

Estimate of surplus potential

Using projections from NREAPs Task 2.1 of
RES4less



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Grant agreement no. IEE-09/999/S12.558312

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November 2011

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Acknowledgement/Preface

This working document reports activities for Task 2.1 of the Intelligent Energy Europe supported project RES4Less.



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Summary

The following questions are addressed in this report:

- a) What is the amount of surplus or deficit for renewable consumption to be expected from the National Renewable Energy Action Plans (NREAP)?
- b) Which are the marginal technologies that Member States have available for trading?

The method applied in this report is to make an inventory of technologies with the highest marginal production costs, thereby considering all three renewable sectors (electricity, heat and transport). The most expensive technologies are then be summed until the total amount equals the surplus.

The countries for which an excess or a deficit has been reported are discussed and suggestions are made for the technologies the excess is consisting of, or which technologies are available to supply the deficit.

Of the 27 European Member States 13 countries reported information on an anticipated excess or deficit of renewable energy by 2020. Two (or three) countries reported a deficit: Italy and Luxembourg (and possibly Estonia). Eleven (or ten) countries reported an excess: Bulgaria, Denmark, Germany, Greece, Spain, Italy, Lithuania, Luxembourg, Hungary, Malta, Slovakia and Sweden (and possibly Estonia).

The report end with conclusions on the methodology applied and provides recommendations for the assessment with the RESolve model in future analyses of the RES4Less project.



1. Introduction

1.1. Task description

From the project plan the following task description is treated in this working document:

Task 2.1 Estimate of surplus potential using NREAPs

The aim of this task is a preliminary estimate of RES surpluses on the basis of published NREAP's. This will give a first indication which Member States have cost efficient renewable surpluses and which countries might need to look to develop potential elsewhere in order to meet their targets in a more cost effective way. We will use the NREAP database that has been set up by ECN (<http://www.ecn.nl/publications/default.aspx?nr=ECN-E--10-069>). The information of this task will be used in the further more detailed analysis of the Valleys of Opportunity and be used in the Resolve model.

The following questions are addressed in this report:

- c) What is the amount of surplus or deficit for renewable consumption to be expected from the National Renewable Energy Action Plans (NREAP)?
- d) Which are the marginal technologies that Member States have available for trading?

The first question is straightforward to answer: the renewable energy surplus or deficit follows for each Member State from a specific table in the NREAP (Table 9 from the Template) and is reported in Section 1.2.

The second question however is more complex. For example, if a Member State reports a surplus, it is not defined which technologies are available for exporting, i.e. for applying flexible mechanisms to. The method applied in this report is to make an inventory of technologies with the highest marginal production costs, thereby considering all three renewable sectors (electricity, heat and transport). The most expensive technologies are then be summed until the total amount equals the surplus. Deficits are not addressed in this approach.

Chapter 2 presents the analysis. Information on methodological aspects can be found in Section 2.1. Limitations to the approach are discussed in Section 2.2. Results are reported in Section 2.3. Conclusions and recommendations can be found in Chapter 3.

Versions of NREAPs used for the analysis

The analysis in this report is based on the February 1st 2011 version of the report ECN-E-10-069. For the projections on deficits and excess additional information from the Member States has been taken into account (in the year 2020 only relevant for Bulgaria).

1.2. Excess and deficit reported in the NREAPs

Table 1.1 indicates the estimated excess and deficit for the year 2020 as reported by all European Member States. Two (or three) countries reported a deficit: Italy and Luxembourg (and possibly Estonia). Eleven (or ten) countries reported an excess: Bulgaria, Denmark, Germany, Greece, Spain, Italy, Lithuania, Luxembourg, Hungary, Malta, Slovakia and Sweden (and possibly Estonia).

Table 1.1 Estimated renewable energy excess and deficit [ktoe] for the year 2020 as reported by all European Member States (status after providing 'Further information' by appr. 70% of the Member States, October 2011). Note: the Bulgarian resubmitted report defines an excess by 2020 at the amount of 341 ktoe (previously 335 ktoe).

	Excess	Deficit
Belgium	n.a.	n.a.
Bulgaria	341	0
Czech Republic	n.a.	n.a.
Denmark	63	0
Germany	3065	0
Estonia	-1	n.a.
Ireland	0	0
Greece	529	n.a.
Spain	2649	0
France	0	0
Italy	0	1127
Cyprus	0	n.a.
Latvia	n.a.	n.a.
Lithuania	61	0
Luxembourg	0	93
Hungary	325	0
Malta	1	0
Netherlands	0	0
Austria	0	0
Poland	n.a.	n.a.
Portugal	n.a.	n.a.
Romania	0	0
Slovenia	0	0

Slovakia	143	n.a.
Finland	0	0
Sweden	486	n.a.
United Kingdom	n.a.	0
Total	7662	1220



2. Analysis

2.1. Methodology

The approach used for the analysis is to determine costs for the renewable energy technologies in as projected in the NREAPs. For the countries that reported surplus the excess energy will be allocated costs starting from the most expensive option, down towards the cheaper options until the cumulative excess amount of energy has been reached.

In order to give a first indication which Member States have cost efficient renewable surpluses and which countries might need to look to develop potential elsewhere in order to meet their targets in a more cost effective way.

In the current report, it is not the purpose to:

- 1) Create a EU-cost curve. This could yield further cost savings (and more trade) but this will be done in other tasks of WP2.
- 2) Take into account the age of the RES park. So analysis will take 2020 as a fixed year, historic development will not be taken into account.

More detail on the approach can be found in Appendix B.

Wholesale costs versus end-user prices

For RES-E we the cost figure used in this exercise is based on electricity generation costs, i.e. no fees and taxes are applied. For the RES-H/C options however end-user prices are used. This results in a consistency problem, of which the reader should be aware. It can be concluded that a bias exists that burdens the RES-H/C options. For the purpose of the current work this is not critical, but for further analysis in the RES4Less project it is recommended to analyse the issue of fair competition in more detail.

2.2. Limitations and restrictions

This section presents the limitations and the possible solutions in performing the analysis outlined in the description for task 2.1.

2.2.1 Limitations to NREAP dataset

Not all energy projection data have been reported in the same level of detail in the NREAPs as provided by Member states. Below, an overview of omissions and, if applicable, the way in which this has been solved.

- Hydropower: subcategories not provided for: BE, BG, EE, HU, IE, NL, PL, UK. Overall hydropower used instead. Pumped storage not considered for any country.
- Wind power: subcategories not provided for: BE. Overall wind power used instead.
- Biomass electricity: subcategories not provided for: EE. Overall biomass electricity used instead.
- Heat pumps: subdivision into source types not used. Overall heat pumps reconstructed by summing subcategories for SK and UK.
- Renewable transport: Article 21.2 fuels (second generation biofuels) are not considered for analysis.
- Renewable transport: renewable electricity not considered.

2.2.2 Limitations to the cost data

Three types of renewable energy are being reported on in the NREAPs: electricity, heating and cooling and transport. For electricity very detailed cost-per-unit-of-energy data are available from the ECN model RESolve-E. For renewable heating and cooling data are less relevant in the framework of the current exercise as for most technologies the level of costs are lower than the ones for electricity. The costs for biofuels are not being considered so far. Subsections below provide information on the assumptions made.

Cost data for renewable electricity

Renewable electricity costs are taken from the ECN RESolve-E model. The level of detail of data available from RESolve-E is much higher than the categorisation known from the NREAPs. For this reason, *matching* of both datasets is required. As a result of the higher level of detail, all technology costs are available in *ranges*, which brings along additional challenges. See also Appendix E.

Cost data for renewable heating and cooling

The costs for the different technologies are discussed below.

Geothermal: technology costs are assumed to be equal for all Member States. Data source: analysis SDE for the Netherlands (Lako 2011).

Solar thermal: it is assumed that solar thermal has country-specific costs of heat. The data source used is the RESolve-H/C database of ECN. Note that this database only covers 25 Member States: costs for solar thermal in Romania and Bulgaria have been assumed equal to neighbouring countries Hungary and Greece respectively.

Biomass: the assumption for heating and cooling is that the costs of producing heat are always lower than for producing electricity. This because the fuel might be cheaper (because of lesser quality requirements) and conversion efficiency generally is higher. This results in a situation where biomass electricity can practically never substitute for biomass heat. More detail on the costs is available in Appendix A.

Renewable energy from heat pumps: based on data published in the IEE supported RES-H Policy project for Austria and the Netherlands.

Cost data for renewable transport

For biofuels the situation is different from the other two sectors: a European-wide biofuels *market* is already in place, which has led to the cheapest fuels being preferred by all Member States, resulting in an efficient allocation of biofuels. The fact that the Europe-wide renewable transport fuel target needs to be respected makes that the substitution principle is not to be applied in the same way as for the other sectors (i.e. additional requirements are in place for biofuel penetrations). Therefore, the biomass penetration is not subject to exchanges in the current analysis and in order to be complete a (artificial) low cost value has been used for this technology (preventing the option to be candidate for inter-country exchanges, i.e. values are kept constant).

Biofuels projections exceeds 10.0% target in NREAP – what are consequences?

The Europe-wide transport fuel target has been defined as 10% of final fuel consumption in the year 2020. Note that the way this target is calculated allows to put more weight on certain renewable options, such as second generation biofuels. Also, renewable electricity and hydrogen in transport are to be considered for the target compliance, where the contribution from renewable electricity is to be counted heavier than other energy carriers (factor 2.5, RED article 3.4c).

In the 'Additional Energy Efficiency Scenario' according to the action plans the plain share of renewables in transport amounts to 10.2% in 2020. However, considering the second generation biofuels and the use of renewable electricity for transport, the share of renewable fuel increases to 11.3% in 2020. See Table 4 on page 18 of report ECN-E--10-069 (version of February 1st 2011) (www.ecn.nl/nreap). This means that the transport fuel target actually is being exceeded by 1.2%, which corresponds to an overshoot by approximately 4 Mtoe¹. Compared to the projected overshoot for use in flexible mechanisms (approximately 7 Mtoe) this is a significant amount.

2.3. Results for individual countries

Only the countries for which an excess or a deficit has been reported (see Table 1.1) are consecutively discussed below. Based on the cost-based principle the following remarks can be made:

Bulgaria (BG): has an estimated excess in 2020 of 341 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Offshore wind (0 ktoe, highest cost)
- Onshore wind (194 ktoe)
- Solar photovoltaic (39 ktoe)
- Renewable energy from heat pumps (0 ktoe)

¹ In the 'Additional Energy Efficiency Scenario' final energy consumption in Transport is estimated as 312 Mtoe in 2020 (see Table 3 in ECN-E--10-069). The renewable transport target (share of 10%) would thus amount to 31.2 Mtoe. The projected RES-T contribution is 35.3 Mtoe (see Table 1 in ECN-E--10-069), so the overshoot is 35.3 minus 31.2 equalling 4.1 Mtoe.

- Biomass (75 ktoe)
- Hydropower (340 ktoe)

The costs associated to these technologies range from 105 to 204 EUR/MWh (average cost).

Denmark (DK) has an estimated excess in 2020 of 63 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Solar thermal (16 ktoe, highest cost)
- Tidal, wave and ocean energy (0 ktoe)
- Offshore wind (458 ktoe)

The costs associated to these technologies range from 139 to 215 EUR/MWh (average cost).

Germany (DE) has an estimated excess in 2020 of 3065 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Solar thermal (1245 ktoe, highest cost)
- Solar photovoltaic (3559 ktoe)

The costs associated to these technologies range from 155 to 195 EUR/MWh (average cost).

Estonia (EE) has projected to use mainly heat from biomass, wind power (both onshore and offshore), biofuels, and electricity from biomass. This means that the most expensive technologies have not been applied: solar thermal (0 ktoe, 234 EUR/MWh) and solar PV (0 ktoe, 200 EUR/MWh). Of the technologies that have been projected, the following are the most expensive:

- Solar thermal (0 ktoe, highest cost)
- Solar photovoltaic (0 ktoe)
- Offshore wind (48 ktoe)

The costs associated to offshore wind is 183 EUR/MWh (average cost).

Greece (EL) has an estimated excess in 2020 of 529 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Offshore wind (58 ktoe, highest cost)
- Hydropower <1 MW (13 ktoe)
- Hydropower >10 MW (481 ktoe)

The costs associated to these technologies range from 142 to 205 EUR/MWh (average cost). In order to meet the European RES target the technologies offshore wind, small hydropower and a considerable share of the projected onshore wind power can be considered marginal and is thus available for sale. As expected, solar thermal is not among the marginal technologies for Greece.

Spain (ES) has an estimated excess in 2020 of 2649 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Tidal, wave and ocean energy (19 ktoe, highest cost)
- Concentrated solar power (1320 ktoe)
- Offshore wind (667 ktoe)
- Renewable energy from heat pumps (51 ktoe)
- Biogas (861 ktoe)

The costs associated to these technologies range from 85 to 202 EUR/MWh (average cost). In order to meet the European RES target the technologies offshore wind and a considerable share of the projected onshore wind power can be considered marginal and is thus available for sale.

Italy (IT) has reported a deficit of 1127 ktoe in 2020. The marginal technology for this country is offshore wind, with an average cost of 209 EUR/MWh. This means that Italy could be interested to purchase excess renewables below this price. From the analysis in this report, this could be:

- From Bulgaria: Onshore wind (194 ktoe)
- From Bulgaria: Solar photovoltaic (39 ktoe)
- From Bulgaria: Biomass (75 ktoe)
- From Bulgaria: Hydropower (340 ktoe)

- From Denmark: Offshore wind (458 ktoe)

- From Germany: Solar thermal (1245 ktoe)
- From Germany: Solar photovoltaic (3559 ktoe)

- From Estonia: Offshore wind (48 ktoe)

- From Greece: Offshore wind (58 ktoe)
- From Greece: Hydropower <1 MW (13 ktoe)
- From Greece: Hydropower >10 MW (481 ktoe)

- From Spain: Tidal, wave and ocean energy (19 ktoe)
- From Spain: Concentrated solar power (1320 ktoe)
- From Spain: Offshore wind (667 ktoe)
- From Spain: Renewable energy from heat pumps (51 ktoe)
- From Spain: Biogas (861 ktoe)

- From Lithuania: Solar photovoltaic (1 ktoe)
- From Lithuania: Renewable energy from heat pumps (14 ktoe)
- From Lithuania: Biomass heat (1023 ktoe)

- From Hungary: Onshore wind (133 ktoe)
- From Hungary: Solar thermal (82 ktoe)
- From Hungary: Solar photovoltaic (7 ktoe)
- From Hungary: Renewable energy from heat pumps (143 ktoe)

- From Malta: Offshore wind (19 ktoe)

- From Slovakia: Solar thermal (30 ktoe)
- From Slovakia: Renewable energy from heat pumps (10 ktoe)
- From Slovakia: Solar photovoltaic (26 ktoe)
- From Slovakia: Onshore wind (48 ktoe)
- From Slovakia: Heat from biomass (690 ktoe)

- From Sweden: Offshore wind (43 ktoe)
- From Sweden: Renewable energy from heat pumps (1046 ktoe)

Lithuania (LT) has an estimated excess in 2020 of 61 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Solar thermal (9 ktoe, highest cost)
- Solar photovoltaic (1 ktoe)

- Hydropower <1 MW (0 ktoe)
- Offshore wind (0 ktoe)
- Renewable energy from heat pumps (14 ktoe)
- Biomass heat (1023 ktoe)

The costs associated to these technologies range from 115 to 223 EUR/MWh (average cost).

Luxembourg (LU) has reported a deficit of 93 ktoe in 2020. The marginal technology for this country is solar thermal energy, with an average cost of 205 EUR/MWh. This means that Luxembourg could be interested to purchase excess renewables below this price. From the analysis in this report, this could be:

- From Bulgaria: Onshore wind (194 ktoe)
- From Bulgaria: Solar photovoltaic (39 ktoe)
- From Bulgaria: Biomass (75 ktoe)
- From Bulgaria: Hydropower (340 ktoe)
- From Denmark: Offshore wind (458 ktoe)
- From Germany: Solar thermal (1245 ktoe)
- From Germany: Solar photovoltaic (3559 ktoe)
- From Estonia: Offshore wind (48 ktoe)
- From Greece: Offshore wind (58 ktoe)
- From Greece: Hydropower <1 MW (13 ktoe)
- From Greece: Hydropower >10 MW (481 ktoe)
- From Spain: Tidal, wave and ocean energy (19 ktoe)
- From Spain: Concentrated solar power (1320 ktoe)
- From Spain: Offshore wind (667 ktoe)
- From Spain: Renewable energy from heat pumps (51 ktoe)
- From Spain: Biogas (861 ktoe)
- From Lithuania: Solar photovoltaic (1 ktoe)
- From Lithuania: Renewable energy from heat pumps (14 ktoe)
- From Lithuania: Biomass heat (1023 ktoe)
- From Hungary: Onshore wind (133 ktoe)
- From Hungary: Solar thermal (82 ktoe)
- From Hungary: Solar photovoltaic (7 ktoe)
- From Hungary: Renewable energy from heat pumps (143 ktoe)
- From Malta: Offshore wind (19 ktoe)
- From Slovakia: Solar thermal (30 ktoe)
- From Slovakia: Renewable energy from heat pumps (10 ktoe)
- From Slovakia: Solar photovoltaic (26 ktoe)
- From Slovakia: Onshore wind (48 ktoe)
- From Slovakia: Heat from biomass (690 ktoe)
- From Sweden: Offshore wind (43 ktoe)

- From Sweden: Renewable energy from heat pumps (1046 ktoe)

Hungary (HU) has an estimated excess in 2020 of 325 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Onshore wind (133 ktoe, highest cost)
- Solar thermal (82 ktoe)
- Solar photovoltaic (7 ktoe)
- Renewable energy from heat pumps (143 ktoe)

The costs associated to these technologies range from 130 to 199 EUR/MWh (average cost).

Malta (MT) has an estimated excess in 2020 of 1 ktoe. Based on average cost estimates, this means that the following technology is the marginal option:

- Offshore wind (19 ktoe)

The average cost associated to this technology amounts to 182 EUR/MWh, which makes it suitable to buy for both Luxembourg and Italy.

Slovakia (SK) has an estimated excess in 2020 of 143 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Solar thermal (30 ktoe, highest cost)
- Renewable energy from heat pumps (10 ktoe)
- Solar photovoltaic (26 ktoe)
- Onshore wind (48 ktoe)
- Bioliquids (0 ktoe)
- Heat from biomass (690 ktoe)

The costs associated to these technologies range from 115 to 177 EUR/MWh (average cost).

Sweden (SE) has an estimated excess in 2020 of 486 ktoe. Based on average cost estimates, this means that the following technologies are marginal options:

- Solar thermal (6 ktoe, highest cost)
- Tidal, wave and ocean energy (0 ktoe)
- Offshore wind (43 ktoe)
- Solar photovoltaic (0 ktoe)
- Renewable energy from heat pumps (1046 ktoe)

The costs associated to these technologies range from 130 to 223 EUR/MWh (average cost).

2.4. Robustness of the outcomes

All technologies have associated a range of costs. The above outcomes are all based on the average costs, but it might be the case that basing the analysis on for example the maximum costs will swap the order of the most expensive technologies.

To quantify this, a 'robustness indicator' has been calculated, indicating whether a technology remains on the same level of the merit order, depending on the cost ranges. A robustness of '3' means that for all cost levels (minimum, average and maximum costs) the technology remains on the same level. A robustness of '1' means that the ranking for minimum and maximum costs have a different technology compared to the average cost-based ranking.

Below an overview is provided for all technologies for 12 countries (all countries mentioned in the previous section without Bulgaria).

Table 2.1 Robustness indicator of technologies

	Robustness indicator		
	3	2	1
Biomass	0	1	5
Geothermal	0	1	0
Hydropower <1 MW	0	1	2
Offshore wind	0	7	3
Onshore wind	0	3	2
Renewable energy from heat pumps	0	7	6
Solar photovoltaic	0	3	4
Solar thermal	0	9	1
Tidal, wave and ocean energy	1	2	0

The above results do not further influence the analysis in this report but is provided for information only.



3. Conclusions

3.1. Surpluses and deficits reported by EU Member States

Of the 27 European Member States 13 countries reported information on an anticipated excess or deficit of renewable energy by 2020. Two (or three) countries reported a deficit: Italy and Luxembourg (and possibly Estonia). Eleven (or ten) countries reported an excess: Bulgaria, Denmark, Germany, Greece, Spain, Italy, Lithuania, Luxembourg, Hungary, Malta, Slovakia and Sweden (and possibly Estonia). Detailed projections have been listed in the table below.

Table 3.1 Estimated renewable energy excess and deficit [ktoe] for the year 2020 as reported in the NREAPs by all individual European Member States. Countries that did not report or projected zero excess and deficit have been left out of the table.

[ktoe]	Excess	Deficit
Bulgaria	341	0
Denmark	63	0
Germany	3065	0
Estonia	-1	n.a.
Greece	529	n.a.
Spain	2649	0
Italy	0	1127
Lithuania	61	0
Luxembourg	0	93
Hungary	325	0
Malta	1	0
Slovakia	143	n.a.
Sweden	486	n.a.
Total	7662	1220

The Member States did not (need to) pronounce on *which technologies* were in surplus. This report introduces a methodology based on which technologies can be allocated to the surpluses reported. Two basic principles shape the methodology:

- A **cost-based principle**: knowing the technology mix in the year 2020 a supply curve can be put together: the marginal technology, i.e. the technology that adds the last units of energy to the supply curve at the highest per-unit cost, can be assumed to be the unit that is available for sale to other Member States, provided that the added amount of energy is in excess of the renewable energy target. In order to pronounce on which technologies are the marginal ones, cost levels (or rather cost ranges) have

been attached to the NREAP 2020 technology mix for each country. Three variants of this method have been presented:

- Determining marginal technologies based on *average technology cost*
- Determining marginal technologies based on *maximum technology cost*
- Determining marginal technologies based on *minimum technology cost*

Note that more advanced methods for determining the marginal technologies can be thought of, notably by considering that for every technology a separate cost-supply curve can be derived for every country. This more complex assessment however is out of the scope for the current report (documenting Task 2.1 of the RES4Less project only). A more elaborate exercise will be set up in Task 2.2 by means of the RESolve modelling environment.

- A **vintage-based principle**: all technologies that have been added in the period from 2019 to 2020 are assumed to be in excess, provided that in the year 2019 the renewable energy target had been met already. This approach is not further presented here.

Section 2.3 has reported in detail on the outcomes of this analysis.

Based on the analysis of the costs and the technologies involved, it can be concluded that based on the assumed cost levels the excess of renewables as announced by the countries listed above is useful to fill the deficit reported by Italy and Luxembourg. In summary, the following technologies are available for both countries, taking into account their costs:

Italy (IT) has reported a deficit of 1127 ktoe in 2020 and the marginal technology for this country is offshore wind, with an average cost of 209 EUR/MWh.

Luxembourg (LU) has reported a deficit of 93 ktoe in 2020 and the marginal technology for this country is solar thermal energy, with an average cost of 205 EUR/MWh.

Various excess renewables that are available at a cost below 205 and 209 EUR/MWh, see listing below:

- From Bulgaria: Onshore wind (194 ktoe)
- From Bulgaria: Solar photovoltaic (39 ktoe)
- From Bulgaria: Biomass (75 ktoe)
- From Bulgaria: Hydropower (340 ktoe)
- From Denmark: Offshore wind (458 ktoe)
- From Germany: Solar thermal (1245 ktoe)
- From Germany: Solar photovoltaic (3559 ktoe)
- From Estonia: Offshore wind (48 ktoe)
- From Greece: Offshore wind (58 ktoe)
- From Greece: Hydropower <1 MW (13 ktoe)
- From Greece: Hydropower >10 MW (481 ktoe)

- From Spain: Tidal, wave and ocean energy (19 ktoe)
- From Spain: Concentrated solar power (1320 ktoe)
- From Spain: Offshore wind (667 ktoe)
- From Spain: Renewable energy from heat pumps (51 ktoe)
- From Spain: Biogas (861 ktoe)

- From Lithuania: Solar photovoltaic (1 ktoe)
- From Lithuania: Renewable energy from heat pumps (14 ktoe)
- From Lithuania: Biomass heat (1023 ktoe)

- From Hungary: Onshore wind (133 ktoe)
- From Hungary: Solar thermal (82 ktoe)
- From Hungary: Solar photovoltaic (7 ktoe)
- From Hungary: Renewable energy from heat pumps (143 ktoe)

- From Malta: Offshore wind (19 ktoe)

- From Slovakia: Solar thermal (30 ktoe)
- From Slovakia: Renewable energy from heat pumps (10 ktoe)
- From Slovakia: Solar photovoltaic (26 ktoe)
- From Slovakia: Onshore wind (48 ktoe)
- From Slovakia: Heat from biomass (690 ktoe)

- From Sweden: Offshore wind (43 ktoe)
- From Sweden: Renewable energy from heat pumps (1046 ktoe)

3.2. Conclusions on methodology

- Exchange of biofuels is not considered in the current analysis, because of the fact that for biofuels a Europe-wide market is in place, by means of which the cheapest fuels are supposed to be consumed first, which guarantees an optimal use of this fuel.
- RED Articles 21 and 3.4c give certain options an additional weight in the target calculation. Considering this, for biofuels an overshoot of 4 Mtoe is available. This amount could be filled with other renewables without compromising the 10% transport target achievement. In the current analysis it is assumed however that the biofuels are not among the most expensive options. In a future exercise, this could be analysed in more detail.
- It is very important to know from which actor's perspective the analysis is to be executed. Is it a Member State's perspective, then the *total RES costs* are the most determining factor. However, in case an investor or an energy consumer is to be taken as a reference, then the additional RES costs are more important, i.e. the difference of the RES technology compared to the conventional energy carrier to be substituted for, i.e. electricity, natural gas (for RES-H/C technologies) or liquid fossil fuels (for the transport sector).
- The current analysis is static and does not involve historic RES development. This may be improved in further work.

3.3. Recommendations for assessment with RESolve (Deliverable D2.2)

- Evaluate whether biofuels correctly have been left out of the current analysis or whether they need to be included.
- Dealing with CHP: how should the various cost components be allocated to either electricity and heat.
- Costs of RES-H/C: the cost data used in the current analysis are referring to end-user price ranges. This makes that the comparison with electricity options is not fair. In future work a methodology can be set up to deal with this issue.
- A static analysis as resented in this report does not take into account the benefits of cost decrease after 2020. Therefore, it is desirable to look as well to the period after 2020.
- It is relatively easy to report possible savings [MEUR] due to avoiding the use of certain expensive renewables. This couldn't be done in this report, but is worthwhile to report in a next deliverable.
- Be sure to agree on parameters for calculating costs: interest rate, lifetime, etc.
- For RES-E we the cost figure used in this exercise is based on electricity generation costs, i.e. no fees and taxes are applied. For the RES-H/C options however end-user prices are used. This results in a consistency problem, of which the reader should be aware. It can be concluded that a bias exists that burdens the RES-H/C options. For the purpose of the current work this is not critical, but for further analysis in the RES4Less project it is recommended to analyse the issue of fair competition in more detail.



4. References

Lako, P. S., L. Luxembourg, A.J. Ruiter, B. in 't Groen: *Geothermische energie en de SDE*. April 2011, ECN-E--11-022.

<http://www.ecn.nl/docs/library/report/2011/e11022.pdf>

IEA, *Renewables for Heating and Cooling*, 2007.

http://www.iea-ret.d.org/files/Heating_Cooling_Final_WEB.pdf

Lako, P.S., et al., *Geothermische energie en de SDE*. February 2011, ECN-E--11-022.

<http://www.ecn.nl/docs/library/report/2011/e11022.pdf>

Reports from IEE supported RES-H Policy project, D13 for Austria and the Netherlands. March. April 2011.

<http://www.res-h-policy.eu/downloads.htm>



Appendix A Technology cost data

A.1 RES-E

The costs for RES-E options are country specific and provided by the RESolve-E model. The country factsheets at the end of this report provide all details.

A.2 RES-H/C

The following heat options are assumed to have country-*independent* costs:

- All biomass technologies (solid/gaseous/liquid)
- Deep geothermal heat
- Ambient heat

The following sources have been used for acquiring the cost data for above-listed technologies:

IEA, Renewables for Heating and Cooling, 2007:

http://www.iea-ret.d.org/files/Heating_Cooling_Final_WEB.pdf

P. Lako et al, Geothermische energie en de SDE. ECN-E--11-022, February 2011: <http://www.ecn.nl/docs/library/report/2011/e11022.pdf> (report in Dutch language)

Reports from IEE supported RES-H Policy project, D13 for Austria and the Netherlands. March, April 2011: <http://www.res-h-policy.eu/downloads.htm>

A detailed overview of the costs according to the above literature sources is presented in Appendix 0. A concise overview is presented below. Note that the data ranges are provided for information purposes only, the calculations performed in this report are based on the 'average' value.

	Heat generation costs			
	Min	Average	Max	
Geothermal (deep)	20	30	40	[EUR/MWh]
Solid biomass	80	115	150	[EUR/MWh]
Renewable energy from heat pumps	110	130	160	[EUR/MWh]

One technology has obvious country-specific costs of heat:

- Solar thermal heat

For this technology the data have been used from the RESolve-H/C model based on solar thermal in industry (the sector with the cheapest potential). Note that this database only covers 25 Member States: costs for solar thermal

in Romania and Bulgaria have been assumed equal to neighbouring countries Hungary and Greece respectively. The resulting costs are presented in the table below. In order to provide minimum and maximum values a range of -10% and +20% have been assumed.

Table A. 1 Costs of solar thermal heats in various countries

Cost of heat (EUR/MWh) in the year 2020	
AT	187
BE	183
CY	83
CZ	224
DE	195
DK	215
EE	234
EL	92
ES	85
FI	233
FR	192
HU	177
IE	214
IT	121
LT	223
LU	205
LV	220
MT	167
NL	214
PL	220
PT	83
SE	223
SI	196
SK	177
UK	212
BG	92
RO	177
Minimum	83
Average	179
Maximum	234

It can be observed that Southern-European Member States have costs associated that are significantly lower than the costs in Middle and Northern European countries. The reason for this is twofold: firstly, the average annual solar yield is highest in Southern Europe, and secondly the high yield allows simpler system layouts, which results in relatively cheap solar thermal systems (thermo-siphon based).

Note that IEA (2007) lists higher prices for solar thermal energy. The prices range from 13 to 418 EUR/MWh, with an average value of 109 EUR/MWh (all data for 2030).

A.3 RES-T

For RES-T dummy cost figures have been used of 25 EUR/MWh (+20% / -10%).



Appendix A Methodology

The approach used for the analysis is to determine costs for the renewable energy technologies in as projected in the NREAPs. For the countries that reported surplus the excess energy will be allocated costs starting from the most expensive option, down towards the cheaper options until the cumulative excess amount of energy has been reached.

In order to give a first indication which Member States have cost efficient renewable surpluses and which countries might need to look to develop potential elsewhere in order to meet their targets in a more cost effective way.

In the current report, it is not the purpose to:

- 3) Create a EU-cost curve. This could yield further cost savings (and more trade) but this will be done in other tasks of WP2.
- 4) Take into account the age of the RES park. So analysis will take 2020 as a fixed year, historic development will not be taken into account.

More detail on the approach can be found in Chapter 2.

The following steps have been carried out:

1. Summarise surplus and deficit from NREAPs (Section 1.2). From this it becomes clear that for the year 2020: 7662 ktoe is in excess (i.e. above the 20% EU-27 target). The projected deficit is 1220 ktoe in 2020. The goal of the analysis is to allocate 7657 ktoe to other Member States
2. How to do this:
 - a. First attach a cost level $C_{s,i}$ to each individual surplus technology (Appendix A)
 - b. Determine for each MS the cost level of the marginal renewable option $C_{m,i}$ for reaching the target (according to NREAP)
 - c. For all countries i with $C_{m,i} > C_{s,i}$ co-operation offers savings. Trading will take place until $C_{m,i} = C_{s,i}$
 - d. The maximum amount of traded volume is 7656 ktoe. Further analysis will take place in other tasks of the RES-4-Less project.

The challenge is to quantify step b of the above listing. If this is available step a follows automatically (based on volume ktoe at target), step c and d is a simple calculation procedure.

In the current report, it is not the purpose to:

- 1) Create an EU-cost curve. This could yield further cost savings (and more trade) but this will be done in other tasks of WP2.

- 2) Take into account the age of the RES park. So analysis will take 2020 as a fixed year, historic development will not be taken into account.

Focus: how to go forward for step b.

1. For every technology t in country i from NREAP determine the 2020 penetration [ktoe]
2. Match t, i to penetration of the most similar technology in cost database (= database containing RES-E, RES-H/C, RES-T options). Note that the cost database will consist of various technology types (thus various cost levels) for each NREAP technology
3. The most basic approach is to assume for each technology a single cost level, for example the average value. This is then being offered for trading
4. A more elaborate approach is to also perform the analysis for minimum or maximum cost levels of each technology.
5. More complex it becomes when all data ranges for the costs are subdivided into distinct amounts of RES, each at their own cost levels. This increases the amount of technologies considered and allows more insight in the trading mechanisms based on cost ranges.
6. The most complex approach would be to match the technologies to the RESolve-E potentials.



Appendix B RES-H/C costs: detailed overview

Table B.1 RES-H/C costs: detailed overview

		Source: IEA for the year 2005 [EUR/MWh]			Source: IEA for the year 2030 [EUR/MWh]			Source: Lako 2011, heat only [EUR/MWh]			RES-H Policy, low price scenario [EUR/MWh]			RES-H Policy, high price scenario [EUR/MWh]			Data range for RES4Less		
		min	average	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max
Geothermal (deep)		0.6	3.3	21.6	0.6	3.8	25.6	34.7	38.6	39.6							20	30	40
Biomass																			
Solid biomass	AT										80	110	180	90	120	200	80	120	150
	NL										70	110	160	80	120	175			
Biogas																			
Bioliquids																			
Renewable energy from heat pumps		10.4	69.5	321.2	9.1	63.4	294.4										110	130	160
Aerothermal heat pumps	AT										110	120	155	120	130	170			
	NL										130	145	180	140	165	200			
Geothermal heat pumps	AT										100	120	170	110	125	170			
	NL										100	120	170	120	135	180			
Hydrothermal heat pumps																			

Note:

- IEA assumes CHP and only part of investment costs for heat.
- See References for source details.

Appendix C Country codes

The country codes used in this report have been based on the ISO codes according to the Interinstitutional Style Guide (<http://publications.europa.eu/code/en/en-000300.htm>). A listing is provided below.

Table C.1 Country names and their ISO codes

Country name	ISO-code
Belgium	BE
Bulgaria	BG
Czech Republic	CZ
Denmark	DK
Germany	DE
Estonia	EE
Ireland	IE
Greece	EL
Spain	ES
France	FR
Italy	IT
Cyprus	CY
Latvia	LV
Lithuania	LT
Luxembourg	LU
Hungary	HU
Malta	MT
Netherlands	NL
Austria	AT
Poland	PL
Portugal	PT
Romania	RO
Slovenia	SI
Slovak Republic	SK
Finland	FI
Sweden	SE
United Kingdom	UK
(All Member States)	(EU-27)

Appendix D Country data

The following pages indicate the cost ranges and the merit order of the most expensive technologies for all excess/deficit countries.





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