Biomass Energy Portfolio for Czech Republic

Monitoring Report 2012
Version 1

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for Czech Republic

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Version 1

Colophon

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1 INTRODUCTION

The project *Biomass Energy Portfolio for Czech Republic* is a Joint Implementation project sponsored by NL Agency (former SenterNove or Senter Internationaal), agency of the Dutch Ministry of Economic Affairs. The project is owned by a Dutch company B.T.G. BioHeat International B.V. (hereinafter “BTG Bioheat”) and administered by its subsidiary, Czech company BTG Central Europe s.r.o. (hereinafter “BTG CE”). After winning a contract (#ERU 0011) in the ERUPT 2000 tender and two years of administrative delays, the project received approval from the Czech Ministry of Environment in 2004, satisfied the contractual requirements of the Dutch government, and started receiving prepayments from Senter Internationaal.

The project is a flexible portfolio of currently 18 subprojects in the Czech Republic where fossil fuels are being replaced with biomass. This document is the ninth monitoring report of the portfolio. It is linked to the original Project Description (BTG, February 2001) and the Validation Reports (SGS, January 2001 and May 2004). It covers emission reductions for the 18 subprojects of the portfolio. The emission reductions are from the period *1st January 2012 to 31st October 2012*. All of the subprojects have passed Initial Verification, six of them will be verified for the 10th time, seven for the 9th time, one for the 8th time and four will be periodically verified for the 4th time.

The First and the Second verification carried out in 2004 and 2005 covered emission reduction for 13 subprojects generated between January 1st and December 31st 2003 and 2004. The 14th subproject (Trebic, Biomass Energy s.r.o.) has been in operation since January 2005. A preliminary verification for the period January – June 2005 was required to assure the subproject was in proper operation. This was done as the 1st Extension to the Biomass Energy Portfolio. The Third, Fourth, Fifth, Sixth and Seventh Verification was carried out in 2006, 2007, 2008, 2009 and 2010 respectively, covering emission reduction for 14 subprojects between 1st January and 31st December of the years 2005, 2006, 2007 and 2008, respectively. In late 2010 a preliminary verification covering the period from 2002 to 2009 was carried out for 4 additional projects, as the 2nd Extension to the Biomass Energy Portfolio. Verifications in 2011 was the first year where the verification was carried out for the emission reductions of all 18 subprojects. The verified period was from January 1st to 31st December 2010. The Ninth Verification of all 18 projects was from January 1st to 31st December 2011. The Tenth verification continues in this sequence and covers emission reductions of the 18 subprojects, as they are presented below:

- Bouzov,
- Bystrice nad Pernstejnem,
- Driten,
- Horni Plana,
- Kasperske Hory,
- Nova Cerekev,
Pelhrimov, Iromez s.r.o.,
Rostin,
Slavicin,
Stitna nad Vlari, Javornik-cz s.r.o.
Trebic, Biomass Energy s.r.o., (K13-ORC)
Trebic, JIH,
Trebic, K13
Trhove Sviny,
Velky Karlov,
Zlate Hory,
Zruc nad Sazavou,
Zlutice.

The purpose of this document is to provide the verifier (TÜV SÜD) with monitored data for the ninth verification round. The primary objective of early monitoring and verification (years 2002 - 2007) was to see whether the progress made within the portfolio went according to plans and allowed the emission reductions to be accounted as Early Credits (AAUs). Since the year 2008, the emission reductions are mostly accounted as Emission Reduction Units (ERUs). To avoid double counting, emission reductions arising from electricity generation are accounted as Assigned Amount Units (AAUs).

This report has seven chapters. The first and the second chapters return briefly to the project description, the project evolution and its current status. They explain the flexible approach of the portfolio and the planned development structure by subproject batches. The third chapter comments on the monitoring methodology, the fourth on the determination of the emission reductions and includes a table summarizing the emission reduction results calculated for period January-October 2012. The fifth chapter introduces the management system and the sixth states comments of each monitored subproject and the way it evolved. Six appendices are attached to this document. These include a Monitoring Protocol, copies of original monitoring forms filled out by representatives of all subprojects, an emission calculation file, copies of assignment letters from all project owners authorizing respective persons to carry out monitoring in the relevant facilities and a statement declaring their acquaintance with the Monitoring Manual, Subproject Monitoring Manual and Reporting and Calculating Procedure Manual for BTG Staff.
2 PORTFOLIO OVERVIEW AND UPDATE

The JI project, *Biomass Energy Portfolio for Czech Republic*, followed the successful implementation of several AIJ projects carried out in Central Europe by BTG in years 1999 and 2000, which involved implementation of technologies where biomass fuels replaced fossil fuels.

The original proposal consisted of 28 subprojects. Currently, the portfolio consists of 18 subprojects, ten of which have been added after the original project submission and replaced other projects.

2.1 Portfolio update

The general idea of project bundling is to facilitate the application of small projects within Kyoto mechanisms. Treating small projects (such as the subprojects of the current report) individually would most likely lead to transaction costs that would be unbearably high. The bundling concept can be applied only when the projects are sufficiently similar. The baseline and emission reduction calculations can then be standardized and neglected small differences compensated by adopting more conservative methods and moderate factors.

Such approach has been taken up in the current project and the portfolio has been treated by the validator as one project. The same approach is assumed for the verification which is also the reason why a bulk monitoring report has been elaborated, rather elaborating separate reports for each subproject.

A part of the project concept was that subprojects could be flexibly replaced if they failed during their initial stages of development, or in general that new subprojects can be added to the portfolio, as long as they maintain the characteristics described in the original proposal:

- With a few exceptions (industrial heat and a single building heat supply), the subprojects are district-heating systems owned by municipalities. The emission reduction takes place primarily by coal-to-biomass fuel-switch and elimination of methane emissions by avoiding biomass residues dumping. New biomass CHPs and energy saving measures also contribute in some subprojects.
- The subprojects range between 0.5 and 9 MW in their thermal output. All subprojects are already in full operation.
- Except one subproject in Pelhrimov, all of them have received financial support from the State Environmental Fund of the Czech Republic (SEF). The SEF process of evaluation guarantees that each of the subprojects is sound in terms of economy, environmental impacts and policy with priorities of the Ministry of Environment of the Czech Republic. Iromez s.r.o., Pelhřimov has not received financial support from the State Environmental Fund, despite the fact that they fulfilled all application conditions, because the SEF in recent years lacked financial resources. Iromez received financial support from the Czech Energy Agency where the evaluation procedure was very similar. Because of its carbon
credit generation, the project has a sufficiently high return on investment and so the project meets the ‘additionality requirement’.

2.2 Previous verifications

The validation of all subprojects was carried out in two batches in 2001 and 2004, respectively, by company SGS Nederland B.V. The verifications were done by the company TÜV SÜD Industrie Service GmbH.

The First Verification of the first batch of subprojects for the period January – December 2003 was carried out in 2004. The Second Verification was carried out in 2005. It covered emission reductions of the 13 subprojects in the portfolio generated between 1st January and 31st December of the year 2004. The 14th subproject (Trebic) has been in operation since January 2005. Preliminary verification for the period January – June 2005 was required to assure the subproject was in proper operation.


Based on the approval from the NL Agency and the Ministry of the Environment of the Czech Republic, 4 new projects (Kasperske Hory, Trhove Sviny, Trebic JIH and K13) were added to the Portfolio to compensate decreasing heat production caused by the warm and short winters in the Czech Republic and extensive insulation of the objects connected to central heating systems. A preliminary verification of these new projects was necessary to assure that their operation is sound with the definition of the Biomass Energy Portfolio.

The Eighth verification of the year 2010 was in 2011. The last conducted in March 2012 verification was the Ninth. It related to realized emission reductions in the year 2011.

2.3 Comments on specific issues

Comments regarding the validation recommendations

In the Validation Report (SGS, January 2001), monitoring of possible changes in the use of land and environmental impacts related to the removal of agricultural residues from soils is recommended to be observed.

So far regarding this matter, neither specific changes to the use of land nor any environmental impacts due to the agricultural residue removal have been observed in connection with the subproject implementation.

Wood fuel used by operators is the waste from forestry or wood-processing industry (saw mills etc.) so there is no direct risk that the implementation of the subprojects will have a negative impact on sustainable forestry. However, the suppliers of fuel, place of biomass origin and any possible environmental impacts which may arise are to be monitored.

The aforesaid recommendations will also be considered during future monitoring as the likelihood of occurrences of these impacts may increase with time of operation.
Comments on emission reductions

The anticipated emission reductions from the baseline study differ from the monitored values. The first submission of the Baseline Study of the Biomass Energy Portfolio for the Czech Republic in 2001 encompassed a total of 28 subprojects. An extension followed in 2004 with another 8 subprojects. The total annual emission reduction anticipated for the year 2012 was 278.5 kERUs (242.5 kERUs for the original baseline study and 36 kERUs for the extension). The current monitored emission reduction is 100,694 ERUs. There are several reasons for such disparity between the two latter values. During the period of the Portfolio’s implementation some of the subprojects were abandoned, which led to a total decrease in the emission reductions. The Portfolio currently includes 18 subprojects. The other reason why the values differ is that in some subprojects higher capacity boilers were to be installed. Instead smaller boilers were installed leading to the reduction of the total annual ERUs.

Comments on environmental and social issues

For energy system installations of less than 50MWth, the Czech legislation does not require the performance of any EIA or screening procedure concerning the necessity of an EIA.

The Building Act No. 183/2006 Coll. of the Czech Republic orders to obtain opinions of local stakeholders. All of the subprojects have had to satisfy this requirement. The fact that all of them have received the construction permit is the evidence that they have passed this screening procedure successfully.

Further to this matter, all of the subprojects have been screened by the State Environmental Fund for their alignment with the national environment protection priorities. The fact that all of the subprojects have a contract with the SEF is further evidence that the environmental and social impacts are positive.

The JI Guidelines of the Czech Ministry of Environment do not require any specific treatment of the environmental and social issues other than the existing national legislation.

All of the projects routinely monitor other than CO₂ emissions according to the Air Protection Act (No. 86/2002 Coll.).
3 MONITORING METHODOLOGY

The initial baseline calculation method was developed by BTG\(^1\) and validated by SGS in 2001\(^2\). The calculated carbon emissions to be avoided were based on assumptions of the number of working hours of the biomass plant, its load factor and capacity. The results provide a realistic estimate of the expected emission reductions. The initial baseline study suggested that monitoring should be focused on “figures of (1) annual heat production and (2) quality and proportions of consumed biomass fuels”.

From the initial verification of the project, BTG CE developed a monitoring methodology according to experience from the project implementation. The monitoring methodology is based on measured annual heat production, estimations of the consumed biomass fuels and additional data quality checks.

In the following section the monitoring methodology is described in detail.

3.1 Determination and calculation of avoided emissions

The principal parameters that are monitored are:

1. the heat and power production in GJ and MWh, respectively, during a period of time – metered at the boiler/turbine outputs and recorded either electronically or manually,

2. the heat and power sales in GJ and MWh, respectively, during a period of time – metered at the take-off places and recorded either electronically or manually,

3. the type and volume of combusted fuel during a period of time – recorded in production diaries.

Baseline emissions are calculated for every type of baseline heat source (central coal/oil/gas boilers, individual coal/wood/oil/gas/electric stoves) individually. There are three possible cases:

**Case 1**

A biomass boiler substitutes an old central boiler with an existing distribution system and subsequently the bio-produced heat substitutes the amount of fossil-produced heat.

**Case 2**

Individual stoves are substituted; the newly installed biomass boiler substitutes just the individual heat demand. There was no district heating system before the biomass district heating system.

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\(^1\) Mr. Meuleman et. al., 2001, Biomass Energy Portfolio for Czech Republic, a baseline study, ERU-PT Programme, January 2001.

Case 3

An old fossil fuelled district heating and individual stoves are replaced with a biomass district heating system.

3.1.1 \textbf{Determination of heat produced by biomass boiler and/or individual stoves}

3.1.1.1 \textit{Heat production by biomass boiler}

\begin{itemize}
  \item Measurement method
    \begin{itemize}
      \item Heat meter equipment measuring heat production of the biomass boiler.
      \item Double check 1: Gathering information on used volume of biomass, (and calculate how much heat would be produced with it, based on average Lower Heating Values (LHVs) and biomass boiler efficiencies).
      \item Double check 2: Gathering information on the heat sold
    \end{itemize}
  \end{itemize}

\begin{itemize}
  \item Calculation method
    \begin{itemize}
      \item The heat produced with the biomass boiler is calculated back to the replaced coal, oil or gas that would be consumed in the baseline situation. The avoided CO2 emissions are calculated with standard emission values of these fossil fuels.
      \item Double checks are performed as much as possible.
      \item If no calibration report of the meter equipment is available, at least one double check is obligatory.
      \item If somehow problems have occurred with the heat production measurement equipment, double check 1 has to be performed, and the final calculation has to take into account the more limited reliability of this method, compared to directly measured heat production.
    \end{itemize}
\end{itemize}

3.1.1.2 \textit{Heat production by biomass boiler – special situations}

\textbf{Combination of gas boiler and biomass boiler}

Combination of both boilers in one boiler house, heat production is measured separately; produced heat is jointly delivered to consumers

\begin{itemize}
  \item Measurement method
    \begin{itemize}
      \item Heat meter equipment measuring heat production of the biomass boiler.
      \item Double check 1: Gathering information on used volume of biomass (and calculate how much heat would be produced with it, based on average Lower Heating Values (LHVs) and biomass boiler efficiencies).
    \end{itemize}
  \end{itemize}

\begin{itemize}
  \item Calculation method
    \begin{itemize}
      \item The heat produced with the biomass boiler is calculated back to the replaced coal, oil or gas that would be consumed in the baseline situation.
    \end{itemize}
\end{itemize}
The avoided CO2 emissions are calculated with standard emission values of these fossil fuels.

- Double check is performed as much as possible.
- If no calibration report of the meter equipment is available, at least one double check is obligatory.
- If somehow problems have occurred with the heat production measurement equipment, double check 1 has to be performed, and the final calculation has to take into account the more limited reliability of this method, compared to directly measured heat production.

**Combination of biomass boiler installed outside project boundary and biomass boiler that is within the portfolio**

Combination of both boilers in one boiler house, heat production is measured separately; produced heat is jointly delivered to consumers, combusted biomass fuel is measured separately.

- **Measurement method**
  - Heat meter equipment measuring heat production of the biomass boiler.
  - Double check 1: Gathering information on used volume of biomass, (and calculate how much heat would be produced with it, based on average Lower Heating Values (LHVs) and biomass boiler efficiencies).

- **Calculation method**
  - The heat produced with the biomass boiler is calculated back to the replaced coal, oil or gas that would be consumed in the baseline situation. The avoided CO2 emissions are calculated with standard emission values of these fossil fuels.
  - Double check is performed as much as possible.
  - If no calibration report of the meter equipment is available, the double check is obligatory.
  - If somehow problems have occurred with the heat production measurement equipment, double check 1 has to be performed, and the final calculation has to take into account the more limited reliability of this method, compared to directly measured heat production.

### 3.1.1.3 Introduction of new households to the district heating system

Connection of new households to the biomass district heating system

- **Determination of baseline**
  - What energy source would they use in absence of the biomass district heating system?
  - Case 1: biomass boiler replaces old central boiler, new households would in base case also be connected to central boiler
• Case 2: individual stoves are substituted, there was no district heating system before the biomass district heating system, so in new households are also individual stoves substituted
  ▪ Option 1: study situation of other households in same region in the same situation
  ▪ Option 2: take replacement of biomass by natural gas-fired individual stoves as a conservative estimate.

• Case 3: an old fossil fuelled district heating is replaced with a biomass district heating system, and the district heating system is extended (new households are substituting individual stoves (conservative approach)).
  ▪ Option 1: study situation of other households in same region in the same situation
  ▪ Option 2: take replacement of biomass by natural gas-fired individual stoves as a conservative estimate.

测量方法
• Heat supply to individual stove, or heat production biomass boiler depending on the case

计算方法
• Also dependent on the baseline: individual stove or heat supply biomass boiler.

3.1.1.4 Measurement of heat production used for emission reductions calculation

The projects of the portfolio differ moderately. As was already described above, in some cases heat is produced not only by biomass boiler(s) included in the portfolio, but also by other boiler(s). Several projects include power production too. Measuring points of produced heat that is used in the calculation sheet for emission reduction calculation of individual projects are summarized in Table 1. The flow-chart diagrams visualising the boiler(s) and position of metering equipments of individual projects are presented in the Chapter 6, where the individual projects are commented.
### Table 1 Determination of produced heat used for emission reduction calculation

<table>
<thead>
<tr>
<th>Project</th>
<th>Determination of produced heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouzov</td>
<td>Heat measured by heat meter at input/output of biomass boilers</td>
</tr>
<tr>
<td>Bystrice nad Pernstejnem</td>
<td>Heat measured by heat meters at input/output of biomass boilers</td>
</tr>
<tr>
<td>Driten</td>
<td>Heat measured by heat meters of consumers</td>
</tr>
<tr>
<td>Horni Plana</td>
<td>Heat measured at input/output of heating system of retirement house</td>
</tr>
<tr>
<td>Kasperske Hory</td>
<td>Heat measured by heat meter at input/output of biomass boilers</td>
</tr>
<tr>
<td>Nova Cerekev</td>
<td>Heat measured by heat meter at input/output of biomass boilers</td>
</tr>
<tr>
<td>Pelhrimov</td>
<td>Heat calculated as described in Chapter 3.2</td>
</tr>
<tr>
<td>Rostin</td>
<td>Heat measured by heat meter at input/output of boiler room</td>
</tr>
<tr>
<td>Slavice</td>
<td>Heat calculated from measured mass flow and temperatures</td>
</tr>
<tr>
<td>Stitna nad Vlari</td>
<td>Heat measured by heat meters at input/output of biomass boilers</td>
</tr>
<tr>
<td>Trebic (Biomass Energy s.r.o.)</td>
<td>Heat measured at input/output of district heating system</td>
</tr>
<tr>
<td>Trebic, JIH</td>
<td>Heat measured by heat meter at input/output of biomass boilers</td>
</tr>
<tr>
<td>Trebic, K13</td>
<td>Heat measured by heat meter at input/output of biomass boilers</td>
</tr>
<tr>
<td>Trhove Sviny</td>
<td>Heat measured by heat meter at input/output of boiler room</td>
</tr>
<tr>
<td>Velky Karlovo</td>
<td>Heat measured by heat meter at input/output of boiler room</td>
</tr>
<tr>
<td>Zlate Hory</td>
<td>Heat measured at input/output of district heating system</td>
</tr>
<tr>
<td>Zruc nad Sazavou</td>
<td>Heat measured by heat meter at input/output of boiler room</td>
</tr>
<tr>
<td>Zlutice</td>
<td>Heat measured by heat meters at input/output of boiler room</td>
</tr>
</tbody>
</table>

3.1.1.5 Comments on biomass quality and its monitoring

The amount of combusted biomass is monitored to double check measured heat production. For the check, the biomass boiler efficiency is calculated from measured heat production divided by biomass heat content. The boiler efficiency is calculated automatically by the calculation sheet using average heating values of biomass. The default values used in calculation are summarized in Table 2.

### Table 2 Default heating values of biomass fuels

<table>
<thead>
<tr>
<th>Biomass fuel</th>
<th>Heating value (GJ/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood chips</td>
<td>10</td>
</tr>
<tr>
<td>Sawdust</td>
<td>10</td>
</tr>
<tr>
<td>Bark</td>
<td>10</td>
</tr>
<tr>
<td>Pellets</td>
<td>17.54</td>
</tr>
<tr>
<td>Straw</td>
<td>16</td>
</tr>
</tbody>
</table>

Heating value of biomass depends strongly on its moisture content as can be seen in Table 3. The moisture content of combusted biomass, especially of wooden biomass (wood chips, sawdust and bark) can vary a lot, depending on its origin: The moisture

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content of fresh wood is about 50%, the waste wood from wood processing companies can have moisture content significantly lower. The calculation of boiler efficiency is therefore just approximate. Monitoring of biomass quality for more exact estimation (e.g. regular laboratory tests of biomass) would be unreasonably expensive considering the capacity of individual subprojects and that the information about biomass heat content is just complementary. The produced heat, measured by heat meters calibrated on a regular basis, is used for the calculation of emission reductions.

Moreover, the biomass is often stored in open space (e.g. in Slavicin), so that the moisture varies a lot depending not only on supplier and type of biomass but also on weather conditions and time. The measurement of its moisture or analyzing the samples in laboratory is in these cases useless. According the Czech law, the quality of fuel should be described by supplier. However, in practice the suppliers of wood chips usually omit this requirement. Some of the projects monitor the moisture of biomass using moisture meters or calculations using the weight of the biomass, however the estimations are very rough.

### Table 3 Biomass lower heat value for different moisture contents (in GJ/t)

<table>
<thead>
<tr>
<th>Fuel \ moisture content</th>
<th>10 %</th>
<th>20 %</th>
<th>30 %</th>
<th>40 %</th>
<th>50 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood chips</td>
<td>16.4</td>
<td>14.28</td>
<td>12.18</td>
<td>10.10</td>
<td>8.1</td>
</tr>
<tr>
<td>Wood</td>
<td>16.4</td>
<td>14.3</td>
<td>12.2</td>
<td>10.1</td>
<td>8</td>
</tr>
<tr>
<td>Bark</td>
<td>16.7</td>
<td>14.6</td>
<td>12.5</td>
<td>10.5</td>
<td>8.4</td>
</tr>
<tr>
<td>Fuel-wood</td>
<td>16</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood residue chips</td>
<td>6-15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.2 Determination of avoided methane production

The calculation of avoided methane emissions expressed in CO₂e, \( EM_{\text{CO}_2,\text{methane}} \), is based on the quantity of wood chips, sawdust and bark consumed, \( M_{\text{wood}} \), expressed in tonnes of dry matter,

\[
EM_{\text{CO}_2,\text{methane}} = M_{\text{wood}} \times DW \times MEF \times GWP \times T,
\]

where

\[
M_{\text{wood}} = V_{\text{(wood wet)}} \times \text{density}_{\text{(wood dry)}}.
\]

\( DW \) is the fraction of biomass that would be in the baseline scenario anaerobically digested, the number is provided by the project owner/operator based on the interview all biomass suppliers. \( MEF \) is the methane forming factor, giving the amount of methane that

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7 Wood Fuels Basic Information Pack. Gummerus Kirjapaino Oy, Saarijarvi, 2002, Table 4.5.
will evolve from 1 t of dry wooden biomass under anaerobic conditions in 1 year, GWP is the global warming potential of methane, 21, and T time for which the methane emissions are calculated, i.e., \( T = 1 \text{ y} \) in this case.

### 3.1.3 Determination of power generation

The baseline emissions due to power generation from biomass (and substitution of the grid power), \( EM_{CO_2,\text{generation}} \), are calculated from the power generated \( P \), electricity emission factor, \( EF_{electricity} \), taking into account avoidance of gross available grid losses \( GL_{GA} \)

\[
EM_{CO_2,\text{generation}} = P \times EF_{electricity} \times (1+GL_{GA})
\]

The emission factor for the Czech Republic has been calculated using the program GEMIS (Öko-Institut Darmstadt) that was used as a standard software by the Czech energy authorities such as the Czech Energy Agency. In the initial PDD (presented in 2001) conservative emission factors for the project lifetime were linearly interpolated. The conservative variant was based on the data of the Czech Power Company (ČEZ) involving all electricity resources including the nuclear power and its substantial increase in the coming years: i.e. replacing 32.2 TWh/y of brown-coal power with 24.1 TWh/y of nuclear power plus 8.1 TWh/y of black-coal power by 2005. From 2005 to 2020 then linearly interpolating was performed. This method gave rather conservative results and for that reason it had been chosen for the baseline emission calculation in 2001.

Given the fact that the interpolated emission factor does not follow real electricity resources, the emission factor for power production provided by the Ministry of Environment of the Czech Republic has been used since the year 2007, see Table 4.

**Table 4 Electricity emission factor for the Czech Republic**

<table>
<thead>
<tr>
<th>Year</th>
<th>t CO₂/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>1.12</td>
</tr>
<tr>
<td>2008</td>
<td>1.11</td>
</tr>
<tr>
<td>2009</td>
<td>1.11</td>
</tr>
<tr>
<td>2010</td>
<td>1.11</td>
</tr>
<tr>
<td>2011</td>
<td>1.11</td>
</tr>
<tr>
<td>2012</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The confirmation of electricity emission factor issued by the Ministry of Environment of the Czech Republic has been delivered to TÜV SÜD in December 2008.

### 3.1.4 General input parameters

Table 11 shows the general input parameters for the emission calculation.

### 3.1.5 Energy efficiency measures

Improvement of energy efficiency is caused especially by reconstruction of old district heating systems with high loses (e.g. in Zlate Hory or Bystrice). The improvement is reflected in a higher value of distribution efficiency. Moreover, the objects connected to
the heating systems are continuously insulated (new windows, better insulation) causing further energy savings. However, the energy savings are not measured and they are not included in the emission reduction calculation.

3.2 Calculation of net heat production at Pelhrimov, Iromez

The company Iromez produces both electricity and heat. The heat provided to the district heating system (the “Net Heat Production”) is however not measured. It is important to determine the heat provided to the district heating system, since this is used to determine the amount of carbon credits generated by this project. In Figure 1 Iromez steam system is shown.

The principles of the estimation procedure are the same as in the previous year calculation. Net heat production is estimated using quarterly data.

The essence of the calculation is to determine the amount of steam used for electricity production, net heat production can be determined indirectly. This is done by subtracting the steam used for electricity production from total steam production. The remaining amount of steam can be used to determine net heat production.

![Figure 1 Configuration of Iromez steam system (drawing from Manual.doc, Markus Knödlseder)](image)

**Methodology**

The calculation basically follows three steps:

1. Calculation of the amount of steam.
2. Calculation of the electricity and heat production given ideal isentropic turbine efficiencies.
3. Determination of the amount of electricity and heat production given non-ideal isentropic turbine efficiencies.

**Step 1**
The amount of steam is calculated by dividing total heat production in a quarter (e.g. in quarter 2: 33,962 GJ) by the enthalpy of the steam at given conditions for quarter 2 (15 bar, 231 °C implies an enthalpy of 2,877.94 kJ/kg steam) to yield the total steam quantity. This is 11,801 tonne in quarter 2. The enthalpy was determined using the on-line Steam Tables Calculator (available at http://www.steamtablesonline.com/steam97web.aspx).

**Step 2**
Following normal practices for turbine calculations (see e.g. http://www.egr.msu.edu/classes/me416/SteamTurbine.pdf), the work done by the backpressure turbine (“T1” in Figure 1) (at ideal (=1) isentropic efficiency) is calculated by assuming constant entropy. Using constant entropy the Steam Tables Calculator gives an enthalpy of the steam at 3.5 bar of 2,600.91 kJ/kg steam. The work done by the (ideal) backpressure turbine is thus (2,877.94 – 2,600.91 kJ/kg steam) 277.0 kJ/kg steam.

Given the above-mentioned enthalpy of the steam at 3.5 bar, the work done by the condensing turbine (“T2” in Figure 1) (at ideal (=1) isentropic efficiency) can be calculated, again using constant entropy, and exhaust conditions of 0.2 bar). The resulting enthalpy is 2,180.69 kJ/kg steam. The work done by the condensing turbine is thus 420.2 kJ/kg.

**Step 3**
The calculations are then adjusted for non-ideal isentropic efficiencies. The procedure for this is explained using efficiencies of 0.572 for the backpressure turbine, and 0.75 for the condensing turbine (same as in the previous years):

- Calculation of the work done by the backpressure turbine using a given efficiency. Considering the efficiency of 57.2 %, the work done by the backpressure turbine is 277.0 kJ/kg * 0.572 = 158 kJ/kg.
- Determining the corresponding enthalpy (=2,877.94 – 158 = 2,719 kJ/kg), and the corresponding entropy (via the Steam Table Calculator).
- Determining with this state (h = 2,719 kJ/kg, p = 3.5 bar) the work done by the condensing turbine in the ideal (isentropic efficiency = 1) case. This yields an enthalpy of 2,276.58 kJ/kg steam, and an amount of work done by the turbine of 442.9 kJ/kg steam. This last figure is higher than the amount of work calculated in step 2 (420.2 kJ/kg steam). The reason for that is that the enthalpy of the steam entering the condensing turbine is higher than in the ideal case.
- Calculation of the work done by the condensing turbine given the efficiency of 75 %, yielding 442.9 kJ/kg * 0.75 = 332.2 kJ/kg.
Following this calculation, the Net Heat Produced for the district heating system is then computed as follows:

- Determine the amount of electricity in MWh/quarter that could be produced by the back-pressure turbine (493 MWh/quarter).
- Calculating the amount of electricity that is lacking (= not produced by the back-pressure turbine). Given the total amount of electricity (669 MWh for quarter 2, see Table 7), 176 MWh must be produced by the condensing turbine in quarter 2.
- Determining the amount of steam needed to produce the amount of electricity with the condensing turbine. In this case this is (176 * 3,600/332.2) tonne/quarter = 1,902 tonne steam/quarter.
- Determining the remaining amount of steam (11,801 – 1,902 tonne steam/quarter) and the corresponding Net Heat Produced (6,902 MWh/quarter).

This procedure is repeated for the other quarters (quarter 1, 3 and 4).

**Iromez 2012 production data**

The calculation for net heat production in 2012 is based on quarterly data from Iromez presented in Table 5. “Point 1” in this table refers to the conditions after the boiler, before the first turbine. “Point 2” refers to the conditions between the first and the second turbine. “Point 3” refers to the conditions after the second turbine.

**Table 5 Quarterly production data Iromez:**

<table>
<thead>
<tr>
<th></th>
<th>Q 1-12</th>
<th>Q 2-12</th>
<th>Q 3-12</th>
<th>Q 4-12</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p= MPa</td>
<td>1.51</td>
<td>1.5</td>
<td>1.49</td>
<td>1.51</td>
<td></td>
</tr>
<tr>
<td>T= °C</td>
<td>234</td>
<td>231</td>
<td>229</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>Q= t/h</td>
<td>8.2</td>
<td>8.1</td>
<td>8</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td><strong>Point 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p= MPa</td>
<td>0.34</td>
<td>0.35</td>
<td>0.36</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>T= °C</td>
<td>150</td>
<td>150</td>
<td>148</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Q= t/h</td>
<td>1.7</td>
<td>3.9</td>
<td>4.2</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td><strong>Point 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p=kPa abs.</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>48</td>
<td>50</td>
<td>50</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>1.7</td>
<td>3.9</td>
<td>4.2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Power production (MWh)

<p>| | | | | | |</p>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>442</td>
<td>669</td>
<td>1,016</td>
<td>591</td>
<td>2,718</td>
</tr>
</tbody>
</table>

Heat production (GJ)

<p>| | | | | | |</p>
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<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41,563</td>
<td>33,962</td>
<td>34,158</td>
<td>46,767</td>
<td>156,450</td>
</tr>
</tbody>
</table>

Steam production (tonne)

<p>| | | | | | |</p>
<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14,645</td>
<td>11,967</td>
<td>12,036</td>
<td>16,479</td>
<td>55,127</td>
</tr>
</tbody>
</table>
Assumptions for the 2011 calculations

The following assumptions are made for the 2012 calculations:

- Mechanical and electrical losses of the turbines: 5%
- Isentropic efficiency of the high pressure turbine: 0.572
- Isentropic efficiency of the condensing turbine: 0.75

These assumptions are the same as for the calculations in previous years.
### Table 6: Estimation of Net Heat Production at Iromez, Q 1 2012

#### Step 1: Determining steam amount Iromez

**Reference:** Steamtable (free) download from: [http://www.simuronline.com/download.htm](http://www.simuronline.com/download.htm) [http://www.heatexchanger.com](http://www.heatexchanger.com)

**Reference:** Steam turbine calculations as in: [http://www.esr.msu.edu/courses/me443/Steam_turbine.pdf](http://www.esr.msu.edu/courses/me443/Steam_turbine.pdf)

<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg St)</th>
<th>S (kJ/kgK)</th>
<th>Steam factor (Xj) (0-100)</th>
<th>Sp. Vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.1</td>
<td>234</td>
<td>2884.99</td>
<td>6.632</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>2</td>
<td>15.1</td>
<td>234</td>
<td>2884.99</td>
<td>6.632</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>3</td>
<td>0.18</td>
<td>48</td>
<td>200.05</td>
<td>0.076</td>
<td>0</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Net heat addition in boiler = enthalpy at 1 - enthalpy at 4

<table>
<thead>
<tr>
<th>Heat value of the steam</th>
<th>41.563 GJ/quarter ** from Iromez, Q1 spreadsheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enthalpy at 1</td>
<td>2.865 kJ/kg St</td>
</tr>
<tr>
<td>Amount of steam</td>
<td>14.407 tonnes/quarter</td>
</tr>
<tr>
<td>This gives</td>
<td>4.679 tonnes/hr</td>
</tr>
</tbody>
</table>

#### Step 2: Calculations of steam/water conditions in ideal case

Ideal case means: isentropic efficiency of both turbines = 1 (100%)

<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg St)</th>
<th>S (kJ/kgK)</th>
<th>Steam factor (Xj) (0-100)</th>
<th>Sp. vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.4</td>
<td>138</td>
<td>2609.19</td>
<td>6.632</td>
<td>93.9</td>
<td>0.006</td>
</tr>
<tr>
<td>2</td>
<td>0.18</td>
<td>58</td>
<td>2171.01</td>
<td>6.632</td>
<td>81.6</td>
<td>6.993</td>
</tr>
<tr>
<td>3</td>
<td>0.18</td>
<td>48</td>
<td>200.05</td>
<td>0.076</td>
<td>0</td>
<td>0.001</td>
</tr>
</tbody>
</table>

#### Step 3: Calculations for non-ideal turbine efficiencies

<table>
<thead>
<tr>
<th>p</th>
<th>eta_{IT, ges}</th>
<th>%</th>
<th>0.872</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>eta_{NT, ges}</td>
<td>%</td>
<td>0.755</td>
</tr>
<tr>
<td>d</td>
<td>h_{1, IT}</td>
<td>kJ/kg</td>
<td>2865</td>
</tr>
<tr>
<td>e</td>
<td>h_{1, NT}</td>
<td>kJ/kg</td>
<td>2865</td>
</tr>
<tr>
<td>f</td>
<td>h_{2, IT}</td>
<td>kJ/kg</td>
<td>2600</td>
</tr>
<tr>
<td>g</td>
<td>h_{2, NT}</td>
<td>kJ/kg</td>
<td>2600</td>
</tr>
<tr>
<td>h</td>
<td>h_{1, IT}</td>
<td>kJ/kg</td>
<td>2171</td>
</tr>
<tr>
<td>i</td>
<td>h_{1, NT}</td>
<td>kJ/kg</td>
<td>2171</td>
</tr>
<tr>
<td>j</td>
<td>Mech &amp; El Loss</td>
<td>%</td>
<td>5.2%</td>
</tr>
<tr>
<td>k</td>
<td>h_{P, HT, max}</td>
<td>MJ</td>
<td>4 101 711</td>
</tr>
<tr>
<td>l</td>
<td>P, MWh</td>
<td></td>
<td>2 226 870</td>
</tr>
<tr>
<td>m</td>
<td>P, MWh</td>
<td></td>
<td>1 139 619</td>
</tr>
<tr>
<td>n</td>
<td>P, MWh</td>
<td></td>
<td>1 718 129</td>
</tr>
<tr>
<td>o</td>
<td>P, MWh</td>
<td></td>
<td>442 442</td>
</tr>
<tr>
<td>p</td>
<td>P, MWh</td>
<td></td>
<td>1 139 619</td>
</tr>
<tr>
<td>q</td>
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</tr>
<tr>
<td>r</td>
<td>P, MWh</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>s</td>
<td>P, MWh</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>t</td>
<td>P, MWh</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>u</td>
<td>P, MWh</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>v</td>
<td>P, MWh</td>
<td></td>
<td>0 0</td>
</tr>
</tbody>
</table>

#### Work done by backpressure turbine in ideal case = h₁ - h₂

\[294.7 \text{ kJ/kg} \]

#### Work done by condensing turbine in ideal case = h₂ - h₃

\[429.2 \text{ kJ/kg} \]

#### Deviations from the ideal case imply higher enthalpies and entropies at points 2 and 3

These are separately listed below.
Table 7 Estimation of Net Heat Production at Iromez, Q 2 2012

<table>
<thead>
<tr>
<th>Step 1: Determining steam amount Iromez</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference: Steam turbine calculations as in: <a href="http://www.egi.msu.edu/classes/sme410/Steam/Turbine.pdf">http://www.egi.msu.edu/classes/sme410/Steam/Turbine.pdf</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg St)</th>
<th>s (kJ/kg K)</th>
<th>Steam factor (X)</th>
<th>Spec. vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>231</td>
<td>2877.94</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>2</td>
<td>5.6</td>
<td>139</td>
<td>2600.91</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
<td>60</td>
<td>2160.69</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
<td>50</td>
<td>2053.34</td>
<td>6.704</td>
<td>100</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Net heat addition in boiler = enthalpy at 1 - enthalpy at 4

Heat value of the steam = 33.962 GJ/quarter ** from Iromez, Q2 spreadsheet

Enthalpy at 1 = 2770.9 KJ/kg

Amount of steam = 2.1801 tonne/quarter ** from Iromez, Q2 spreadsheet

This gives 1457 hours/quarter op = 2.26 kg/sec

<table>
<thead>
<tr>
<th>Step 2: Calculations of steam/water conditions in ideal case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal case means: Isentropic efficiency of both turbines = 1 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg)</th>
<th>s (kJ/kg)</th>
<th>Steam factor (X)</th>
<th>Spec. vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>231</td>
<td>2877.94</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>2</td>
<td>5.6</td>
<td>139</td>
<td>2600.91</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
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<tr>
<td>3</td>
<td>0.2</td>
<td>60</td>
<td>2160.69</td>
<td>6.622</td>
<td>100</td>
<td>0.145</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
<td>50</td>
<td>2053.34</td>
<td>6.704</td>
<td>100</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Work done by backpressure turbine in ideal case = h1 - h2

dp, hT = 2770.9 KJ/kg

Work done by condensing turbine in ideal case = h2 - h3

dp, NT = 420.2 KJ/kg

Deviations from the ideal case imply higher enthalpies and entropies at points 2 and 3. These are separately listed below.

<table>
<thead>
<tr>
<th>Step 3: Calculations for non-ideal turbine efficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference: Steam turbine calculations as in: <a href="http://www.egi.msu.edu/classes/sme410/Steam/Turbine.pdf">http://www.egi.msu.edu/classes/sme410/Steam/Turbine.pdf</a></td>
</tr>
</tbody>
</table>

| Point nr | b (a) HT, Ges % | e (a) NT, Ges % | c (a) | d (a) HT | e (a) NT | f (a) T | g (a) m_D (t) | h (a) Mech. & El. Loss % | i (a) P, max | k (a) MW | l (a) MW | m (a) MW, Gen | n (a) MW, therm | o (a) Rated capacity HT | p (a) Rated capacity NT | q (a) m_D, Abdamp (t) | r (a) h, Entnahme (d1) | s (a) h, End (d1) | t (a) h, End (d1) | u (a) Nutzü. Entnahme | v (a) ausgkoppelte NutzW |
|----------|-----------------|-----------------|-------|--------|---------|-------|-------------|-------------------------|-------------|--------|--------|---------------|------------------|------------------------|------------------------|----------------------|------------------|------------------|------------------|------------------|
| 1        | 5.64            | 5.64            | 5.64  | 5.64   | 5.64    | 5.64  | 5.64        | 5.64                    | 5.64       | 5.64  | 5.64  | 5.64          | 5.64            | 5.64                   | 5.64                   | 5.64                 | 5.64            | 5.64            | 5.64            | 5.64            |
Table 8 Estimation of Net Heat Production at Iromez, Q 3 2012

<table>
<thead>
<tr>
<th>Step 1: Determining steam amount Iromez</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference: <a href="http://www.egr.msu.edu/classes/me416/SteamTurbine.pdf">Steam turbine calculations</a></td>
</tr>
<tr>
<td><strong>Point nr</strong></td>
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<tr>
<td>1</td>
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<tr>
<td>4</td>
</tr>
<tr>
<td><strong>Net heat addition in boiler = enthalpy at 1 - enthalpy at 4</strong></td>
</tr>
<tr>
<td><strong>Heat value of the steam</strong></td>
</tr>
<tr>
<td><strong>Enthalpy at 1</strong></td>
</tr>
<tr>
<td><strong>Amount of steam</strong></td>
</tr>
<tr>
<td><strong>This gives</strong></td>
</tr>
<tr>
<td><strong>Step 2: Calculations of steam/water conditions in ideal case</strong></td>
</tr>
<tr>
<td><strong>Ideal case means, isentropic efficiency of both turbines = 1 (100%)</strong></td>
</tr>
<tr>
<td><strong>Point nr</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td><strong>Work done by backpressure turbine in ideal case = h 1 - h 2</strong></td>
</tr>
<tr>
<td><strong>dh WT</strong></td>
</tr>
<tr>
<td><strong>Work done by condensing turbine in ideal case = h 2 - h 3</strong></td>
</tr>
<tr>
<td><strong>dh NT</strong></td>
</tr>
<tr>
<td><strong>Deviations from the ideal case imply higher entropies and entropies at points 2 and 3</strong></td>
</tr>
<tr>
<td><strong>These are separately listed below</strong></td>
</tr>
<tr>
<td><strong>Step 3: Calculations for non-ideal turbine efficiencies</strong></td>
</tr>
<tr>
<td><strong>Ideal case</strong></td>
</tr>
<tr>
<td><strong>p</strong></td>
</tr>
<tr>
<td><strong>c</strong></td>
</tr>
<tr>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>d</strong></td>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>t</strong></td>
</tr>
<tr>
<td><strong>q</strong></td>
</tr>
<tr>
<td><strong>h1</strong></td>
</tr>
<tr>
<td><strong>n</strong></td>
</tr>
<tr>
<td><strong>l</strong></td>
</tr>
<tr>
<td><strong>h1</strong></td>
</tr>
<tr>
<td><strong>j</strong></td>
</tr>
<tr>
<td><strong>k</strong></td>
</tr>
<tr>
<td><strong>m</strong></td>
</tr>
<tr>
<td><strong>n</strong></td>
</tr>
<tr>
<td><strong>o1</strong></td>
</tr>
<tr>
<td><strong>o1</strong></td>
</tr>
<tr>
<td><strong>p</strong></td>
</tr>
<tr>
<td><strong>q</strong></td>
</tr>
<tr>
<td><strong>r</strong></td>
</tr>
<tr>
<td><strong>s</strong></td>
</tr>
<tr>
<td><strong>t</strong></td>
</tr>
<tr>
<td><strong>u</strong></td>
</tr>
<tr>
<td><strong>v</strong></td>
</tr>
</tbody>
</table>
**Table 9 Estimation of Net Heat Production at Iromez, Q 4 2012**

**Step 1: Determining steam amount Iromez**


<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg) St</th>
<th>S (kJ/kg)</th>
<th>Steam factor (X)(0-100)</th>
<th>Sp. Vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16,1</td>
<td>232</td>
<td>2879,95</td>
<td>6,823</td>
<td>100</td>
<td>0,145</td>
</tr>
<tr>
<td>2</td>
<td>9,3</td>
<td>137</td>
<td>2591,21</td>
<td>6,823</td>
<td>94,3</td>
<td>0,409</td>
</tr>
<tr>
<td>3</td>
<td>0,15</td>
<td>49</td>
<td>2658,15</td>
<td>6,823</td>
<td>81,4</td>
<td>7,248</td>
</tr>
<tr>
<td>4</td>
<td>0,15</td>
<td>49</td>
<td>2658,15</td>
<td>6,823</td>
<td>98,9</td>
<td>0,081</td>
</tr>
</tbody>
</table>

Net heat addition in boiler = enthalpy at 1 - enthalpy at 4

Heat value of the steam 46.767 [GJ/quarter] **from Iromez, Q4 spreadsheet**

Enthalpy at 1 2.880 [kJ/kg St]

Amount of steam 16.233 tonne/quarter **from Iromez, Q4 spreadsheet**

6.20 tonne/hr **from Iromez, Q4 spreadsheet**

22.8 kg/sec

This gives 1980 hours/quarter op. 22.8 kg/sec

**Step 2: Calculations of steam/water conditions in ideal case**

Ideal case means: Isentropic efficiency of both turbines = 1 (100%)

<table>
<thead>
<tr>
<th>Point nr</th>
<th>p (bar)</th>
<th>t (°C)</th>
<th>h (kJ/kg) St</th>
<th>S (kJ/kg)</th>
<th>Steam factor (X)(0-100)</th>
<th>Sp. Vol (m³/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16,1</td>
<td>232</td>
<td>2879,95</td>
<td>6,823</td>
<td>100</td>
<td>0,145</td>
</tr>
<tr>
<td>2</td>
<td>9,3</td>
<td>137</td>
<td>2591,21</td>
<td>6,823</td>
<td>94,3</td>
<td>0,409</td>
</tr>
<tr>
<td>3</td>
<td>0,15</td>
<td>49</td>
<td>2658,15</td>
<td>6,823</td>
<td>81,4</td>
<td>7,248</td>
</tr>
<tr>
<td>4</td>
<td>0,15</td>
<td>49</td>
<td>2658,15</td>
<td>6,823</td>
<td>98,9</td>
<td>0,081</td>
</tr>
</tbody>
</table>

Work done by backpressure turbine in ideal case = h 1 - h 2

\[ dh_{NT} = 284.7 \text{kJ/kg} \]

Work done by condensing turbine in ideal case = h 2 - h 3

\[ dh_{NT} = 445.7 \text{kJ/kg} \]

Deviations from the ideal case imply higher enthalpies and entropies at points 2 and 3

These are separately listed below

**Step 3: Calculations for non-ideal turbine efficiencies**

<table>
<thead>
<tr>
<th>p</th>
<th>( \eta_{NT, des} )</th>
<th>( \eta_{NT, des} ) %</th>
<th>1</th>
<th>0,75</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>H_1</td>
<td>kJ/kg</td>
<td>h</td>
<td>2,880</td>
</tr>
<tr>
<td>d</td>
<td>dh_{NT}</td>
<td>kJ/kg</td>
<td>d</td>
<td>165</td>
</tr>
<tr>
<td>dh</td>
<td>H_2</td>
<td>kJ/kg</td>
<td>e</td>
<td>2,715</td>
</tr>
<tr>
<td>dh</td>
<td>H_3</td>
<td>kJ/kg</td>
<td>e</td>
<td>353</td>
</tr>
<tr>
<td>dh</td>
<td>gh_{ges}</td>
<td>kJ/kg</td>
<td>g</td>
<td>2,315</td>
</tr>
<tr>
<td>gh</td>
<td>m_D</td>
<td>tonne/quarter</td>
<td>g</td>
<td>16,239</td>
</tr>
<tr>
<td>h_1</td>
<td>Mech. &amp; El. Loss %</td>
<td>5,9%</td>
<td>5,9%</td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>P_{H, max}</td>
<td>MJ</td>
<td>4,688,636</td>
<td>2,542,805</td>
</tr>
<tr>
<td>l</td>
<td>MWh</td>
<td></td>
<td>1,302</td>
<td>706</td>
</tr>
<tr>
<td>h_1</td>
<td>Mech. &amp; El. Loss %</td>
<td>5,9%</td>
<td>5,9%</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>P_{NT, max}</td>
<td>MJ</td>
<td>7,237,644</td>
<td>5,448,687</td>
</tr>
<tr>
<td>k</td>
<td>MWh</td>
<td></td>
<td>2,010</td>
<td>1,513</td>
</tr>
<tr>
<td>h</td>
<td>P_{ges, Gen}</td>
<td>MWh</td>
<td>691</td>
<td>569</td>
</tr>
<tr>
<td>l</td>
<td>P_{ges, Therm}</td>
<td>MWh</td>
<td>591</td>
<td>569</td>
</tr>
<tr>
<td>n</td>
<td>P_{H, max}</td>
<td>MWh</td>
<td>1,302</td>
<td>706</td>
</tr>
<tr>
<td>n1</td>
<td>Rated capacity HW</td>
<td>kW</td>
<td>658</td>
<td>357</td>
</tr>
<tr>
<td>o</td>
<td>P_{NT, max}</td>
<td>MWh</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>o1</td>
<td>Rated capacity NT</td>
<td>kW</td>
<td>1,015</td>
<td>764</td>
</tr>
<tr>
<td>p</td>
<td>m_D, Abdampf</td>
<td>tonne</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>q</td>
<td>m_D, Entnahme</td>
<td>tonne</td>
<td>16,239</td>
<td>16,239</td>
</tr>
<tr>
<td>r</td>
<td>h Entnahme (d1)</td>
<td>kJ/kg</td>
<td>2,591</td>
<td>2,715</td>
</tr>
<tr>
<td>s</td>
<td>h kond (h 4)</td>
<td>kJ/kg</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>t</td>
<td>dh Entnahme</td>
<td>kJ/kg</td>
<td>2,386</td>
<td>2,510</td>
</tr>
<tr>
<td>u</td>
<td>Nettwarme Entnahme</td>
<td>MJ</td>
<td>38,746,970</td>
<td>40,763,706</td>
</tr>
<tr>
<td>v</td>
<td>ausgekoppelte Nutz</td>
<td>MWh</td>
<td>10,763</td>
<td>11,320</td>
</tr>
</tbody>
</table>
Calculation of net heat production at Iromez in individual quarters of the year 2012 is presented above in Table 6 - Table 9. The results are summarized in Table 10:

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Value</th>
<th>Unit</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter 1</td>
<td>10,089</td>
<td>MWh</td>
<td>36,321</td>
<td>GJ</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>6,902</td>
<td>MWh</td>
<td>24,846</td>
<td>GJ</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>4,289</td>
<td>MWh</td>
<td>15,440</td>
<td>GJ</td>
</tr>
<tr>
<td>Quarter 4</td>
<td>11,320</td>
<td>MWh</td>
<td>40,754</td>
<td>GJ</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32,600</strong></td>
<td><strong>MWh</strong></td>
<td><strong>117,361</strong></td>
<td><strong>GJ</strong></td>
</tr>
</tbody>
</table>

Total Net Heat Production is thus **32,600 MWh/year** (117,361 GJ/ year).

### 3.3 Metering system

#### 3.3.1 Metering equipment

The metering equipment is installed at each boiler (boiler house) to measure heat/power production. The metering and invoicing procedures have to follow the Czech energy law, Act no.458/2000 Coll, of 28 November 2000. Article 78 describes the obligations, which have to be carried out by the heat producer and the heat seller.

#### 3.3.2 Metering system – uncertainties

There are some key factors:

- **Proper installation.** Metering systems have to be installed within the range of metering conditions, e.g. temperature ranges as to guarantee its proper functioning.

- **Metering systems** have to be calibrated regularly as to ascertain they measure correctly.

- **Accuracy of the metering system.** Every metering system has an accuracy range in which it functions.

These uncertainties are dealt with in the following way:

#### 3.3.2.1 Proper installation

All metering systems have to be calibrated when they are installed. During calibration, also the proper installation and functioning of the metering equipment is checked.
3.3.2.2 Calibration

All metering systems have to be calibrated when they are installed, for such there is usually no calibration document, only the installation document is available and there is a special label on the metering equipment. All metering systems have to be regularly calibrated (according No. 344/2002 Coll of 11 July 2002). The Authorized metrological institutions can provide them with the calibration document (which is more costly) or just with the label on the metering equipment.

3.3.2.3 Accuracy

Every metering system has its own accuracy. The uncertainty is inversely proportional to the heat flow, which means that a low heat flow causes relatively higher uncertainties. On the other hand during summer when the heat demand is very low (uncertainty is high) the generated emission reductions are also low, which has a reducing effect on the uncertainty caused by the accuracy of the metering system.

The accuracy of heat meters is not determined for every individual heat meter because it involves extensive testing at different heat flows and temperatures, which is not practical. Therefore, Authorized metrological institutions do not provide documents indicating the specific uncertainty per metering system and do calibration reports not contain an indication of accuracy for individual metering systems. (Mr. Huryta Authorized Metrological Centre ZPA Nová Paka, a.s., Czech Republic, phone +420 493 761 332)

Before a new metering system is introduced to the market, the accuracy is determined according to technical standards. The European standard EN 1434 (in the Czech Republic adopted version CSN EN 1434) determines the accuracy of heat metering systems, the accuracy for flow sensors are well within the range of +/- 5%, for classes no. 2 and no.3. The accuracy of steam metering systems (regulation TPM 3723/03) has the same range: it is more accurate than +/- 5%. Taken into account the above mentioned effect that most heat demand is related to higher flow rates, it is estimated that the total accuracy throughout the year is more accurate than +/- 3%.

Because the heat meters in the projects are properly installed and calibrated, these factors do not add to the total uncertainty of the metering system. The accuracy of the metering systems is expected to be lower than +/- 3%, and the total uncertainty will therefore remain under +/- 5%. Such uncertainty corrections are already applied in the emission calculation methodology.

In the methodology there are three levels of uncertainty:

high (H) 95%;
medium (M) 85%;
low (L) 75%.

The level of precision can be adjusted according the reliability of the delivered data, however a 5% deduction is applied anyhow as to be on conservative side.
3.4 Monitoring manual

3.4.1 Monitoring Protocol

The detailed Monitoring Protocol is presented in APPENDIX A. The electronic version of the report contains a separate MS Excel file “Appendix A monitoring protocol form_2012_eng.xls”. The Protocol has 12 main sections where the projects are described in details. The technical project identification and its technical description are presented in introductory parts. The monitored produced/sold heat and power are presented in the next section. Strong attention is also paid to the consumed biomass fuel. The fuel suppliers and its fuel sources are presented to monitor the sustainable origin of the biomass in terms of forest management.

Besides, the involved third parties responsible for invoicing are monitored, since the invoices are the most reliable instruments for data check.

In the second part of the Monitoring Protocol is the summary of procedures connected with data monitoring and archiving.

Projects owners/operators are encouraged to comment monitoring and reporting procedures, eventually to propose improvement of procedures building on their experiences with project operation. The space for their comments is in the second part of the Monitoring Protocol.

Content of the Monitoring Protocol

Introduction

1. Project identification
2. Project technical description
3. Project realization

I.

4. Heat and power measurements
5. Bio-fuel sources
6. Moisture content
7. Combusted biomass - Environmental impacts
8. Report on heat and power produced and sold

II.

9. Data collection and archiving
10. Communication with BTG Central Europe s.r.o.
11. Protocol’s attachments
12. Remarks and comments of project owner/operator
The filled-in Monitoring Protocols from all subprojects are presented in APPENDIX B as hardcopies.

3.4.2 Monitoring manual

All procedures connected with subprojects monitoring were developed to be easy understandable and practicable by subprojects operators, so that misunderstandings or misinterpretations are rare. In case of any uncertainties project operators are asked to contact BTG Central Europe s.r.o.

All necessary procedures for proper monitoring and reporting are summarised in the detailed manual for subproject owners/operators. The manual (in the Czech language) is attached as APPENDIX E.

The manual is available at all subproject’s sites so that the proper monitoring of the project will not be affected by sudden personal changes.

The manual covers following topics:

- Data recording
- Completion of Monitoring Protocol
- Data archiving
- Verification
- Troubleshooting procedures
- Communication with BTG Central Europe

The signed declarations about acquaintance with the Manual are attached in APPENDIX D. The projects operators are obliged to inform involved parties about their tasks in JI project monitoring.

3.4.3 Data archiving

All operational and accounting documents about the quantity of heat and power produced and sold, about the power consumed and about the quantity and type of fuel combusted, especially operational records and invoices, will be archived by the project operator at a safe place for the period of the project lifetime plus minimally for 2 years.

Project operators are aware about their obligation of archiving of all relevant data. The procedure of archiving is precisely described in the Monitoring manual that is available at all subproject’s sites. Besides the obligation of data archiving is incorporated in the Monitoring Protocol, which is sent to subprojects each year.

Relevant data has been already archived from the beginning of the project.

The projects owners (operators) are obliged to backup the monthly production data and to archive them on the separate place from originals.
### Table 11 General input parameters

<table>
<thead>
<tr>
<th>Fuel emissions factors $EF_i$</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and other solid fossil fuel</td>
<td>t CO2/TJ fuel input</td>
</tr>
<tr>
<td>Oil and other liquid fossil fuel</td>
<td>t CO2/TJ fuel input</td>
</tr>
<tr>
<td>Natural gas</td>
<td>t CO2/TJ fuel input</td>
</tr>
<tr>
<td>Biomass</td>
<td>t CO2/TJ fuel input</td>
</tr>
<tr>
<td>Power emission factor $EF_{electricity}$</td>
<td>t CO2/MWh</td>
</tr>
</tbody>
</table>

**Losses in the electricity grid**

- Gross available $GL_{ga}$ % 4.66 % BS
- End use $GL_{eu}$ % 5.32 % BS

**CH4 emissions anaerobic digestion wood**

- Carbon content in (hemi-)cellulose 44.5% BS
- Forming factor (carbon convertible to methane) dry basis 50% BS
- (hemi-)Cellulose content of wood dry basis 65% BS
- Degradable carbon t C/t dry wood 0.29 BS
- Emission period (wood decomposition period) year 2 BS
- Methane emission factor MEF t CH4/t dry wood/y 0.10 BS
- CO2 equivalent of CH4 GWP t CO2 eq./t CH4 21 BS

**Moisture content in wood** % 50% BS

**Heating value of wood, sawdust, bark** GJ/t wet 10 BS

**Wood chips density (15% moisture content)** t dry/cubic meter 0.25 Ref. 1

**Sawdust density (15% moisture content)** t dry t/cubic meter 0.25 Ref. 1

**Bark density (15% moisture content)** t dry t/cubic meter 0.40 Ref. 2

**Boiler efficiencies $E_i$**

**Baseline scenario**

- Central coal boilers % 60% BS
- Central gas boilers % 80% BS
- Central oil boilers % 70% BS
- Individual wood stoves % 50% BS
- Individual brown coal stoves % 55% BS
- Individual coal stoves % 60% BS
- Individual gas stoves % 90% BS
- Individual oil stoves % 60% BS
- Individual electric heaters % 90% BS

**Project scenario**

- Central biomass boiler % 70% BS

**Data sources:**

- BS - Baseline Study
- MP - Monitoring Protocol
- Ref. 2 - The Handbook of Regional Biomass Utilization (in Czech), Czech Energy Agency, Prague, 1999
- Ref. 3 - the letter of the Ministry of Environment of the Czech Republic dated December 18th 2008
4 EMISSION REDUCTION CALCULATION

4.1 Emission calculation manual

The procedures related to the emission reduction calculation are described in this chapter. The outlined calculation method for avoided baseline emissions based on the monitoring data was worked out in detail by BTG for the initial verification of the project. For the calculation the spreadsheets are used. The annual data for the calculation are formulated in the Monitoring Protocol and delivered by each subprojects to the project manager. One spreadsheet file is used for all subprojects where data per year are calculated. The spreadsheet has four parts. In the first part, General Input Parameters, all general parameters are presented, see Table 11. In the second part, Project Input Parameters, data from Monitoring Protocol are entered:

- annual heat production,
- annual heat supply,
- share of central boilers and individual stoves,
- share of individual stove, if different from the Project Description,
- amount and type of combusted biomass in measured unit; if required units differ from the delivered ones, the recalculation using the densities follows: sawdust (50% moisture content) 0.60 t/m3, wood chips and bark (50% moisture content) 0.27 t/m3, wood chips (30% moisture content) 0.21 t/m3, straw bales (20% moisture content) 0.20 t/m3. 8,
- fraction of biomass that would be anaerobically digested, if different from the Project Description.

The level of precision can be adjusted according the reliability of the delivered data. There are three possibilities: high (H), medium (M), low (L).

The third and the fourth part, Calculation of Project Emissions, respectively Calculation of Baseline Emissions, are automatically calculated.

If error occurs, the troubleshooting procedure will be followed.

4.2 Reporting and Calculating Procedure Manual

The detailed manual of calculating procedures and gathering relevant data for BTG staff was elaborated, in order to ensure a proper continuation of the project in case of any personnel changes. The Manual is attached as APPENDIX F.

4.3 Emission reduction calculation

The calculation of emissions reductions for all projects is enclosed in the following tables. The electronic version of the report contains a separate MS Excel file “Appendix C.

---

8 SIMS, R. The Brilliance of Bioenergy. James & James, London, 2002, Table 1.4.R.E.H.
emission calculation_2012”. The hardcopy version contains the MS Excel file “Appendix C emission calculation_2012” in APPENDIX C.

The emission reduction overview of ERUs for a period January – October 2012 is presented in the Table 12. The total emission reduction per 2011 is 100,694 tCO2.

**Table 12 Portfolio emission reductions overview for the year 2012**

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Name/site</th>
<th>ERUs/ t CO2 eq per 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bouzov</td>
<td>4,486</td>
</tr>
<tr>
<td>2</td>
<td>Bystrice nad Pernstejnem</td>
<td>11,077</td>
</tr>
<tr>
<td>3</td>
<td>Driten</td>
<td>2,311</td>
</tr>
<tr>
<td>4</td>
<td>Horni Plana</td>
<td>418</td>
</tr>
<tr>
<td>5</td>
<td>Kasperske Hory</td>
<td>3,606</td>
</tr>
<tr>
<td>6</td>
<td>Nova Cerekev</td>
<td>1,895</td>
</tr>
<tr>
<td>7</td>
<td>Pelhrimov, Iromez</td>
<td>30,884</td>
</tr>
<tr>
<td>8</td>
<td>Rostin</td>
<td>1,830</td>
</tr>
<tr>
<td>9</td>
<td>Slavicin</td>
<td>1,675</td>
</tr>
<tr>
<td>10</td>
<td>Stitna nad Vlari</td>
<td>426</td>
</tr>
<tr>
<td>11</td>
<td>Trebic, K13-ORC</td>
<td>17,115</td>
</tr>
<tr>
<td>12</td>
<td>Trebic, EkoBio - JIH</td>
<td>6,715</td>
</tr>
<tr>
<td>13</td>
<td>Trebic, EkoBio - K13</td>
<td>853</td>
</tr>
<tr>
<td>14</td>
<td>Trhove Sviny</td>
<td>2,820</td>
</tr>
<tr>
<td>15</td>
<td>Velky Karlov</td>
<td>527</td>
</tr>
<tr>
<td>16</td>
<td>Zlate Hory</td>
<td>2,735</td>
</tr>
<tr>
<td>17</td>
<td>Zruec nad Sazavou</td>
<td>4,804</td>
</tr>
<tr>
<td>18</td>
<td>Zlutice</td>
<td>6,517</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100,694</td>
</tr>
</tbody>
</table>
5 MANAGEMENT SYSTEM

The Forward Action Requests in the first Verification report⁹ and further explanations by TÜV SÜD and practical experience of BTG CE gained with management of the portfolio have been used to prepare the present documented set of procedures for:

- Project organization
- Communication between BTG CE and project owners
- Data processing & quality management
- Troubleshooting

5.1 Project organization

Figure 2 shows the project organization of the project. BTG Bioheat has delegated the daily project management to BTG CE. At level 1 all data and information comes together and are processed into overviews with calculated emission reductions, and other relevant project information. At level 2 the project owners operate the plants and measure the necessary data.

---

5.2 Communication between portfolio manager and project owners

Most of the instructions on data collections are described in the Monitoring Protocol (MP) and in the Manual for BTG staff.

- The Monitoring Protocol (MP) consists of a (1) data registration form and (2) detailed instructions on the monitoring procedures. The data registration form is used by project owners to report all project information needed to calculate the avoided greenhouse emissions and other relevant project information to the portfolio manager (BTG CE) on a yearly base. The portfolio manager sends the data registration form once a year (by email) to all project owners at the latest on 31 November before the start of the new calendar year that will be monitored.

- The project owners can contact the portfolio manager by telephone, email or fax for additional information on the MP.

- The project owners send the Monitoring Protocol with monitoring data back to the project manager at the date as stated in the contract between the project owner and BTG Bioheat covering monitoring data on the previous calendar year.

- Every year the portfolio manager will evaluate the MP. If necessary, the MP will be updated as to reflect:
  - changes in monitoring procedures or other changes as indicated in the verification report of the previous verification;
  - changes initiated by the portfolio manager as to improve data collection quality and communication toward the project owners.

- The portfolio manager sends the updated MP as soon as possible to the project owners. Indicative date: August of year X+1.

- Beside information supply through the data registration form, which is submitted on a yearly base, the project owner will inform the portfolio manager within two weeks in case:
  - technical problems occur with the installation that could lead to substantial lower electricity and/or heat production than foreseen,
  - problems occur that could endanger the monitoring data collection (broken measurement equipment, problems with data registration form, etc),
  - the project owner introduces a new contact person (e.g. for instance if a new mayor is elected) for the communication with the portfolio manager.

- In case the project owner introduces a new contact person, the portfolio manager will contact the new contact person and take care that he or she is fully informed about the monitoring procedures. In addition the portfolio manager will advise on the need for training (data collection, processing, and interpretation, knowledge of measurement equipment).
Solving technical problems are the responsibility of the project owners. The portfolio manager however should be informed as this could effect the resulting avoided carbon emissions in the project.

In case problems occur that could endanger proper monitoring, troubleshooting procedures will be applied.

In addition, a manual will be provided to the project owners with all relevant information on data collection, communication and quality management.

Figure 3 Communication chart

The communication regarding the Monitoring Protocol between BTG CE and all individual projects is described in the Figure 3. The same procedure is applied in all other situations (communication, problems discussion, information delivery, troubleshooting procedure) initiated by BTG CE or individual partners.
The table below provides the yearly planning of monitoring, verification and evaluation/updating the Monitoring Protocol.

Table 13 Annual monitoring planning

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<td>Jan</td>
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<tr>
<td>Monitoring</td>
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<td>Delivery monitoring data to portfolio manager</td>
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<tr>
<td>Data processing</td>
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<td>Monitoring Report</td>
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<td>Verification</td>
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<td>Updating Monitoring Protocol*</td>
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<tr>
<td>Sending updated Monitoring Protocol to project owners*</td>
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*) If necessary according to evaluation

5.3 Data processing & quality management

The procedures below are related to the activities of the portfolio manager. Detailed instructions on data collection and processing for individual project owners are formulated in the Monitoring Protocol.

- The portfolio manager stores and keeps the contracts, filled in data sheets and additional documentation (for instance confidentially agreements with project owners) in an orderly way, organized either by document type or by subproject.

- The portfolio manager keeps all paper and electronic documents at a safe place during the JI project period, and longer if so required according to the JI guidelines that are applicable to this project. All paper and electronic documents are stored at the office of BTG Central Europe with the back-up of electronic documents at BTG Bioheat.

- The data collected from the project owners (i.e. heat production, heat supply, biomass types and volumes) are processed in the following way:
  - Data are checked on completeness. If the data set is not complete, the portfolio manager contacts the project owner by phone, email or fax to ask for additional information.
  - Data are checked on calculation errors. If calculation errors appear (for instance use of TJ instead of GJ, mixing up of produced and sold heat, other obvious errors) the project owner is contacted by phone, email or fax and asked for clarification, and if necessary additional explanation is given. This type of errors is noted, and taken into account in the evaluation of the MP.
Data are entered into the central database, an excel sheet that contains all necessary calculation rules.

Two consistency checks are carried out. Heat production of the boiler is compared with (1) total heat supply to the individual clients (2) heat production that could take place with the noted volume of biomass, using standard lower heating values and biomass boiler efficiencies. Calculated heat and distribution efficiencies of each project are compared to the project operation in former monitored years. In case the heat or distribution efficiency varies more than 10% comparing to other years, the project owner is asked for a clarification. The project owner and the portfolio manager will jointly formulate a plausible explanation for the inconsistencies. If this approach does not work, troubleshooting procedures will be followed.

The calculated emission reductions and other relevant information, like change of the project boundary (for instance new households connected to the district heating system) are reported in the monitoring report and offered to the verification body.

- The procedures for data processing, calculations and quality management are elaborated and summarized in a manual for use at the BTG office.

5.4 Troubleshooting procedure

Since the portfolio consists of several projects, it is possible that problems occur related to the monitoring of the project performance, for instance data collection, measurement equipment, the data registration form, etc. The portfolio manager will execute the following actions if problems are directly related to the monitoring of projects:

- The portfolio manager will try to explain and indicate solutions for problems by phone, email or fax.
- If necessary and if it is contributing to the solution of the problem, the portfolio manager will pay a visit to the project site, or the project owner will visit the office of the portfolio manager.
- In case of problems that cannot be easily solved, the portfolio manager will contact the director of BTG Bioheat. They will jointly formulate an approach to solve the problem.
- All disputes that arise from the contract between BTG Bioheat and the project owners will be settled as described in the contract between BTG Bioheat and the project owners.
6 COMMENTS ON INDIVIDUAL SUBPROJECTS

Bouzov

- Biomass boilers with total heat output of 2.4 MW\textsubscript{th} were installed in 2002 to replace individual wood (5%), brown coal (75%) and gas stoves (5%) or electric heaters (15%) in Bouzov.

- In October 2009 the planned extension of the biomass boiler room took place to reach planned heat production. Presently, the total heat output of the boiler room is 3.6 MW\textsubscript{th}.

- The low heat distribution efficiency is caused by low heat demand in summer time, when the heat is mostly used only for hot water preparation.

- The overall scheme of installed biomass units and heat meters is presented at Figure 4.

![Figure 4 Flow-chart of the project in Bouzov]
Bystrice nad Pernstejnem

- In an original Project Description there were two subprojects planned. In subproject A, a 9 MW\textsubscript{th} biomass-fired boiler was to substitute a coal-fired boiler. In project B, a 5 MW\textsubscript{th} biomass-fired boiler was to substitute a natural gas-fired boiler. Eventually, the two subprojects were combined in one and two biomass-fired boilers with the total heat output of 9 MW\textsubscript{th} were installed with perspective of a possible expansion in the future.

- The project boundary was extended with an additional heat district. Several individual households are heated by the biomass boiler that had not been connected to the original central heating system. The heat from biomass substitutes heat from central coal boilers by 52,6 %, heat from central gas boilers by 35,8 % and the rest 11,6 % substitutes heat from individual stoves. The share of brown coal stoves is 87,89 % and of the oil stoves it is 12,11 %.

- The overall scheme of installed biomass units and heat meters is presented at Figure 5.

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**Figure 5 Flow-chart of the project in Bystrice nad Pernstejnem**
Dritten

- There were two subprojects planned in the original Project Description. Subproject A substituted a coal-fired boiler for 1.2 MW\textsubscript{th}, biomass-fired boiler. Subproject B substituted a mixture of individual stoves for a 3 MW\textsubscript{th} biomass-fired boiler. Currently, project A has been realized with a 2 MW biomass boiler-house to substitute the coal-fired boiler and partly individual stoves.

- The heat production meter has been taken out because there were supply problems due to the pressure loss. However it was recommended to reinstall the meter to measure heat production. The reinstallation has not taken place yet because of the financial reason.

- As result of the missing heat meter for heat production, the emission calculation is based on the sold heat instead the produced heat. The sold heat is measured by calibrated heat meters. This approach is very conservative.

- The heat from biomass substitutes heat from central coal boiler by 38 %, the rest 62 % replace individual stoves. The shares of original individual brown coal stoves and wood stoves reach 93,5 % and 6.5 %, respectively.

- The overall scheme of installed biomass unit and heat meters is presented at Figure 6.

![Figure 6 Flow-chart of the project in Dritten](image-url)
Horni Plana

- The biomass-fired boilers with the total thermal output of 0.6 MWth were planned in the original Project Description. Unfortunately, two biomass boilers with the total thermal output of 0.5 MWth have been installed. Due to operational difficulties were in 2010 these two boilers replaced by one biomass boiler of 0.39 MWth. The biomass boiler replaced old brown coal boilers.

- Heat is supplied to a retirement home in Horni Plana, the owner of the project, and also sold to a local Elementary school. The metering system was installed in March 2003 in order to measure heat production in the retirement home. The Elementary school is invoiced for their measured heat consumption.

- In this subproject, the produced heat is considered to be equal to the heat supplied, as the biomass boilers are situated in the building of the home and the Elementary school is only about 20m away from the home.

- The solar system with the area of 72 m² was implemented in the garden of the retirement home during 2004. The solar system supports heating up of the hot service water.

- The overall scheme of installed biomass units and heat meters is presented at Figure 7.

**Figure 7 Flow-chart of the project in Horni Plana**

![Flow-chart of the project in Horni Plana](image)
Kasperske Hory

- The project involves an implementation of two new biomass boilers, a boiler house and a district heating network in the city of Kasperske Hory. The project is in operation since 2006.

- The biomass boilers with total heat output of 4 MWth were installed in 2005 to replace individual brown coal, light fuel oil and gas stoves or electric heaters. The shares of original individual brown coal stoves, gas stoves, oil stoves and electric heaters reach 90%, 2%, 7% and 1%, respectively. These shares changed compare to the last year due to the new connected objects.

- The produced heat is measured at the input/output of the biomass boiler house.

- The overall scheme of the installed biomass units and heat meters is presented in Figure 8.

**Figure 8 Flow-chart of the project in Kasperske Hory**
In the original Project Description there were two subprojects planned: subproject A with a 4.6 MW\textsubscript{th} biomass-fired boiler and subproject B with a 1.7 MW\textsubscript{th} biomass-fired boiler. Nonetheless, a 2 MW biomass-fired boiler has been installed within the subproject A.

The heat from biomass substitute’s heat from individual wood stoves, brown coal stoves, gas stoves and individual electric heating by 10\%, 80\%, 1\% and 9\%, respectively.

The overall scheme of installed biomass unit and heat meters is presented at Figure 9.

**Figure 9 Flow-chart of the project in Nova Cerekev**
Pelhrimov, Iromez s.r.o.

- In the original Project Description biomass-fired boiler with the total thermal output of 5 MW_th was planned to replace a 5 MW_th oil boiler and a 150kW_e electrical heating. Eventually, biomass boiler with the total thermal output of 6 MW_th was installed in combination with a turbogenerator set of 1 MW_e in 2004. The company supplies part of the town of Pelhrimov with the generated bio-heat together with the second biomass boiler (already installed in 1995 and this is not included in this project). The produced power is being fed in power grid.

- Both biomass-fired boilers use one fuel storage house. Invoices for bio-fuel are combined for both of them. The heat meters measure heat production per each boiler separately. The measured heat of the involved biomass boiler also measures the heat, which is afterwards used for power production. The unused heat together with heat from the second boiler is combined and delivered to the town district heating system and afterwards invoiced. The calculation is described under the chapter 3.2 Calculation of Net Heat Production at Iromez. Based on the above, we consider the produced (calculated) heat equivalent to the sold heat. The project owner was advised to install the metering system anyway.

- The company Iromez s.r.o. was bought by a company MVV Energie CZ a.s. in November 2009. The newly appointed persons responsible for the management of the here data has been acquainted with all the relevant procedures and documents, such as the Manual for individual subproject, Monitoring protocol etc.
Two biomass-fired boilers with the total thermal output of 5.7 MW\textsubscript{th} were planned in the original Project Description. Eventually, biomass-fired boilers with the total thermal output of 4 MW\textsubscript{th} have been installed. These boilers have substituted individual stoves in the proportions of 80%, 15% and 5% fuelled on brown coal, electricity and wood, respectively.

For an emergency heat supply there is also a light fuel oil (LFO)-fired boiler in the heating plant. The boiler has not been in operation during the period January–December 2012.

The overall scheme of installed biomass units and heat meters is presented at Figure 10.

**Figure 10 Flow-chart of the project in Rostin**
Slavicin

- A biomass-fired boiler of 1.6 MW was to replace one of two natural gas-fired boilers in Slavicin in December 2003. Presently, part of the town is heated with bio-energy. The heat meters measure heat production for each boiler separately, biomass and gas. The heat from both boilers is delivered to the town district heating system and consequently is invoiced. Based on the above, the produced heat is considered to be equivalent to the sold heat.

- The produced heat is calculated in computer from measured mass flow and temperatures at the output and input of the biomass boiler. The mass flow and temperatures are measured by calibrated meters that are connected to the above mentioned computer (see Figure 11). The calculation is secured and certified by an accredited company.

**Figure 11 Flow-chart of the project in Slavicin**
Stitna nad Vlari, Javornik-cz-plus s.r.o.

- In the original Project Description biomass-fired boilers with the total thermal output of 0.72 MW\textsubscript{th} were planned. Eventually, two biomass-fired boilers with the total thermal output of 0.8 MW\textsubscript{th} were installed. The heat production from the new boilers replaced heat produced from coal (59.5%), gas (35%) and oil boilers (5.5%).

- A wood-processing private company Javornik-CZ-PLUS s.r.o implemented the boilers to supply heat within its commercial premises. Heat production is measured by a metering system; the heat supplies are measured at each building.

- The waste from wood-processing (specifically furniture production), which is combusted in the biomass boilers, is produced on the project site by the owner of the project.

- The checkpoint for heat production based on the combusted biomass showed the efficiency of biomass boilers over 100 % in monitored previous years. It was caused by using default values corresponding to wood chips with moisture content of 50 %, while drier wood chips were used by this project. The project owner was recommended to test the quality of fuel in laboratory or to regularly measure its moisture content. In 2011, the project owner quarterly measured moisture content of combusted biomass by a moisture meter. The measured moisture did not exceed 30 %.

- Amount of combusted biomass is measured in tonnes and recalculated to cubic meters. The bulk density of wood chips with 30 % moisture (0.21 t/m\textsuperscript{3}) is used for recalculation instead of previously used bulk density of wood chips with 50 % moisture (0.27 t/m\textsuperscript{3}).

- The overall scheme of installed biomass units and heat meters is presented at Figure 12.

![Flow-chart of the project in Stitna nad Vlari](image-url)
Trebic, Biomass Energy s.r.o. (previously TTS cz s.r.o.)

- In the original Project Description biomass-fired boilers with a total thermal output of 14 MW\textsubscript{th} were planned. Eventually, biomass-fired boilers with a total thermal output of 7 MW\textsubscript{th} were installed in combination with an Organic Rankine Cycle (ORC) system of 1.0 MWe.

- The company supplies part of the town with the generated bio-heat. The produced heat is sold to a sister company at the site of production, thus the produced and the sold heat is equal.

- The produced heat replaces heat from central gas-fired boilers reaches 66% and the rest 34% replaces individual gas-fired stoves. The shares changed due to the new connected objects in 2012.

- The trading name of the company was changed in October 2009. The new name is Biomass Energy s.r.o.

- The overall scheme of installed biomass and CHP units and heat meters is presented at Figure 13.

![Figure 13 Flowchart of the project in Trebic](image)

Figure 13 Flowchart of the project in Trebic
Trebić – JIH, Ekobioenergo

- The project involves an installation of two straw-fired boilers in the boiler house JIH in the city of Trebić and a construction of a new district heating network. The project is in operation since 2007.
- The total installed thermal output of the boilers is 10 MWth (each boiler has a thermal output of 5 MWth). The central biomass boilers substitute original local natural gas-fired boilers.
- The produced heat is measured at the input/output of each biomass boiler.
- The overall scheme of the installed biomass units and heat meters is presented in Figure 14.

Figure 14 Flow-chart of the project Trebić - JIH
Trebić – K13 (straw), Ekobioenergo

- The project involves an installation of a straw-fired boiler in the central boiler house K13 in the city of Trebić and an extension of an original district heating network. The project is in operation since 2007.

- The thermal output of the boiler is 5 MW<sub>th</sub>. The produced heat replaces heat from central gas-fired boilers by 67% and the rest 33% replaces individual gas-fired stoves. The shares changed due to the new connected objects in 2012.

- The produced heat is measured at the input/output of the biomass boiler.

- The overall scheme of the installed biomass unit and heat meters is presented in Figure 15.

**Figure 15 Flow-chart of the project Trebić – K13 (straw)**
Trhove Sviny

- The project involves an installation of two biomass boilers and a cogeneration unit in the central boiler house in the city of Trhove Sviny and an extension of an original district heating network.

- The boilers were installed in stages replacing old natural gas-fired boilers and some domestic heating stoves. The first 2.5 MWth biomass boiler was installed in April 2000, the second 3.5 MWth biomass boiler was installed in August 2005 together with a cogeneration unit with electrical output of 600 kWc.

- The produced heat substituted the heat from central gas boilers until 2005. In 2005, the district heating network was extended and new objects were connected. Currently, the heat from biomass substitutes the heat from central gas boilers by 95 %, the rest 5 % replaces individual stoves. The shares of original individual brown coal stoves and electric heaters reach 95 % and 5 %, respectively.

- The produced heat is measured at the input/output of the boiler house. Besides the biomass boilers, there are back-up natural gas boilers in the boiler house. Currently the gas boilers are not in operation (except for annual tests of boilers), since both biomass boilers produce enough heat to cover the heat demand. The consumption of natural gas is monitored to prove it.

- Annual heat production of gas boilers, shall they be in operation, is calculated from the amount of consumed natural gas, its heating value (34 MJ/m³) and the boiler efficiency known from previous operation (85 %). Annual heat production of biomass boilers is than calculated as the difference between measured heat production of the boiler house and heat production of gas boilers. The double check based on consumed biomass shows reliability of this calculation.

- The overall scheme of the installed biomass units and heat meters is presented in Figure 16.
Figure 16 Flow-chart of the project in Trhové Sviny
Velky Karlov

- The municipality of Velky Karlov implemented a 1 MW$_{th}$ biomass-fired boiler to replace individual old coal-fired stoves. The straw-fired boiler was implemented in 2001. The reconstruction of the distribution heating system was part of the project. The calibrated heat meter is in place since the operating of the boiler.

- For an emergency heat supply there is also a light fuel oil (LFO)-fired boiler in the heating plant. The boiler is used only in case of failure of the biomass boiler. The boiler had been in use in the monitored year. Energy content of the consumed LFO has been deducted from the heat production and supply values without consideration of the boiler efficiency, thus the calculation is very conservative.

- The overall scheme of installed biomass units and heat meters is presented at Figure 17.

![Figure 17 Flow-chart of the project in Velky Karlov](image-url)
Zlate Hory

- Biomass boilers with total heat output of 4.99 MWth were installed to replace a 5.8 MWth coal boiler in Zlate Hory in March 2003.
- During the year 2004 a small turbine of 0.15 MWe was installed to utilize steam for power production. The generated power is partly consumed at the boiler house’s premises and partly being fed to the power grid.
- For emission reduction calculation the heat fed to the district heating system is used. The heat is measured by a calibrated heat meter.
- The overall scheme of installed biomass units and heat meters is presented at Figure 18.

Figure 18 Flow-chart of the project in Zlate Hory
Zruč nad Sazavou

- The municipality of Zruč nad Sazavou implemented two biomass-fired boilers in total capacity of 4.3 MWth (2.5 MWth and 1.8 MWth) as planned. An old coal boiler of 4.4 MWth capacity was replaced.

- The heat is supplied to the district heating system together with heat from a natural gas boiler house. Therefore, the sold heat is calculated from heat production from biomass with given monthly heat distribution efficiency.

- The biomass boiler house contains also cogeneration units. „Heat production“, which is used for emission reductions calculation is calculated as heat produced in biomass boiler house minus heat from cogeneration units – see Figure 19.

- One of the biomass fuels used for combustion is plant waste granulate. The heating value of this fuel is 16 GJ/t as it was laboratory approved (the same as for straw).

![Flow-chart of the project in Zruč nad Sazavou](image-url)
Zlutice

- In the original Project Description the biomass-fired boilers with the total thermal output of 10 MW\textsubscript{th} were planned. Eventually, biomass-fired boilers with the total thermal output of 7.9 MW\textsubscript{th} were installed.

- The produced heat replaces the heat from coal-fired boilers by 75% and the rest 25% replaces individual brown coal-fired stoves.

- The overall scheme of installed biomass units and heat meters is presented at Figure 20.

![Flow-chart of the project in Zlutice](image-url)
APPENDICES

Appendix A - The Monitoring Protocol Form (English Version)

Appendix B - The filled-in forms of Monitoring Protocols (in Czech language, available as hard copies)

Appendix C - MS Excel file “Appendix C emission calculation_2011”

Appendix D - The authorization letters for monitoring co-operation issued by the subproject and the declaration about acquaintance with the Monitoring Manual (available as hard copies)

Appendix E - Monitoring Manual for Subprojects

Appendix F - Reporting and Calculating Procedure Manual for BTG Staff
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