Ricardo Energy & Environment

Comprehensive Assessment of the Potential for Efficient Heating and Cooling Report for Point G

Report for Point G - An Overview of the Legislative and Non-Legislative Measures to Realise the Economic Potential

Report for Ministry of Energy Commerce and Industry (MECI) of the Republic of Cyprus

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1 Introduction

This revision of the NCA has reviewed the Cost Benefit Analysis considering updated heating and cooling demands in Cyprus. This modelling and associated point F report shows that the most effective measures for heating and cooling are primarily consistent with the previous NCA (2021), in that heat pumps combined with solar PV is shown to be the most economic option. The main distinction is that revised assumptions show that LPG or oil CHP is no longer an economic option (for either private or public investment) for heating and cooling, however biomethane CHP (assuming this becomes readily available) is an economic and best solution for all industrial and some of the service sector.

In the Point F report, the economic potential for efficient heating and cooling for Cyprus is set out. This potential was evaluated via a Cost Benefit Analysis (CBA) involving a Discounted Cash Flow (DCF) for efficient District Heating/Cooling (DHC) and a range of efficient heating and cooling technologies. The CBA also evaluated the Financial Net Present Value (FNPV) for all selected options.

The CBA describes the economic potential as those technical solutions that have a positive Net Present Value (NPV), using a DCF and a Discount Rate (DR) of 4% for ENPV and 12% for FNPV, when evaluated against an established baseline technology or technologies. The baseline technology varies by sector and building type. The range of high efficiency technologies evaluated, and the established baselines are set out in detail in the Point F report.

The high efficiency technology solutions under consideration here fall into two broad categories:

(1) District Heating and Cooling (DHC) solutions using, as the centralised source of heat, high efficiency cogeneration (both renewable and non-renewable), non-combustion high efficiency renewable heating technologies (heat pumps) and the recovery of waste heat from large combustion sites, and

(2) Individual site or building level high efficiency technologies

These two broad solution types compete against each other to cost effectively supply the heating and cooling demand in 879 Post Codes and 2 sub post code tourist areas[1]. Where a DHC solution is found to provide the heating and cooling demand at a lower cost than a suite of individual site/building level solutions, DHC is declared to be the cost effective technology, and vice versa. As discussed in the Point F report, in the vast majority of cases, individual site/building level solutions proved to be the most cost effective options.

The existing policy measures applying in the Republic of Cyprus, which have an effect on heating and cooling, are discussed in the Point E report. In the sections below we discuss the results of the CBA in the context of existing policies affecting heating and cooling, specifically from the point of view of whether these existing policies are able to support the realisation of the identified cost effective potential. Where it appears that the existing policies are not sufficient to support realisation of the potential, policy suggestions are made.

2 Existing Policy Measures and District Heating and Cooling (DHC) Solutions

<u>Issue</u> **-** In the modelling, out of 879 post code areas there is only one example of a DHC solution that is cost effective at post code level (i.e. positive ENPV). This involves the recovery of waste heat from one power station. **Policy suggestions to increase the number of cases where this could become cost effective are discussed later**.

With the exception of two sub post code detailed tourist areas evaluated, for all other DHC solutions, both the ENVP and FNPV are negative. In the case of the two tourist areas both the FNPV and ENPV are positive. For these tourist sub post code areas, though DHC has a positive FNPV and EPNV, DHC is not the most economic option, heat pumps + solar PV still remains the most economic option.
This shows that for DHC, there might be positive ENPV but these need to be studied further to confirm that that these two areas are still cost effective when more detailed localised analysis is carried out.

Based on our findings that DHC is cost effective within the two local areas studied, there is a reasonable basis to justify studies on further areas of Cyprus which also have high density of tourist areas and hotels. These studies should look into the technical, financial and practical feasibility of DHC. If DHC is still found to

[1] Owing to considerations of grade of heat, not all technologies are capable of supplying all the heat demand. Susceptible heat demand here therefore means the demand for heat in a post code (or sub post code area) which is of a grade that can be satisfied by the technology under consideration.

be effective in these smaller (more densely populated areas) and proves to be the best solution, then support mechanisms might be considered.

The results of this Comprehensive Assessment should be taken into account when a new thermal electricity generation installation is planned. In so far as these are very likely to be located on the same site or very close to the existing power stations and this CBA has found cost effective potential for the recovery of heat from one existing power station and its supply to a DHC scheme serving the post code in which it is located, this supports the view that cost benefit analyses should continue to be carried out in respect of new thermal electricity generation installations. Currently there are plans for one new power station to be constructed in Vassilios only. This is distant from any population centres, so as in 2021, it is assumed that waste heat is unsuitable for DHC.

Regarding the cost effectiveness of the one waste heat recovery DHC solution, this is aided by the absence of fuel and environmental costs and by the fact that the waste heat is generated in reciprocating engines, which means recovering heat has no impact on electricity generation.

However, as it stands, recovery of heat from other power stations (Vasilikos previously mentioned and Moni) is not viable. There are two reasons for this.

- Power stations using technologies from which waste heat is available without the need to alter the technology (i.e. open cycle gas turbines) have load factors which indicate that they are operating as peaking plant and, therefore, would not be reliable sources of heat for DHC.
- With the exception of the one cost effective example mentioned above, all other power stations that are understood to be using condensing steam turbines. In order for heat to be extracted from these, the steam turbines would need to be pass-out condensing steam (POCO) turbines. The cost of replacing existing condensing STs with POCO STs would not be justified, but once these turbines are due for replacement or refurbishment the options for heat extraction and development of DHC should be considered.

However, the marginal additional cost associated with specifying a POCO ST as opposed to condensing ST when a power station is designed is far lower and, for that reason, much more likely to yield a DHC scheme that is cost effective.

Recommendation – In light of the issue highlighted above, we would recommend that consideration is to be given for new thermal power stations undergoing planning to be made CHP ready, with the caveat that a cost benefit analysis is carried out in respect of each individual case before this is made a condition of permitting. This also should apply to existing stations once they are at the stage of refurbishments or upgrades. Studies carried out in Cyprus have shown that for large, planned power stations, the supply of heat extracted from the steam turbine of a CCGT would have to be delivered to a heat network no further than 4 km away for this to be cost effective. Similar distance constraints on heat linking can be anticipated for other planned power stations. There are other constraints that could have a deleterious effect on the cost effectiveness of making a power station operate as a CHP, which would only come to light via a proper study. Examples of such constraints are the possible need for the power station to provide frequency response to the network, which could adversely affect the economics of heat supply, and the ability of the installation to meet the primary energy saving requirements. Space constraints for auxiliary equipment, such as district heating connections and hot water storage may also materially impact the proposition.

As explained in the Point F report, by far the most cost effective high efficiency heating and cooling technologies, as applicable to the residential and Service sectors, is the generation of electricity using PV and the use of this electricity as an input for heat pumps to provide space heating and cooling and, where not currently provided by solar, sanitary hot water.

There are two existing policy instruments which should be reviewed in order for this potential to be realised. These are the “proper recovery systems for F-gases equipment” and the “support scheme for the production of electricity from renewable sources for own use”. These are discussed in Sections 2.1 and 2.2.

2.1 Preparation of a Proper Recovery System for F-Gases in Equipment

Issue - This is an obligation according to EU and national legislation but, as explained in the Point E report, is still not properly implemented. Implementation of this will become important in the next 5-10 years as the number of heat pumps in deployment increases, as the number reaching the end of their lives will also increase going forward. A proper system for recovery is needed where heat pumps reach the end of their lifecycles (10-20 years). It is understood that there have been technical issues with proper recovery systems for F-gases. In lieu there are plans to proceed with a campaign for collecting recovered refrigerants and exporting them for destruction in 2024. This campaign aims to meet a 5% recovery target.

Recommendation - Review the work to date on the F-gas recovery system in the context of the large cost effective potential for heat pump deployment in the residential and service sectors. There is no specific budget specified in the 2023 NECP for the collection campaign. Ensure that delivery timelines and budget set aside for the preparation of this system are commensurate with the opportunity presented by significant deployment of heat pumps. It is recommended that the development of F-gases collection processes and guidance is be considered over the next 5 years.

2.2 Support Scheme for the Production of Electricity from Renewable Energy Sources for Own Use

Issue - The large potential for PV + heat pumps in the residential and service sectors is partly underpinned by assumptions relating to the sizing of the PV panels and specifics of their operation. As explained in the Point F report, PV panels are modelled such that the capacity is sufficient to generate, over the year, all heat pump electricity demand to deliver space heating and space cooling. Since PV generation will not always be in phase with heat pump electricity demand, as driven by the demand for heating and cooling, either electricity storage or net metering is required. In the modelling net metering is assumed. This avoids the need for battery storage and therefore has the advantage of keeping the Capex of the solution down and obviating any issues with the availability of space for battery storage.

As explained in the Point E report, the support scheme for the production of electricity is capped at 30 MW for residential and at 18 MW for non-residential per annum and is renewed each year. The total PV capacity needed to realise the cost effective potential where PV + heat pump is the best solution is 1,589 MWe, with approximately 50% of this is in each of the residential and service sectors. Clearly, for the current net metering provision to support more than a modest proportion of this capacity the capacity caps would have to be raised significantly. Heat pumps will need to be supported by net-metering for Solar PV systems, otherwise they are restricted to using grid electricity and/or storage. At present the 48MW total capacity support will not facilitate the delivery of identified solutions, mainly heat pumps combined with Solar PV. The results identified in Point F report assume net metering is available for all the installed capacity required, therefore net metering will need to be scaled up to more than 300MW per year to realise the cost effective potential identified.

Recommendation – The capacity caps have been raised since the previous NCA, though will still only meet around 3% of the capacity required. Consider raising the capacity cap for PV with and expansion of the net metering policy. Further work should be undertaken to understand how far the capacity cap could be raised in a way that is sustainable for the stakeholders involved. In respect of a revised cap, the modelling could be refined to identify the tranche of potential where savings are maximised for this cap. Policy could be formulated to facilitate the realisation of this specific tranche of potential. In respect of the currently identified potential which would exceed any new cap, the modelling would have to be refined to assess the relative cost effectiveness of the following options (1) importing electricity at times when PV generation is insufficient to meet heat pump demand, and (2) installing storage batteries of the required capacity and whether this can be done at the individual building level or at the system level, whereby central battery storage is employed. When that work is complete, it should be possible to assess whether new fiscal measures and policies are required to realise potential available which would not fall within the cap.

In further assessing options it should be kept in mind that, in the vast majority of cases, Point F report has shown that heat pumps powered by grid electricity also serves as a cost effective option relative to the baseline.

3 Existing Policy Measures and Individual Site Level Industrial Heating and Cooling Demand

Within the industry sector, the only practical high efficiency solutions are CHP fuelled by biomethane, oil or LPG. Neither oil nor LPG CHP solutions are cost effective from either the Economic (ENPV) and Financial (FNVP) perspectives. Therefore, when viewed through the architypes modelled in this work, oil and LPG CHP technologies are no longer justified from a public and private investment perspective. No further policy measures are recommended in light of the fact that CHP schemes using LPG or oil products do not produce a positive ENPV. In addition, CHP schemes, using oil products like gasoil, would be unable to meet the EU directives carbon indicators of less than 0.27 kgCO2e/kWh (of total useful energy), but biomethane CHP will be able to meet this carbon indicator and has proved to be a cost effective solution.

3.1 Biomethane CHP

A compressed biomethane supply chain is under development, this gives the best and only potentially widespread socially cost effective solution. The additional analysis carried out by Ricardo shows that biomethane CHP is cost effective from the Economic (ENPV) and Financial (FNVP) perspectives, in all industrial architypes modelled (sites not currently in the ETS with low grade hot water or steam requirements) and in some service sectors (hotels and retail). As cost effective from a financial perspective, there should be no policy measures to subsidise biomethane uptake in CHP for industrial sites, aside from education and possibly loan schemes to assist with the capital cost.

3.2 Support Scheme for the Production of Electricity from Renewable Energy Sources for Own Use

At present there is a support scheme under Category B: Net-billing, for the production of electricity from renewable energy sources for own use which supports commercial and industrial consumers. Net-billing is available for different types of RES installations including Solar PV. The generated RES electricity that is not self-consumed is credited to the consumer at the respective wholesale price of electricity from RES and that amount is subtracted from the cost of the electricity bought from the grid. In March 2024, the total installed capacity of PVs in the net-billing category was 67.88MW (across both commercial and industrial users).

Recommendation: Additional investigation should be carried out into the uptake of this support measures for industrial users, and whether there are any barriers limiting solar PV installations in this sector.

4 Required subsidy for greenhouse architypes

MECI have expressed interest in understanding the level of subsidy that might be required for agriculture. With the main agricultural subsector being greenhouses, the table below summarises the amount of subsidy that would be required to make the most effective measure cost neutral in terms of FNPV. The measure with the most positive ENPV for this subsector is Heat Pumps + Solar hot water in all cases.

Subsector	Climatic region	Total support required where ENPV is positive and FNPV Negative (= -FNPV)	Annualised support requirement over 20-year lifetime at 12% discount rate €/Year	Total Heating + cooling + SHW provided (no SHW if baseline-solar) MWh	Support required €/MWh heat supplied
Greenhouses	Semi_Mountainous	€ 705	€ 94	1.7	€ 54
Greenhouses	Mountainous	€ 897	€ 120	2.4	€ 50
Greenhouses	Low_Land	€ 854	€ 114	2.2	€ 51
Greenhouses	Coastal	€ 1,056	€ 141	3.0	€ 47
Greenhouses	Average				€ 51

This solution was modelled as with other non-industrial sectors. However, in practice, solutions involving heat pumps and solar thermal or PV for greenhouses are likely to be impractical and installing solar panels is likely to be counterproductive. This leaves biomethane, oil or LPG CHP as the only remaining high efficiency solutions and none of these has a positive ENPV relative to the baseline so the best modelled solution is to remain with the baseline which entails oil, biomass or LPG boilers in 95%, 4% and 1% of greenhouses respectively. Biomethane boilers may offer a better high efficiency solution.

5 Impacts of Realising the Economic Potential

Assuming policy measures are designed and put in place to realise the identified economic potential (based on positive ENPV), the following benefits would result in 2030, 2035, 2040, 2045 and 2050, relative to the "With Existing Measures" (WEM) baseline.

5.1 Greenhouse Gas Emissions Reductions

Table 5-1 In year CO_2 savings associated with the implementation of cost effective best high efficiency solutions, relative to the WEM projection

Year	Baseline CO_2 Associated with Heating and Cooling ($ktCO_2$)	Absolute Reductions w.r.t Baseline ($ktCO_2$)	% Reductions w.r.t Baseline
2030	1,778	1,478	83%
2035	1,494	1,092	73%
2040	1,330	870	65%
2045	1,239	735	59%
2050	1,162	622	54%

Since the WEM baseline has ever decreasing CO_2 emissions associated with it, the sooner the high efficiency cost effective potential is implemented, the greater will be the in-year reductions in heating and cooling CO_2 emissions.

5.2 Primary Energy Savings

Table 5-2 In year primary energy savings associated with the implementation of cost effective best high efficiency solutions, relative to the WEM projection

Year	Baseline Primary Energy Associated with Heating and Cooling (GWh)	Absolute Reductions w.r.t Baseline (GWh)	% Reductions w.r.t Baseline
2030	9,836	3,787	39%
2035	9,134	2,815	31%
2040	8,726	2,252	26%
2045	8,502	1,896	22%
2050	8,315	1,599	19%

Since the WEM baseline has an ever decreasing ratio of primary energy input to delivered energy output for electricity generation, as increasing proportions of primary renewables such as solar PV, solar thermal and wind are introduced, the in-year primary energy savings associated with implementation of cost effective high efficiency solutions decreases year on year. Therefore, the sooner the high efficiency solutions are implemented the greater will be the additional benefit to primary energy reduction.

5.3 Impact on Share of High Efficiency Cogeneration

For the purposes of this analysis, it is assumed that the CHP electricity generation in 2018 is maintained. Point F report has identified cost effective additional CHP potential for biomethane CHP only.

Table 5-3 In year effect of implementation of best CHP high efficiency solutions on CHP electricity generation

Year	Current CHP Electricity Generation (GWh)	Additional CHP Generation Associated with Cost Effective Potential (GWh)	% Increase in CHP Generation w.r.t Baseline
2030	57.9	467	806%
2035	57.9	467	806%
2040	57.9	467	806%
2045	57.9	467	806%
2050	57.9	467	806%

5.4 Impact on Share of Renewables in National Energy Mix in Heating and Cooling Sector

Table 5-3 In-year share of renewable energy in primary energy supply associated with WEM projection and if the cost effective best high efficiency solutions are implemented

Year	Share of Renewables of Primary Energy Supply for Heating and Cooling Generation in Baseline	Share of Renewables of Primary Energy Supply for Heating and Cooling Generation if Economic Potential Realised	Additional Benefit Associated with Implementation of High Efficiency Solutions (
2030	28%	76%	+47%
2035	38%	84%	+46%
2040	44%	89%	+45%
2045	47%	92%	+45%
2050	50%	94%	+44%

The implementation of the best high efficiency always increases the share of renewable energy associated with the provision of heating and cooling, relative to the WEM baseline. However, as share of renewables in the baseline increases, the additional renewables contributed by the best cost effective solutions decreases.

5.5 Cost Savings for the Public Budget and Market Participants

The high efficiency solutions which are cost effective are so because they generate positive cash flow, relative to the baseline technologies, for years outside of capital expenditure. Below are the total in-year savings to be enjoyed, relative to the baseline, if all of the cost effective high efficiency solutions identified in Point F are implemented.

These effective measures demonstrate that the country will reduce their costs by implementing the proposed energy efficient solutions, as they have proved more cost effective options than the baseline. This results in the economic and financial savings relative to baseline. Overall, as share of renewables in the baseline increases the potential savings are reduced.

With a large proportion of the best solutions constituting PV + heat pumps, with significant free energy flows in the form of ambient heat and solar insulation, the in years are significant in absolute and relative terms.

Table 5-4 In-year economic and financial savings relative to the baseline

Year	In-year Positive Economic Cashflow Associated with Implementation of High Efficiency Solutions (€m)	% Economic Saving	In-year Positive Financial Cashflow Associated with Implementation of High Efficiency Solutions (€m)	% Financial Saving
2030	671	54%	864	55%
2035	600	51%	810	54%
2040	579	51%	824	54%
2045	627	53%	894	56%
2050	613	52%	891	56%