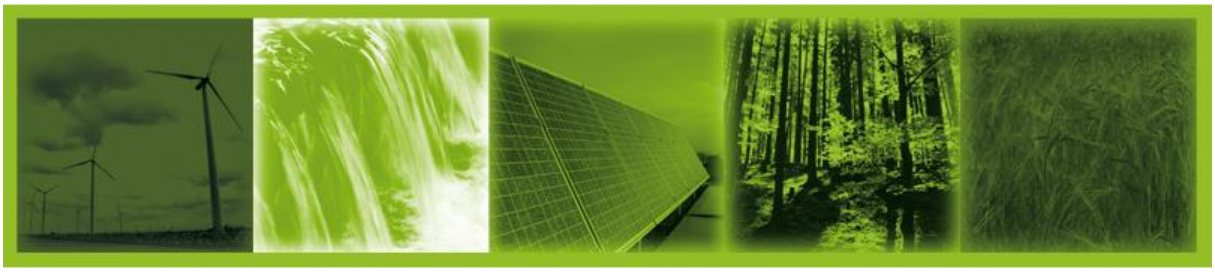
REPAP 2020

Renewable Energy Policy Action Paving the Way towards 2020



Renewable Energy Industry Roadmap for Finland

-Draft -

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Intelligent Energy Europe

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1 The case of Finland

1.1 Current situation

1.1.1 Background

Finland is characterised by relatively high levels in energy R&D and if nuclear R&D is excluded, the government of Finland spends more than Japan and the United States on a per-GDP basis. With Finland having mainly nuclear, biomass and hydro as domestic sources, it is highly depend on energy imports. All fossil fuels need to be imported and electricity imports can reach 15 – 20% of total consumption depending on the precipitation in a particular year. Of particular concern is the security of supply. With Russia being the only supplier of oil and gas, Finland gets all of its natural gas supply from one company and through one pipeline. Currently, the government tries to reduce this vulnerability.[1]

As Finland has a small electricity market itself, it makes extensive use of trade with the Nordic electricity market as well as with Russia and the Baltics. The Nordic wholesale market composed of Sweden, Norway, Denmark and Finland is considered as one of the most competitive in the world. The electricity market of Finland is fully liberalised and the Energy Market Authority (EMA) as regulator oversees the market operations. The transmission system is owned and operated by Fingrid Oy.[2]

The Ministry of Employment and the Economy (MEE) is in charge of co-ordinating and planning within the energy policy field and conducts a Renewables and Energy Efficiency Division. The Finnish Funding Agency for Technology and Innovation (Tekes) finances R&D projects for companies, research centres and universities. The expert energy company, Motiva, operates as an affiliated Government agency and has the objective to implement policies on energy conservation and the promotion of renewable energy sources and therefore disseminates information, develops and markets energy audits as well as other management procedures to promote energy-efficient technologies. The EMA is the authority in charge of supervision of the pricing of transmission, distribution and other network services in the electricity and natural gas market.[3]

1.1.2 Current status of renewable energies

Finland's renewable energy supply is mostly driven by hydro and biomass. New renewable technologies such as wind and solar are estimated to have a great potential but still they represent a negligible amount.[4]

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[1] IEA/OECD (2008), pag. 7, 10, 22, 23 and 39

[2] IEA/OECD (2008), pag. 7, 24, 88 and 92

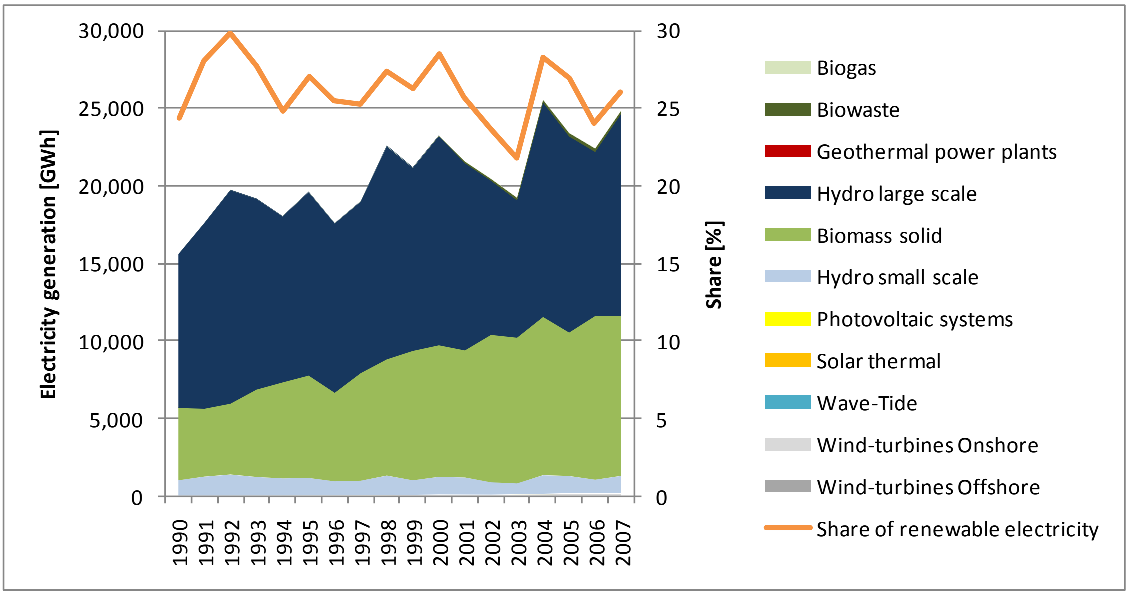
[3] IEA/OECD (2008), pag. 18-20

[4] IEA/OECD (2008), pag. 61

Electricity:

Renewable electricity generation in Finland grew from about 15,606 to 24,270 GWh between 1990 and 2007 corresponding to a compound annual growth rate (CAGR) of 2.6%. The share of renewable electricity almost remained stable with values between 24% and 26% during the same time period.[5] The development is illustrated in **Figure 1-1**.

Figure 1-1: Development of RES-Electricity generation in Finland 1990 – 2007



Source: Eurostat (2009)

In general, hydro electricity dominates the market. Its share of total renewable electricity production was 70% in 1990 and 58% in 2007, of which 92% were produced from hydro large-scale facilities. In 2007 the second highest renewable electricity market share was achieved by solid biomass. The development of photovoltaic systems, tidal & wave and wind electricity is still very low despite a relatively high potential, specifically for wind onshore and offshore electricity. Detailed renewable electricity generation data can be seen in **Table 1-1**.[6]

[5] Eurostat (2009)

[6] Ibid.

Table 1-1: Renewable electricity generation and generation growth in Finland

Technology	Electricity generation			CAGR		
	1990 [GWh]	2000 [GWh]	2007 [GWh]	1990-2007 [%]	1990-2000 [%]	2000-2007 [%]
Biogas	5	22	29	10.9	16.0	4.0
Biomass solid	4,682	8,476	9,661	4.4	6.1	1.9
Biowaste	4	35	210	27.1	25.7	29.2
Geothermal power plants	0	0	0	:	:	:
Hydro large-scale	9,867	13,468	12,972	1.6	3.2	-0.5
Hydro small-scale	1,048	1,192	1,206	0.8	1.3	0.2
Photovoltaic systems	0	2	4	:	:	10.4
Solar thermal	0	0	0	:	:	:
Tide & wave	0	0	0	:	:	:
Wind-turbines offshore	0	0	0	:	:	:
Wind-turbines onshore	0	78	188	:	:	13.4
RES-E total	15,606	23,273	24,270	2.6	4.1	0.6

Source: Eurostat (2009)

The installed capacity of both hydro large- and small-scale had a small CAGR of less than 2% between 1990 and 2007. Biomass solid and biogas achieve a CAGR of 4% and 11%, respectively. Photovoltaic systems and wind-turbines onshore entered the market later with an installed capacity average growth of 8% and 16% between 2000 and 2007 (**Table 1-2)**.[7]

Table 1-2: Renewable electricity capacity and capacity growth in Finland

Technology	Capacity			CAGR		
	1990 [MW]	2000 [MW]	2007 [MW]	1990-2007 [%]	1990-2000 [%]	2000-2007 [%]
Biogas	1	6	8	10.9	16.0	4.0
Biomass solid	983	1,500	1,757	3.5	4.3	2.3
Biowaste	1	5	0	-100.0	22.4	-100.0
Geothermal power plants	0	0	0	:	:	:
Hydro large-scale	2,322	2,574	2,786	1.1	1.0	1.1
Hydro small-scale	298	308	316	0.3	0.3	0.4
Photovoltaic systems	0	3	5	:	:	7.6
Solar thermal	0	0	0	:	:	:
Tide & wave	0	0	0	:	:	:
Wind-turbines offshore	0	0	0	:	:	:
Wind-turbines onshore	0	38	110	:	:	16.4
RES-E total	3,605	4,433	4,982	1.9	2.1	1.7

Source: Eurostat (2009)

[7] Ibid.

Heat:

Renewable heat generation had a CAGR of 3% between 1990 and 2007. The growth rate since 2000 is lower than the growth rate in the nineties. The market is dominated by solid biomass (non-grid) with a share of more than three-quarter followed up by solid biomass (grid) with 21% in 2007. Since 2000, heat pumps could achieve a CAGR of 45%, solid biomass for the grid of 18% and biowaste of 12% (**Table 1-3**).

Table 1-3: Renewable heat generation, growth and share in Finland

Technology	Generation			CAGR		
	1990 [ktoe]	2000 [ktoe]	2007 [ktoe]	1990-2007 [%]	1990-2000 [%]	2000-2007 [%]
Biogas (grid)	0.0	11.0	17.0	:	:	6.4
Solid biomass (grid)	0.0	394.0	1249.0	:	:	17.9
Biowaste (grid)	0.0	13.0	28.0	:	:	11.6
Geothermal heat (grid)	:	:	:	:	:	:
Solid biomass (non-grid)	3522.0	4903.0	4450.0	1.4	3.4	-1.4
Solar thermal heating and hot water	0.0	0.0	1.0	:	:	:
Heat pumps	:	9.7	128.1	:	:	44.5
RES-H total	3522.0	5330.7	5873.1	3.1	4.2	1.4

Source: Eurostat (2009)

Transport:

According to Eurostat, there was no consumption of biofuels in 2005. In 2006 and 2007, 1 ktoe of biofuels was consumed. The following table gives an overview of the biofuel situation in Finland.

Table 1-4: Biofuel consumption and share of biofuels in Finland

Technology	Unit	2005	2006	2007
Biodiesel	[ktoe]	:	:	:
Bioethanol	[ktoe]	0	1	1
Biofuels, total	[ktoe]	0	1	1
Share Biofuels	[%]	0.0	0.02	0.02

Source: Eurostat (2009)

1.1.3 Current renewable energy support policies

Electricity:

Companies are eligible for investment subsidies up to 40% of the construction costs for renewable energy plants in the case of wind energy. Recently, wood plants for energy and fuel production have been mostly benefitting as they received 60% of the total grants in 2006, while biogas plants received 7% of the total budget of that year. Every electricity supplier has to pay a tax per kWh, which they pass on to their end consumer. This tax is refunded to suppliers of renewable electricity. The amount of this “tax aid“, depends on the technology used; wind energy and forestry waste - 0.69 €ct/kWh; small hydropower plants and biomass systems - 0.42 €ct/kWh; recycling fuels - 0.25 €ct/kWh. Currently, additional support measures in form of feed-in tariffs or green certificates are considered for onshore wind power.[8]

Heat:

Renewable energy plants are eligible for investment subsidies of up to 30% of total construction costs. Finnish households can benefit from energy grants for residential buildings. Thereby, up to 25% of the costs can be granted as subsidy. Taxes imposed on heat are calculated on the basis of net carbon emissions. Hence, renewable heat not emitting CO_2 is freed of taxes.[9] [10]

Transport:

The law on the promotion of biofuels in transport, which was adopted on 13 April 2007, obliges the distributors of transport fuels to blend them with a certain share of biofuels. The quota was 2% in 2008 and rose to 4% in 2009 and 5.75% in 2010. Distributors not fulfilling the quota will have to pay a penalty fee.

The Law on Vehicle Tax (Ajoneuvoverolaki) provides a tax exception for vehicles using biofuels, which is not dependent on fuel type or technology.

1.2 Targets & trajectories

1.2.1 Overall renewable energy targets and trajectories

Until 2020, the share of renewables in total final energy consumption have to reach 38% according to the EU Directive, which is a challenging target regarding the initial share of 28.5% in 2005. The respective trajectories up to 2020 set by the EU can be seen in **Table 1-5**.

Table 1-5: Overall renewable energy targets and trajectories - Finland

2005	Average 2011 - 2012	Average 2013 - 2014	Average 2015 - 2016	Average 2017 - 2018	2020
28.50%	30.40%	31.35%	32.78%	34.68%	38.00%

Source: Directive 2009/28/EC

[8] EREC (2009), pag. 4, 5 and National Board of Customs, Finland (2008), pag. 10

[9] EREC (2009), pag. 5 and National Board of Customs, Finland (2008), pag. 5

[10] The Electricity Market Act No. 386/1995 (Sähkömarkkinalaki) http://www.finlex.fi/sv/laki/kaannokset/1995/en19950386.pdf

1.2.2 Sectoral targets and trajectories

Possible future developments of the renewable energy sector in Finland until 2020 have been assessed based on two scenarios using the Green-X model, the NAT and the ACT scenarios (defined in Appendix 1) and considering a moderate energy demand (based on PRIMES 20% case scenario).[11]

Finland can exceed the 2020 target by 1.6 percentage points. Renewables in the heating and cooling sector contribute the most to the gross final energy consumption in 2020 in the NAT scenario. The sector has a share of 73% of the consumption of renewables in this year in this scenario. This equals to a growth of 42% in the NAT scenario from 2005 to 2020. Detailed data is depicted in the following table.

Table 1-6: Sectoral targets and trajectories – NAT scenario Finland

Finland		NAT (National target fulfillment)					
Indicator	**Unit**	**2005**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020 Targets**
Expected Gross Final energy consumption	**Ktoe**	26,021	26,758	26,878	26,955	26,903	26,917
Total share of RES in final energy consumption	**%**	28.8%	35.5%	36.0%	36.7%	37.5%	39.6%
Gross Final Consumption of RES-E	**Ktoe**	2,027	2,452	2,487	2,557	2,502	2,462
Share of RES-E in gross final electricity consumption	**%**	26.9%	30.5%	30.3%	30.3%	28.7%	27.2%
Gross final energy consumption RES-H	**Ktoe**	5,464	6,868	6,920	7,049	7,259	7,765
Share of RES-H in final Heating and Cooling consumption	**%**	40.0%	50.0%	50.7%	52.2%	55.0%	60.3%
Final energy from renewable sources consumed in transport	**Ktoe**	0	191	257	286	328	425
Share of RES in gross final transport energy consumption	**%**	0.0%	4.4%	6.0%	6.7%	7.7%	10.0%

Source: Green-X Model (2009)

In the ACT scenario, the total share of RES in final energy consumption is with 46.5% clearly above the required 38% target in the Directive. Renewable electricity profits the most from the proactive support in the ACT scenario compared to the other two sectors and the respective consumption grows by 84% between 2005 and 2020.

[11] Results and figures for a low energy demand scenario (based on PRIMES high energy efficiency case scenario) are shown in Appendix 2.

Table 1-7: Sectoral targets and trajectories – ACT scenario Finland

Finland		ACT (proactive support - realisable deployment)					
Indicator	**Unit**	**2005**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020 Targets**
Expected Gross Final energy consumption	**Ktoe**	26,021	26,758	26,878	26,955	26,903	26,917
Total share of RES in final energy consumption	**%**	28.8%	36.7%	38.4%	40.4%	42.8%	46.5%
Gross Final Consumption of RES-E	**Ktoe**	2,027	2,609	2,852	3,133	3,375	3,734
Share of RES-E in gross final electricity consumption	**%**	26.9%	32.5%	34.7%	37.2%	38.8%	41.2%
Gross final energy consumption RES-H	**Ktoe**	5,464	7,023	7,220	7,480	7,808	8,370
Share of RES-H in final Heating and Cooling consumption	**%**	40.0%	51.2%	52.9%	55.3%	59.1%	65.0%
Final energy from renewable sources consumed in transport	**Ktoe**	0	191	257	286	328	425
Share of RES in gross final transport energy consumption	**%**	0.0%	4.4%	6.0%	6.7%	7.7%	10.0%

Source: Green-X Model (2009)

Motiva Oy likes to stress that the Ministry of Employment and the Economy published a package of obligations concerning renewable energy in April 2010 estimating the final energy consumption in 2020 of Finland to 327 TWh (28.117 ktoe) and a respective amount of 124 TWh (10.662 ktoe) of energy from renewable sources to reach the 38% target. Moreover, the document introduced a possible three-part support package to strengthen the competiveness of wood energy, which contains subsidies for wood chipping and electricity production as well as a feed-in tariff for new small plants of combined heat and power.

1.2.3 Contribution of renewables to electricity consumption

In the NAT scenario, renewable electricity consumption increases until a peak point is reached in 2015 and 2016. Afterwards, the consumption declines again.

Solid biomass and hydro large scale electricity still dominate the renewable electricity market in 2020 in the NAT scenario as in 2005. The electricity consumption from hydro large scale facilities rises only slightly from 2005 to 2020. Solid biomass can meanwhile catch up with a growth of 34% and the share in RES generation is with 43% slightly lower than the 46% of hydro large scale.

Table 1-8: Contribution of renewables to electricity consumption– NAT scenario Finland

Finland	NAT (National target fulfillment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020 Targets	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Biomass	1,748.9	9,490	2,434.2	13,579	2,507.7	13,957	2,597.7	14,444	2,410.6	13,639	2,255.0	13,152
Solid	1,720.0	9,238	2,368.2	13,194	2,434.8	13,530	2,512.3	13,943	2,307.5	13,035	2,127.1	12,410
Biogas	5.9	22	19.5	95	27.3	143	39.8	216	57.5	319	82.3	458
MSW	23.0	230	46.5	291	45.6	285	45.6	285	45.6	285	45.5	285
Liquid	:	:	:	:	:	:	:	:	:	:	:	:
Concentrated Solar Power	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Geothermal	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Hydro, total	3,089.4	13,932	3,242.1	14,397	3,250.7	14,435	3,280.9	14,573	3,285.9	14,598	3,285.9	14,598
>10MW	2,783.4	12,796	2,865.9	13,055	2,874.6	13,093	2,904.8	13,231	2,909.7	13,255	2,909.7	13,255
<10MW	306.0	1,136	376.2	1,342	376.2	1,342	376.2	1,342	376.2	1,342	376.2	1,342
Of which pumping	:	:	:	:	:	:	:	:	:	:	:	:
Photovoltaic	4.0	3	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0
Ocean	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Wind	82.0	153	217.8	541	215.4	536	287.7	726	338.3	862	344.4	884
Onshore	82.0	153	195.3	475	192.8	470	265.1	660	315.8	796	321.8	818
Offshore	0.0	0	22.5	66	22.5	66	22.5	66	22.5	66	22.5	66
Gross Final Consumption of electricity from RES	4,924.3	23,578	5,894.3	28,517	5,974.0	28,928	6,166.5	29,744	6,034.9	29,098	5,885.4	28,634

Source: Green-X Model (2009)

The consumption of renewable electricity is with the higher support levels and with lower barriers in the ACT scenario about 50% higher than in the NAT scenario. Wind electricity has a strong growth in this scenario and can reach about 8.5 TWh not only by wind onshore, which contributes about 6.5 TWh, but also by the in the NAT scenario almost unexploited wind offshore electricity.

In general, Motiva Oy foresees a lower potential on forest biomass for energy production than in this study. This is especially due to a newly implemented tax on imported wood raw material from Russia and because there is a substantial need for pulpwood in the country which cannot be used for energy production any more. Another comment concerns wind power. Motiva Oy points out that the target set in the National Climate Energy Strategy is 2.000 MW and 6 TWh, which exceeds the respective value in the NAT scenario but still is below the achieved capacity and consumption in the ACT scenario. For solar energy, the grid connection and the future support mechanisms are the main barriers, which need to be clarified to determine a possible prospective pathway.

Table 1-9: Contribution of renewables to electricity consumption– ACT scenario Finland

Finland	ACT (proactive support - realisable deployment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Biomass	1,748.9	9,490	2,610.4	14,724	2,856.8	16,226	3,055.0	17,416	2,983.8	17,364	2,959.7	17,728
Solid	1,720.0	9,238	2,543.6	14,334	2,781.5	15,783	2,964.5	16,883	2,871.1	16,698	2,805.4	16,823
Biogas	5.9	22	20.3	100	29.7	158	44.9	248	67.1	381	108.8	620
MSW	23.0	230	46.5	291	45.6	285	45.6	285	45.6	285	45.5	285
Liquid	:	:	:	:	:	:	:	:	:	:	:	:
Concentrated Solar Power	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Geothermal	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Hydro, total	3,089.4	13,932	3,274.3	14,519	3,339.5	14,774	3,380.5	14,946	3,400.9	15,032	3,400.9	15,032
>10MW	2,783.4	12,796	2,874.6	13,093	2,908.0	13,244	2,942.5	13,395	2,962.9	13,481	2,962.9	13,481
<10MW	306.0	1,136	399.8	1,426	431.5	1,531	438.0	1,551	438.0	1,551	438.0	1,551
Of which pumping	:	:	:	:	:	:	:	:	:	:	:	:
Photovoltaic	4.0	3	134.9	95	335.7	234	733.0	502	1,537.5	1,033	3,374.1	2,241
Ocean	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Wind	82.0	153	397.3	1,008	767.9	1,937	1,443.7	3,571	2,435.2	5,818	3,601.3	8,428
Onshore	82.0	153	340.4	843	683.7	1,690	1,290.5	3,110	2,154.0	4,961	3,014.8	6,626
Offshore	0.0	0	56.9	165	84.2	246	153.2	461	281.2	857	586.5	1,802
Gross Final Consumption of electricity from RES	4,924.3	23,578	6,416.9	30,346	7,299.9	33,171	8,612.2	36,436	10,357.3	39,248	13,335.9	43,430

Source: Green-X Model (2009)

1.2.4 **Contribution of renewables to heating & cooling consumption**

In both scenarios, the vast majority of the renewable heat is consumed in form of solid biomass in 2020 and has a market share of more than 90%. The development in the renewable heating and cooling sector is very similar in both cases. The ACT scenario has a higher consumption from solar thermal, heat pumps and solid biomass. Especially, the consumption of solar thermal heat is 6 times higher in the ACT scenario. Despite the high relative change, the absolute consumption of solar thermal heat remains of minor importance for the renewable heat market. More detailed data is given by **Table 1-**10 and **Table 1-**11.

Table 1-10: Contribution of renewables to heating and cooling consumption– NAT scenario Finland

Finland	NAT (National target fulfillment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe
Biomass	0	5,367	38,359	6,772	37,889	6,782	37,895	6,868	38,482	7,012	40,301	7,388
Solid	0	5,324	37,993	6,652	37,519	6,661	37,514	6,746	38,086	6,890	39,896	7,265
Biogas	:	14	155	37	164	38	175	39	190	41	200	41
Biowaste	:	29	210	83	206	82	206	82	206	82	206	81
Geothermal	:	0	0	0	0	0	0	0	0	0	0	0
Solar Thermal	:	0	11	0	11	0	10	0	10	0	691	23
Heat pumps	:	97	615	95	891	138	1,167	181	1,593	246	2,284	353
Gross final energy consumption from RES in heating and cooling	0	5,464	38,985	6,868	38,791	6,920	39,072	7,049	40,084	7,259	43,276	7,765

Source: Green-X Model (2009)

Table 1-11: Contribution of renewables to heating and cooling consumption– ACT scenario Finland

Finland	ACT (proactive support - realisable deployment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe
Biomass	0	5,367	38,359	6,880	37,890	6,988	37,895	7,142	38,483	7,356	40,314	7,782
Solid	0	5,324	37,993	6,760	37,519	6,867	37,514	7,021	38,086	7,234	39,896	7,658
Biogas	:	14	155	37	164	38	176	39	190	41	213	43
Biowaste	:	29	210	83	206	82	206	82	206	82	206	81
Geothermal	:	0	0	0	0	0	0	0	0	0	0	0
Solar Thermal	:	0	523	18	1,206	41	1,894	64	2,731	93	4,194	142
Heat pumps	:	97	810	125	1,239	192	1,768	274	2,317	359	2,882	446
Gross final energy consumption from RES in heating and cooling	0	5,464	39,692	7,023	40,334	7,220	41,557	7,480	43,530	7,808	47,390	8,370

Source: Green-X Model (2009)

1.2.5 Contribution of renewables to transport fuel consumption

While there has been no biofuels consumption at all in 2005, this value increases up to 425 ktoe in 2020. The biofuel sources are 29% bioethanol and 71% imports. Biodiesel is produced at the beginning of the decade with a peak in 2013 and 2014, but is later dropping to the favor of bioethanol and biofuel imports and already 0 in 2015 and 2016 again. 2nd generation biofuels don't play a role at all until including 2020. The following table depicts the development of biofuels. The mandatory target for biofuels of the Directive is fulfilled within this model runs.

Table 1-12: Contribution of renewables to transport consumption - all scenarios Finland

Finland		NAT			ACT		
Technology	**Unit**	**2005**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020**
Bioethanol	**ktoe**	0.0	38.4	65.4	81.2	100.9	123.1
Of which imported	**ktoe**	:	:	:	:	:	:
Biodiesel	**ktoe**	0.0	2.1	4.1	0.0	0.0	0.0
Of which imported	**ktoe**	:	:	:	:	:	:
Biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material	**ktoe**	:	0.0	0.0	0.0	0.0	0.0
Of which imported	**ktoe**	:	:	:	:	:	:
Hydrogen from RES	**ktoe**	:	:	:	:	:	:
Renewable electricity	**ktoe**	:	:	:	:	:	:
Biofuel import	**ktoe**	:	150.8	187.3	205.2	227.6	302.1
Final energy from renewable sources consumed in transport	**ktoe**	0.0	191.2	256.8	286.4	328.5	425.2

Source: Green-X Model (2009)

According with information provided by Motiva Oy, there is currently the plan of implementing a national target for biofuels of 20% by 2020. Furthermore, major energy companies, namely Neste Oil and St1, are performing research in the field of biofuels and have great expectations on the biofuel market in the near future.

1.3 Measures for achieving the target

1.3.1 Policy measures

Measures on administrative procedures, regulations and codes:

- **Should authorisation procedure take into account the specificities of different renewable energy technologies? If yes, how?**

According to Motiva Oy, the authorisation procedure should take into account the special features of each renewable energy technology.

Should the renewable energy potential be taken into account in spatial planning?

Generally RES, and their respective potential, are insufficiently taken into account in spatial planning. In many countries and regions future development of RES projects is not taken into account at the moment of drawing up spatial planning programmes. This means that spatial planning programmes have to be adopted in order to allow for the implementation of a RES project in a specific area (e.g. RES-E), especially when there is a high RES potential involved in that particular area. This process can take a very long time. Often the acquirement of permits related to spatial planning is the longest trajectory of the overall period needed for development of the project. This is especially the case for projects in the field of wind and biomass. Responsible authorities should be stimulated to anticipate the development of future RES projects in their region, by allocating suitable areas.

Spatial planning, construction permits and EIA (environmental impact assessment) procedures are key problems for regulators. In the RES-E sector to obtain the necessary permits can take years in countries where the authorities take into account the opinion of many stakeholders that are hard to harmonise. Since RES-E development is not taken into consideration in the spatial planning, every project and project variants have to be evaluated on an individual basis. The number of the often long lasting appeal procedures could be effectively decreased by including RES-E development plans in local and regional spatial planning. In Germany, for example, these problems have been solved to a large extent. In the case of onshore wind projects the administrative barriers regarding spatial planning are low thanks to the Building Code (1996), which made states designate areas for onshore wind parks. Thanks to this, a wind farm can be established within 1 year. A similar approach is being followed for offshore wind parks. The federal states and the Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) are responsible for designating areas and issuing permits for offshore wind installations.

Motiva Oy points out that the renewable energy potential should be taken into account in spatial planning and furthermore in transportation planning as it could have a great impact on the utilization of renewable energy potentials.

- **Should timetables for processing applications be communicated in advance?**

Usually long lead times are needed to obtain necessary permits. Time needed to obtain all necessary permits for the construction of a RES plant can take many years (e.g. RES-E). Also it can be unclear what the exact length of a procedure will be. Clear guidelines for authorisation procedures are highly recommended together with obligatory response periods for authorities involved in such procedures.

Motiva Oy stresses that there should be timetables communicated in advance and that a one-stop-shop solution would be a suitable possibility for Finland.

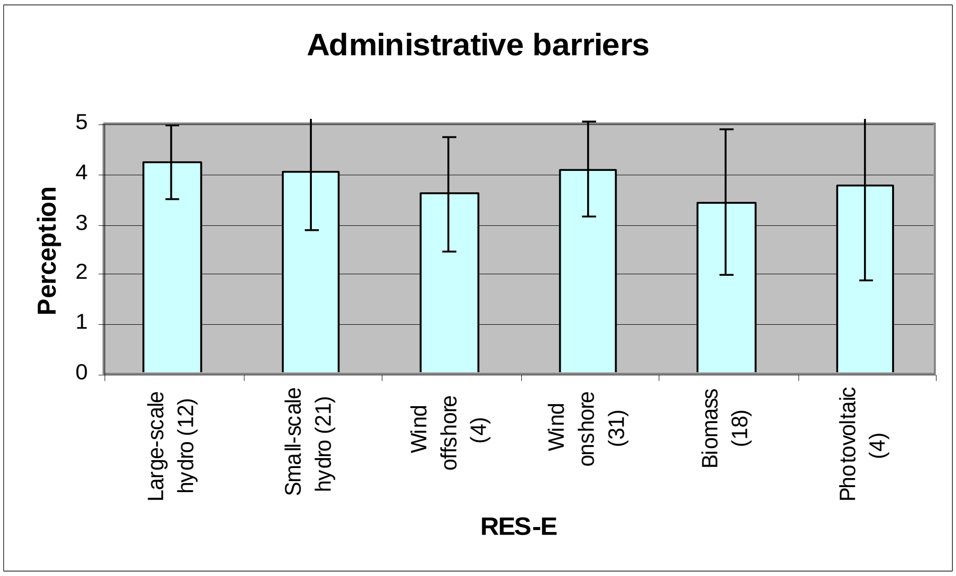
- **How many steps should be needed to obtain the final authorisation? Should there be a one-stop shop for coordinating all the steps?**

Generally, a high number of authorities are involved to obtain the final authorisation. Often many authorities are involved in both permitting as well as support related procedures for renewable energy projects. Responsible authorities usually comprise several administrative bodies at national, regional and local level. An important improvement would be to reduce the number of local, regional and national administrations involved in the authorisation processes for permits and financial support. Project developers are much more positive in situations where a single administrative body has been made responsible for co-ordination of several administrative procedures, such as the Bundesamt for off-shore wind in Germany.

Furthermore, there is a lack of co-ordination between different authorities. In many cases project developers need to submit similar information multiple times to different authorities. A suggestion to reduce the administrative burden for RES development would be to standardise procedures, such as standardized administrative requirements and application forms between different authorities.

In **Figure 1-2** the perception of administrative barriers per renewable energy source is shown, as identified by the stakeholder consultation.[12]

Figure 1-2: Perception of administrative barriers



Source: OPTRES (2007)

Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of received answers per source is provided in brackets, while standard deviation is marked by bars. Only those RES-E types with at least 4 answers have been depicted.

Figure 1-2 shows that the respondents of the stakeholder consultation perceived the administrative problems to be highest for hydropower projects and on-shore wind. However, also for the other renewable energy sources the administrative barriers are perceived an important obstacle in the development of renewable energy projects.

Motiva Oy points out possible advantages of a one-stop-shop solution. This kind of system would reduce overlapping work and harmonise the process. Furthermore, the zoning and permit processes would probably become more coherent in the different zones of Finland and information about schedules of different projects' permits could be easily provided. However, it is unclear yet when and how such a system could be established in Finland.

[12] OPTRES (2007).

Measures concerning Buildings:

- **What measures should be introduced into the building codes to ensure the share of renewable energy used in the building sector will increase?**

Policy instruments should be introduced that provide incentives for integrating a RES-H/C device into the heating/cooling system. But since RES-H/C applications operate only effectively if they are fitted to the overall system design, the chosen policy instrument should create incentives for a good overall system performance. Hence, it should also support the reduction of a building's energy consumption (e.g. by improving its insulation) and motivate for an efficient use of the RES-H/C equipment.

As far a possible the policy instrument should motivate the utilization of high efficiency equipment, e.g. through linking the financial incentives to quality standards of a determined minimum rate of efficiency.

Motiva Oy stresses, that the role of local building control is essential and that it would be important to develop and support it. New energy regulations came into force in January 2010, which steer builders to favor the use of renewable energy. While district heating is often recommended for block of flats, Motiva Oy sees heat pumps and efficient ventilation systems with heat recovery as noteworthy choices in detached houses. Measures are currently being discussed at the Ministry of Environment by experts, such as by RE industry members, who therewith can have a direct influence on the forthcoming building codes.

- **How should an obligation for minimum levels of renewable energy in new and newly refurbished buildings be drafted to best ensure renewable energy integration in buildings? At what levels should it be set?**

The obligation should take the different target groups and their different needs into account and might be different for each of these groups. The target groups are private homeowners living in their own home, homeowners renting to others as well as private, municipal and social housing organizations. As such companies often own and manage a large number of buildings they can become a key driver (but also key barrier) for switching buildings to RES-H/C.

Whereas housing companies often have sufficient technical skills to handle even innovative RES-H/C technologies they generally base their economic calculation on shorter pay back times e.g. private building owners in the domestic sector. In addition, the level of willingness to pay might generally be lower than with small scale investors. These circumstances should be considered in the setting of minimum levels for RES and in the corresponding support schemes.

From the perspective of the building owner (investor) apart from the level of support one of the main indicators is the share of the investment costs he can and/or legally is allowed to allocate to the tenants (by increasing the rent). From the perspective of tenants the crucial question concerns the relationship between the financial burden that might derive from an allocation of the investment costs on the rent and potentially reduced costs for heating/cooling due to the reduced use of conventional fuel.

The chosen obligation should ensure that investment is still effectively motivated. Costs for building owners and tenants shall not be too high to discourage investments (e.g. by postponing the reconstruction of heating systems as long as possible).

In the workshop about the Finnish case, different aspects were raised by participants. Similar obligations were already implemented in other European countries and have lead to the adoption of solar systems and small scale wind mills. The Finnish Wind Energy Association backs up such a regulation as long as investment and energy subsidies are available for renewable energy, too. A concrete example mentioned would be that municipalities could get tax reliefs from the state in case they prefer energy efficient neighborhoods in their planning or that private persons and societies in energy efficient buildings receive tax breaks. However, Motiva Oy is the opinion that it is not likely that such measures come in force in near future.

- **What is the projected increase of renewable energy use in the building sector until 2020?**

Motiva Oy points out that currently no target in the building sector is set making it difficult to project an increase of renewable energy in the building sector.

Measures on information:

- **How should specific information be targeted at different groups, as end consumers, builders, property managers, property agents, installers, architects, farmers, suppliers of equipment using renewable energy sources, public administration?**

The question is basically about information sharing to all stakeholders. General information for example about subsidies for renewable technologies needs to be broadcasted to all stakeholders. As the internet offers 24 hours access to information and can be updated easily, a base for general information would be a web page. A best practice examples is given in Luxembourg, where Subsidies for heat in households are communicated with the information paper “Förderprogramm zur Energieeinsparung und Nutzung erneuerbarer Energien im Wohnbereich” of the Ministère de l'Environnement of Luxembourg in an easy manner. Thereby, the paper targets not only public administration, but also especially end consumers, property managers and agents, installers and architects and is kept in an understandable and clear style.

End users can be informed by customer information brochures about the possibility to make use of support for renewables. The information brochures can be shared among installers, property managers and suppliers of equipment to hand them over to the end consumers.

Furthermore, there could be a subsidy for consultancy on renewable energy and energy efficiency related topics for end consumers. This would give the advantage, that consumers would choose the most appropriate efficiency and renewable energy option according to an energy expert.

Renewable energy and energy efficiency exhibitions are a great possibility to get to know information physically and are therefore for energy experts as well as for technology end consumers adequate. With expositions, it is possible to share specific information as well. For instance, the SOLTEC exhibition in Germany is mainly focusing on solar technologies and through this focus, information can be shared in more detail.[13]

Workshops and speeches provide the possibility to share specific information only of major interest for a small target group. Workshops and speeches can be integrated to exhibitions as well.

Experts and public administration members need the most up to date information having a higher degree of details than the ones for example for end users. Regularly reports published by the responsible administrative bodies keep the legal framework up-to-date. A best practice example is the German "Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit", which published a brochure of the environment policy from 2005 to 2009 in July 2009 being detailed and giving an overview of the topic as well.14 With published articles in RES journals, the dynamics of the market can be analyzed in detail.

Specific information for a smaller target group can be shared via internet as well. It would be possible to establish a work group in a small field of work being responsible for specific field publishing news on their own internet platform.

Motiva Oy stresses that there is ongoing informative support through several alternative sources of information and that information about the possibilities to combine different support measures would be of special interest. Current programs cover e.g. energy efficiency agreements and energy audits for different sectors in Finland as well as consumer advice. With these programs and through the advisors, information on both renewable energy and on energy efficiency is provided.

- **How should guidance for planners and architects be provided to help them consider the optimal combination of renewable energy sources, high efficiency technologies and district heating and cooling when planning, designing, building and renovating industrial or residential areas?**

Planners and architects should be provided with an internet platform that holds information on possible options of including renewable energy, high efficiency technologies and districts heating and cooling into new or existing buildings. It should not only contain up-to-date

[13] Information about the exhibition is given on the web page: http://www.soltec.de/s

[14] Document available on http://www.bmu.de/ministerium/aufgaben/aufgaben/doc/44214.php

information on technology, how it can be installed and how profitable such investments are on the long run. It should also include detailed information on successfully completed exemplary projects, legislation and events related to the topic. Local information on the applicability of solar technology and the availability of district heating and cooling is desirable. Furthermore it should be possible to order printed copies of the contained information as well as publications explaining the various concerns in greater detail. Contact information to all relevant professional associations and their local members would complete the web page's content.

The information should be gathered in consultation with experts in energy, technology, construction and installation and be updated continuously to secure a high level of relevance and actuality. The web page should be supervised with the help of the chambers of architects as well as planners associations respectively consumers advice centers to secure that the target groups are addressed properly. These organizations could also contact their members and customers to raise the web page's awareness level within the target groups.

It is the opinion of Motiva Oy that different administrative sectors such as the Ministry of Education and the Ministry of Employment and the Economy should cooperate in order to ensure a proper training on energy issues for architects and designers.

Measures on electricity infrastructure development:

For the future electricity infrastructure, Motiva Oy likes to stress that remote electricity meters will be installed in the near future enabling the adoption of intelligent electricity networks, which could facilitate the decentralized energy production.

- **Should there be priority connection rights or reserved connection capacities provided for new installations producing electricity from renewable energy sources?**

In general and according to stakeholder consultation, the legally guaranteed access to the grid for RES-E sources and priority transmission and distribution is not considered as a key barrier in countries where this guarantee is currently not applied.

Introduction of positive discrimination of RES-E as regards the guarantee of grid access or transmission and distribution of RES-E, however, may become an additional motivating factor for reasons of investment security, low transaction costs and the acknowledgement of RES-E system benefits.

Priority/Guaranteed Access to the grid:

In Finland, plants generating electricity from renewable energy sources are entitled to preferential connection to the grid (Reg. 7 (2) PRESR). The plant operator is contractually entitled to the conclusion of an agreement of connection with the grid operator EneFinland. The contractual terms shall comply with the network code. Furthermore, RES-E sources are also granted priority in dispatch.

The costs of a connection to the grid are borne by the plant operator, but some authorities may require the grid operator to bear the full or partial costs for grid extensions and upstream grid reinforcements. There is a relatively shallow level of connection sharing. Due to the low penetration of RES-E, the legal framework does not currently provide for special regulations on the distribution of the costs arising from the promotion system. The plant operator is entitled to the expansion of the upstream grid as specified by the agreement of connection. All other costs arising from the preferential treatment of RES-E (e.g. forecast of production and balancing) are borne by the grid operator.

- **Should priority or guaranteed access be ensured? Explain.**

Priority grid access is an essential condition for the rapid expansion of renewable energies. In Member States in which it is applied it has enabled new entrants to the market in particular to supply and sell the power they have generated under clear-cut conditions and at foreseeable costs. Priority grid connection prevents the existing oligopolies from squeezing out renewable energy producers, especially in markets where networks and generation capacity are largely in the hands of similarly-sized companies.

- **How should it be ensured that transmission system operators, when dispatching electricity generating installations give priority to those using renewable energy sources?**

Clear statutory regulations and consistent enforcement are required.

- **How should the transmission and distribution of electricity from renewable energy sources be guaranteed by the transmission and distribution system operators?**

1.3.2 Financial support

Table 1-13 gives an indication on the necessary financial support by illustrating the weighted average (2011 to 2020) levelised (to a period of 15 years) total remuneration per MWh of RES generation for new installations in the investigated cases (NAT and ACT). This shows the gross support requirements as besides the financial premium offered by a RES support scheme also default revenues from the selling of the produced energy on the related energy market are included.[15] Gross figures were selected here as net expenditures largely depend

15 For the case of small-scale RES heating systems this shall mean the price of heat supply based on a typical conventional reference technology.

on the future development of energy and carbon prices at European as well as at global scale.[16]

A comparison of the technology- or sector-specific figures by scenario shows significant differences between both cases. This illustrates the need to increase support levels if an ambitious and accelerated RES deployment is targeted. However, the figures of the ACT case represent the upper limit of such support requirements, where a fine tuning of the EU-wide equally conditioned technology-specific support levels to the circumstances in Finland offers a significant potential for cost reduction.[17]

Consequently, if Finland follows the NAT policy track the support requirements would decrease significantly. An important precondition for that is, however, that the implemented RES policy needs to be classified as stable and the investor's risk is reduced to a low level (e.g. by offering a guaranteed duration of support (incl. support levels)).

Table 1-13: Weighted average (2011 to 2020) total remuneration for yearly new RES installation in Finland – NAT and ACT scenario

RES policy indicator (i.e. required total remuneration)	Weighted average (2011 to 2020) total remuneration for yearly new RES installations [€/MWh$_{RES}$]	
	NAT (National target fulfillment)	ACT (proactive support - realisable deployment)
Biogas	61.3	106.3
(Solid) Biomass	63.7	130.5
Biowaste	57.1	95.7
Geothermal electricity	0.0	0.0
Hydro large-scale	61.5	106.1
Hydro small-scale	0.0	108.2
Photovoltaics	0.0	350.3
Solar thermal electricity	0.0	0.0
Tide & Wave	0.0	0.0
Wind onshore	62.1	87.5
Wind offshore	0.0	106.5
RES-E (average)	63.3	137.8
RES heat (district heat)	49.2	78.8
RES heat (decentral)	86.8	129.0
Biofuel (average)	101.7	101.7

16 Obviously, also gross figures are not independent from the future development of energy prices. As the price development for energy related equipment in the years before the financial crisis (2008) has shown, prices (and largely also cost) for most types of power plants coincided to a large extent with rising energy and raw material prices.

The overall impact of energy prices on support cost is however seen larger on net compared to gross figures.

17 Compare e.g. total remuneration for RES in the heat sector: Although support is significantly higher in the ACT case differences in terms of resulting RES deployment are comparatively small.

Source: Green-X Model (2009)

1.3.3 Increasing biomass availability

The total primary energy use of biomass in 2020 is with 10,444 ktoe in the NAT and 11,862 ktoe in the ACT scenarios similar in both scenarios.

In both scenarios, forestry products and forestry residues are strongly dominating the market, while only small amounts of biomass get imported.

Table 1-14: Availability of biomass in Finland – NAT scenario

Finland		NAT (National target fulfillment)			
Feedstock category	Unit	Total 2015	Imports 2015	Total 2020	Imports 2020
Agricultural products	[ktoe]	168	35	220	129
Agricultural residues	[ktoe]	329	:	407	:
Forestry products	[ktoe]	4,976	:	5,259	:
Forestry residues	[ktoe]	3,872	153	3,970	183
Biowaste	[ktoe]	233	:	275	:
Total biomass availibility	[ktoe]	9,765		10,444	

Source: Green-X Model (2009)

Table 1-15: Availability of biomass in Finland – ACT scenario

Finland		ACT (proactive support - realisable deployment)			
Feedstock category	Unit	Total 2015	Imports 2015	Total 2020	Imports 2020
Agricultural products	[ktoe]	217	35	267	129
Agricultural residues	[ktoe]	334	:	448	:
Forestry products	[ktoe]	5,573	:	6,046	:
Forestry residues	[ktoe]	3,872	313	4,020	675
Biowaste	[ktoe]	234	:	276	:
Total biomass availibility	[ktoe]	10,577		11,862	

Source: Green-X Model (2009)

1.3.4 Flexibility/Joint projects/European perspective

Excess and deficit production of renewable energy compared to the indicative trajectory

Table 1-16 (NAT), **Table 1-17** (EU)[18] and **Table 1-18** (ACT) depict that Finland will have an excess in RES production every year under all discussed policy cases considering the indicative trajectory of the national 2020 RES target. Given the implemented cooperation

[18] Defined in Annex 1.

mechanisms in the RES directive this represents an opportunity for additional incomes to compensate Finland's policy expenditures. The excess generation can be virtually exported by means of e.g. statistical transfers to other EU member states possessing a deficit in RES deployment compared to their given RES targets.

Motiva Oy points out that co-operation mechanisms are currently not intended to be used.

Table 1-16: Excess and deficit production of renewables compared to the indicative trajectory in Finland – NAT scenario

Finland		NAT (National target fulfillment)				
Sector	**Unit**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020**
Excess	**[ktoe]**	1,377	1,238	1,058	761	424
Deficit	**[ktoe]**	:	:	:	:	:

Source: Green-X Model (2009)

Table 1-17: Excess and deficit production of renewables compared to the indicative trajectory in Finland – EU scenario

Finland		EU (European perspercitve)				
Sector	**Unit**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020**
Excess	**[ktoe]**	1,433	1,362	1,332	1,170	900
Deficit	**[ktoe]**	:	:	:	:	:

Source: Green-X Model (2009)

Table 1-18: Excess and deficit production of renewables compared to the indicative trajectory in Finland – ACT scenario

Finland		ACT (proactive support - realisable deployment)				
Sector	**Unit**	**Average 2011 - 2012**	**Average 2013 - 2014**	**Average 2015 - 2016**	**Average 2017 - 2018**	**2020**
Excess	**[ktoe]**	1,689	1,903	2,065	2,183	2,301
Deficit	**[ktoe]**	:	:	:	:	:

Source: Green-X Model (2009)

1.4 Estimated costs & benefits of RES policy support measures

Expected renewable energy use

The consumption of renewable energy is 10,652 ktoe in the NAT and 12,530 ktoe in the ACT scenario in 2020.

RES-H is the most important source of renewable energy in both scenarios and has a share in total consumption of renewables of 73% in the NAT and 67% in the ACT scenario.

Expected GHG reduction

The cumulative savings of CO_2 emissions between 2005 and 2020 from new plants are 174 $MtCO_2$ in the NAT. The savings in the ACT scenario are well above with 251 $MtCO_2$.

With the higher support in the ACT scenario, the relative saving of CO_2 in the electricity sector is with roughly two third the highest. The reason is a higher GHG reduction in the electricity sector, while the savings in the heat and electricity sector are pretty much the same compared to the NAT scenario. The contribution of the transport sector is marginal in both scenarios.

Expected job creation

The effects on the job market are based on the study EmployRES published by Fraunhofer ISI, EEG, Rütter + Partner, LEI and SEURECO. In this study, the total gross employees due to the renewable energy field are analyzed in three scenarios. The first scenario is a business as usual scenario (BAU scenario) assuming the current renewable energy policy will be retained. The second scenario assumes a stronger RES policy (advanced policy scenario) and is comparable to the EU scenario of Green-X. The third scenario is a hypothetical scenario assuming that no further support for renewables is given after 2006.

The efforts to achieve the target to produce 38% of Finland's energy from renewable sources will add in the BAU and advanced policy scenario the following total gross jobs figures:

Table 1-19: Additional employees in the renewable energy sector of Finland

Indicator	Unit	2010	2015	2020
BAU scenario	**1000 employees**	38.5	37.1	47.9
Advanced policy scenario	**1000 employees**	39.2	39.5	52.3

Source: Fraunhofer ISI; EEG; Rütter + Partner; LEI; SEURECO (2009)

Avoided fossil fuel imports

Avoided fossil fuel imports in energy terms:

Cumulatively seen, the avoided fossil fuels in energy terms in all three sectors between 2005 and 2020 are 55 Mtoe in the NAT and 78 Mtoe in the ACT scenario.

While in the NAT scenario almost half of the avoidance is due to the electricity and the other half to the heat sector, the share of the electricity sector is with 60% higher in the ACT scenario. The contribution of the transport sector is marginal.

Avoided fossil fuel imports in monetary terms:

The cumulative avoided fossil fuels in monetary terms is 18,340 M€ in the NAT scenario and 24,251 M€ in the ACT scenario. In both scenarios the RES-E and RES-H sectors represent the mayor contribution with more than 90% of the total avoided fossil fuels in monetary terms.

Avoided external costs

To obtain the avoided external costs, the total avoided GHG emissions of the scenarios got multiplied with the future CO_2 prices as expected in the Green-X model.

In 2020, the avoided external costs in Finland are 790 M€ in the NAT and 1,278 M€ in the ACT scenario.

Expected capital expenditures

The cumulative capital expenditures between 2005 and 2020 are the lowest in the NAT scenario with 15,302 M€. The respective costs in the ACT scenario are higher with 32,435 M€.

In terms of a sectoral breakdown the highest capital expenditures are reached in the NAT scenario in the heat sector (67%), while the highest ones of the ACT scenario are reached in the electricity sector (60%). In both scenarios, investments in the transport sector are practically not made.

Expected costs of achieving the 2020 target

Policy costs:

The policy costs differ strongly in both scenarios. Cumulatively calculated between 2005 and 2020, the consumer expenditures due to RES support are the lowest in the NAT scenario (1,926 M€) and get higher in the ACT scenario (23,691 M€).

In the national target fulfillment scenario, the highest expenditures have to be made in 2010 consisting of costs for the electricity and heat sector. Transport creates no costs in 2010 but in 2015 and is increasing up to 72 M€ in 2020. 54% of the cumulated policy costs between 2005 and 2020 are created by the electricity segment followed by transport (34%) and heat (12%).

In the ACT scenario, the proactive support results in high expenditures. The annual consumer expenditures due to RES support are very high in 2015 (1,954 M€) and even increase to 3,995 M€ in 2020. The cumulative costs are mainly caused by the RES-H sector (62%). That shows, compared to the NAT scenario, that higher support levels require higher expenditures mainly in the heating and cooling sectors.

Additional generation costs:

The cumulative additional generation costs between 2005 and 2020 are 268 M€ in the NAT scenario. The additional costs increase to 3,510 M€ in the ACT scenario due to the higher support.

The costs differ strongly among the scenarios. In the NAT scenario, almost 90%of the additional costs are caused by the transport sector. In the ACT scenario over 90% of the costs are because of the electricity sector.

1.5 References

EEG. (2005). The Green-X Model.

EREC. (2009). Renewable energy policy review - Finland. Retrieved from http://www.erec.org/policy/national-policy.html

Eurostat. (2009). Eurostat. Retrieved 2009, from http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

Fraunhofer ISI; EEG; Rütter + Partner; LEI; SEURECO. (2009). EmployRES - The impact of renewable energy policy on economic growth and employment in the European Union. Retrieved July 2009, 17, from http://ec.europa.eu/energy/renewables/studies/renewables_en.htm

IEA/OECD. (2008). Energy Policies of IEA Countries - Finland 2007 Review. Paris.

National Board of Customs, Finland. (2008, April). Energy excise duties. Retrieved June 9, 2009, from http://www.tulli.fi/en/finnish_customs/publications/excise_tax/excise_taxation/021_2008.pdf

Ragwitz, M., Resch, G., Morthorst, P.E., Coenraads, R., Konstantinaviciute, I., Heyder, B. (2007). OPTRES – "Assessment and optimization of renewable energy support schemes in the European electricity market". http://ec.europa.eu/energy/renewables/studies/doc/renewables/2007_02_optres.pdf

Appendix 1 - Overview on investigated cases

Within this project we have calculated three different scenarios of the future renewable energy development up to 2020. These scenarios are meant to form a basis for establishing the 27 national energy roadmaps. The following gives an overview of the three aims of the scenarios. Generally, in all scenarios it is preconditioned to pursue the overall 20% RES by 2020 on EU scale. All results of the scenario calculations are depicted in terms of RES deployment as well as the associated costs and benefits.

NAT – National target fulfillment:

Within the NAT scenario each Member States tries to fulfil its national RES target by its own. The use of cooperation mechanisms as agreed in the RES Directive is reduced to necessary minimum: For the exceptional case that a member state would not possess sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a member state possesses barely sufficient RES potentials, but their exploitation would cause significantly higher consumer expenditures compared to the EU average, cooperation would serve as complementary tool to assure target achievement. As a consequence of above, the required RES support will differ comparatively large among the countries.

EU – European perspective:

In contrast to the NAT case, within the EU scenario the use of cooperation mechanisms does not represent the exceptional case: If a member state would not possess sufficient potentials that can be economically[19] exploited, cooperation mechanisms as defined in the RES directive would serve as a complementary option. Consequently, the prior aim of the EU scenario is to fulfil the 20% RES target on EU level, rather than fulfilling each national RES target purely domestically. Generally, it reflects a 'least cost' strategy in terms of consumer expenditures (due to RES support). In contrast to simple short-term least cost policy approaches, the applied technology-specification of RES support does however still allow an EU-wide well balanced RES portfolio.

ACT – proactive support – realizable deployment:

Finally, the ACT scenario depicts an optimistic future with respect to RES exploitation. The assumption is taken that all EU member states apply proactive RES support whereby EU-wide equal incentives are preconditioned for individual RES technologies (e.g. by applying a harmonised but technology-specific premium feed-in system to support RES-E). With EU-

[19] In the EU case economic restrictions are applied to limit differences in applied financial RES support among countries to an adequately low level. Consequently, if support in a country with low RES potentials and / or an ambitious RES target exceeds the upper boundary, the remaining gap to its RES target would be covered in line with the flexibility regime as defined in the RES Directive via (virtual) imports from other countries.

wide effective and efficient RES support this scenario ends up with a higher RES exploitation as foreseen in the RES directive.

Appendix 2 - Results and figures for a low energy demand

<u>Based on PRIMES high energy efficiency case scenario</u>

Sectoral targets and trajectories – NAT scenario Finland

Finland		NAT (National target fulfillment)					
Indicator	Unit	2005	Average 2011 - 2012	Average 2013 - 2014	Average 2015 - 2016	Average 2017 - 2018	2020 Targets
Expected Gross Final energy consumption	Ktoe	26,021	26,336	25,654	25,059	24,621	24,111
Total share of RES in final energy consumption	%	28.8%	36.0%	37.6%	39.3%	40.7%	43.7%
Gross Final Consumption of RES-E	Ktoe	2,027	2,444	2,479	2,541	2,478	2,423
Share of RES-E in gross final electricity consumption	%	26.9%	29.9%	30.8%	32.0%	31.3%	30.7%
Gross final energy consumption RES-H	Ktoe	5,464	6,857	6,911	7,032	7,240	7,738
Share of RES-H in final Heating and Cooling consumption	%	40.0%	52.0%	54.3%	56.9%	60.0%	66.0%
Final energy from renewable sources consumed in transport	Ktoe	0	189	250	272	304	381
Share of RES in gross final transport energy consumption	%	0.0%	4.4%	6.0%	6.7%	7.7%	10.0%

Source: Green-X Model (2009)

Sectoral targets and trajectories – ACT scenario Finland

Finland		ACT (proactive support - realisable deployment)					
Indicator	Unit	2005	Average 2011 - 2012	Average 2013 - 2014	Average 2015 - 2016	Average 2017 - 2018	2020 Targets
Expected Gross Final energy consumption	Ktoe	26,021	26,336	25,654	25,059	24,621	24,111
Total share of RES in final energy consumption	%	28.8%	37.3%	40.2%	43.4%	46.6%	51.0%
Gross Final Consumption of RES-E	Ktoe	2,027	2,609	2,852	3,133	3,369	3,577
Share of RES-E in gross final electricity consumption	%	26.9%	31.9%	35.5%	39.5%	42.6%	45.3%
Gross final energy consumption RES-H	Ktoe	5,464	7,023	7,220	7,480	7,802	8,335
Share of RES-H in final Heating and Cooling consumption	%	40.0%	53.3%	56.7%	60.5%	64.7%	71.0%
Final energy from renewable sources consumed in transport	Ktoe	0	189	250	272	304	381
Share of RES in gross final transport energy consumption	%	0.0%	4.4%	6.0%	6.7%	7.7%	10.0%

Source: Green-X Model (2009)

Contribution of renewables to electricity consumption – NAT scenario Finland

Finland	NAT (National target fulfillment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020 Targets	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Biomass	1,748.9	9,490	2,419.8	13,485	2,493.3	13,863	2,568.3	14,252	2,372.1	13,392	2,199.2	12,798
Solid	1,720.0	9,238	2,353.8	13,100	2,420.4	13,436	2,483.8	13,758	2,275.4	12,826	2,084.8	12,136
Biogas	5.9	22	19.5	95	27.3	143	38.9	210	51.2	281	68.9	377
MSW	23.0	230	46.5	291	45.6	285	45.6	285	45.6	285	45.5	285
Liquid	:	:	:	:	:	:	:	:	:	:	:	:
Concentrated Solar Power	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Geothermal	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Hydro, total	3,089.4	13,932	3,242.1	14,397	3,250.7	14,435	3,280.9	14,573	3,285.9	14,598	3,285.9	14,598
>10MW	2,783.4	12,796	2,865.9	13,055	2,874.6	13,093	2,904.8	13,231	2,909.7	13,255	2,909.7	13,255
<10MW	306.0	1,136	376.2	1,342	376.2	1,342	376.2	1,342	376.2	1,342	376.2	1,342
Of which pumping	:	:	:	:	:	:	:	:	:	:	:	:
Photovoltaic	4.0	3	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0
Ocean	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Wind	82.0	153	217.8	541	215.4	536	287.7	726	326.6	831	303.2	780
Onshore	82.0	153	195.3	475	192.8	470	265.1	660	304.1	765	280.7	714
Offshore	0.0	0	22.5	66	22.5	66	22.5	66	22.5	66	22.5	66
Gross Final Consumption of electricity from RES	4,924.3	23,578	5,879.9	28,423	5,959.6	28,834	6,137.1	29,552	5,984.7	28,821	5,788.4	28,176

Source: Green-X Model (2009)

Contribution of renewables to electricity consumption – ACT scenario Finland

Finland	ACT (proactive support - realisable deployment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Biomass	1,748.9	9,490	2,610.4	14,724	2,856.8	16,226	3,055.0	17,416	2,974.3	17,302	2,902.7	17,358
Solid	1,720.0	9,238	2,543.6	14,334	2,781.5	15,783	2,964.5	16,883	2,861.6	16,636	2,748.4	16,453
Biogas	5.9	22	20.3	100	29.7	158	44.9	248	67.1	381	108.8	620
MSW	23.0	230	46.5	291	45.6	285	45.6	285	45.6	285	45.5	285
Liquid	:	:	:	:	:	:	:	:	:	:	:	:
Concentrated Solar Power	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Geothermal	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Hydro, total	3,089.4	13,932	3,274.3	14,519	3,339.5	14,774	3,380.5	14,946	3,400.9	15,032	3,400.9	15,032
>10MW	2,783.4	12,796	2,874.6	13,093	2,908.0	13,244	2,942.5	13,395	2,962.9	13,481	2,962.9	13,481
<10MW	306.0	1,136	399.8	1,426	431.5	1,531	438.0	1,551	438.0	1,551	438.0	1,551
Of which pumping	:	:	:	:	:	:	:	:	:	:	:	:
Photovoltaic	4.0	3	134.9	95	335.7	234	733.0	502	1,537.5	1,033	3,374.1	2,241
Ocean	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Wind	82.0	153	397.3	1,008	767.9	1,937	1,443.7	3,571	2,435.2	5,818	2,967.6	6,971
Onshore	82.0	153	340.4	843	683.7	1,690	1,290.5	3,110	2,154.0	4,961	2,635.9	5,962
Offshore	0.0	0	56.9	165	84.2	246	153.2	461	281.2	857	331.8	1,008
Gross Final Consumption of electricity from RES	4,924.3	23,578	6,416.9	30,346	7,299.9	33,171	8,612.2	36,436	10,347.8	39,186	12,645.3	41,602

Source: Green-X Model (2009)

Contribution of renewables to heating and cooling consumption – NAT scenario Finland

Finland	NAT (National target fulfillment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe
Biomass	0	5,367	38,326	6,762	37,868	6,774	37,850	6,851	38,415	6,993	40,202	7,362
Solid	0	5,324	37,960	6,642	37,498	6,653	37,470	6,730	38,028	6,871	39,810	7,240
Biogas	:	14	155	37	164	38	174	39	181	40	187	40
Biowaste	:	29	210	83	206	82	206	82	206	82	206	81
Geothermal	:	0	0	0	0	0	0	0	0	0	0	0
Solar Thermal	:	0	11	0	11	0	10	0	10	0	691	23
Heat pumps	:	97	611	95	889	138	1,166	181	1,592	246	2,283	353
Gross final energy consumption from RES in heating and cooling	0	5,464	38,948	6,857	38,768	6,911	39,027	7,032	40,017	7,240	43,177	7,738

Source: Green-X Model (2009)

Contribution of renewables to heating and cooling consumption – ACT scenario Finland

Finland	ACT (proactive support - realisable deployment)											
Technology	2005		Average 2011 - 2012		Average 2013 - 2014		Average 2015 - 2016		Average 2017 - 2018		2020	
	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe	MWth	Ktoe
Biomass	0	5,367	38,865	6,880	38,794	6,988	39,076	7,142	39,918	7,351	41,806	7,746
Solid	0	5,324	38,499	6,760	38,424	6,867	38,694	7,021	39,521	7,228	41,387	7,623
Biogas	:	14	155	37	164	38	176	39	190	41	213	43
Biowaste	:	29	210	83	206	82	206	82	206	82	206	81
Geothermal	:	0	0	0	0	0	0	0	0	0	0	0
Solar Thermal	:	0	523	18	1,206	41	1,894	64	2,731	93	4,194	142
Heat pumps	:	97	810	125	1,239	192	1,768	274	2,317	359	2,882	446
Gross final energy consumption from RES in heating and cooling	0	5,464	40,198	7,023	41,239	7,220	42,738	7,480	44,966	7,802	48,882	8,335

Source: Green-X Model (2009)

Contribution of renewables to transport consumption – all scenarios Finland

Finland		NAT			ACT		
Technology	Unit	2005	Average 2011 - 2012	Average 2013 - 2014	Average 2015 - 2016	Average 2017 - 2018	2020
Bioethanol	ktoe	0.0	38.4	65.4	81.2	100.9	123.1
Of which imported	ktoe	:	:	:	:	:	:
Biodiesel	ktoe	0.0	2.1	4.1	0.0	0.0	0.0
Of which imported	ktoe	:	:	:	:	:	:
Biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material	ktoe	:	0.0	0.0	0.0	0.0	0.0
Of which imported	ktoe	:	:	:	:	:	:
Hydrogen from RES	ktoe	:	:	:	:	:	:
Renewable electricity	ktoe	:	:	:	:	:	:
Biofuel import	ktoe	:	148.8	180.7	191.0	203.1	257.8
Final energy from renewable sources consumed in transport	ktoe	0.0	189.3	250.2	272.2	304.0	380.9

Source: Green-X Model (2009)

Appendix 3 - Short characterization of the Green-X model

As in previous projects such as FORRES 2020, OPTRES or PROGRESS the ***Green-X*** model was applied to again perform a detailed quantitative assessment of the future deployment of renewable energies on country-, sectoral- as well as technology level. The core strength of this tool lies on the detailed RES resource and technology representation accompanied by a thorough energy policy description, which allows assessing various policy options with respect to resulting costs and benefits. A short characterisation of the model is given below, whilst for a detailed description we refer to www.green-x.at.

*Short characterisation of the **Green-X** model*

*The model **Green-X** has been developed by the Energy Economics Group (EEG) at Vienna University of Technology in the research project "Green-X – Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market", a joint European research project funded within the 5th framework program of the European Commission, DG Research (Contract No. ENG2-CT-2002-00607). Initially focussed on the electricity sector, this tool and its database on RES potentials and costs have been extended within follow-up activities to incorporate renewable energy technologies within all energy sectors.*

***Green-X** covers geographically the EU-27, and can easily be extended to other countries such as Turkey, Croatia or Norway. It allows to investigate the future deployment of RES as well as accompanying cost – comprising capital expenditures, additional generation cost (of RES compared to conventional options), consumer expenditures due to applied supporting policies, etc. – and benefits – i.e. contribution to supply security (avoidance of fossil fuels) and corresponding carbon emission avoidance. Thereby, results are derived at country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2020, accompanied by concise out-looks for the period beyond 2020 (up to 2030).*

Within the model, the most important RES-Electricity (i.e. biogas, biomass, biowaste, wind on- & offshore, hydropower large- & small-scale, solar thermal electricity, photovoltaics, tidal stream & wave power, geothermal electricity), RES-Heat technologies (i.e. biomass – subdivided into log wood, wood chips, pellets, grid-connected heat -, geothermal (grid-connected) heat, heat pumps and solar thermal heat) and RES-Transport options (e.g. first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulotic bioethanol, BtL) as well as the impact of biofuel imports) are described for each investigated country by means of dynamic cost-resource curves. This allows besides the formal description of potentials and costs a detailed representation of dynamic aspects such as technological learning and technology diffusion.

Besides the detailed RES technology representation the core strength of the model is the in-depth energy policy representation. Green-X is fully suitable to investigate the impact of applying (combinations of) different energy policy instruments (e.g. quota obligations based on tradable green certificates / guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at country- or at European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.