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Energy & Environment

Development of Heating and Cooling Strategy at Local Level

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Wrap Up - Nicosia
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BACKGROUND OF WORK

The JRC Study

JRC prepared the EED Comprehensive Assessment (CA) for Cyprus.
This work resulted in:

1. An interactive map of heating and cooling consumption in 2013

2. A comprehensive assessment of heating and cooling potential as reported in the document 'Cost-benefit analysis for the potential of high-efficiency cogeneration in Cyprus'.

The Ricardo Energy & Environment Study

- The overarching JRC finding that DH is only cost effective in Larnaca and Limassol assuming heat can be provided from nearby power stations from the economic point of view….surprising ……..as the areas that where identified are mostly Residential.

- Suspicion is that the aggregate nature of the JRC analysis may have missed more localised economic potential for DH

- Therefore, REE commissioned to build on the CA work but analyse at greater level of spatial disaggregation and take into account local conditions, in order to:
  - Check if DHC is cost effective in the post code areas of Cyprus with overall demand for heating, hot water and cooling >15 GWh p.a.
  - Assist MECIT with the development of a heating and cooling strategy at the local level

GEOGRAPHICAL AREAS EVALUATED

Areas for Which Potential Was Evaluated - General

- 10 distinct Geographical Areas (GAs) evaluated
- Evaluated areas in: Nicosia, Larnaca, Limassol, Paphos and Ayia Napa
- Relied heavily on data from Department of Land and Surveys (DLS) to tell us the types of building in each area
- Selected areas for analysis which were (according to DLS data) predominantly residential, service or a mixture of the two
- Carried out on-the-ground surveys to confirm the exact nature of building type in 3 of the 10 GAs, in:
  - Nicosia (PC1097) – 6 service sector buildings
  - Hotels in Poseidonos Avenue area of Paphos – 25 hotels
  - Hotels in Kyro Avenue area of Ayia Napa – 20 hotels
- Carried out analysis for each of these 10 areas to evaluate:
  - The cost effective potential for District Heating and Cooling (DHC) solutions, relative to a business-as usual baseline [Economic basis DR = 6%) and Financial basis (DR = 12%)]
  - The cost effective potential for certain building level "high efficiency" heating solutions, relative to a business-as usual baseline [Economic basis DR = 6%) and Financial basis (DR = 12%)]
  - The CO_2 savings of the above solutions, relative to the baseline
  - The Primary Energy Savings (PES) of the above solutions, relative to the baseline

Areas for Which Potential Was Evaluated- Technical Details

10 Geographical Areas were evaluated:

Area Name	Relevant Postcodes	DHC Model ID	Post Code Wide/Detailed Analysis	Total No. Buildings	Total No. Properties	No. Apartments	No. Houses	No. Service Buildings	Gross Bldg. Floor Area (m^2)
Area 1 PC_{1097} Nicosia 1097 Nicosia	1097	1	Post Code Wide	51	59	21	6	32	114,233
Area 2 PC_{1097} Nicosia	1097	2	Detailed	6	6	0	0	6	37,055
Area 3 Poseidonos Avenue, Paphos	8041, 8042, 8204	3	Detailed	25	25	0	0	25	209,665
Area 4 Kyro Avenue, Ayia Napa	5330	4	Detailed	20	20	0	0	20	117,157
Area 5 PC_{1082} Nicosia	1082	5	Post Code Wide	213	871	748	78	45	272,213
Area 6 PC_{2003} Nicosia	2003	6	Post Code Wide	179	1,104	992	83	29	223,931
Area 7 PC_{3105} Limassol	3105	7	Post Code Wide	89	703	673	30	0	113,120
Area 8 PC_{3106} Limassol	3106	8	Post Code Wide	250	1,165	1,012	150	3	288,123
Area 9 (PC_{6022}) Larnaca	6022	9	Post Code Wide	115	584	557	23	4	173,406
Area 10 PC_{6023} Larnaca	6023	10	Post Code Wide	169	535	503	32	0	254,254

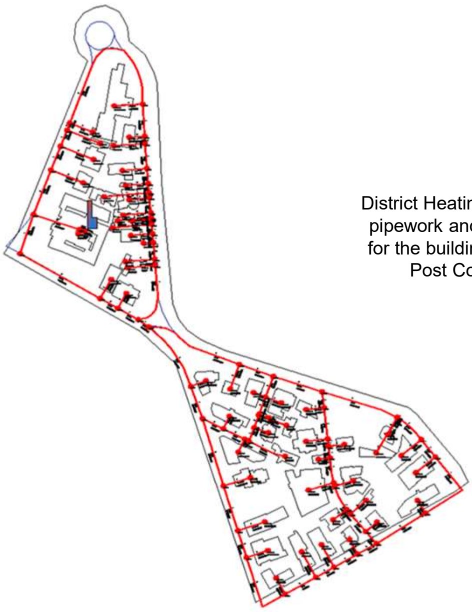
Areas for Which Potential Was Evaluated- Energy Data

Heating and Cooling requirements for the 10 Geographical Areas:

Area Name	DHC Model ID	Post Code Wide/Detailed Analysis	Space Cooling Consumption (MWh)	Space Heating Consumption (MWh)	Sanitary Hot Water Consumption (MWh)*	Peak Space Cooling Demand (kWth)	Peak Space Heating Demand (kWth)	Peak Sanitary Hot Water Demand (kWth)	Length of DHC Network (m)
Area 1 PC_{1097} Nicosia 1097 Nicosia	1	Post Code Wide	21,942	15,028	1,312	25,677	8,918	150	3,266
Area 2 PC_{1097} Nicosia	2	Detailed	6,246	5,812	0	7,309	3,449	0	384
Area 3 Poseidonos Avenue, Paphos	3	Detailed	51,966	16,909	9,808	80,906	11,849	1,119	5,451
Area 4 Kyro Avenue, Ayia Napa	4	Detailed	29,153	9,710	5,647	45,388	6,805	644	2,400
Area 5 PC_{1082} Nicosia	5	Post Code Wide	9,832	5,423	0	11,506	3,218	154	10,287
Area 6 PC_{2003} Nicosia	6	Post Code Wide	9,337	5,196	0	10,927	3,084	173	9,090
Area 7 PC_{3105} Limassol	7	Post Code Wide	10,022	5,092	0	15,604	3,568	152	6,404
Area 8 PC_{3106} Limassol	8	Post Code Wide	11,439	5,561	0	17,810	3,897	235	11,981
Area 9 (PC_{6022}) Larnaca	9	Post Code Wide	6,798	3,262	0	10,584	2,286	112	5,976
Area 10 PC_{6023} Larnaca	10	Post Code Wide	15,510	5,306	0	24,148	3,719	164	7,866

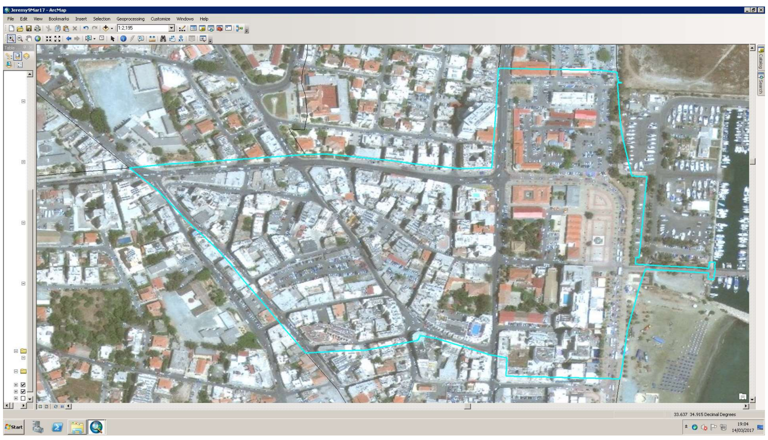
**Estimated consumption where not currently supplied by solar thermal*

Example of Area DHC Modelled – Nicosia (Post Code 1097)

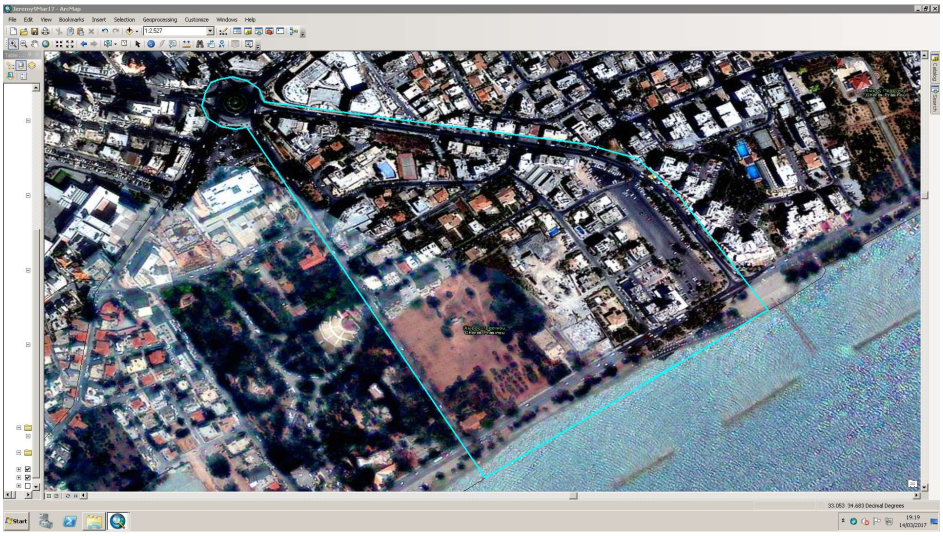


District Heating and Cooling pipework and connections for the buildings in Nicosia Post Code 1097

Services Postcode 6023 (Larnaca)



Services Postcode 3105 (Limassol)



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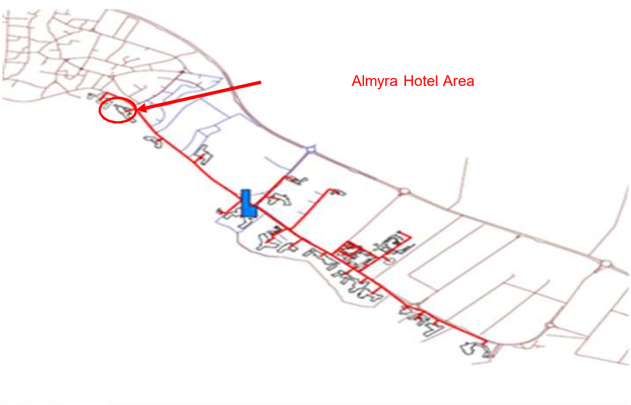
Paphos DHC Scheme, detailed analysis for post codes 8042 & 8204



District Heating and Cooling Solutions (DHC) Solutions Evaluated

Three "Types" Evaluated

Type 1 – 2-pipe, central generation of heating and cooling. Only heating or cooling can be delivered at any one time via the network

Type 2 – 4-pipe, central generation of heating and cooling. Heating and cooling can both be delivered at any one time via the network

Type 3 – 2-pipe, central generation of heat, local generation of cooling using local absorption chiller with heat delivered to these chillers via the network. Only heating delivered by the network.

District Heating and Cooling Solutions (DHC) Solutions Evaluated

Technologies Evaluated

- Biomass CHP
- Oil CHP
- LPG CHP
- Refuse Derived Fuel (RDF) CHP
- Water Source Heat Pumps (WSHPs) – for GAs adjacent to sea

District Heating and Cooling Solutions (DHC) Solutions Evaluated

Combination No.	DHC Solution Type	No. Pipes (2 or 4)	Primary, Central Heating Plant	Top-up Central Heating Plant	Primary Central Cooling Plant	Top-up Central Cooling Plant	Localised Top-up SHW	Localised Top-up Cooling Plant
1	Type 1	2 pipe	Biomass CHP	Biomass boiler	Absorption chiller	Electric chiller	As per baseline	Not required
2	Type 2	4 pipe	Biomass CHP	Biomass boiler	Absorption chiller	Electric chiller	As per baseline	Not required
3	Type 3	2 pipe	Biomass CHP	Biomass boiler	N/A (Cooling generated locally)	N/A	As per baseline	Local Absorption chiller + Reversible heat pump (for residential buildings)
4	Type 1	2 pipe	Oil CHP	Oil	Absorption chiller	Electric chiller	As per baseline	Not required
5	Type 2	4 pipe	Oil CHP	Oil	Absorption chiller	Electric chiller	As per baseline	Not required
6	Type 3	2 pipe	Oil CHP	Oil	N/A (Cooling generated locally)	N/A	As per baseline	Local Absorption chiller + Reversible heat pump (for residential buildings)
7	Type 1	2 pipe	LPG CHP	LPG	Absorption chiller	Electric chiller	As per baseline	Not required
8	Type 2	4 pipe	LPG CHP	LPG	Absorption chiller	Electric chiller	As per baseline	Not required
9	Type 3	2 pipe	LPG CHP	LPG	N/A (Cooling generated locally)	N/A	As per baseline	Local Absorption chiller + Reversible heat pump (for residential buildings)
10	Type 1	2 pipe	WSHP	Not required	WSHP	Not required	As per baseline	Not required
11	Type 2	4 pipe	WSHP	Not required	WSHP	Not required	As per baseline	Not required
12	Type 3	2 pipe	WSHP	Not required	WSHP	Not required	As per baseline	Not required
13	Type 1	2 pipe	RDF CHP	RDF boiler	Absorption chiller	Electric chiller	As per baseline	Not required
14	Type 2	4 pipe	RDF CHP	RDF boiler	Absorption chiller	Electric chiller	As per baseline	Not required
15	Type 3	2 pipe	RDF CHP	RDF boiler	N/A (Cooling generated locally)	N/A	As per baseline	Local Absorption chiller + Reversible heat pump (for residential buildings)

15 discrete DHC solutions evaluated for each of the 7 GAs
12 discrete solutions evaluated for 3 GAs (GAs in Nicosia)

Individual Building Level Solutions Evaluated

Technologies Evaluated

- Biomass CHP
- Oil CHP
- LPG CHP
- Reversible heat pump
- Solar thermal

Individual Building Level Solutions Evaluated

Combination No.	Primary Heating Plant	Primary Cooling Plant	Top-up Cooling Plant	Primary SHW Plant
1	Biomass CHP	Absorption chiller	Electric chiller	Where not solar thermal, Biomass CHP/biomass boiler
2	Oil CHP	Absorption chiller	Electric chiller	Where not solar thermal, Oil CHP/Oil boiler
3	LPG CHP	Absorption chiller	Electric chiller	Where not solar thermal, LPG CHP/LPG boiler
4	Heat pump	Heat pump	None	Solar thermal
5	Solar thermal	Absorption chillers	Electric chillers (for hotels) Baseline (for other non-domestic and domestic buildings	Solar thermal

DHC Results – Poseidonos (Paphos) Avenue Area

Solution Combination No.		ENPV relative to baseline for all technical potential (€m)	FNPV relative to baseline for all technical Potential (€m)	CO2 Savings for all technical potential (tkCO2)
1	Biomass CHP with 2 pipe DHC (DC in summer and DH in winter)	-23.8	-38.0	901.5
2	Biomass CHP with 4 pipe DHC	-18.9	-36.5	984.5
3	Biomass CHP with 2 pipe DH + individual absorption chillers	-60.8	-67.0	1061.3
4	Oil CHP with 2 pipe DHC (DC in summer and DH in winter)	38.1	-2.9	89.9
5	Oil CHP with 4 pipe DHC	45.6	-0.2	121.3
6	Oil CHP with 2 pipe DH + individual absorption chillers	22.6	-14.9	-188.8
7	LPG CHP with 2 pipe DHC (DC in summer and DH in winter)	-54.1	-60.4	457.3
8	LPG CHP with 4 pipe DHC	-52.8	-61.5	512.7
9	LPG CHP with 2 pipe DH + individual absorption chillers	-85.9	-82.7	439.0
10	Reversible water source heat pumps with 2 pipe DHC (DC in summer and DH in winter)	-197.7	-150.6	82.8
11	Reversible water source heat pumps with 4 pipe DHC	-211.6	-161.5	102.3
12	Reversible water source heat pumps with 2 pipe DH + individual absorption chillers	-207.3	-157.7	102.3
13	RDF CHP with 2 pipe DHC (DC in summer and DH in winter)	57.9	9.5	765.3
14	RDF CHP with 4 pipe DHC	68.1	14.1	839.5
15	RDF CHP with 2 pipe DH + individual absorption chillers	42.1	-7.2	889.6

DHC solutions based oil fired CHP and RDF fired CHP are cost effective from an economic point of view
Best result is Solution 14 RDF CHP with 4-pipe solution

DHC Results – Kryo Avenue, Ayia Napa (5330 Detailed)

Solution Combination No.		ENPV relative to baseline for all technical potential (€m)	FNPV relative to baseline for all technical Potential (€m)	CO2 Savings for all technical potential (tkCO2)
1	Biomass CHP with 2 pipe DHC (DC in summer and DH in winter)	-13.0	-21.0	510.3
2	Biomass CHP with 4 pipe DHC	-9.9	-19.8	558.1
3	Biomass CHP with 2 pipe DH + individual absorption chillers	-35.4	-38.6	601.2
4	Oil CHP with 2 pipe DHC (DC in summer and DH in winter)	21.2	-1.6	51.9
5	Oil CHP with 4 pipe DHC	25.9	0.2	69.9
6	Oil CHP with 2 pipe DH + individual absorption chillers	11.6	-9.2	-106.7
7	LPG CHP with 2 pipe DHC (DC in summer and DH in winter)	-30.8	-34.1	259.3
8	LPG CHP with 4 pipe DHC	-29.7	-34.5	291.2
9	LPG CHP with 2 pipe DH + individual absorption chillers	-49.7	-47.4	249.8
10	Reversible water source heat pumps with 2 pipe DHC (DC in summer and DH in winter)	-109.3	-83.2	48.0
11	Reversible water source heat pumps with 4 pipe DHC	-117.0	-89.2	59.2
12	Reversible water source heat pumps with 2 pipe DH + individual absorption chillers	-115.2	-87.6	59.2
13	RDF CHP with 2 pipe DHC (DC in summer and DH in winter)	33.1	5.9	433.4
14	RDF CHP with 4 pipe DHC	39.3	8.8	476.1
15	RDF CHP with 2 pipe DH + individual absorption chillers	22.7	-4.7	504.2

DHC solutions based oil fired CHP and RDF fired CHP are cost effective from an economic point of view
Best result is Solution 14 RDF CHP with 4-pipe solution

DHC Results – Larnaca Service (6023 Post Code Level)

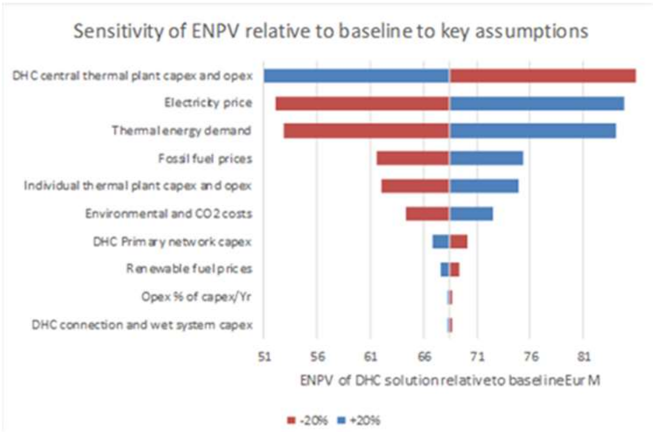
Solution Combination No.		ENPV relative to baseline for all technical potential (€m)	FNPV relative to baseline for all technical Potential (€m)	CO2 Savings for all technical potential (tkCO2)
1	Biomass CHP with 2 pipe DHC (DC in summer and DH in winter)	11.9	2.7	255.5
2	Biomass CHP with 4 pipe DHC	6.3	-2.3	255.5
3	Biomass CHP with 2 pipe DH + individual absorption chillers	-35.0	-28.6	169.8
4	Oil CHP with 2 pipe DHC (DC in summer and DH in winter)	28.7	17.9	25.6
5	Oil CHP with 4 pipe DHC	23.1	12.8	25.6
6	Oil CHP with 2 pipe DH + individual absorption chillers	-11.8	-7.9	-122.2
7	LPG CHP with 2 pipe DHC (DC in summer and DH in winter)	2.7	0.4	129.3
8	LPG CHP with 4 pipe DHC	-2.9	-4.7	129.3
9	LPG CHP with 2 pipe DH + individual absorption chillers	-40.9	-27.3	-1.3
10	Reversible water source heat pumps with 2 pipe DHC (DC in summer and DH in winter)	-33.4	-26.7	27.3
11	Reversible water source heat pumps with 4 pipe DHC	-39.1	-31.8	27.3
12	Reversible water source heat pumps with 2 pipe DH + individual absorption chillers	-29.9	-23.6	27.3
13	RDF CHP with 2 pipe DHC (DC in summer and DH in winter)	35.0	16.6	217.0
14	RDF CHP with 4 pipe DHC	29.4	11.6	217.0
15	RDF CHP with 2 pipe DH + individual absorption chillers	-7.2	-12.4	123.3

DHC solutions based oil fired CHP and RDF fired CHP are cost effective from an economic point of view
Best result is Solution 13 RDF CHP with 2-pipe solution

DHC Results - Sensitivity

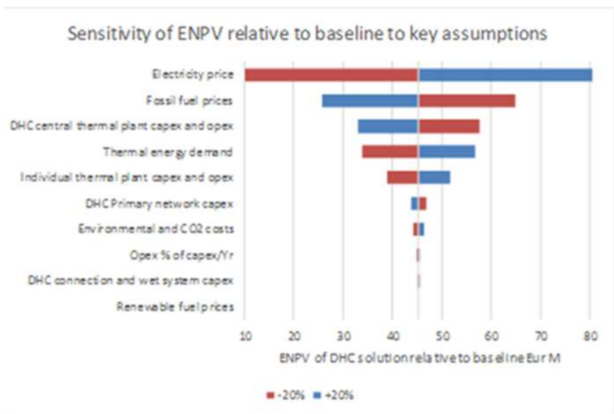
Poseidonos Avenue (Paphos) Solution 14 (Sensitivity of ENVP)
RDF/SRF CHP with 4 pipe system)

Solution most sensitive to Capex of central heating and cooling plant



DHC Results - Sensitivity

Poseidonos Avenue Solution 5 – Reciprocating Engine based CHP (Sensitivity of ENVP)- Oil fired CHP with 4 pipe DHC system



Note result now very sensitive to electricity price assumed

Detailed Individual Building Level Solution Results

Area Name: Nicosia - Service (1097 Detailed Level)

	Individual CHP solution no.	Total ENPV relative to baseline for all technical potential (€m)	Total FNPV relative to baseline for all technical potential (€m)	Total CO2 savings for all technical potential (kTCO2)	Total CO2 savings for all technical potential (kTCO2)	Total PES for all technical potential (GWh)	Total PES for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)
Biomass CHP	1	-0.2	-1.3	118.4	118.4	-130.1	-130.1	99.5	99.5	126.4	126.4
Oil CHP	2	4.1	5.1	-0.9	-0.9	177.5	177.5	99.5	99.5	338.2	338.2
LPG CHP	3	-8.9	-2.9	52.7	52.7	171.2	171.2	99.5	99.5	338.2	338.2
Individual heat pumps and solar hot water	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar space, heating, cooling and hot water in hotels	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Area Name: Poseidonos Avenue, Paphos (8041,8042,8204 Detailed)

	Individual CHP solution no.	Total ENPV relative to baseline for all technical potential (€m)	Total FNPV relative to baseline for all technical potential (€m)	Total CO2 savings for all technical potential (kTCO2)	Total CO2 savings for all technical potential (kTCO2)	Total PES for all technical potential (GWh)	Total PES for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)
Biomass CHP	1	-8.9	-19.2	950.4	950.4	-342.9	-342.9	428.7	428.7	852.0	852.0
Oil CHP	2	20.9	23.7	165.7	165.7	1719.7	1719.7	428.7	428.7	2279.0	2279.0
LPG CHP	3	-64.5	-29.2	521.5	521.5	1672.8	1672.8	428.7	428.7	2279.0	2279.0
Individual heat pumps and solar hot water	4	-26.6	-26.0	178.1	178.1	291.1	291.1	-194.5	-194.5	0.0	0.0
Solar space, heating, cooling and hot water in hotels	5	0.4	-19.0	501.9	501.9	-947.5	-947.5	571.6	571.6	0.0	0.0

Area Name: Kryo Avenue, Ayia Napa (5330 Detailed)

	Individual CHP solution no.	Total ENPV relative to baseline for all technical potential (€m)	Total FNPV relative to baseline for all technical potential (€m)	Total CO2 savings for all technical potential (kTCO2)	Total CO2 savings for all technical potential (kTCO2)	Total PES for all technical potential (GWh)	Total PES for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity consumption reduction for all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)	Total electricity generationfo r all technical potential (GWh)
Biomass CHP	1	-4.9	-10.7	538.8	538.8	-189.6	-189.6	240.5	240.5	481.3	481.3
Oil CHP	2	11.2	12.9	95.0	95.0	975.9	975.9	240.5	240.5	1287.5	1287.5
LPG CHP	3	-37.1	-17.0	296.1	296.1	949.5	949.5	240.5	240.5	1287.5	1287.5
Individual heat pumps and solar hot water	4	-16.0	-15.5	102.4	102.4	167.1	167.1	-111.8	-111.8	0.0	0.0
Solar space, heating, cooling and hot water in hotels	5	-1.4	-11.9	284.1	284.1	-530.1	-530.1	320.7	320.7	0.0	0.0

Individual Solution

Technology	Areas
Oil CHP	Nicosia 1097, Paphos, Ayia Napa
Ind HP + Solar HW	Nicosia 1082/2003, Limassol 3105/3106, Larnaca 6022/6023

Key Take Away Points on DHC Solutions and Individual Building Level High Efficiency Solutions (1)

- District Heating and Cooling (DHC) solutions using RDF fired CHP and oil fired CHP are cost effective relative to the baseline when viewed from an economic perspective, i.e. applying a Discount Rate (DR) of 6%.
- When viewed from a financial perspective (i.e. **applying a DR of 12%), generally, DHC solutions based on RDF CHP remain cost effective**. However, for a number of Geographical Areas (GAs), oil fired CHP solutions, which were cost effective from an economic point of view, cease to be cost effective
- The cost effectiveness of the RDF based solutions is strongly driven by the relatively low cost **(€9/tonne, €2/MWh) assumed for this fuel in this study** . Further consideration should be given to the possibility of supplying RDF at this price.
- DHC solutions based on the other technologies evaluated (biomass CHP, LPG CHP and Water Source Heat Pumps) are not cost effective.
- The economic performance of DHC 4-pipe solutions is better than 2-pipe solutions only when there is appreciable year round demand for both heating and cooling.
- Of the DHC solutions that are cost effective, the RDF fired CHP solution can be relied upon to deliver CO_2 savings relative to the baseline over the lifetime of these projects.
- Oil fired CHP find it progressively difficult to deliver CO_2 savings, with the result that over the lifetime of the project these particular solutions often do not deliver CO_2 savings.

Continue…..

Key Take Away Points on DHC Solutions and Individual Building Level High Efficiency Solutions(2)

- In general terms, Primary Energy Savings (PES) are delivered by the DHC solutions evaluated, with the exception of those based on CHP using steam turbines. In practice this means CHP using biomass and RDF. The relatively low efficiency of power generation by steam turbines and the projected increase, over time, of the efficiency of generation of grid electricity, which would be displaced by this CHP generated electricity, leads to negative PES over the lifetime of these particular DHC solutions.

- Sensitivity analysis indicates that the cost effectiveness of the DHC solutions is substantially driven by five key assumptions. These are:
  1. The Capex of the plant generating heat at the central location of the DHC scheme
  2. The electricity price
  3. The thermal demand that the DHC scheme is assumed to supply
  4. The price for fossil fuels, and
  5. The Capex of the individual plant generating heat/cooling locally, but the order of these is dependent upon the technology being used.

- The results relating to cost effectiveness of the individual building level CHP solutions evaluated broadly mirror those for the same CHP solutions supplying a DHC network, i.e. oil fired CHP is the only technology that is cost effective from both an economic and financial perspective (RDF fired CHP having not been evaluated as a practical solution at the individual building level). The same physical factors determining the ability of a particular technology to deliver CO_2 and primary energy when applied that the DHC level play out when the technology is applied at the individual building level.

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