**14. <u>10 pages description</u> including <u>one page summary</u>: background information on system history, configuration of production units, distribution network, number of square footage of buildings served, average age of production and distribution system.**

## Summary:

Qatar District Cooling Company "Qatar Cool" was incorporated in November 2003 as a Qatari Closed Stock Company. The company was set up with the intention of providing district-cooling services to the public, commercial and industrial sectors of Qatar.

Qatar Cool is currently the leading commercial provider of district cooling services to the public, commercial and industrial sectors of Qatar.

The company's first plant in West Bay has a capacity of 30,000 Ton of Refrigeration, began operations in September 2006, the second plant in West Bay, with a capacity of 37,000 Ton of Refrigeration started operations in October 2009. Both Plants are providing cooling service to almost 50% of existing towers in West Bay of Doha.

Qatar Cool's Integrated District Cooling Plant on The Pearl-Qatar was inaugurated in November 2010 with a capacity of 130,000 Tons of Refrigeration, which made it the main eco-friendly technology on the island and the largest district cooling plant in the world.

The total area served is more than 3.9 million square meters (41 million square feet), occupied by 45,000 residents more than 100 towers that include approximately 15,000 apartments and 1,500 villas.

## Description:

Qatar Cool accepted the challenge to own and operate the largest district cooling plant in the world, located on The Pearl Qatar, to serve the 41 million square feet man-made island. The Pearl Qatar is the first real estate project in Qatar with true international dimensions and appeal. The Pearl Qatar is a four phase mixed use development comprising of 10 themed districts to be developed over five (5) years housing beachfront villas, elegant town homes, luxury apartments, exclusive penthouses, five (5) stars hotels, marinas, schools as well as upscale retail and restaurant offerings. It will be a destination, a lavish, secure and exclusive island retreat with a Riviera style community.

Qatar Cool's Integrated District Cooling Plant on The Pearl-Qatar was inaugurated in November 2010 with a capacity of 130,000 Tons of Refrigeration, which made it the main eco-friendly technology on the island and the largest district cooling plant in the world.

The Plant has 52 centrifugal chillers arranged in 26 models in series counter flow arrangement forming a 5,000 Ton of Refrigeration train. It has 26 horizontal double suction condenser water pumps (Constant Flow) with a rate of 7,500 US gallons per minute.

Integrated District Cooling Plant (IDCP) was commissioned in November, 2010. The term integrated is added to emphasize the integration of two chiller plants into one plant to serve east and west chilled water Pipe Distribution Network (PDN).

The capacity of IDCP is 130,000 Tons of Refrigeration, designed at a Delta-T of 8.9 degrees Celsius and chilled water flow of 195,000 U.S gallons per minute.

The plant has 26 vertical turbine condenser water pumps with flow rate of 11,170 US gallons per minute. IDCP has 26 cooling towers with Variable Frequency Drive (VFD) fans.

The plant has seven (7) centrifugal vertex type side stream filtration systems with 40 micron cartridge type filter, filtering 10% of overall condenser water capacity.

The primary power system is supplied with an 11kV multi – feeder supply, 11kV-3.3kV step-down transformers to serve the chillers. The remainder of the system is supplied with 415 volts. IDCP is operated, controlled and monitored by a SCADA system; it allows for online, real time diagnostic of all rotating machinery and is important for higher reliability and lower operating costs.

The plant has an automatic chemical analysis and dosing system to ensure constant water properties as well as has onsite water laboratory. In addition to the usage of the fresh water the plant is equipped to use the Treated Sewage Effluent (TSE) water.

IDCP cooling towers blow down water could be discharged to the sea or the sewer system or used for irrigation purposes.

On each customer's premises, Qatar Cool installs, operates and maintains an Energy Transfer Station (ETS). The ETS is configured to allow redundancy and reliability. The control system operates both the primary and the customer's secondary systems. Our engineers continually work with the building operators to introduce advanced energy saving and failsafe concepts. The Pearl Qatar PDN has a total rated capacity of 147,000 Tons of Refrigeration made possible by the 92 kilometers (57 miles) of underground supply and return pre insulated steel pipes diameters ranging between 75 mm to 1400 mm. The network has one (1) boosting station. Construction of the piping network was started in 2006 and physical installation was finalized in 2010. Although the network was developed in stages, the first phase was operational in 2008 based on service demand. The network became fully operational in 2011. The PDN has an average age of 25 years.

All ETSs' are linked to the plant through a Fiber Optic Communication Network allowing for centralized monitoring and control of district cooling for The Pearl-Qatar development. The Pearl-Qatar Schematic diagram for PDN is found in Appendix B.

The total area served is more than 3.9 million square meters (41 million square feet), occupied by 45,000 residents more than 100 towers that include approximately 15,000 apartments and 1,500 villas. The island comprises of hotels, shopping centers and other facilities. Since 2010 Qatar Cool has been contracting with end users at The Pearl-Qatar, unlike is the company's practice in the West Bay district of Doha. The end users, whether individual owners or tenants, are billed directly by Qatar Cool for cooling service provided.

Qatar Cool serves major international brands outlets in this district such as Hugo Boss, Stefano Ricci, Rolls- Royce, Giorgio Armani, Calvin Klein, Ralph Lauren, Vodafone, Caribou and Costa Coffee Shops, and many more.

Every contracted customer has his own Energy Transfer Station (ETS) and all ETSs are connected through a fiber optic network to a central control room.

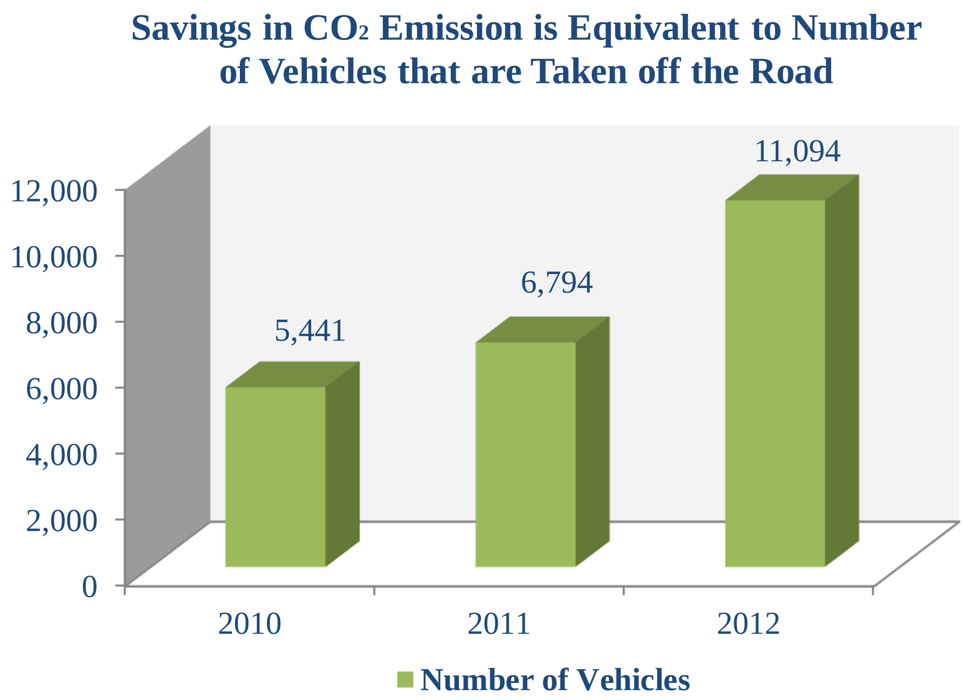
Qatar Cool takes system efficiency very seriously and dedicates substantial, continuous efforts to improving it. The performance data is reviewed daily in order to enhance efficiency of all equipment to ensure customer satisfaction. Since the inception of the company, a weekly meeting is conducted to review past-week results where we identify opportunities to further improve efficiency of Qatar Cool's operations.

Qatar Cool's system design operating criteria is 0.95 kW of power consumption and 2.20 US gallons of water to produce 1.0 Ton of Refrigeration. Appendix C shows IDCP performance for the past three (3) years.

On the environmental side, a study made by Qatar Cool showed, the produced cooling capacity by IDCP the past three (3) years saves a tremendous amount of $CO_2$ emission in comparison to the conventional cooling systems. The table below demonstrates the amount of $CO_2$ emission saved.

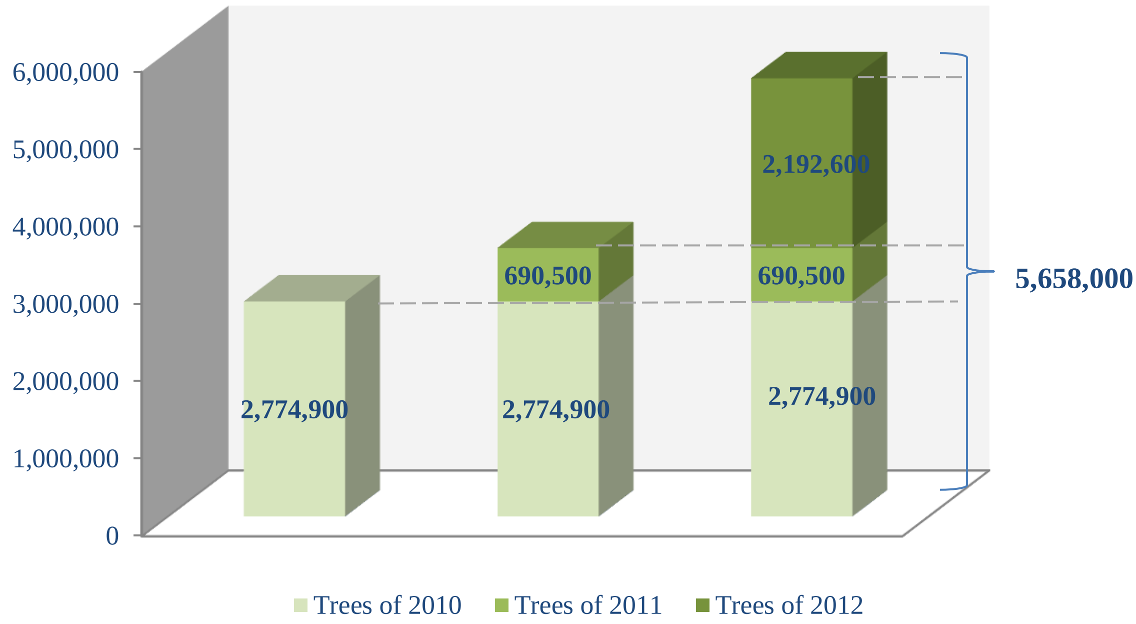
| Year | $CO_2$ Emission Saved (Metric Tons) |
|---|---|
| 2010 | 27,749 |
| 2011 | 34,654 |
| 2012 | 56,580 |

Scientifically speaking a typical passenger vehicle emits 5,100 Kilogram of $CO_2$ annually. Savings in the $CO_2$ emission annually is equivalent to removing vehicles from the road as highlighted in the following chart.




An additional study also made by Qatar Cool demonstrated that the amount of $CO_2$ emissions saved by IDCP in the past three (3) years is equivalent to planting mature trees.

According to a scientific study, a mature tree can absorb 10 kg of $CO_2$ per year; therefore, the total number of trees that could be possibly planted at the end of 2012 is 5,658,000 trees. The chart below shows the increase in the number of trees the past three (3) years.




In regards to the Ecoheat4cities calculation tool, we were unable to use the calculation tool completely due to the following reasons:

1. The plant operates using electricity supplied by local utility provider which prevents generating its own electricity from non-renewable sources, thus the factors of fP,dc and nren (non-renewable primary energy factor of District Cooling ) cannot directly applied.
2. The plant uses water cooled chillers and not absorption chillers so the ratio of cooling from renewable/surplus heat carriers to the total cooling is not applicable.

The attached sheet in Appendix D containing figures related to cooling delivered to buildings (MWh), Auxiliary electricity use (MWh) and Fuel energy output. For result labeling criteria, we included anonymous vales of Spain since Qatar is not included in the drop down list of countries.

In terms of innovation, Low Delta-T syndrome is a common issue in most of the district cooling schemes and it becomes worse during the winter season as the cooling consumption drops drastically, which reduces the chiller plant utilization to almost 15% to 20 % of the designed capacity, also led to increasing the plant power consumption by 10% above the designed parameters.

To overcome this issue, a study was carried out to convert chiller trains from soft starter to Variable Speed Drive (VSD) and convert the fixed volume primary pumps to variable volume. However, there were major modifications required in the plant equipment, which demanded more space and interruption of service to the customers. The cost required to convert one chiller train from soft starter to VSD was approximately U.S Dollars 1.5 million each, which did not justify the return on investment; especially with the presence of a TES tank and the increase in customers cooling load demand at that time.

As the VSD solution was not considered due to complicated implementation and high cost, an alternate solution was studied, which was based on controlling factors associated with chiller tons (Delta-T multiplied Flow).

As controlling Delta-T was not feasible due to poor control of the customer's building Heating Ventilation and Air Conditioning (HVAC) system, it was decided to control the chilled water flow through the chillers within operational limits of (5,500 US gallon per minute to 9,100 US gallons per minute) of the chillers as specified by the chiller's manufacturer. In absence of variable primary pumps, the control over the flow of chilled water was achieved by converting the chilled water outlet valve from on/off to modulating type, control based on operator's interface temperature set point and cutoff limit for chilled water flow.

The said control enables variable flow through the chiller train providing the following advantages in the plant operation:

•Increasing the chiller production capacity by 5% to 8% more than its design through lowering the condenser water temperature

•Low Delta-T was compensated by increased chilled water flow through the chiller by ensuring that the chillers are loaded 100%.

The power loss from primary chilled water pumps due to throttling the pump discharge was almost negligible.

The solution implemented to tackle the low Delta-T syndrome was unique and innovative due to following reasons:

a. The low Delta-T drawback of the district cooling scheme was used as an advantage, for example, the low return temperature enabled the chillers to accommodate more flow than its designed parameters.

b. All the study and implementation of the solution was done using in-house expertise and experience from day to day operation of the plant.

c. In-depth analysis and co-ordination were done with the chiller manufacturer to understand the design conditions of the chillers and the limits to which the chillers can operate without affecting the equipment operational life.

d. Lowering the condenser water temperature more than the designed conditions specified by the chiller manufacturer enabled us to extract 5% to 8 % extra capacity from the chillers.

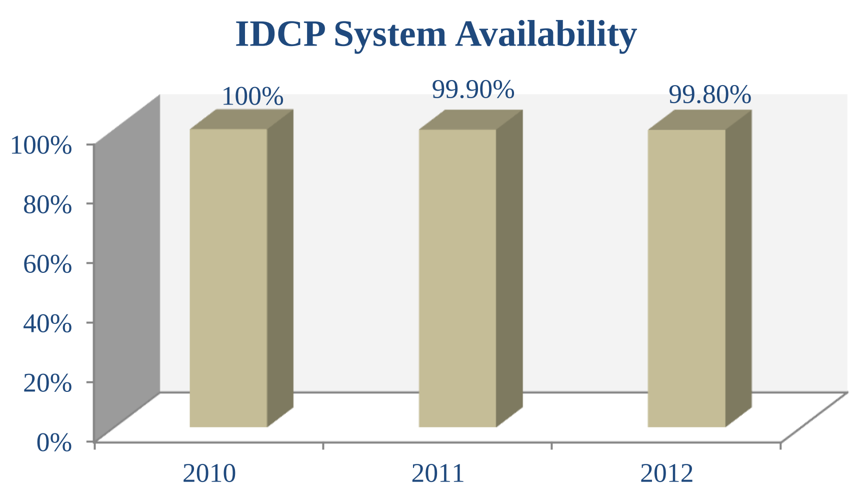
e. To achieve better power efficiency from the chillers at partial load conditions, VSD based chillers and primary pumps are ideally required. In our program we ensured loading the chillers to 100 % of its capacity by pumping higher flow through the chiller thus improving the chiller efficiency at partial load condition.

The improved energy efficiency by this project was demonstrated through the utility consumption as shown below:

| Produced Cooling Ton-Hrs | Design Performance Kw / TR | Actual Electricity Performance kW/TR | Design Performance US gal/TR | Actual Water Performance US gal/TR-Hr |
|---|---|---|---|---|
| 105,689,508 | 0.95 | 0.87 | 2.20 | 2.02 |

Furthermore, the plant has an automatic system for chemical analysis and dosing system to ensure constant water properties and an onsite water laboratory. In addition to the usage of the fresh water the plant is equipped to use the Treated Sewage Effluent (TSE) water. In addition, the blow down water from the cooling towers at IDCP could be discharged to the sea or the sewer system or used for irrigation purposes.

Furthermore, Qatar Cool strives to maintain a 100% reliability IDCP system overall service reliability is calculated through dividing the hours of interruption on the total of customer hours as highlighted in the chart below for years of 2010, 2011 and 2012.



Community Impact:

Our Corporate Social Responsibility initiatives are aimed at public awareness and environment protection towards a sustainable future for Qatar. We believe change can be brought about through awareness, education, robust peer initiatives and public-private partnerships.

In order to increase awareness on district cooling technology we organize and sponsor a seminar every other year, along with our subsidiaries, to promote the benefits of this technology in Qatar. This allows suppliers, vendors and facility management companies to come together, share ideas and promote dialogue.

We also take part in local cultural and charitable initiatives. Qatar Cool arranges an annual blood donation drive with local hospitals where all our staff is encouraged to donate blood. We actively sponsored the operatic return of Placido Domingo to Qatar, a hugely successful event further strengthening our commitment to adding value to our community.

Peer on peer initiatives allow for the sharing of ideas and technological advancement. Our support of the Qatar Society of Engineers in Qatar has brought a wealth of information exchange.

Another key pillar of our Corporate Social Responsibility strategy is the youth of Qatar. We participate in youth initiatives with school and university students. Our engineers are often invited to present to students in Education City - Qatar, especially those studying at Texas A&M - Qatar. We take part in career fairs, small and big and are always open to supporting any educational or environmental initiatives in line with our Corporate Social Responsibility policy.

Our annual internship program has been a great success year on year. Not only do the interns learn a wealth of on-the-job experience, but our company is injected with fresh ideas and new thinking, blending the old with the new and limiting the possibility of stagnation in the company. This program is offered to local and foreign students from around the world such as the United States, Europe, Africa and the Middle East, making Qatar Cool truly international.

We believe in preparing young students early. We organize visits for local school to increase awareness about our industry.

# Appendix D

| | |
|---|---|
| File: | Ecoheat4Cities Calculation Tool v 1.3 |
| Date: | 11 oktober 2012 |
| Project: | Ecoheat4Cities |
| Concerns: | Calculation of performance indicators based on fuel inputs and outputs |
| **Part** | **Introduction** |

This sheet has pages for case specific data, fuel default conversion factors, design values,
calculations for DC using Ecoheat4Cities default labeling criteria and National default labeling criteria
and overall results .

Page with notes on this version has a grey background

Input page has a green background with

open input fields

Page with conversion factors for the fuels has a brown-orange background

Fixed values are given in

light yellow fields

Own input values are given in

open input fields

Page with system design values has a light blue background

Design values are given in

light blue fields

Pages with calculations and results have a light yellow background with

yellow output fields

# Cont. Appendix D

**Part** **Input**

**Regional information**

| | | |
|---|---|---|
| Country | Spain | Target share of renewables in 2020 is country-dependent |

**Input district cooling system**

**Delivered cooling**

| | | |
|---|---|---|
| Cooling delivered to buildings | 376.7 | MWh |

**Auxiliary electricity**

| | | |
|---|---|---|
| Auxiliary electricity use | 116.2 | MWh |

**Fuel input and output**

| | description production facility | production facility type | type of fuel | Fuel energy input (MWh) | Cooling output (MWh) |
|---|---|---|---|---|---|
| 1 | District Cooling Plant (130,000 TR) | Chiller | Electricity | 116.2 | 371.6 |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
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| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | | | | | |

**Absorption chillers**

| | description | | | $Q_{ext}$ (MWh) | Cooling output (MWh) | $f_{P,ext}$ | $K_{P,ext}$ | $R_{ext}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

$K_{P,ext}$ in kg $CO_2$/MWh

**Exported heat**

| | description | Exported heat (MWh) | $f_{P,displ}$ | $K_{P,displ}$ |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

$K_{P,displ}$ in kg $CO_2$/MWh

Cont. Appendix D

**Part** **Results District Cooling**

`

**SUMMARY RESULTS LABELING CRITERIA**

**District cooling**

| | Ecoheat4Cities default | | National default | |
|---|---|---|---|---|
| $f_{P,dc,nren}$ | 1.60 | | 1.60 | |
| $K_{P,dc,nren}$ | 259 | kg $CO_2$ / MWh | 259 | kg $CO_2$ / MWh |
| $R_{dc}$ | 20 | % | 20 | % |
| Class $f_{P,dc,nren}$ | 5 | | 5 | |
| Class $K_{P,dc,nren}$ | 5 | | 5 | |
| Class $R_{dc}$ | 3 | | 3 | |
| Petals $f_{P,dc,nren}$ | 3 | | 3 | |
| Petals $K_{P,dc,nren}$ | 3 | | 3 | |
| Petals $R_{dc}$ | 5 | | 5 | |

**Values reference DC system**

| | Ecoheat4Cities default | | National default | |
|---|---|---|---|---|
| $f_{P,dc,nren}$ | 0.74 | | 0.74 | |
| $K_{P,dc,nren}$ | 120 | kg $CO_2$ / MWh | 120 | kg $CO_2$ / MWh |
| $R_{dc}$ | 20 | % | 20 | % |

| Part | Default conversion factors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Ecoheat4Cities default*** | | | | | | | | | | | |
| Fuel class | Fuel/energy carrier | $f_{P,F,nren}$ | $K_{F(i)}$ (kg $CO_2$ /MWh) | $R_{F(i)}$ | Alternative $\eta_{elec}$ - 2001 | Alternative $\eta_{elec}$ 2002 | Alternative $\eta_{elec}$ 2003 | Alternative $\eta_{elec}$ 2004 | Alternative $\eta_{elec}$ 2005 | Alternative $\eta_{elec}$ 2006-2011 | Alternative $\eta_{elec}$ 2012-2015 |
| Fossil | Natural gas | 1.1 | 230 | 0 | 0.517 | 0.519 | 0.521 | 0.523 | 0.524 | 0.525 | 0.525 |
| Fossil | Liquid gas | 1.1 | 260 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Light oil | 1.1 | 290 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Heavy oil | 1.1 | 300 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Coal | 1.1 | 370 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Lignite | 1.1 | 370 | 0 | 0.403 | 0.407 | 0.411 | 0.414 | 0.416 | 0.418 | 0.418 |
| Renewable | Primary bio fuel, liquid | 0.1 | 20 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Renewable | Primary bio fuel, gas | 0.1 | 20 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Renewable | Primary bio fuel, wood | 0.1 | 20 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Renewable | Primary bio fuel, agricultural | 0.1 | 20 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Renewable | Refined primary bio fuel, liquid | 0.2 | 40 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Renewable | Refined primary bio fuel, gas | 0.2 | 40 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Renewable | Refined primary bio fuel, wood | 0.2 | 40 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Renewable | Refined primary bio fuel, agricultural | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Secondary bio fuel, liquid | 0.1 | 20 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Recycled | Secondary bio fuel, gas | 0.1 | 20 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Recycled | Secondary bio fuel, wood | 0.1 | 20 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Recycled | Secondary bio fuel, agricultural | 0.1 | 20 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Refined Secondary bio fuel, liquid | 0.2 | 40 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Recycled | Refined Secondary bio fuel, gas | 0.2 | 40 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Recycled | Refined Secondary bio fuel, wood | 0.2 | 40 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Recycled | Refined Secondary bio fuel, agricultural | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Residual fuel from other process, gas | 0.2 | 40 | 1 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Recycled | Residual fuel from other process, liquid | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Residual fuel from other process, solid | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as fuel, gas | 0 | 0 | 1 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Recycled | Waste as fuel, liquid | 0 | 0 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as fuel, solid | 0 | 0 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as heat | 0 | 0 | 1 | | | | | | | |
| Renewable | Geothermal heat | 0 | 0 | 1 | | | | | | | |
| Renewable | Solar heat | 0 | 0 | 1 | | | | | | | |
| Electricity | Electricity | 2.6 | 420 | 0.2 | | | | | | | |
| Renewable | Renewable / recycled / free cooling | 0 | 0 | 1 | | | | | | | |

Primary energy en CO2 values according to E4C guidelines draft 26 April 2012

## Cont. Appendix D

Values with white background are not fixed and may be changed

***National default***

| Fuel class | Fuel/energy carrier | $f_{P,F,nren}$ | $K_{F(i)}$ (kg $CO_2$ /MWh) | $R_{F(i)}$ | Alternative $\eta_{elec}$ - 2001 | Alternative $\eta_{elec}$ 2002 | Alternative $\eta_{elec}$ 2003 | Alternative $\eta_{elec}$ 2004 | Alternative $\eta_{elec}$ 2005 | Alternative $\eta_{elec}$ 2006-2011 | Alternative $\eta_{elec}$ 2012-2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fossil | Natural gas | 1.1 | 230 | 0 | 0.517 | 0.519 | 0.521 | 0.523 | 0.524 | 0.525 | 0.525 |
| Fossil | Liquid gas | 1.1 | 260 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Light oil | 1.1 | 290 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Heavy oil | 1.1 | 300 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Coal | 1.1 | 370 | 0 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Fossil | Lignite | 1.1 | 370 | 0 | 0.403 | 0.407 | 0.411 | 0.414 | 0.416 | 0.418 | 0.418 |
| Renewable | Primary bio fuel, liquid | 0.1 | 20 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Renewable | Primary bio fuel, gas | 0.1 | 20 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Renewable | Primary bio fuel, wood | 0.1 | 20 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Renewable | Primary bio fuel, agricultural | 0.1 | 20 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Renewable | Refined primary bio fuel, liquid | 0.2 | 40 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Renewable | Refined primary bio fuel, gas | 0.2 | 40 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Renewable | Refined primary bio fuel, wood | 0.2 | 40 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Renewable | Refined primary bio fuel, agricultural | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Secondary bio fuel, liquid | 0.1 | 20 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Recycled | Secondary bio fuel, gas | 0.1 | 20 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Recycled | Secondary bio fuel, wood | 0.1 | 20 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Recycled | Secondary bio fuel, agricultural | 0.1 | 20 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Refined Secondary bio fuel, liquid | 0.2 | 40 | 1 | 0.427 | 0.431 | 0.435 | 0.438 | 0.44 | 0.442 | 0.442 |
| Recycled | Refined Secondary bio fuel, gas | 0.2 | 40 | 1 | 0.401 | 0.406 | 0.41 | 0.414 | 0.417 | 0.42 | 0.42 |
| Recycled | Refined Secondary bio fuel, wood | 0.2 | 40 | 1 | 0.304 | 0.311 | 0.317 | 0.322 | 0.326 | 0.33 | 0.33 |
| Recycled | Refined Secondary bio fuel, agricultural | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Residual fuel from other process, gas | 0.2 | 40 | 1 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Recycled | Residual fuel from other process, liquid | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Residual fuel from other process, solid | 0.2 | 40 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as fuel, gas | 0 | 0 | 1 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Recycled | Waste as fuel, liquid | 0 | 0 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as fuel, solid | 0 | 0 | 1 | 0.231 | 0.235 | 0.24 | 0.244 | 0.247 | 0.25 | 0.25 |
| Recycled | Waste as heat | 0 | 0 | 1 | | | | | | | |
| Renewable | Geothermal heat | 0 | 0 | 1 | | | | | | | |
| Renewable | Solar heat | 0 | 0 | 1 | | | | | | | |
| Electricity | Electricity | 2.6 | 420 | 0.2 | | | | | | | |
| Renewable | Renewable / recycled / free cooling | 0 | 0 | 1 | | | | | | | |

## Cont. Appendix D

| Part | Design values | | |
|---|---|---|---|

**Production types district cooling**

Absorption chiller
Chiller
Free cooling

| Data reference district cooling system | | Ecoheat4Cities default | National default |
|---|---|---|---|
| Delivered cooling / electric input | | 3.50 | 3.50 |
| Target for market share of renewables | $\beta_R$ | 0.2 | 0.2 |
| PEF of electricity | $f_{P,el}$ | 2.6 | 2.6 |
| PEC of electricity | $K_{el}$ | 420 | 420 |

**EU 20:20:20 target for share of renewables**

| | (%) |
|---|---|
| Austria | 34 |
| Belgium | 13 |
| Bulgaria | 16 |
| Cyprus | 13 |
| Czech Rep | 13 |
| Denmark | 30 |
| Estonia | 25 |
| Finland | 38 |
| France | 23 |
| Germany | 18 |
| Greece | 18 |
| Hungary | 13 |
| Ireland | 16 |
| Italy | 17 |
| Latvia | 40 |
| Lithuania | 23 |
| Luxemburg | 11 |
| Malta | 10 |
| Netherlands | 14 |
| Poland | 15 |
| Portugal | 31 |
| Romania | 24 |
| Slovak Rep | 14 |
| Slovenia | 25 |
| Spain | 20 |
| Sweden | 49 |
| UK | 15 |
| EU27 | 20 |