Quantification of energy delivery for financial incentives

(Deliverable 13)

WIP Renewable Energies

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Abstract

It is generally agreed that Renewable Heating and Cooling requires additional financial incentives in order to develop mature markets and produce services which are compatible to fossil fuels applications. In this respect it is very important that the financial incentives are restricted only to the generated and useful energy amount. While this is a comparatively simple task in the renewable electricity sector, various questions occur in the renewable heating and cooling sector, since there concrete metering applications are not available in many small scale applications.

The project K4 RES HEAT has addressed the vital question of quantifying heat delivery for financial incentives in several working tasks and has compiled relevant information in the two relevant sectors “heat measurement” and “financial incentives”:

In the field of heat measurement …

- …D9 has given clear recommendations how to quantify the energy delivered by single geothermal installations (measuring vs. calculation) for the purpose of financial incentive schemes.
- …D10 has compiled all relevant data about existing technologies for the concrete measurement of heat applications in all three technology sectors.
- …D11 has developed an objective methodology for the calculation of energy delivery.

In the field of financial regulation…

- D17 hast given a common methodological framework for the analysis of the Key Issue Financial Incentives in each Technology Sectors.

This report now brings together the different information sources for formulating a conclusion on how to quantify heat measurement for financial schemes.

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INDEX

CHAPTER ONE
INTRODUCTION

1 Objectives

It is the objective of this report to formulate a strategy for quantifying energy delivery for financial incentives based on the findings of the relevant working steps of K4 RES HEAT.

2 Structure of the Report

This Report in the second chapter summarises the main findings in the field of existing technologies and methodologies to quantify energy delivery.

In the third chapter the report summarises the main findings for financial incentives.

In the fourth chapter the report gives an outline on how to quantify energy delivery for financial schemes.

CHAPTER TWO
TECHNOLOGIES AND METHODOLOGIES TO QUANTIFY HEAT DELIVERY

1 Geothermal Sector

The Geothermal technology has to be divided in two areas which require different recommendations:

- for geothermal direct use systems (typically larger systems with deep boreholes (>200 m)
- for the very low enthalpy systems that use a heat pump (GSHP).

LARGE GEOTHERMAL DIRECT USE INSTALLATIONS

In these systems, quantifying energy delivery by measurement is recommended.
The systems sometimes are quite large (several MWth of heat output) and can have a complex schematic. Here it is important to distinguish between the geothermal part of the system (typically for base load) and the additional, conventional energy systems providing peak load or back-up in case of interruptions of the geothermal production.

In larger geothermal systems, the flow volume of the geothermal water is measured, as well as the water temperatures from and to the wells.
A good measurement point would be the heat exchanger separating the geothermal water circuit from the heating system circuit.

In case of deep borehole heat exchangers (BHE), the circulation flow in the BHE, and the fluid temperatures at exit and entrance of the BHE are measured.
From flow volume and temperature difference, the heat delivery can be calculated using the formula below, and can be integrated, by continuous monitoring, over the full operation period.

$$P = \rho * Cp * V * (t_{in} - t_{out})$$

With :

- P : the heat delivery [J/h]
- ρ : the volumetric mass [kg/m³]
- Cp : the mass heat capacity [J/(kg*K)]
- V : the flow volume [m^3/h]
- t_{in} t_{out} . the fluid temperatures [K]

With this method, the geothermal energy delivery can be quantified rather accurately, as is done already in almost all larger installations. The subsequent steps towards the heat use may have a few losses (circulation pumps), which generally are below 5 %.
All other steps only may add energy from other sources (heat pump activation energy, energy in peak load boilers), which cannot be considered part of the geothermal energy delivery.

For the relatively large size of this kind of geothermal direct use systems, the cost for measurement equipment are acceptable.
In most cases authorities will require the measuring of flow rate and temperature of water from the geothermal well as a part of the license, so this equipment has to be installed anyway.
Reporting of the data has to be done to the relevant authorities (water or mining); the data could be transferred to the statistical services either through these authorities, or by enforcing a direct communication from the plant operator.

GEOTHERMAL HEAT PUMPS (GSHP)

Also for GSHP, a direct measurement can be done, in particular for larger systems.
It is recommended to set a limit of heat pump heating capacity, above which a measurement and reporting should be required (e.g. >250 kW).

For the measuring of systems using borehole heat exchangers (BHE), in the formula given above, the heat capacity of the water/antifreeze-mixture has to be considered, which typically is substantially lower than that of pure water (10-20 %). To avoid this problem, a standard procedure is to measure the heat delivery side of the heat pump, where only water is used in the heating circuit, and to deduct the energy input for the heat pump operation (usually electric power). This is a good enough approximation of the geothermal heat.

For smaller units, the measurement equipment becomes relatively expensive compared to the energy delivered, and the reporting of data from a large number of small units can cause a bureaucratic problem.

For this kind of installations, the calculation of energy delivery from the number of installed units, the size and some efficiency considerations is recommended.
For the statistics, it would be perfect to have an exact count of the number of GSHP, and the rated heating output of each; however, the number of units sold in a given year, and an estimation of the average heat output might be the only data that could be expected reasonably in most cases.

In this case, a calculation is suggested using the following formula:

$$\mathbf{P = N_{HP} * Q_{mean} * h_a * ((COP-1)/COP)}$$

With :
- P : the annual heat delivery [kWh/a]
- N_{HP} : the number of heat pumps operating in a country, state, region, province…
- Q_{mean} : the average heating capacity (heat output) of these heat pumps [kW]
- h_a : the annual operation hours (full-load hours, depending on the climate) [h/a]
- COP . the seasonal mean COP, as an average for all heat pumps considered

The heat pump output and efficiency (COP) should be given according to standards EN 255, EN 14511, or other applicable standards of the member states. Using this formula will allow to assess only the geothermal part of the GSHP systems.

$$COP = \frac{useful\ heat}{electric\ power\ input}$$

For more details on the calculation method, see deliverable 8 on a methodology for the calculation of energy delivery..

2 Solar Thermal Sector

Solar thermal systems in the built environment are used for:

- Domestic Hot Water systems (DHW), being the major application.
- Space Heating, mainly in Northern Europe
- Space Cooling in the Mediterranean area

By far, most of the systems are used for Domestic Hot Water (90%). Other applications are space heating (in almost all cases these are combination systems) and pool water heating (mostly by unglazed collectors).

The applied solar thermal technology can be distinguished in:

- Flat glazed thermo-siphon systems of about 2-3 m^2 can be found mostly in Southern Europe.
- Flat glazed forced circulation systems of about 2-6 m^2 is installed in Mid- and Northern Europe.
- Evacuated Tube Collectors which have about 15% higher efficiency in south Europe and about 30% in northern Europe than the flat plate collector.
- Unglazed collectors.

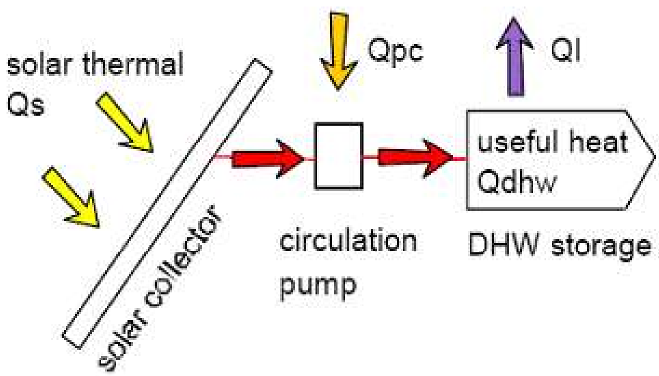

Figure 2. Solar Thermal

Renewable Energies from solar thermal (Qs) is produced if:

(Qdhw-Ql) > (Qpc)

where (Qpc) is primary energy input (for electric power)

The International Energy Agency's Solar Heating & Cooling Programme, together with the European Solar Thermal Industry Federation[1] [EST2006] and other major solar thermal

[1] www.estif.org

trade associations have decided to publish future statistics in MW_{th} (Megawatt thermal) and have agreed to use a factor of 0.7 kW_{th}/m^2 to convert square meters of collector area into MW_{th}

As a consequence the data as published by the industry federation is based on installed systems and shows the capacity. In addition the European certification scheme, the Solar Keymark [Est 2005] for solar thermal collectors (EN 12975) and factory made systems (EN 12976) is more and more accepted, both by the industry and by public authorities.

Another method for calculation of heating systems in buildings, in particular thermal solar systems is under preparation by CEN/TC 228. The document is in enquiry stage. Two methods are presented in the standard:

- a calculation using system data
- a calculation using component data

With the completion of this new calculation method a valuable basis will be created for financial incentives.

3 Biomass Sector

Whenever possible, statistics have to be based on measurements. Such data are generally available when heat is sold and for large scale. Often the biomass for heat and the bioheat are not measured, especially in the case of small scale applications. In this case a calculation methodology is needed. The following equations are proposed for discussion.

3.1 Small scale systems.

As small scale systems are considered stoves and boilers (automatic or not) that can use several types of biofuels (logs, chips, pellets).

Two approaches can be applied and compared for cross checking the data:

a. Based on fuel

amount of biomass for heat (kg) x lower heating value - LHV (kWh/kg) x conversion efficiency (%) = bioheat (kWh)

This approach will be particularly efficient for certain types of biofuels like pellets for which the quantity of biomass is measurable because it is sold (production level or capacity of pellets production units, import/exports, etc.).

LHV and conversion efficiency can be approximate on the base of studies and test in laboratories. However it should be noted that figures representing real life conditions should be used and not optimal efficiency of the boilers for example. It would also be possible to launch test in real conditions on a significant number of families (100 for example) that will monitor and measure precisely the amount of wood they are using during a winter season. The results will then be used to extrapolate the results to a certain region.

b. Based on use

number of units (n) x installed capacity (kW) x hours (h) x load factor (%) = biomass for heat (kWh)

biomass for heat (kWh) x conversion efficiency (%) = bioheat (kWh)

In this approach we need to know the number of units. This should be done through survey and energy questionnaires. However such questionnaire cannot be too detailed and some factors of the equation have to be evaluated like capacity, hours and load factor. This latter factor takes into account the fact that a system does not work always at full capacity. Another approach is to take theoretic hours of full capacity operations. These factors are also depending on regions, climate and year.

In addition technologies have to be classified and the calculation carried out for each class. Traditional stoves as additional heating systems have totally different running hours and efficiencies as compared to automatic pellet boilers.

CHAPTER THREE
FINANCIAL INCENTIVES FOR RES HEATING AND COOLING TECHNOLOGIES

Financial incentives schemes (FIS) can play an important role in promoting RES-H, if they are well designed, carefully managed and accompanied by appropriate flanking measures. If they are not, their positive effect is limited and can be even counter-productive in the medium and long term. This document develops criteria for a successful design and management of FIS and flanking measures.

The key positive effects of well designed and managed financial incentive schemes are:

- Reduction of the upfront investment costs, or of the fuel costs in the case of biomass
- Psychological effect: signal of the public authority to the potential users

These are the mainkinds of FIS for RES-H used so far in Europe:

- Direct grants
- Tax breaks (direct and indirect taxes)
- Loans at privileged rates
- Incentive linked to housing subsidies

The K4 RES HEAT analyses of the strengths and weaknesses of these tools has shown that no explicit recommendation should be given. If the principles of best practice discussed above are fulfilled, each kinf of FIS can be successful. These guidelines comprise of:

- Continuity
- Coherence
- Clear target
- Simplicity
- Open markets
- Fair amounts of incentive

Particularly the last item is of vital importance for the heat measurement for this reason additional information should be given: It is recommended to link the amount of the incentive to the assumed or measured amount of renewable energy provided by the system. In this way, the FIS adds on the natural incentive for the private investor to maximise the energy yield of the RES-H system to be installed

The requirements on measurement of renewable heating and cooling should be related to their costs and benefits.

CHAPTER FOUR
OUTLINE ON HOW TO QUANTIFY ENERGY DELIVERY FOR FINANCIAL SCHEMES.

Different than in the electricity sector, exact measuring of energy is not usual in the heating sector. For instance, the sharing of the heating bills in multifamily residential buildings with a central heating system is often based on very approximate measuring, or in some cases even simply on the surface of the apartments. If a FIS for RES-H sets excessive measurement requirements, it may end creating costs and hurdles not justified by the direct benefit of the measurement. The survey has shown that it is not possible to generally define for all technology sectors a clear criteria when the additional expenses do not justify the installation of concrete measurement units. Yet, it is clear that every technology sector has a small scale sector particularly in the field of private premises where technical measurement obviously is not economically feasible.

In the case of large heating systems, where measurement devices are installed anyway, the FIS can be based on the measured amounts, though it must be evaluated if the uncertainty and the transaction costs for both sides (the beneficiary and the public administration) linked with payment after the measurement are justified.

For small systems, however, exact measurement is not a standard feature of RES-H systems because its costs are higher than the technical benefit. From a technical point of view, a function control is in many cases more appropriate. Therefore, for small RES-H systems, it is recommended to link the financial incentive with the calculated energy output based on the installed capacity or other simple parameters. In all technology sectors first calculation platforms exist or are under preparation. It is very important that the relevant stakeholders now quickly agree about a suitable technology and make sure that this set-up then is used homogenously all over Europe. It is to be underlined that this is a political process and consequently a task for the political actors the European Union.