GUIDELINE ON FINANCING OPTIONS, CONTRACTS, OWNERSHIP MODELS AND BUSINESS MODELS FOR BIOENERGY VILLAGES

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SKGO – Stalna Konferencija Gradova i Opstina (Serbia)

Lead Partner for the compilation of this document:
Klimaschutz- und Energieagentur Baden-Württemberg GmbH (Germany)

Contact:
KEA Klimaschutz- und Energieagentur Baden-Württemberg GmbH
Kaiserstr. 94a
76133 Karlsruhe / Germany
Ms. Konstanze Stein
Phone (+49) 721 9 84 71 – 0
Fax: (+49) 721 9 84 71 – 20
www.kea-bw.de:
konstanze.stein@kea-bw.de

Authors of this report
Konstanze Stein (KEA); Martina Riel (AEA), Herbert Tretter (AEA), Dominik Rutz (WIP), Martina Krizmanic, (REGEA) Valerija Vrcak (REGEA), Velimir Segon (REGEA), Miljenko Jagarcec (REGEA); Vasil Bozhikliev (SDEWES); Miodrag Gluscevic (SKGO); Spela Scap (GIS); Polona Hafner (GIS), Nike Krajnc (GIS)

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Further information about the BioVill project on: www.biovill.eu

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Abbreviations and Acronyms

CEO  Chief Executive Officer
CHP  Combined Heat and Power
CO   Carbon Monoxide
ECM  Energy Conservation Measures
EEA  European Energy Award
EPEEF Environmental Protection and Energy Efficiency Fund
ESCO Energy Service Company
EU   European Union
FNR  Fachagentur Nachwachsende Rohstoffe (Agency for Renewable Resources)
GNG  Greenhouse Gas
GI   General investor
GmbH  Limited liability company (Gesellschaft mit beschränkter Haftung)
HVAC Heating, Ventilating and Air Conditioning
IEE  Intelligent Energy Europe
IRR  Internal Rate of Return
ISO  International Standard
KfW  Kreditanstalt für Wiederaufbau
KPIs Key Performance Indicators
kWh  Kilowatt hour
LCA  Lifecycle Analysis
LCC  Lifecycle Costs
LLC  Limited Liable Companies
M&V  Measurement and Verification
m²   square meter
MSW  Municipal Solid Waste
MWh  Megawatt hour (1 MWh = 1,000 kWh)
NERM Non-Energy-Related Measures
NPV  Net Present Value
nZEB nearly Zero-Energy Buildings
ÖNORM Österreichisches Normungsinstitut (Austrian Standards Institute)
ORC  Organic Rankine Cycle
PME  Plants Methylester
PR   Public Relations
QM   Qualitätsmanagement (Quality Assurance)
R&M  Repair & Maintenance
ROI  Return on Investment
SEAP Sustainable Energy Action Plan
SME  Small and Medium Enterprise
SNG  Synthetic Natural Gas
SRP  Short Rotation Plantation
TPF  Third Party Financing
VDI  Verein Deutscher Ingenieure (Society of German Engineers)
VEXAT Austrian Explosive Atmosphere Ordinance (Verordnung explosionsfähige Atmosphären)
1. Introduction

1.1 The BioVill Project

BioVill is a three years project supported by the European Union’s Horizon 2020 research and innovation programme with a budget of around 1.99 million Euros. The project started in March 2016 and is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in collaboration with eight partners from the BioVill target partner countries Croatia, Macedonia, Romania, Serbia and Slovenia, as well as from Germany and Austria.

Many South East European countries have high biomass potentials, but these potentials are often not or only inefficiently used for local energy supply and regional economic development. Thus, the overall objective of the BioVill project is to support the development of regional bioenergy concepts and the establishment of bioenergy villages in Croatia, Macedonia, Romania, Serbia and Slovenia. This will be achieved by identifying suitable biomass value chains according to local and regional needs and transferring existing experiences in Austria, Germany and other European countries to the South-Eastern European partners. Thereby the market uptake of domestic bioenergy supply chains will be increased and the role of locally produced biomass as a main source of energy supply and added value for the local and regional economy will be strengthened.

Core activities of the BioVill project include national and local framework analyses, technological and economic assessments of local bioenergy value chains, development of the institutional set-up and energy management concepts for the potential bioenergy villages as well as capacity building on financing schemes and business models. As a key factor of success, the BioVill project uses a multi stakeholder approach fostering the involvement and active participation of the citizens and all relevant stakeholders in the planning and implementation process.

Major results of the BioVill project will be the initiation of at least five bioenergy villages in the target partner countries up to the investment stage for physical infrastructure, the raise of public acceptance and awareness of a sustainable bioenergy production and its commercial opportunities as well as increased capacities of users and key actors in business and legislation to sustainably manage bioenergy villages and to enact national and EU legislation. Altogether, the BioVill project will contribute to the expansion and sustainability of the bioenergy markets in the European Union and the rest of Europe.

1.2 Scope and structure of the guideline

This guideline documents existing and advanced business models for the development of bioenergy villages. All of them focus on holistic energy solutions. Therefore, their approach includes energy conservation measures in buildings as well as the implementation of renewable energy systems to produce power or heat in the bioenergy villages.

The objective of this document is to provide guidance and a toolkit for financing options, contractual issues or ownership models. Key elements of the guideline are possible financing options, operating and ownership models and contractual issues between the different actors, based on the experience gathered in Germany and Austria. The existing and often applied components of the “toolkit” for bioenergy villages are described in the following chapters on basis of a business model evaluation of bioenergy villages in South West Germany through KEA and long-term experience in the establishment and the accompaniment of bioenergy villages by AEA, KEA and WIP.

The first two chapters are dedicated to a typical process of setting up a bioenergy village. Here, the relevance of social engagement of the initiators and working groups for successfully initiating and preparing bioenergy villages is stressed. Additionally, the necessity of cooperating with proficient partners, the active use of existing favourable local framework conditions and lessons learnt are integrated in these chapters. This information will create understanding for the following explanation of the key elements of bioenergy villages that have to be considered in each case. These components range from the involved stakeholders, the applied feedstocks and technologies, the legal structures and the economic assessment to the financing and the risk assessment. Sub-Chapter 2.5.2.2 also provides examples for financial and technical model calculations. However, these calculations very much depend on the specific framework conditions in the respective villages. Therefore, calculation procedures and key factors influencing the calculations are further described in the relevant chapters of the guideline in order to create a comprehensive understanding of the approaches.

In the following chapter 3 the key contents of the relevant contracts are presented. Depending on the selected technology, the applied feedstock and resources, the involved stakeholders and the existing legal framework conditions, the necessary contracts are very different.
Finally, three business models are described in detail in order to illustrate the concrete application of the described components of the business model and the outstanding experiences that are available in Austria and Germany.

The successful implementation of bioenergy villages very much depend on the existing framework conditions. These interactions cannot be considered in this guideline in detail, but the specific national and local requirements are already documented in the BioVill reports “National framework conditions to support the establishment of bioenergy villages in Croatia, Macedonia, Romania, Serbia and Slovenia”¹ and “Local framework conditions to support the establishment of a bioenergy village”². Nevertheless, important framework conditions and its relevance for the establishment of bioenergy villages are mentioned in the respective paragraphs.

1.3 Definition of a bioenergy village

Neither on the European level nor within national legislation exist a coherent definition of what is a bioenergy village. Bioenergy villages have social, ecological, economic and technical dimensions. However, this guideline considers a bioenergy village as a village, municipality, settlement or community or a part of it which produces most of its energy for electricity and heating from local biomass as well as from other renewable energy sources. Key success factors of a bioenergy village are:

- **Sustainability**: The biomass feedstock is produced locally and in a sustainable way.
- **Energy Self Sufficiency**: A large share of the electricity and heat demand is covered by locally produced biomass or other renewable energies.
- **Local Ownership**: The business model allows also consumers, farmers and forest owners to become shared owners of the installations.
- **Regional Development**: The added value remains in the village and supports the local and regional economic development.
- **Public Participation**: The creation and management of a bio-energy village is based on a high level of public participation.
- **Resource Efficiency**: The energy concept of a bioenergy village includes also energy efficiency and energy saving measures.

![Figure 1: Schematic draw of a typical bioenergy village (FNR, 2014-1)](http://biovill.eu/wp-project/uploads/2016/09/2017-03-17-d2.6_nat.framew.cond__final_revised-1.pdf)

With regard to the EBPD requirements of reducing consumption first and then provide energy supply, it will be necessary to add the topic “energy efficiency” on the to-do list of bioenergy villages. Currently, most bioenergy villages focus on heat and power supply. Therefore, the ECMs are added and business models that include this holistic approach are described deeper within this guideline.

The German “Fachagentur für Nachwachsende Rohstoffe” evaluated applied technologies for heat generation in existing bioenergy villages: Nearly 80% biogas plants, 60% wood chip plants and 40% of both technologies are used in the villages. The high share of biogas plants is linked with the very good support conditions for this technology that were granted by the German Renewable Energy Act in former years. Livestock manure and energy plants are the most applied substrates in biogas plants (FNR, 2014-1).

### 1.4 Definition of a business model

In general, a business model “describes the method or means by which a company tries to capture value from its business” (Financial times lexicon). A business model can be also understood as “a model representation of logical relationships, such as an organization or company that can create value for customers and secure income for the organization” (Grösser).

Therefore, a business model always includes different fields or categories such as how a company or an organization produces, distributes, prices or promotes its products. The business model focusses on creation of values and describes a company’s core strategy to generate economic value.

Though, an organization’s business model cannot be regarded as a closed system. It is essential to consider the environment of the business model and the relations and interactions between the components of the business model and the environmental influences, too. This is because significant changes in the respective conditions often draw necessary adjustments to the business model. This macro environment of a business model can be classified in six categories:

![Environment of Business Models](Schallmo, 2013a)

Because these factors are often very volatile and their changes have a high impact on the success of the business model, the analysis of the framework conditions before establishing the business model and afterwards are crucial. On the other hand, the analysis of the framework conditions enables to focus on the most important drivers, risks can be assessed and de-risking strategies can be set up clearly.

From the perspective of the BioVill project, the business model approach will be used to display the integrated services, cash flows (costs, revenues), incentives and the risks from these interactions appropriately.

The periodic analysis of all relevant framework conditions is a precondition for the development of a business strategy, in which the business model is embedded and about that, the complete strategy for the company.

In order to understand the business model "Bioenergy Village", the individual components of the business model and their interactions are initially identified. The main components, the interactions between the components and partially between the environment and the business model are described in the next chapters.
2. Elements of business models for bioenergy villages

2.1 Planning, implementation and operation of a bioenergy village

The Fachagentur für nachwachsende Rohstoffe published a guideline that illustrates the process of establishing a bioenergy village which is representative for the majority of the existing projects (FNR, 2010). Within this process, there are many ways to continue the project or to stop because of high obstacles. Therefore, the main steps of the preparation, implementation and operation process are described within the following sub-chapters.

Figure 3: Phases of the establishment of a bioenergy village

2.1.1 Initial Brainstorming, first citizens meeting and determination of working groups

The initiation of bioenergy villages depends on those who decide to take on the project. Main drivers can be:

- Citizen initiative
- Municipal mayor
- Municipal council
- Other key persons in the village
- External consultants
- External companies interested in energy supply
The first step is to establish a prospective working-group, to be the driving force of the project, and to verify the suitability of the village or district for conversion to a bioenergy village. During the initial phase, the objectives of the bioenergy village are clarified. Such objectives can be:

- Reduction of energy costs
- Refurbishment of the technical systems
- Increase in the use of renewable energies in the village and independence from fossil fuels
- Reduction of GHG emissions
- Strengthening of local economies and circuits
- Improved energy efficiency in the village

These general objectives can be refined by estimating rough quantitative indicators that are derived from existing plans, if possible on municipal or regional level e.g. Sustainable Energy Action Plans (SEAP), Climate Protection Concepts or strategies linked with the European Energy Award (EEA). If such strategic papers do not exist, then national or European targets can be scaled down on local level.

The initiators of the project have to evaluate different preconditions for a bioenergy village on the basis of the existing framework conditions as well as on many quantitative and qualitative criteria for the development of bioenergy villages. For example, if the legislation prohibits biogas plants in water protection areas, this option cannot be realized or much effort is needed for special measures regarding the legal requirements. Or, if a district heating system is planned for the village, but there exists a gas net providing gas for most of the households at a very low price, then, the realization of this district heating system will be very difficult. However, the gas net can be useful for very large biogas plants that process biogas to the quality of natural gas in the gas net.

This first phase is elementary for roughly clarifying the eligibility of the village as a bioenergy village and for preparing the further steps. At this early stage of the project, both social and technical issues are addressed.

- **Social aspects: Stakeholders, drivers and potential customers**

  The initial group has to look for proficient and engaged people who support the idea, collect information, talk with local decision makers and relevant persons in the village and trigger the project as far as possible. Initiators should evaluate the possibilities of bioenergy villages on the basis of the social relations in the villages which means to integrate key persons, to compile proven communication channels to think about potential customers and so on. Initiators should also be aware that a bioenergy village can only be established, if the citizens have a need for the added values produced by the measures implemented in the bioenergy village. Therefore, these values should be ascertained in the initial phase, the arguments compiled and facts that are of negative value for the bioenergy village should be checked very carefully. This work will be very useful for the further decision-making procedure as well as for convincing skeptical citizens e.g. in the first citizen meeting.

  In the initial phase, initiators should brainstorm about large risks for the funding of the measures and potential obstacles. The definition of detailed financing measures will be more important in a later stage.

  Because people are the most relevant factors in the bioenergy village, these tasks are very important and key elements for the next activities.

---

**Key questions at that stage:**

What is the starting point, the core idea of the project?
Who are the key stakeholders and who are potential supporters? What are the potential intentions to join the project?
What are the relationships between the relevant participants?
What are the suitable communication channels within the first stage of the project?
How are the social structures in the village?
How is the decision making organized in the village?
Who are the potential customers and what added value is generated for the customer?
What are pros and cons for the project that have to be addressed by the communication strategy?
• Technical aspects: Evaluation of resources and energy demand

The existing and potential resources have to be evaluated as a base for the measures that will be realised in the bioenergy village. In this stage, resources mean in particular agricultural material, manure and slurry, or other useful waste from local or regional companies, waste heat from industrial enterprises and others. The rough compilation of these potentials is one first indicator for the selection of appropriate technologies that could be used in the village (see chapter 2.3). The evaluation should also include special content such as the availability of the arable land and the grassland as a resource for the bioenergy project and contractual agreements between farmers and other customers.

Rough indicators can be used for the estimation of the power- and heat demand of the households. On basis of these data, the power and heat generation of the potential technologies can be roughly calculated (see chapter 2.8).

Key questions:
Who are potential local project partners (farmers, enterprises with waste heat...)?
What resources do they have?
Which options do exist in order to involve potential feedstock suppliers?
What is the heat and power demand of the consumers?
What resources for biomass / renewable energy already exist in the region or can be used?
What is the level of resources? Is that sufficient for a bioenergy village?
What measures (energy saving measures within the buildings, heat and power generation with biomass or/and renewable energies) can be implemented within the bioenergy village?
Which technologies are already present and which have yet to be established?
Which technologies are best suited for use in the bioenergy village?
Depending on the results of the former questions:
Is the district or village suitable for transitioning considering the evaluated resources and the heat/power demand?

The initiators should compile all gathered information very accurately because that is the base for the further procedure and actions. Web-based clouds and other tools are very useful instruments to bundle all different information and to structure the data.

If the result of this first preparatory phase is positive and initiators are convinced about the feasibility of the project, then they should start with the active communication and organize the first citizen meeting.

Provided that the fundamental suitability of the village has been confirmed for the changeover process, further steps can be taken: First, major decision makers (local council, the mayor, farmers, relevant civic associations, etc.) should be involved so that they again act as multipliers. In order to present the project to a wider public and to encourage active participation, a first information meeting should be scheduled. The following points should be addressed:

- Intention to implement a bioenergy village
- Pros and cons
- Results of the suitability/feasibility test
- Business model of reference village
- Formation of working groups for further project preparation
- Timeline

Due to the complexity of the project, it is advisable to establish working groups for special fields of actions. These working groups allow much deeper insights, evaluations and specific activities. One or more persons must manage the complete process and to clarify interfaces between the working groups as well as organize periodic meetings of representatives of the individual working groups or of all involved people. Working groups should prepare minutes from the meetings and decisions made, that can be read by all involved people. The working groups are established at the first citizens meeting. The areas of the working groups are:
Working group: Public relations

Open and transparent communication and comprehensive local networking are indispensable for a bioenergy project. Therefore, during the preparatory phase, the relevant stakeholders / target audience and appropriate communication channels are found and the channels are then regularly used.

In the field of communication, the individual target groups (see chapter 2.2) and target group-related messages and the appropriate communication channels should first be determined. In addition, it makes sense to use different local events and media, bearing in mind that an individual approach is always most effective. Also, on-site visits and the analyses of similar projects are good means of persuasion.

Several information sessions are necessary as part of the project preparation, in accordance with the individual project steps, which do not always end in consensus. Therefore, it is important to discuss controversial issues openly and to gather arguments while spreading the relevant information about the local / regional network as widely as possible.

Since the motivations, objections and questions of the people often are very different, a specific communication to the single target groups with concrete messages within a coordinated communication process is recommended.

Main target groups and key messages:

<table>
<thead>
<tr>
<th>Target group</th>
<th>Key messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public administration</td>
<td>Integrating municipal buildings in the bioenergy village could set an example for other building owners.</td>
</tr>
<tr>
<td></td>
<td>Bioenergy villages support the local/regional economy.</td>
</tr>
<tr>
<td></td>
<td>Bioenergy villages strengthen the image of the village.</td>
</tr>
<tr>
<td></td>
<td>Synergies can be used e.g. additional cables or tubes (telecommunication, water pipes...) can be laid in the excavation.</td>
</tr>
<tr>
<td>Private building owners</td>
<td>The prices for district heating will not be higher than the comparable cost for a renewed decentral heating boiler.</td>
</tr>
<tr>
<td></td>
<td>Added values can be created such as more space in the cellar, less work with the heating system and others.</td>
</tr>
<tr>
<td></td>
<td>Bioenergy and renewables reduce GHG emissions.</td>
</tr>
<tr>
<td>Farmers</td>
<td>Bioenergy villages help to gain new business areas and customers.</td>
</tr>
<tr>
<td></td>
<td>Farmers will get stable incomes.</td>
</tr>
<tr>
<td></td>
<td>The image of the local farmers will improve.</td>
</tr>
<tr>
<td>Local companies</td>
<td>Waste heat can be a basis for additional revenues that improve the company’s economy.</td>
</tr>
</tbody>
</table>
Large heating consumers are a good starting point for a district heating system, thus other households and consumers will be more easily convinced.

The target groups as well as the key messages should be adapted to the real circumstances of the village in order to enable an authentic discussion with the people.

However, word of mouth will be the most successful way to involve and convince people and to find answers to the individual questions. Because the communication is very important in the beginning of the project and the efforts should be bundled, the PR group should determine responsibilities based on streets / districts in the village. In addition, key people of the village are driving forces for the process, in particular during the preparation period of the process. These people should be integrated as speakers in citizens meetings, and as commentators in the media (including social media), leaflets and brochures.

**Working group: Biomass, renewable energy, and energy efficiency**

The tasks of this working group are closely linked with the technical execution — working group. But before the technical equipment is selected and single options are discussed, the resources and potentials of the region have to be elaborated. Therefore, this working group has to gather the information listed in chapter 2.3. Participants of this working group can use rules of thumb to estimate the produced heat energy from the existing biomass resources (see chapter 2.3).

**Working group: Technical execution**

This working group is responsible for the selection and a first assessment of the technical measures, a first survey of the heat consumers and the cooperation with professional planners as described in detail below (see chapter 2.1.2).

Often, there are many specific technical questions that have to be clarified. These questions are very important for the communication of the PR group because they are based on doubts and biases of people such as:

- A typical smell of slurry will emerge in the village.
- A biogas plant needs a lot of “feeding” therefore higher traffic loads will appear, in particular with heavy agricultural vehicles.

**Working group: Implementation and operation**

During the initial phase, the implementation and operation of the technical devices are remote from the current discussions, whereas when the technical concept is fixed then a discussion about the best way of financing, implementing and efficient operating should be started.

At that time, the working group needs to think about different financing and operating models, about legal structures including their pros and cons. This decision-making process has also to take into account all relevant local circumstances (Biovill, 2016a).

It has to be emphasized that all above described tasks form a very important part of the complete process. There needs to be clarification about what specific expertise is provided by the working groups and the relevant areas where external experts should be involved. The funding and the remuneration of such experts have to be agreed on at an early stage.

Minimum requirements and conditions, in particular regarding the necessary resources and the energy and power demand of the consumers, have to be fulfilled (see chapter 2.4). All working groups must be aware of the high responsibility regarding the decision making based on their investigations, analyses, collected information and recommendations.

**2.1.2 Further planning**

The planning is carried out in several phases. It starts with the compilation of much data from the village which is used for the elaboration of the feasibility study later. The proficient planning is the core element of a successful bioenergy village. The quality assurance already starts within the development of a bioenergy village, in particular through the compilation of a coherent and consistent data base. Since many different stakeholders are involved in the collection of valuable data, the data base needs to be well prepared.

Because district heating systems are the core technology in most bioenergy villages, the planning and implementation process is explained in detail for this technology in the following paragraphs. While the procedure
differs a little bit with regard to the planned measure, the next pages show the common methodology how to set up and to implement a bioenergy village. An adapted procedure is necessary which depends on the relevant requirements of each measure or on the specific local environment. In this chapter, we describe the development process of the project. The relevant inputs for the collection of data, the selection of appropriate technologies or the economic calculation are given in chapters 2.4, 2.5, 2.8.

Step 1: Collection of data and rough estimations
Beside the evaluation of relevant national or regional framework conditions (legal requirements, existing plans, financing structures, availability of technical equipment and other, see report on local and national framework conditions (Biovill, 2016a)) different data have to be compiled from the relevant working groups:

Working group: Biomass, renewable energy, and energy efficiency
- The number of farmers or agricultural companies
- Areas available for biomass production (arable land, grassland, forest, etc.)
- Identification of other resources (organic waste, waste heat, etc.)
- Existing biomass plants or possible locations for new biogas plants
- Identification of renewable energy systems (wind, solar, thermal energy, etc.) or possible locations for renewable energy systems
- Potential locations for heating centers, solar plants, wind turbines and others
- Requirements for the use of the areas (water protection areas, conservation area, nature reserve and others)
- Conditions for biomass supply (price, logistic and others)

Working group: Technical execution
- Compiling data on building typologies and usage structure (see chapter 2.4) related to representative building and construction types (dwelling, commercial, industry) and their time of construction, type of construction (light/middle/heavy), deep retrofit measures (insulation of the building shell) and total floor space of building types
- Deriving the average heating and power demand (kWh/m²yr) for the building types and usage profiles and determining heat/power densities along the streets or in specific neighborhoods
- Rough overview about necessary energy conservation measures (ECM) in buildings (heating dissemination, warm water generation, control, lighting, insulation of the building envelope) in combination with construction measures
- Collecting information about local / regional requirements or specifications regarding renewable energies and biomass plants (land-use plans, municipal development plans, particulate emissions and other relevant information)
- Looking for planning documents from the municipal administration
- Preparing a survey of heat consumers
- Accompanying of the experts during the planning process
- Collecting arguments regarding specific technical questions
- Drafting the potential pipeline route from a district heating system
- Collecting specific energy prices for the different types of buildings / users
- Rough estimation of heat prices for the new heating system and for reference scenarios for the different building types, e.g. a decentral heating system with fossil fuels

Working group: Implementation and operation
This working group can start with determining interest of citizens in contributing to an operating company.

The working groups can collect all data in different ways:
- Individual meetings with the relevant people
After compiling and analysing all data, the evaluated data and the key conclusions are presented at the second citizens meeting.

The calculation tools and the approaches that are explained in the following chapters can be used for the first rough estimation of the heat prices. On basis of the vote of the participants on the meeting, the working groups continue with the

**Step 2: Survey of the demand side**

The survey of the potential power and heating consumers provides a basis for decisions about the continuation of the project and the detailed analysis within the framework of a feasibility study. This survey is the crucial basis for the calculation of the business cases and the reliability of the economic results. The technical plants will be dimensioned based on the evaluated and adapted heat and power demand (including potential energy conservation measures). Thus, the survey can be considered as an inventory of all relevant buildings based on real data.

First, the survey provides general data such as the address, the use of the building, building owner or tenant.

On basis of the estimated heat price (during data collection phase) the households / building owners surveyed are asked for their interest in obtaining heat from the district heating system.

In the households which state their interest, additional general and technical data has to be collected in a short audit:

- Interest in contributing to the bioenergy village initiative (voluntary work)
- Interest in participating in an energy cooperative or other mutual funding scheme
- Type and age of the existing heating boiler system, system requirements, assumed year of replacement
- Annual fuel consumption (oil, gas, wood, electricity...) and electricity consumption including specific prices, price schemes and annual overall costs;
- Information on long term energy contracts
- Necessary or planned energy conservation measures (ECMs) in the building

Probably, the interviewed citizens need additional information to fill-in the questionnaires, which can be provided in face to face meetings with working group members. In order to enable people to clarify their questions and biases, a public information point e.g. in the city hall is recommended. The plausibility of the collected data should be checked immediately by the interviewers in order to avoid a wrong data base.

If there are many farmers around the village, an additional survey of the supply side is necessary. Otherwise, the local agricultural company can be visited to talk about the required data (above). It is recommended to ask for an early memorandum of understanding during this interview on the basis of a more binding structural planning process taking into account the different influences on the price and supply conditions for the farmers / the agricultural company.

For decision making the following basic criteria can be used:

- District heating system: For the first estimation, areas will be gathered regarding their heating demand intensity. Around demand hot-spots the estimation of the feasibility is likely to be successful. If possible, it can also be considered to link some of those hot-spot areas. More than 50% of the heat demand in the district surrounding the future heat-centre should be covered by interested heating consumers. These buildings should be connected to the district heating system during the first year. The profitability of the project decreases with less heating consumers, low heating density per meter of heating pipe and longer delays in connecting to the district heating system.
- Heating from a biogas driven CHP: At least 2000 m³ slurry and 50 ha arable land should be available. The slurry stabilizes the fermentation. The biomass from the arable land and the slurry are essential for biogas production that can be generated by a 100 kWel engine and can cover the electricity demand of 150³ households and the heat demand of 33³ households.
- Focus on energy cooperative or another legal structure, founded by the inhabitants of the village, that is responsible for its’ funding, implementing and operating: The citizens should show a high level of willingness to give financial contribution to the entity. The extent of the payments depends on the investment costs of the project and the number of involved people / households supplied with energy. The greater the equity share funded by the members of the legal structure, the better the legal entity will be rated by a financing institution.
- The active participation on the project is also crucial for the success. Therefore, the more motivated people are involved the lower will be the effort for each single person. In order to work very efficiently in the working groups, at least 10 people should support the project intensively, but more people are welcome to contribute to the process.

The working group “Implementation and operation” analyses the questionnaires and derives the results and recommendations. Foreseeable changes to social and economic framework conditions needs to be considered, e.g.: Which buildings will still be in operation in the future and what will be the purpose of the building? In that context, first sensitivity calculations can be realized at this stage.

Quality assurance and quality checks are essential. On basis of the compiled data, the working group carries out a rough estimation whether a bioenergy village is feasible and which additional pre-requisites would be necessary to accomplish feasibility.

Within the third public meeting, the working group presents all results of the survey and the recommended next steps to the interested citizens. If in the eyes of the speakers, the results are a good basis for the establishment of a bioenergy village, then further activities have to be discussed:

- Asking for at least three offers from proficient consultants (engineering company, energy agency or others) regarding the feasibility study
- Clarifying the funding of the feasibility study
- Compiling the framework conditions and data that are necessary for the feasibility study.
- Defining the detailed tasks that the consultant has to fulfil
- Determining the time frame of the feasibility study including milestones

**Step 3: Feasibility study**

The feasibility study delivers the decision basis for the real implementation of the bioenergy village. Therefore, the information flows during the elaboration of the feasibility study, the used calculation schemes including the data bases and the approaches selected are crucial for the outcome of this study.

If there is a very experienced engineer or planner in one of the working groups, who is able to carry out the feasibility study, an external advisor is not needed. The real technical and economic feasibility of the bioenergy village is determined in the feasibility study. In order to reduce the energy demand, ECMs should be considered in individual buildings. The synergies developed through the reduced energy consumption, like for example reduced installation costs for the heat producers and the district heating system should be addressed. Furthermore, different types of heat and electricity generation as well as the use of renewable energies should be compared according to the local situation. This often requires an iterative process combined with intensive feedback given by the working groups.

Within the feasibility study, a cost calculation should be made considering data about the underground (stone layers, groundwater etc.) or other cost relevant issues. This would also mean that an appropriate plant location (heating center or others) should be determined.

A very reliable tool for the calculation of the economic outcomes should be applied in the feasibility study. A life-cycle approach is such a tool and additionally takes into account the dynamic development of the different costs categories. More information on this is given in chapter 2.8.

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³ On basis of an annual power demand of 4,200 kWh/household on average
⁴ On basis of an annual heat demand of 30,000 kWh/household on average
Considering potential ECMs on the demand side is important at this stage: within the feasibility study, also potential energy savings through energy efficiency measures in the buildings should be included, since these measures can decrease the energy demand and facilitate the viability of the planned installations, e.g. a district heating system. Therefore, this lower energy demand should be compensated through a higher line density and the connection to more heat consuming buildings. Planners should already investigate this issue within the feasibility study, because decreasing heat consumption in the operation phase caused by building refurbishments also influences the economic outcome.

A possible structure of the feasibility study:

1. **Database for the calculation**
   1.1. Database of the demand side
       1.1.1. Energy demand
       1.1.2. Energy prices
       1.1.3. Energy savings and reduced energy demand
   1.2. Database of the supply side
       1.2.1. Existing biomass resources
       1.2.2. Other resources
       1.2.3. Feedstock prices

2. **Technical concepts**
   2.1. Reference scenarios
   2.2. Bioenergy concepts

3. **Economic calculation**
   3.1. Economic assessment of reference scenarios
       3.1.1. Investment and capital costs
       3.1.2. Maintenance and operation costs
       3.1.3. Energy costs
   3.2. Economic assessment of Bioenergy concepts
       3.2.1. Investment and capital costs
       3.2.2. Maintenance and operation costs
       3.2.3. Energy costs
   3.3. Comparison of options
       3.3.1. Comparison between reference scenarios and bioenergy scenarios
       3.3.2. Sensitivity analysis
       3.3.3. Risk assessment

4. **Ecological impacts**
   4.1. Ecological assessment of reference scenarios
   4.2. Ecological assessment of bioenergy concepts

5. **Decision making and recommendations**
   5.1. Decision making criteria
   5.2. Decision making matrix

6. **Recommendations**

If heat consumers pay a very attractive heat price, the incentive to carry out refurbishment measures is low. This argument should be taken into consideration during planning neighbourhood-concepts including a district heating system.
At the end of the feasibility study stands a matrix of decision making criteria which are derived from the specific targets of the citizens. The set-up of a decision making matrix will have a strong impact on the selection of the technical measures as well as on the investments costs and the business model. This decision making matrix will be used to prepare the decision making for a technical concept and during the major steps of planning, design and implementation of the bioenergy village.

Decision making criteria can be technical, environmental and economic metrics.

- **Technical criteria:** Technical quality of the recommended measures and use of sustainable investments with high residual value, excellent source energy balance and a high share of technologies based on renewable energies.
- **Economic criteria:** The scope of costs (e.g. investment, energy costs) and revenues (e.g. feed in tariffs etc.) will be evaluated over a defined time frame by the Net Present Value (NPV): all expenditures and revenues of the bioenergy village project are cumulated over the pay back term on today’s value. In addition, the impacts on the local or regional economy (e.g. regional suppliers of woodchips ...) can be considered as well.
- **Environmental criteria:** The carbon food print, the reduction of GHG emissions or of primary energy can be taken into account.

Within the decision-making procedure, the relevant criteria can also be combined and weighted or a qualitative deliberation process can be carried out. For the economic calculation, the procedure documented in chapter 2.8 can be used.

If the outcome of the economic evaluation in the feasibility study is positive and the decision-making procedure is finished, then, by that date at the latest, the different legal structures and appropriate operating models have to be examined (see chapter 2.6 and 2.7). In choosing the legal structure for the company, different criteria should be weighed in detail in view of the specific local conditions:

- Funding
- Knowledge
- Risks
- Suitability
Funding of the feasibility study:
The working group “implementation and operation” should look at the availability of public subsidy programmes, energy efficiency funds or others. Some European countries set up grants or soft loans to support feasibility studies. Another source of funding is by the citizens themselves, a big local company or the municipality.

The further steps depend on the selection of the operating model:

Figure 1: If the measures will be implemented by the citizens organized in a suitable legal structure, then the established working groups continue the planning and project preparation.

Figure 2: If an external company will be involved (e.g. for implementing and operating a district heating system), the further activities will be set up by this company or essential tasks should be delegated to the third party at this stage.

The results of the feasibility study as well as of the assessment of the suitable legal structure are presented on the fourth citizen meeting. The decision-making base should be understandable documented and presented that citizens can make informed decisions about how to continue or stop the process. When citizens aspire an own managed legal structure, participants of the meeting shall discuss and decide the next steps concerning founding of a legal entity. Depending on the measures, setting up a predecessor company is recommended for establishing e.g. district heating systems.

Step 4: Predecessor Company and Preliminary Planning
If citizens focus on own citizens company, it is recommended to have the previously established structures that lead to a predecessor company in order to obtain a clear legitimacy for further prosecution steps and being able to act on preliminary contracts. To accomplish this, a streamlined legal structure can possibly be used.

On the other hand, if citizens are not able to fulfil all task that are linked with an own company, then they should look for an experienced company in the region.

It is important to trigger the process since heat and electricity customers will now have preliminary contracts finalized as well as the farmers and foresters will have preliminary supply contracts signed.

If the citizens continue the project, then the workings groups have to fulfill many tasks:

Working group: Technical execution
- Motivating more households to participate on the project and compiling all relevant data of the households (see above)
- Collecting data about installed pipes (water, sewage), cables (telecommunication, electricity) in the streets and planned replacement measures
- Gathering data about the street surfaces and green stripes
- Refining the energy consumption data of the consumers
- Analysing the height differences in the village that are relevant for the calculation of the pump sizes (only in areas with significant height differences)

Working group: Biomass, renewable energy, and energy efficiency
- Preparing biomass supply contracts
- Elaborating concepts for crop rotation and cultivation together with local experts (farmers)
- Clarifying logistic issues such as available vehicles, transport barrels (slurry) and machineries
- Discussing the commissioning of external staff (agricultural cooperatives, agricultural service staff)
- Storing of silage, digested residues and others (location, capacity, etc.)
- Evaluating many details about the farmers or/and the local agricultural enterprises (supply volume of biomass, size of the arable areas, share of own land and leased land
- Negotiating prices for biomass supply and specific supply conditions (cycle, interfaces, etc.)

Working group: Public relation
- Informing all inhabitants of the village about the process
• Organising citizen meetings
• Creating and distributing information leaflets about the project in accord with the current stage of the project
• Publishing information on suitable media (newspaper, newsletter, mailings, social media, local radio etc.)

**Working group: Implementation and operation**

• Preparing the new predecessor company (legal structure, corporate contract with necessary agreements – with external support as the local circumstances require)
• Preparing the preliminary contracts with the heating consumers
• Disseminating the preliminary contracts and evaluating the signed contracts
• Preparing the biomass supply contracts with farmers or agricultural enterprises
• Clarifying the suitable legal structure and operation models for the operating company (see chapter 2.6, 2.7)
• Identifying potential plant operators roughly
• Involving persons additionally in the project in order to extent the resources (knowledge, financing…)
• Discussing contractual safeguards in advance for all necessary contracts
• Clarifying the funding of the measures and available grants/subsidies
• Handling of the cash flows during the operating time
• Estimating the major costs and sources of income
• Evaluating the marginal price that the customer pays
• Assessing risks and compiling available de-risking
• Defining quality assurance instruments

**Content of the corporate contract:**

• Name, location and objective
• Rights and duties of the members
• Entities of the company, their tasks and rights
• Decision making
• Distribution of profit and losses
• Closure

Many interested citizens should contribute on the predecessor company – including financial contribution as well as playing an active role. Thus, citizens take already over financial risks in this stage of the project and they collect experience in cooperating within a legal entity. At this stage, it is recommended to establish a very simple legal structure that fulfills the purposes of the predecessor company (see chapter 2.7). The foundation of the predecessor company requires a meeting with all citizens who are interested in contributing on the company.

Preparing the different preliminary contracts is one of the key tasks of the predecessor company. These contracts should be presented to and discussed with the members of the predecessor company.

In particular, a detailed price calculation is necessary for the draft of the preliminary heat supply contract (district heating systems), that means a complete calculation of all costs based on the number of registered heating consumers (see chapter 2.8). Based on the number of signed preliminary contracts, the evaluated biomass supply conditions, and the results of an iterated rough economic calculation, the preliminary planning can be started and pushed forward. In most cases, a proficient and competent expert is involved in this planning phase and carries out the planning supported by the working groups.

The drafts of all contracts (biomass supply, heat supply...), the results of the signing action for the preliminary heat supply contracts, the results of the rough economic analysis and the recommendation for the commissioning of the preliminary planning should be addressed in a meeting of the predecessor company members again.
The financing of the preliminary planning can be covered on the same way as the funding of the feasibility study. In addition, the financial contribution to the predecessor company can be used to cover the costs of the planning. The costs are probably higher than the costs of the feasibility study.

The main tasks within the preliminary planning are the elaboration of the technical and economic concept in more detail considering the defined objectives of the bioenergy project. That means, that the planner has to consider all framework conditions such as the evaluated energy demand e.g. from the heat consumers, the concrete prices from the biomass materials in the region as well as from the technical devices on basis of list prices, the real financial conditions from the financing institutions and available subsidies. Considering ECMs, heat and power generation systems and the integration of renewables, a modelling and simulation process should be started, that includes different types of measures and different targets on remaining energy demand (base-case / few measures on the demand side / new building standard or low-energy house up to passive house). The modelling approach has to be determined according to the type and precision of the results it is expected to provide, and by the available data. When ECM bundles are modelled, the results have to be revised with regard to the synergetic effects between ECMs and energy supply measures.

The design of the ECMs and supply measures need to follow the national industry or other standards and must consider recent developments in standardized design solutions. In addition, they must provide the necessary technical accuracy which includes everything necessary, avoids unnecessary work and materials and also considers a certain cushion.

The result of the preliminary planning is crucial for the further process. The economic calculation should be based on a total cost calculation and take also into account changes of costs in the next years in terms of a life cycle cost balance – as far as possible (see item 2.8). If the economic result of the study is not positive and the planner recommends the stop of the project, all previous efforts and payed money is lost. That underlines the importance of the steps before.

For the investment cost estimate, a functional specification of the major building components (wall, roof, basement insulation, windows, lighting, ventilation, supply options) has to be defined: The non-energy related investment costs, i.e. repurposing costs and additional benefits such as increasing usable floor space etc., should be determined for the investment cost estimate.

The results of the preliminary planning are presented to the members of the predecessor company transparently. If there are any increases of costs, more discussions will emerge and the effects for the consumers have to be reflected within the meeting.

If the participants agree to continue the process, the foundation of the operating company has to be prepared immediately. Therefore, the draft of the by-law of the company is presented on the meeting. The selection process of the suitable legal structure should be finalized at this date. The working group “Implementation and operation” is in charge of the comparison of the different legal structures including their pros and cons. If necessary, external consultants can be interviewed. In addition, this working group should amend and finalize the by-law of the operating company taking into account the recommendations of predecessor company member’s and describing the tasks of responsible persons working for the operating company.

**Step 5: Foundation of the operating company and further planning**

As already mentioned for the foundation of the predecessor company, the formal foundation process should be carried out very exactly in order to avoid mistakes that endanger the complete process. Afterwards, the predecessor company can be dissolved. The preliminary planning is transferred to the new operating company, thus the financial contribution of citizens to the processor company can refinanced so far.

On basis of the preliminary planning including amendments that take into consideration the requirements of the public authorities, the project will be expedited through to approval and execution planning. It should be clarified in accordance with national legislation, which measures are necessary to fulfill legal requirements. In the context of this stage, further fields of action such as emission control, disposal of waste and sewage, recycling of materials, noise protection, system, and process safety are elaborated intensively.

Aside of the technical requirements, the operating company clarifies the financing, including fundraising and compares financing conditions of different financing institutions. In this phase, applications for grants and subsidies are prepared.

On basis of a completed economic calculation, the heat consumers, who already signed the preliminary contract, receive the final heat contract. In addition, more interested people should be motivated to sign the heat contract. Also, the contracts with the farmers / the agricultural cooperatives can be concluded now.
2.1.3 Implementation

**Step 6: Implementation**

After the planning application is approved, the implementation of the measures can start. The work can be carried out by a general contractor or by the planner, the operating company commissions each field separately. Sometimes, the building owners or members of the operating company are also interested in participating in the works, e.g. installing the house connection pipes.

It’s also recommendable to work in parallel groups in order to accelerate the implementation period of the district heating system. The time frame of implementation has to be agreed with all involved people. Also, traffic obstructions should be planned in detailed and announced in the village. The working group “PR” informs the inhabitants about the stages of the implementation process and about delays.

2.1.4 Operation

Different tasks have to be managed during operation. This will of course depend decisively on the resources used by the technical installations as well as the operator model. The main tasks are listed below:

**Biomass Extraction / Use of Resources**
- Determination of the cultivation plan and crop rotation
- Field and forest management up to harvest
- Drying of biomass and storage
- Loading/feeding of biomass plants
- Disposal of waste products from biomass plants
- Machinery maintenance
- Quality assurance for biomass material

If fossil fuels are used for example to cover the peak loads, they should be ordered when needed.

**Management of technical equipment**
- Operational monitoring of equipment
- Ongoing optimization of plant operations
- Measurement and Verification
- Documentation
- Maintenance

**Accounting and Controlling**
- Procurement for and negotiations with contractors
- Insurance contracts
- Accounting and payment of employees, biomass suppliers and other companies
- Year planning and year contracts
- Payroll, taxes, banking
- Revenues from heat sale
- Dunning process
- Documentation
- Economic calculation and income statement
- Caring for members of operating company

**Communication and distribution**
- Communication of results
- Press and public relations
- Acquisition of new customers
2.2 Stakeholders, their roles, resources and intentions

Since bioenergy projects are following a citizen-driven approach, the citizen participation process is crucial for successful implementation. Therefore, the citizen participation should start as early as possible. Citizens are not only involved in the decision-making procedure, they are also relevant customers, biomass suppliers, executive tradesmen or operators of the bioenergy plant. For the potential bioenergy village and its’ inhabitants, the establishment of a bioenergy village can lead to many advantages:

- Establishing a new political culture of citizens participation
- Realising added values for the village and increasing the local income
- Improving the ecological environment
- Setting up more economic connections within the village
- Improving the satisfaction of citizens with the individual energy costs and indoor quality
- Creating a higher awareness for joint local activities.

Figure 4: Regional added values of a sample bioenergy village in 2015 (Heck, 2015)

Already in the beginning of the project, the participation of the citizens and the eligible stakeholder groups is a crucial point for the public consent of the project. Addressing the advantages mentioned above can help to avoid resistance from some people both in the beginning of the project and beyond.

The identification of eligible stakeholders on local, regional and national levels is one of the first steps in the beginning of the project. Stakeholders that are most often involved in the project are shown in the chart below.
Figure 5: Classification of stakeholders

All these stakeholders take on specific roles in the project and follow specific intentions that sometimes lead to different interests and point of views. An analysis of stakeholders’ resources, their potential roles in the project and their interests will provide a first useful overview:

<table>
<thead>
<tr>
<th>Key Stakeholders</th>
<th>Key Resources</th>
<th>Stakeholders roles in the process and their interests</th>
</tr>
</thead>
</table>
| **Feedstock suppliers** (farmers, municipal waste disposal companies, wood industry, etc.) | • Agricultural and forestry areas  
  • Biomass resources  
  • Agricultural waste  
  • Knowledge of crop rotation, etc.  
  • Machinery  
  • Facilities for drying and storage  
  • Equity/credit  
  • Local networks | Role:  
  • Supply of feedstocks  
  Interest:  
  • New sources of income  
  • Switch from fossil to renewable fuels |
| **Plant Operators** (citizens company, public utility, ESCO) | • Equity/Credit  
  • Technical, architectural, and business knowledge  
  • Experience in marketing and sales  
  • Networking with other specialty firms (energy efficiency measures and maintenance...) | Role:  
  • Efficient operating of the plants  
  • Performing a one stop shop concepts for customers  
  • Reliable supply of heat/power  
  Interest:  
  • Economic/Profitable Plant Operation |
| **Heat and Power Customers** (private, public and commercial consumers) | • Demand for heat and power supply  
  • Financial contribution to operating company | Role:  
  • Buying heat/power from the supplier  
  Interest:  
  • Affordable and reliable heat and power supply  
  • Additional values in the building |
| **Municipal administration** | Supporting decision making in the municipality  
High influence on citizens of the municipality  
Same issues as consumers, permission administrations | **Role:**  
Promotion of and creating trust in the project  
Same issues as consumers, permission administrations  
**Interest:**  
Establishing a successful project  
Achieving local objectives (GHG emissions and others)  
Creating added value in the region |
|-----------------------------|-------------------------------------------------|------------------------|
| **Financing partners** (private and public institutions, fund administrations, crowd funding platforms ...) | Funding | **Role:**  
Rating of implementation/operation company  
Checking the economic outcome of the project  
**Interest:**  
Selling loans and earn money |
| **Grant administration** | Grants and subsidies | **Role:**  
Checking project regarding the requirements of grant programmes  
**Interest:**  
Distributing grants and subsidies |
| **Engineers and planning offices** | Planning knowledge and technical experience  
Advising citizens in eligible and feasible technical options | **Role:**  
Carrying out the feasibility study  
Advising the citizen working group  
**Interest:**  
Selling technical-economic concepts |
| **Citizens, public, local groups and informal key decision makers** | Promotion of the project within their groups | **Role:**  
Promoting of the project  
Distributing information  
**Interest:**  
Realising municipal objectives  
Creating additional values in the municipality and for their specific group  
Avoiding additional costs for the municipality |
| **Public authorities responsible for permissions** | Permission of specific measures | **Role:**  
Checking authorisations approvals  
**Interest:**  
Avoiding unlawful acts |
| **Local and regional companies** (heating installers, electricians...) | Technical knowledge and appliances for installation and services | **Role:**  
Installing technical and constructional measures  
Maintenance services  
Emergency services  
**Interest:** |
Table 1: Classification of stakeholders’ resources and roles

<table>
<thead>
<tr>
<th>Stakeholder Type</th>
<th>Resources and Services</th>
<th>Role</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturers of technical equipment</td>
<td>Technical plants, Know-how in manufacturing technical plants, Warranty services</td>
<td>Delivering technical plants</td>
<td>Selling devices and appliances</td>
</tr>
<tr>
<td>Regional / State government</td>
<td>Public relations, Legal requirements, Financial resources</td>
<td>Prepare laws, acts and action plans, Setting up framework conditions for the projects, Reducing obstacles for the projects</td>
<td>Carrying out development strategies by themselves and by stakeholders</td>
</tr>
</tbody>
</table>

Nevertheless, some of the stakeholders can cause negative influences on the project, especially within the preparation phase. Therefore, first signs should be taken into consideration very carefully (see chapter 2.1.1).

Basically, the analysis of the stakeholders will also determine which experts can be involved locally, what resources can they provide, and which resources should be provided through a third party. For this purpose, a strength/weakness analysis for each stakeholder is recommended.

The involved stakeholders vary in the single stages of the project. Some of the stakeholders only contribute in few stages of the project, whereas others are in charge of the complete implementation and operation period (tradesmen, feedstock suppliers...). This means, that stakeholders are linked by different relationships in a formal or informal way. Contracts are the basis of formal relationships (see chapter 3).

The following two charts highlight that the actors involved in bioenergy villages are very diverse in the different stages of the project:

Figure 6: Project partners of a bioenergy heating plant in the construction and assembly phase

(Own illustration, acc. to FNR 2014-2)
The following figure shows the project partners of a bioenergy heating plant for the operational phase:

![Figure 7: Project partners of a bioenergy heating plant in the operational phase](Own illustration, acc. to FNR 2014-2)

### 2.3 Available biomass and renewable resources

#### 2.3.1 Relevant renewable energy sources and biomass resources

The following list gives an overview of different types of renewable energy sources. For every renewable energy source, its main trade-able energy carriers and/or utilizable energy forms (power, heat or transport fuel) are indicated in brackets. The bold energy sources are the ones which the BioVill project focuses on.

- **Bioenergy**
  - **Solid biomass** (mainly dry biomasses below 55% humidity, like log wood, pellets, briquettes, wood chips, bark, waste wood, straw, agricultural waste materials, etc., usually for heat-only production, occasionally for combined power and heat production (CHP))
  - **Gaseous biomass** (Biogas from a wide range of digestible wet biomasses often much above 55% humidity, mainly for CHP, occasionally upgraded to substitute natural gas for transport or all other gas grid related energy uses)
  - **Liquid biomass** (plant oils, biodiesel, bioethanol as fuels for transport)

- **Solar energy**
  - Photovoltaic (electricity)
  - Solar thermal energy (heat, occasionally CHP)

- **Wind energy** (electricity)

- **Hydro energy** (electricity)

- **Ambient heat**
  - Deep geothermal energy > 400 m under ground level (heat, occasionally CHP)
  - Shallow geothermal energy < 400 m under ground level (heat from earth, ground water)
  - Ambient heat from air (heat)

If a village or a region wants to become sustainable in terms of energy supply and utilization, probably all types of actually available renewable energy sources need to be exploited to a certain extend.

#### 2.3.2 Biomass to energy conversion pathways

The types of biomass sources and energy carriers mentioned above can be derived from a very wide range of biomass feedstock and energy conversion technology pathways (see figure below).
Normally the main local bioenergy source for heat and CHP is wood; in case that there is no forest, it is waste biomass from agriculture or industry.

The BioVill project focuses on biomass feedstock and final energy carriers for heat-only and combined power and heat production. Therefore, the following text does not consider biomass feedstock for transport fuels.

### 2.3.3 Sustainable bioenergy utilization preferred

Usually every bioenergy source should only be exploited to an extent, which allows the feedstock source to deliver the same amount of biomass again, without diminishing the ability to constantly deliver that annual amount over a long period of time. In agriculture, the ground must be able to keep its fertility and its ability to meet human’s nutrition and all other needs of the nature, like preserving habitats and biodiversity. Exploitation of biomass – both from forests or agriculture – for energy purposes should not harm these needs.

The definition of sustainability was invented by foresters long time ago. In forests this means, that only less than the average annual wood growth in a certain region can be taken out for both, material and energy purposes every year. The forest area and its standing wood stock should remain at least constant over hundreds of years, despite exploitation.

Please consider:

Pellets, for example, can be transported even trans-nationally economically. Wood-chips normally are not transported over a distance of more than 60-100 km.

Material usage should be the prioritized utilization pathway for wood assortments with higher quality (i.e. round wood with higher diameters). Material usage of wood usually allows a higher added value and greenhouse gas mitigation effect (especially in construction industry) compared to energy utilization. If a wood-based industry is established in a country or region, the energy utilization pathways can benefit from it. Especially sawmills play a crucial role for wood mobilization from forests. Energy utilization alone cannot mobilize comparable...
amounts of wood. Often only forestry management “must-does” like thinning operations allow a material-usage-decoupled mobilization for energy purposes only.

2.3.4 Bioenergy supply benefits from material utilization pathways

In many countries, saw mills are the “engine” of forestry wood mobilization. Bioenergy mobilization benefits at several stages from this material-usage-driven mobilization operations.

At forest streets, wood tops, branches and cuttings can be sun and air dried, where they are chipped when needed for burning. In saw mills bark and other wood residues like industrial wood-chips, shavings and saw dust account for 40% of the total mass of round wood sawn annually. Both, wood shavings and saw dust, in larger saw mills, are already utilized for wood pellets production often. Bark at saw mills often is utilized as heat source for pellets production or for their wood drying chambers. Saw mill by-products are also important material feedstock for paper, pulp and wood panel industry.

So there is feedstock competition between wood-based industry and energy utilization. This is the case for larger centralized biomass plants too, where industrial round-wood assortments are often used for wood-chip production. Industrial round-wood is also the main material feedstock for paper and pulp industry. Wood panel industry, because of feedstock competition, partly switched to waste wood as feedstock.

Saw mills are the main wood-mass mobilization facilities for example in Austria. Because of high forest area (48% of national area) and good wood mobilization, constantly growing for decades now, Austria has well-developed wood-based industry sectors and imports large amounts of round wood.

2.3.5 Template on technical biomass potential

The BioVill project has developed a questionnaire to systematically assess the amount of a village’s or regions’ technical bioenergy potential. The template (Sheet Bioenergy Sources) asks for most of the potential biomass sources and its main feedstock and considers material usages and the aspect of feedstock conflicts with biomass material utilization industry, respectively.

Regarding biogas feedstock from farms, the critical size of farms is indicated by a minimal number of animal livestock per farm, which necessary to allow for collection and centralized utilization of feedstock (critical mass of biomass feedstock).

All kind of bioenergy feedstock captured by this questionnaire needs to be further processed to allow them to be delivered to end consumers as final energy carriers. Bioenergy carriers for individual end consumers normally are used to generate heat only. Transport fuels and CHP from biomass feedstock are produced in centralized plants, rather. The aspect of applicable technologies for different consumer types is dealt with in chapter 2.5. The aspect of critical mass of feedstock or energy carriers, respectively, is also dealt with in this chapter, as it is linked to the available applicable feedstock collection and energy conversion technologies.

2.4 Energy Demand

2.4.1 Energy conservation measures and remaining energy demand

Energy efficiency measures should have priority to a fuel switch for bioenergy: A combination of lowest as possible useful energy demand and highly efficient bioenergy conversion systems allows bioenergy to cover a large part of the local energy demand in a sustainable way. Therefore, the assessment of necessary ECMs in buildings on the demand side and the calculation of potential savings as a basis for the design of the heat or power generation systems are crucial for the implementation of low-energy neighbourhoods with regard to the EBPD.

The methodology of saving calculation for single measures can be derived from evaluated case studies that are documented in chapter 5.

What after the ECMs is needed by consumers is the useful part of energy, i.e. electricity, heat at a certain temperature or transport fuel. The useful energy demand, e.g. in space heating is the heat provided by radiators to compensate heat losses through the building shell. The amount of space heat required depends - inter alia - on the thermic quality of the building shell and indoor gains on energy.

As useful energy normally needs an energy conversion step from final energy carriers (e.g. log wood, pellets, etc.) to useful energy (e.g. piped hot water), the efficiency of energy supply depends on the efficiency of
the decentralized or centralized energy conversion system itself as well. The definitions of useful and final energy are visualized in the following figure.

**Figure 9: Definitions of Heating Terms (Reiter, 2010)**

### 2.4.2 Estimation of energy demand (top-down)

If a village or a region wants to estimate how its bioenergy supply potential matches its potential demand for bioenergy, but does not have bottom-up data of the final energy (carriers) demand of its sectors of economy, i.e.

- Residential sector,
- Private and public service sector,
- Industrial sector,
- Agricultural and forestry sector,
- Transport sector,
- Energy sector,

A top-down analysis of energy demand might be a useful way to start, alternatively. In case no bottom-up data exist, averaged national figures are a possible starting point.

A good basis for a top-down analysis of local energy demand is the national energy balance. The energy balance states the annual demand of all types of final energy carriers, ranging from fossil to renewable energy sources, for all sectors of economy listed above, for a longer period of years.

**Top-down-calculation:**

The energy demand of a village or region can be estimated roughly, if for every sector its final energy carriers’ demands in TJ are divided by the national population and multiplied by the village’s or region’s inhabitants.

Normally Terajoule (TJ) is the energy unit used (3.6 TJ = 1 GWh; 1 GWh = 1 Mio. kWh).

This allows a rough estimation of energy demand for every sector of economy, sub-divided to all final energy carriers. Electricity and transport fuels are final energy carriers per definition. Heat is a final energy carrier only in case of district heat. Where final energy carriers are directly used for heat production only, e.g. log wood, coal or fuel oil in the residential sector, they correspond to heat demand. Please be aware that natural gas in the residential sector can be used for cooking also. To get accurate space heat demand figures, the data must be corrected for annual climate changes (normalisation of heating degree days).

The question how much of fossil fuel demand currently used for heating could be replaced “technically” by bioenergy considering the ECMs in the buildings can be estimated based on the identified bioenergy poten-
tial, locally available. This can be done for example for replacing coal, fuel oil and (part of the) natural gas used in the residential, agricultural and private and public service sector, by appropriate bioenergy carriers, easily.

In industry, the quality of heat itself can be more complex and demanding (e.g. temperature and pressure level). Technically, bioenergy can deliver such heat qualities as well.

The question how much of fossil fuel demand currently used for heating could be replaced “economically” by bioenergy can be estimated based on an economic assessment of typical energy demand pathways that allow utilization of bioenergy (see Chapter 2.8).

2.4.3 Estimation of energy demand (bottom-up)

The BioVill project is focused on heat-only and CHP bioenergy plants for the energy supply. For both, in-house and centralized bioenergy systems accurate figures on the actual and future remaining heat demand of all heat consumer objects after ECMs in the area of the (potential) site for a new CHP or heat-only plant delivers crucial information determining the size of these plants. All types of these plants are dimensioned according to the calculated heat demand and to the seasonal run of the thermal load in the form of an annual load duration curve.

Within BioVill a guidance note was developed that should help to efficiently collect data relevant for the dimensioning of CHP and heat-only plants. Only optimization of the energy system according to accurate heat demand figures will ensure both, cost efficiency and economic efficiency. A template on basis of Excel for data capture and a guidance note serves as a starting-point for further dimensioning and economic assessment aspects. Furthermore, data collection for a fuel-switch at existing fossil fuelled district heating plants is provided. Please note that the guidance note and Excel file for the heat demand survey aim at providing basic guidance regarding pre-planning of bioenergy systems and delivers information for a stakeholder participation process.

Information about single objects or objects connected to a heating grid must be listed separately in the columns of this Excel file. There is however a differentiation regarding the data scope for different types of objects. Small heat consumers (e.g. single family houses or semi-detached houses) and typical residential buildings require lowest data details. The larger the heat consumption of an object connected is, the more accurate and comprehensive data should be collected.

The BioVill project provides Excel tools for assessing the economic profitability are described in chapter 2.8.

All these tools use the results of a bottom-up heat demand survey for dimensioning of the bioenergy plant. The heat demand survey guide and the heat demand survey Excel tool are provided within the BioVill project.

Please consider:
Poor heat demand surveys may lead to over-dimensioned heating grids (i.e. > 50% of total investment of a biomass district heating plant) and biomass boilers of a bioenergy plant, which in turn leads to unnecessary high investment costs and high energy conversion, heat distribution losses and emissions.

2.5 Applicable technologies and assessment of the technical feasibility

Utilization of bioenergy is a rather complex field of activity compared to fossil counterparts. Fossil fuels are much easier to harvest at large scale and have a higher energy density than biomass feedstock. It took nature millions of years to converse biomass to coal, crude oil or natural gas. With biomass to bioenergy the conversion process is run through by mankind in a real time circular economy.

Since BioVill focuses on bioenergy technologies, we only present these contents. However, we want to stress that the huge field of ECMs for reducing the energy demand in the buildings and other technologies using renewables (solar, wind, ambient heat, hydro power, etc.) that are applied in bioenergy villages as well.

2.5.1 Applicable technologies

2.5.1.1 Biomass feedstock / final bioenergy carrier supply

As there is a lot of literature about cultivating and harvesting of biomass feedstock, these processes are not described here again. The same applies to biomass feedstock logistics and conversion of feedstock into usable, final bioenergy carriers. In chapter 1.2 an overview of biomass sources and possible biomass to energy conversion pathways was given.
If demand for final bioenergy carriers is created by sufficient investment security (e.g. by establishing a level playing field) the relevant companies themselves usually develop the ability to deliver the amounts required. Nevertheless, the market needs reliable and stable framework conditions also for non-economic aspects (fuel quality norms, rules for technical implementation of biomass equipment, etc.).

Selected literature:
http://www.biomasstradecentreii.eu/data/upload/D5_5_Biomass_supply_chains_eubionet_1_(1).pdf

2.5.1.2 Biomass energy conservation equipment

If bioenergy utilization starts from scratch, the establishment of a critical mass of demand for a certain biomass sources can be a hurdle. An investment into a new wood chipper requires a certain amount of over-regional low-quality wood that can be chipped and marketed as wood-chips. If a critical mass is surpassed by early market movers, increased competition can make the supply of final bioenergy carriers more competitive. The same applies to equipment suppliers and their local R&M services.

As with log woods, pellets supply usually is no problem anymore, at all. Pellet bags for ovens (typically 15 kg bags) often are available at local construction markets. Loose pellets, alternatively to silo trucks, can be transported by semi-trailers, allowing international long-distance transports from sources where pellets are cheap.

Nowadays there is a large variety of biomass energy conversion equipment available on the market. Important aspects are high energy efficiency and low emissions at all possible load operation levels and high availability and reliability over a long technical service life (> 20 years).

Please consider:
For biomass heat-only equipment there is a general rule, that cheap low-quality biomass fuels require more complex and robust, i.e. more expensive, conversion equipment. A wood-chip fuel with humidity above 45% needs a furnace unit with refractory concrete (fireclay) structures to evaporate the high-water amount incoming constantly, for example. On the other hand, equipment for higher priced fuels of high and constant quality (e.g. pellets) can be designed to allow much lower specific investment (EUR/kW nominal load). If an investor decides for low specific investment equipment and wants to utilize low quality biomass fuels, this may incur serious energy efficiency and operational problems. Appropriate planning is crucial.
The type of biomass fuel to be utilized determines the whole logistic chain, including fuel storage and ash disposal. It is recommended to consult not only an engineering office during planning phase but also the equipment and fuel suppliers. Fuel suppliers have specific requirements regarding fuel (and ash) logistics. If these requirements are not considered during planning and construction phase, fuel delivery can become severely more expensive. The biomass volume per delivery can massively drop due to wrong street load capacities or radiuses, or too low space (free height) for dumping. A pillar on a wrong place in a fuel storage room can result in an ineffective system for fuel delivery to the boiler.

2.5.1.3 Main components of a biomass heating plant

Local energy conversion pathways that potentially allow (a switch for) utilization of bioenergy carriers are:

- de-centralized, in-house space and domestic hot water heating systems for a wide range of residential, agricultural, public and private service as well as commercial/industrial buildings (e.g. switch for log wood, wood-chips, pellet boilers); ovens might be the simplest systems
- centralized biomass district or micro-grid heating systems supplying heat for space heating and domestic hot water preparation and for low temperature process heat (< 130 °C) via hot water pipes;
  - plants with smaller heating grids mostly provide heat-only (based on wood-chips or pellet boilers)
  - plants with larger heating grids can utilize (combined power and) heat conversion (CHP) systems (burning solid biomass or biogas)
- industrial in-house biomass applications can be either heat-only systems covering all types of heat demand (including steam) or CHP systems; the latter are often operated in a heat demand driven mode; where possible excess or waste heat can be supplied as district heat to third parties.

The following list shows the main components of a biomass heating plant:

- Biomass storage and boiler house
- Feeding system, biomass furnace and boiler (hot water, steam, thermal oil)
- Stack, flue gas piping and flue gas cleaning system (depending on emission laws)
- Heat recovery system (optional)
- Hydraulic installations (optional including hot water buffer storage)
- Electrical installation of all components of the boiler
- Main control system (load management), visualisation (> 500 kW)
- District heating network with hot water pipes and consumer heat exchangers
- Ash manipulating system

The following pictures document examples of a biomass storage and boiler house, feeding system, biomass furnace and boiler:

Picture 4: Small biomass plant with fuel bunker discharge (room holding) and furnace with integrated boiler (Source: Dietmar Hagauer, Austrian Energy Agency).
Picture 5: Larger biomass district heating grid plant with a boiler house with separated furnace and boiler
(Source: Dietmar Hagauer, Austrian Energy Agency)

Picture 6: Hydraulic installations (with redundant grid pumps, optional including hot water buffer storage)
(Source: Dietmar Hagauer, Austrian Energy Agency)

Picture 7: Electrical installations
(Source: Dietmar Hagauer, Austrian Energy Agency)
2.5.1.4 Bioenergy conversion technologies for non-industrial end users

The following list shows the most common bioenergy conversion systems applicable for individual end users. Individual bioenergy conversion systems mostly deliver heat by radiation or hot water. Only in few cases, power and heat are supplied.

- Biomass (log wood, pellets, briquettes) ovens or tiled stoves
- Small scale biomass boilers (log wood, pellets, wood-chips) for buildings with a central heating system (with hot water pipes and radiators or floor/wall heating)
- Medium scale biomass boilers (wood-chips or pellet)
- Occasionally (depending on subsidies): biomass micro CHP plants (wood-chips or pellet based Stirling engines, or wood-gasification plants applying a gas engine or a gas turbine)

Biomass tiled stoves and ovens typically are able to provide space heat for rooms of 20 to 80 m².
**Small scale biomass boilers**

They typically have a nominal heat output of 10 to 100 kW.

**Medium scale biomass boilers**

These boilers typically have a nominal heat output of 100 to 5,000 kW.
**Biomass micro CHP plants**

This technique typically has a nominal power of 3 kW<sub>el</sub> to 100 kW<sub>el</sub>.

![Biomass micro CHP plants](image13.png)

*Picture 13: Examples of 30 kW<sub>el</sub> and 45 kW<sub>el</sub> biomass micro CHP (Source: Spanner Re² GmbH)*

### 2.5.1.5 Bioenergy conversion technologies for centralized and industrial in-house plants

**Medium scale biomass boilers**

In central heating stations and industrial complexes, the above mentioned medium scale biomass boilers can be applied, too.

![Medium scale biomass boilers](image14.png)

*Picture 14: Examples of medium scale biomass boilers in industrial area (Source: Thomas Eggler, Biomasseheizwerk Zürs GmbH)*

![Biomass district heating plant](image15.png)

*Picture 15: Biomass district heating plant in Zürs, Austria (Source: Thomas Eggler, Biomasseheizwerk Zürs GmbH)*
**Biomass CHP plants**

Bigger CHP plants often use steam turbines on basis of wood-chips or pellets.

![Industrial process heat and power production](image1)

![Boilers and Steam Turbine](image2)

![Integrated Pellet Production](image3)

**Wood-gasification plants based on wood-chips**

Another way to generate renewable heat and power is the deployment of a gas engine or a gas turbine.

![CHP (2x 120 kW_{el}, 580 kW_{th})](image4)

(Source: Dietmar Hagauer, Austrian Energy Agency)

Picture 16: Storages and steam turbines in industrial areas
(Source: Dietmar Hagauer, Austrian Energy Agency)

Picture 17: CHP (2x 120 kW_{el}, 580 kW_{th})
(Source: Fernwärme GmbH Neumarkt)
2.5.2 Development and assessment of bioenergy plants

2.5.2.1 Checklists for the development of technology and infrastructure concepts

There is a lot of literature and best practice guidelines about developing bioenergy projects and the infrastructure required along the value chain. The following table shows a rough, overall checklist for the development of locally adapted technology and infrastructure concepts for heat supply and combined heat and power (CHP) supply, based on bioenergy and the interactions with the economic assessment.

<table>
<thead>
<tr>
<th>Technical criteria</th>
<th>Economic criteria</th>
<th>Other criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local conditions</td>
<td>Capital demand &amp; subsidies</td>
<td>Organization and structure</td>
</tr>
<tr>
<td>Site, development, traffic connection, Load demand (peak, winter, summer), heat demand, grid connection, heat temperature level etc.</td>
<td>Investment, machines and plant equipment, process and control technic, buildings, planning</td>
<td>Project partners for erection, for operational phase, ownership structures, responsibilities, legal aspects etc.</td>
</tr>
<tr>
<td>Supplied objects, new /existing etc.</td>
<td>Financing (Equity, Loan, Leasing, Contracting etc.)</td>
<td></td>
</tr>
<tr>
<td>Fuel &amp; fuel supply</td>
<td>Capital and running cost</td>
<td>Authorities</td>
</tr>
<tr>
<td>Which biomass, required/available quantity, characteristics and quality, supply type and intervals, storage, fuel preparation, transport</td>
<td>Redemption, interest, repair and maintenance, insurance, Personnel, fuel, other running cost</td>
<td>Verification of authorization requirements, building and water permits, emissions etc.</td>
</tr>
<tr>
<td>Technology concept &amp; construction aspects</td>
<td>Economics</td>
<td>Acceptance</td>
</tr>
<tr>
<td>Base/Peak/reserve load, existing equipment, required availability, flue gas cleaning, heat distribution, electric installations, control equipment etc.</td>
<td>Variants: energy carriers, concept, revenues etc.</td>
<td>Internal, external</td>
</tr>
<tr>
<td>Buildings, outdoor facilities</td>
<td>Risk assessment, future developments</td>
<td>Overall assessment, Investment decision</td>
</tr>
</tbody>
</table>

Table 2: Technical, economic and other criteria for the selection of technical equipment
(Source: Siegfried Aigner, klimaaktiv qm heizwerke)

Under the following text headers some relevant aspects mentioned above are highlighted in more detail. Focus is on biomass heat only plants as these bioenergy plants have the highest potential to substitute fossil fuels in the heat markets and suit best to (space) heat demand patterns.

Please consider:
Combined heat and power biomass plants run cost and energy efficient only, if base load heat (> 6,000 h/a) is needed. Such conditions are given mainly in industry only (process heat). Furthermore, due to low electricity prices biomass CHP currently is not competitive, without high subsidies per kWhel. In general heat only plants require much less financial incentives related to equal heat output (lower greenhouse gas mitigation cost). Electricity from wind and photovoltaic is produced with less subsidy requirements than from biomass.

2.5.2.2 Assessment of technical feasibility

The following paragraphs describe the basic criteria for the assessment of the economic and technical feasibility of bioenergy village concepts under specific local conditions. Kindly consider the different phases of a bioenergy project presented in chapter 2.1. At the beginning, when a biomass project is taken under consideration, some basic parameters of the potential biomass project shall be outlined that are relevant for a stop or go decision in the early phase of the project.

The following table gives an overview of the information to be collected in the initial phase of project idea/sketch.
Project outline; parameters required

- Plant site
- Data of energy consumers, especially heat demand
- Biomass demand
- Average annual supply distance
- Time course of supply
- Fuel characteristics
- Modus of fuel supply
- Type of long-term storage
- Fuel preparation required
- Number, type and capacity of conversion units for heat, cold and electricity production
- Type of combustion technic
- Type of power production technic
- Type of flue gas cleaning technic
- Dimensioning data and operation parameters
- Parameters of essential equipment
- Area requirement
- Construction volume
- Length and pipe diameters of grid trass
- Number of heat exchange stations

The planned project is to be stopped in that initial phase in case of:

- insufficient biomass supply (quality and quantity)
- unrealizable/unacceptable authorization requirements
- insufficient area or space availability
- insufficient financial viability
- no person in charge of project lead or investor available
- insufficient nearby heat demand in relation to grid length (or period of sufficient heat demand increase to long, respectively)
- insufficient acceptance of neighbours, required adaptations to costly

Please consider:
The initial project phase is also crucial as the level of energy generation cost is determined mainly in the planning phase, already. Professional planning and implementation decides about success or failure.
Acceptance of residents

A project realization without sufficient acceptance may lead to high additional cost after start of operation and can cause close down or another siting of the project. Especially bioenergy plants nearby or inside of residential buildings have to take care of sufficient information of residents and have to avoid often replicated planning failures, leading to loss of acceptance.

The siting of the project is the most crucial aspect, here. Projects inside of buildings of potential heat consumers are the most difficult ones to realize. Planning and implementation in any case must avoid problems like:

- noise (i.e. acoustic decoupling of all plant components connected to concrete, e.g. by plastics; no cheap equipment that emits noise despite acoustic decoupling by itself)
- fuel delivery traffic (i.e. sufficient fuel storage capacity and taking care of delivery times)
- dust (fuel delivery and storage not in the area where dust may be of harm)
- flue gas and water clouds must not disturb people in case of windy or inversion weather conditions (i.e. high enough flue gas stacks, down-wind-side situation of chimneys, no chimneys nearby balconies or terraces)

If these potential problems are already considered in the planning phase, the acceptance of the residents can increase as well.

Delivery and storage of biomass fuels

In case of delivery of loose wood pellets, a pellet truck should be able to fill the storage facility from a distance of maximal 30 meters to a house. Distances of 50 m are also possible but the fine particle matter in the pellets will increase due to the longer duration of abrasive pumping (with 70 km/h). It must be made sure that within the storage, opposite to the inlet connecting flange, is a rubber lining clad for protection of the wall. Connecting flange and suction flange must be clearly different. In Austria, the covers of the flanges at pellet storages < 30 tons must allow some air circulation in the pellet storage room to avoid problems with CO. Storages > 30 tons must have air ventilation. Warm, fresh pellet can emit CO that is why pellet delivered must not be warmer than 40°C. Fine particles must be below 1 mass %. Flow pipes must not have knees, which cause high abrasion and temperature rise. Fine wood particles (must stay below 2 mass % in the storage). As fine wood particles, particles of concrete from the wall can cause malfunction of the pellet plant. Before pellet delivery, the pellet boiler must be out of operation and cooled down. The pellet storage room itself must be constructed in line with national building codes, fire protection rules and standards (in Austria ÖNORM M 7137). It must be kept free from humidity and water. Small household pellet boilers normally have a storage facility with a capacity corresponding to the annual pellet demand (in Austria about 6 to/a).

Larger, commercial pellets storages must be constructed in line with Directive 99/92/EC (ISO 238, WG7 is in progress). Larger (also intermediate) pellet storages > 100 to capacity must fulfil the VEXAT explosion pro-
tection rules. Cleaning of pellet rooms must be performed always by suction technic, not by blowing, because of hazardous fine particle dust.

As with wood pellets also wood chip trucks need access to unload their fuels. Streets must allow 4 m of height and 3 m in width, a weight of at least 22 t to and a turning radius of 10 m (with 80 m³ capacity 20 m radius). If wood-chips are to be tipped off a free space of 3 m back from the pivot point and 6 m in height is required near the unloading point. Larger pellets or wood-chips storage facilities should have a storage that bridges at least Christmas holidays, i.e. the volume should cover at least 10 days of full-load capacity. As the storage cannot be filled by 100% (remaining free space) the storage must have a corresponding larger volume.

Example - Needed space to store biomass fuel (biomass boiler with 100 kW of nominal load for space and domestic hot water heating)\(^5\):

- Wood-chips (Austrian climate/building quality conditions): 60 m³/a store volume for 10 days of full-load operation (16 h/day), 250 m³/a wood-chips demand, fuel storage for one year 370 m³
- Wood-Pellets (Austrian climate/building quality conditions): 12 m³/a store volume for 10 days of full-load operation (16 h/day), 67 m³/a pellets demand, fuel storage for one year 90 m³.

### Takeover and settlement of biomass fuels

Pellets are a standardized product (ISO 17225-2). Household pellet boilers normally use pellets of the quality class A1, A2 and B quality class pellets can be used in larger (commercial) boilers. If “En Plus” certified pellets are sold, the consumer can be sure that the trader ensures that the pellets delivered are in line with the ISO 17225-2 standard and that this quality is tracked and guaranteed from production to the point of delivery. If the consumer sees that the pellets do not fulfil the ISO standard (e.g. > 2 mass-% fine particles in the storage) the trader must take them back on his cost. Pellet trucks have an integrated, gauged on-board weighing system. As pellets, because of standardisation, have a uniform humidity of 8% and a lower calorific value of 4.8 MWh/to fresh material, pricing is quite transparent. The consumer can easily calculate the price of the fuel per MWh.

Wood-chips do not have as harmonized characteristics, as pellets. Nevertheless, they are standardized (by ISO 17225-1) in different wood-chip classes according to the fractions of the trees they consist of (trunk material only or fractions of lower quality) and according to its particle size and humidity. As with pellets, different particle size classes are allowed to have a limited fraction of fines only. The general rule is that very cheap, low quality biomass fuels require more expensive combustion units. Vice versa high quality biomass fuels, with high energy density (wood can never have more than 5.3 MWh per absolute dry ton or mass) enable cheaper combustion technologies. That means that running a cheap boiler with low quality biomass fuels may cause malfunctions and low burning efficiency. Combustion chambers suitable for wet wood-chips (fresh wood can have up to 60% water content) need a lining of refractory bricks to work efficiently. This and other features of low quality burning combustion units (e.g. to cope with earth and stones, a high content of fines etc.) causes additional cost.

Where possible, wood-chips shall be traded per to absolute dry matter, i.e. in atro tons. In agricultural regions with grain production, weighbridges normally are within reachable distances. The wood-chip truck goes there empty and loaded to measure the wood-chip mass delivered. When humidity is measured (e.g. by quick measurement equipment or by a kiln) the atro tons are known. When the share of different wood species in the truck load is known the lower calorific energy content of the load can be calculated. A corresponding calculation tool can be downloaded at [www.bioenergy4business.eu](http://www.bioenergy4business.eu) (Services/Wood parameters calculation tool).

Trading by the tree parameters volume, wood species and humidity at larger plants should be done only, when no weighbridge is within reasonable distance, as volume can be too vague. Volume may shrink when hauled by compacting bumps and a truck load can have different particle sizes at different areas of the load. There are standards available how to assess humidity, particle size and fuel quality of a truck load of wood chips that should be applied in that (and any) case. Trading per volume of loose material, without measuring humidity can cause a rapid bankruptcy of a bioenergy plant. For larger (non-household) bioenergy plants a fuel deliver contract is recommended in any case (see chapter 3).

Regarding humidity one should be aware that an 8% higher humidity causes 1% less annual energy conversion efficiency. In case of no flue gas condensation unit (and a corresponding low temperature heat demand)

---

\(^5\) Calculations of Austrian Energy Agency, Residential space and domestic hot water heating with a 100 kW biomass boiler, for Austrian Climate Conditions.
this aspect should also be reflected in the fuel delivery contract. Often price reduction tables take account for efficiency losses due to higher humidity.

**Conceptualizing a bioenergy plant – technology choice and dimensioning**

As mentioned above available fuel quality and quantity, available area and space determine the size of the plant and the technology choice. Criteria that determine the plant concept are:

- Heating period operation or operation including summer
- Heat demand survey, including load patterns and base load characteristic of heat demand
- Number of achievable full-load operating hours, load management (boiler dimensioning)
- Required reliability of heat supply (back-up and reserve capacities)
- Expansion steps
- Fuel prices
- Investment and running cost

It is very crucial to perform a comprehensive and sound heat demand survey in the area of the potential bioenergy plant. Qualities and (base and peak loads or better load duration curves) and quantities of the heat demand (for space, process heat and domestic hot water preparation) of every (especially larger) heat consumer must be collected.

Future heat demand changes (due to energy efficiency measures, activity expansions or settlement development) must be taken into consideration in the plant concept. Economic stop or go benchmarks regarding connection of additional heat consumers to a heating grid (e.g. minimum number of kWh sold per annum per meter of grid trass) shall be applied. Within BioVill a corresponding heat demand survey data collection sheet and guidance was developed and used by the partners for pre-feasibility level.

Crucial aspects of the technical planning are dimensioning of plant equipment and how the required heat load is covered by different boiler units (load management). Especially with biomass district heating plants over-dimensioning of biomass boilers is a widespread error. These aspects are described in the manual of the "Bioenergy4Business BioHeat Profitability assessment" tool, which is part of the tool itself. The tool can be used to techno-economically assess biomass micro and district heating plants as well as in-house boiler biomass plants.

The maximum thermal power demand in a district heating system is much lower than the sum of the individual actual heat load demands of its heat customers. This effect is known as “simultaneity factor” and is caused by the temporal spreading of the customer's individual heat demand. A district heating plant with 100 households connected typically needs to cover only 60% of the accumulated actual heat loads of the households. If hot water buffer storages are implemented in the plant (for covering morning or evening peak loads) the total boiler capacity of the heating plant can be reduced further.

Load management means, that the biomass boiler is not dimensioned to cover the maximum heat load of the whole heating plant. In larger biomass heating plants a base load and a medium load boiler are installed, which together cover about 60% of the maximum heat load of the whole plant. This is because maximum heat load is needed only for several days in a year and is covered by a fossil fuelled reserve or back-up boiler normally. For peak load normally natural gas is utilized, if not available fuel oil. The main reason for covering peak load by fossil fuelled boilers is minimization of heat generation costs (see next figure).
The result of load management (minimization of heat generation cost) is that only several % of total annual heat amount delivered (< 10%, often only some % points) are supplied by fossil energy carriers.

The following two graphs show a representative seasonal run of the thermal load to be delivered by a biomass plant in the form of an annual load duration curve. It can be seen that the biomass boilers cover about 60% of the maximum heat load of the plant.

One reason for having two biomass boilers instead of one, see graph below, is that biomass boilers should not operate below 30% of its installed nominal load. Otherwise this could lead to poor boiler efficiency and higher emissions. Another reason is to have as much full-load operation hours as possible for both biomass boilers, i.e. to reduce capital-related cost per kWh heat output and to increase boiler efficiency because of lower part load operation. A second biomass boiler also increases security of heat supply.
For larger plants additionally a flue gas condensing unit (an economizer) can be economical, which requires a correspondent low temperature heat demand, however. In the graph above an economizer is taken into account.

The following table shows recommendations for the configuration of smaller biomass plants with a maximum head load of 0.5 to 1 MW. The higher the heat demand, the rather a more sophisticated boiler configuration can become economic or is advisable, respectively.

<table>
<thead>
<tr>
<th>Requirement regarding</th>
<th>Option A</th>
<th>Option B</th>
<th>Option C</th>
<th>Option D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 biomass boilers, no heat storage</td>
<td>2 biomass boilers, incl. heat storage</td>
<td>1 biomass boiler, 1 oil/gas boiler, no heat storage</td>
<td>1 biomass boiler, 1 oil/gas boiler, incl. heat storage</td>
</tr>
<tr>
<td>Fuel assortment</td>
<td>Particle size up to P45, humidity &lt; 50% at low heat load operation</td>
<td>Particle size up to P45, humidity &lt; 50% at low heat load operation</td>
<td>No limitation</td>
<td>No limitation</td>
</tr>
<tr>
<td>Additional equipment</td>
<td>Automatic ignition for small boiler</td>
<td>Automatic ignition for small boiler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation modus</td>
<td>Summer operation possible</td>
<td>Summer operation possible</td>
<td>Summer operation possible</td>
<td>Summer operation possible</td>
</tr>
<tr>
<td>Full-load-hours biomass boiler(s)</td>
<td>&gt; 1,500 h/a</td>
<td>&gt; 1,500 h/a</td>
<td>&gt; 2,500 h/a</td>
<td>Target 4,000 h/a</td>
</tr>
<tr>
<td>Heating grid expansion</td>
<td>In stages not possible</td>
<td>Step by step possible</td>
<td>Step by step possible</td>
<td>Step by step possible</td>
</tr>
</tbody>
</table>

For multi-boiler plants: Peak-load coverage normally with cheap plant technology (fossil fuelled mostly). Peak-load coverage with biomass boiler at low biomass prices and proved economic feasibility only.

Table 3: Recommendations for the configuration of smaller biomass plants (Aigner)
Technology choice – interaction between fuel quality and height of installation systems’ investment

From an overall perspective planning, investment, operating and fuel costs should be sound. As mentioned above two approaches are possible in general and one shall be chosen during planning phase.

<table>
<thead>
<tr>
<th>Installation of (a) biomass boiler(s) which accept(s) a wide range of fuel quality and humidity</th>
<th>Installation of (a) biomass boiler(s) which accept(s) a high fuel quality (with low humidity) only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel supply Installation:</td>
<td>Fuel supply installation:</td>
</tr>
<tr>
<td>Large biomass fuel bunker with push floor delivery</td>
<td>Automated fuel bunker discharge (room holding), Smaller bunker volumes</td>
</tr>
<tr>
<td>Fuel tipping possible, no additional fuel manipulation</td>
<td></td>
</tr>
<tr>
<td>General characteristics</td>
<td>General characteristics</td>
</tr>
<tr>
<td>- Cheap biomass acceptable</td>
<td>- High quality biomass acceptable only</td>
</tr>
<tr>
<td>- Higher installations’ investment</td>
<td>- Lower installations’ investment</td>
</tr>
<tr>
<td>- High demand-related costs due to high ash content</td>
<td>- Higher operation-related costs due to lower equipment quality</td>
</tr>
<tr>
<td>Failure to be avoided</td>
<td>Failure to be avoided</td>
</tr>
<tr>
<td>No screws for combustion chamber delivery – avoid such a bottleneck in fuel delivery; otherwise higher, more expensive fuel qualities are acceptable only</td>
<td>Bottlenecks in fuel delivery (see above)</td>
</tr>
</tbody>
</table>

Table 4: Approaches for the selection of biomass boilers (Aigner).

All the above mentioned data are used in technical model calculations that are carried out by using the calculation tools (see chapter Error! Reference source not found.) that cover both technical and economic calculation. The technical data are the basis of the economic results. Depending on the chosen technical system and the extent of the measures, different tools are available.

In the following, examples for the technical calculation are described for two different grids. Version 1 shows a grid where 400 consumers are connected while version 2 is smaller and provides heat for 40 people.

Version 1: Large biomass heating system

![Biomass Heating System Table]

---

**Biomass Heating System**

- **Parameter**
- **Unit**
- **Input Value**

**Annual Heat Demand**

- District heating projects: MWh/a
- Total consumer nominal connection capacity: MW
- Number of connected consumers: 
- Simultaneity factor of the heating plant: %

**Heat Grid Expansion plan**

- Grid Trass/Trench length incl. trusses to households (at 100% grid expansion): m
- Grid Expansion Year 1 (start of operation): %
- Grid Expansion Year 2: %
- Grid Expansion Year 3: %
- Grid Expansion after Year 3: 100%

**Grid related Heat Losses**

- Old (existing), new or no district heating grid % 20.00%
- New Heating Grid %

**Biomass Heating System**

- Total nominal capacity of the heating plant (max. peak load to be covered): MW

**Biomass Boiler(s)**

- 1. Biomass boiler nominal heat generation capacity: MW
- 2. Biomass boiler nominal capacity (if applicable): MW
- 3. Biomass boiler nominal capacity (if applicable): MW
- Total nominal biomass boiler capacity: MW
- Average annual energy use efficiency biomass boiler(s): %
## Fossil fuelled Stand-by / Peak Load Boiler

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuelled Stand-by/Peak Load boiler, nominal capacity (if applicable)</td>
<td>MW</td>
<td>3.30</td>
</tr>
<tr>
<td>Actually installed total thermal capacity of the heating plant (must be ( \geq ) cell value 2034)</td>
<td>MW</td>
<td>5.50</td>
</tr>
<tr>
<td>Old (existing) or new fossil fuel boiler (if applicable)</td>
<td></td>
<td>New</td>
</tr>
<tr>
<td>Average annual energy use efficiency Fossil fuel Boiler (if applicable)</td>
<td>%</td>
<td>88.0%</td>
</tr>
<tr>
<td>Heat fraction generated with fossil fuels</td>
<td>%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Heat fraction generated with Biomass</td>
<td>%</td>
<td>91.0%</td>
</tr>
</tbody>
</table>

## Biomass Fuel Storage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilizable fuel storage room (equivalent to x days of full load operation at 16 h/d)</td>
<td>d</td>
<td>7.0</td>
</tr>
<tr>
<td>Fuel Storage Size (including un-utilizable room)</td>
<td>m³</td>
<td>602</td>
</tr>
<tr>
<td>Utilizable fuel storage room in comparison to the annual biomass consumption</td>
<td></td>
<td>2.3%</td>
</tr>
</tbody>
</table>

## Electricity Consumption

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Electricity Consumption heat grid</td>
<td>kWh/a/MWhheated</td>
<td>6.00</td>
</tr>
<tr>
<td>Specific electricity consumption biomass boiler(s)</td>
<td>kWh/a/MWhheated</td>
<td>11.00</td>
</tr>
<tr>
<td>Specific electricity consumption fossil fuel boiler</td>
<td>kWh/a/MWhheated</td>
<td>4.00</td>
</tr>
</tbody>
</table>

## Calculated energy flow Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal energy delivered/sold to end consumers</td>
<td>MWhheated/a</td>
<td>9,500.0</td>
</tr>
<tr>
<td>Total heat produced by plant (injected into the heat grid)</td>
<td>MWhheated/a</td>
<td>11,075.0</td>
</tr>
<tr>
<td>Fuel Heat Input Biomass (net calorific value, NCV)</td>
<td>MWhheated/a</td>
<td>12,713.2</td>
</tr>
<tr>
<td>Fuel Heat Input Fossil fuel (NCV)</td>
<td>MWhheated/a</td>
<td>1,214.3</td>
</tr>
<tr>
<td>Total fuel heat input (NCV)</td>
<td>MWhheated/a</td>
<td>13,927.7</td>
</tr>
</tbody>
</table>

### Electricity:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MWhheated/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Electricity Consumption heat grid (100% heat delivery)</td>
<td>71.3</td>
</tr>
<tr>
<td>Annual Electricity Consumption biomass boiler</td>
<td>116.9</td>
</tr>
<tr>
<td>Annual Electricity Consumption fossil fuel boiler</td>
<td>4.3</td>
</tr>
<tr>
<td>Annual Electricity Consumption plant (100% heat delivery)</td>
<td>194.4</td>
</tr>
</tbody>
</table>

## Performance benchmarks of the biomass heating plant

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>MWhheated/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network heat utilization ratio</td>
<td>1.338</td>
</tr>
<tr>
<td>Network utilization ratio</td>
<td>kW/m</td>
</tr>
<tr>
<td>Average annual full-load operating hours of installed biomass boilers</td>
<td>4.912</td>
</tr>
<tr>
<td>Average annual full-load operating hours of connected consumers</td>
<td>4.912</td>
</tr>
<tr>
<td>Annual energy use efficiency of the biomass boilers</td>
<td>%</td>
</tr>
<tr>
<td>Annual energy use efficiency of the heating grid</td>
<td>%</td>
</tr>
<tr>
<td>Annual energy use efficiency of the plant</td>
<td>%</td>
</tr>
</tbody>
</table>

## Fossil Fuelled Reference System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal heat capacity fossil fuelled boiler 1</td>
<td>MW</td>
<td>2.50</td>
</tr>
<tr>
<td>Nominal heat capacity fossil fuelled boiler 2</td>
<td>MW</td>
<td>2.50</td>
</tr>
<tr>
<td>Nominal heat capacity fossil fuelled boiler 3</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>Fossil fuelled boilers' total installed nominal heat capacity</td>
<td>MW</td>
<td>5.00</td>
</tr>
<tr>
<td>Specific Electricity consumption fossil fuel boiler(s)</td>
<td>kWh/a/MWhheated</td>
<td>4.00</td>
</tr>
<tr>
<td>Average annual energy use efficiency of fossil boilers</td>
<td>%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Total Fuel Heat Input (net calorific value)</td>
<td>MWhheated/a</td>
<td>12,194</td>
</tr>
</tbody>
</table>
Version 2: Small biomass heating system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Heat Demand</td>
<td>MWh/a</td>
<td>950</td>
</tr>
<tr>
<td>Total consumer nominal connection capacity</td>
<td>MW</td>
<td>0.55</td>
</tr>
<tr>
<td>Number of connected consumers</td>
<td>#</td>
<td>40</td>
</tr>
<tr>
<td>Simultaneity factor of the heating plant</td>
<td>%</td>
<td>80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat Grid Expansion plan</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Tras/Trench length incl. trusses to households (at 100% grid expansion)</td>
<td>m</td>
<td>800</td>
</tr>
<tr>
<td>Grid Expansion Year 1 (start of operation)</td>
<td>%</td>
<td>50%</td>
</tr>
<tr>
<td>Grid Expansion Year 2</td>
<td>%</td>
<td>75%</td>
</tr>
<tr>
<td>Grid Expansion Year 3</td>
<td>%</td>
<td>100%</td>
</tr>
<tr>
<td>Grid Expansion after Year 3: 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grid related Heat Losses</th>
<th>New Heating Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old (existing), new or no district heating grid</td>
<td></td>
</tr>
<tr>
<td>Heat grid consumer structure (Category A, B or C - See Manual)</td>
<td>A</td>
</tr>
<tr>
<td>Grid related Heat Losses</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biomass Heating System</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total nominal capacity of the heating plant (max. peak load to be covered)</td>
<td>MW</td>
<td>0.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biomass Boiler(s)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Biomass boiler nominal heat generation capacity</td>
<td>MW</td>
<td>0.25</td>
</tr>
<tr>
<td>2. Biomass boiler nominal capacity (if applicable)</td>
<td>MW</td>
<td>0.15</td>
</tr>
<tr>
<td>3. Biomass boiler nominal capacity (if applicable)</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>Total nominal biomass boiler capacity</td>
<td>MW</td>
<td>0.40</td>
</tr>
<tr>
<td>Average annual energy use efficiency biomass boiler(s)</td>
<td>%</td>
<td>85,0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fossil fuelled Stand-by / Peak Load Boiler</th>
<th>Fossil fuelled stand-by boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuelled Stand-by/Peak Load boiler, nominal capacity (if applicable)</td>
<td>MW</td>
</tr>
<tr>
<td>Actually installed total thermal capacity of the heating plant (must be &gt; = cell value 2004)</td>
<td>MW</td>
</tr>
<tr>
<td>Grid (existing) or new fossil fuel boiler (if applicable)</td>
<td>N/A</td>
</tr>
<tr>
<td>Average annual energy use efficiency Fossil fuel Boiler (if applicable)</td>
<td>%</td>
</tr>
<tr>
<td>Heat fraction generated with fossil fuels</td>
<td>%</td>
</tr>
<tr>
<td>Heat fraction generated with Biomass</td>
<td>%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biomass Fuel Storage</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>h/di</td>
<td>d</td>
<td>7.0</td>
</tr>
<tr>
<td>Fuel Storage Size (including un-utilizable room)</td>
<td>m²</td>
<td>102</td>
</tr>
<tr>
<td>Utilizable fuel storage room in comparison to the annual biomass consumption</td>
<td></td>
<td>4.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electricity Consumption</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific electricity Consumption heat grid</td>
<td>kWh/h/MWhₚₜₚ</td>
<td>6.00</td>
</tr>
<tr>
<td>Specific electricity consumption biomass boiler(s)</td>
<td>kWh/h/MWhₚₜₚ</td>
<td>11.00</td>
</tr>
<tr>
<td>Specific electricity consumption fossil fuel boiler</td>
<td>kWh/h/MWhₚₜₚ</td>
<td>4.00</td>
</tr>
</tbody>
</table>
Other helpful model calculations are provided at the websites that are listed in chapter 5. However, an uniform calculation can’t be realised because the regional and local conditions (energy prices, weather conditions, used fossil fuel, etc.) are very different. Therefore, the Life Cycle Approach (German VDI Guideline 2067) that is described in chapter Error! Reference source not found. should be the basis and adapted to the regional circumstances.

2.5.3 Austrian/German/Swiss good practice - Quality improvement program QM Holzheizwerke®

The Quality Assurance for Wood Combustion Plants named “QM Holzheizwerke®” is a comprehensive and project-oriented quality management system to assure a high technical quality of biomass-based in-house and heating grid based systems leading to sustainable, durable and economic bioheat systems. This quality management system was invented in Switzerland and further developed by a consortium of Austrian experts (now working at) AEE INTEC, German experts from CARMEN and Swiss experts from HSLU, all being experts in the field of biomass (district) heating systems and therewith related issues.

The quality management system “QM Holzheizwerke®” and specially trained quality delegates respectively, accompanies projects from an early planning phase through the whole design and construction process as well as the commissioning and optimization of the plant. Theses project stages are represented by the five Milestones of the quality management system:

- Milestone 1 - preliminary study
  Results: reasonable project model

- Milestone 2 – design engineering
  Results: Detailed planning, grant application data
Milestone 3 – tender procedure  
Results: Fixed project design, service contracts

Milestone 4 – plant construction and acceptance inspection  
Results: Acceptance certificates

Milestone 5 – Monitoring and Optimisation  
Results: Optimised plant and district heating network

"QM Holzheizwerke®" is currently applied in Germany and Switzerland on a voluntary basis. In Austria, the quality management system is an integral part of the Austrian climate protection initiative “klimaaktiv” funded by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, managed by AEE INTEC. Furthermore, it is connected to the Austrian funding scheme for biomass district heating systems and therefore obligatory in order to receive investment subsidies.

Since all relevant data of the Austrian projects accompanied by “QM Holzheizwerke®” are recorded in a central database, a detailed benchmarking and evaluation of the projects is possible. Results thereof show that “QM Holzheizwerke®” leads to a significant improvement of the efficiency and quality of Austrian district heating plants based on RES.

QM Holzheizwerke® offers guidelines and planning handbooks that are in line with the developed quality management principles (see chapter 5).

The European Court of Auditors made an audit of the Austrian funding scheme and found that the quality management system is a “…good practice example…” and that “…a quality management tool for biomass heating plants assured proper monitoring arrangements…” (European Court of Auditors).

2.6 Operational models

Three main categories of operating models are described in this chapter. They take into account that a general model does not exist since all models vary in accordance with the regional circumstances. In concrete projects, the individual operating model should be adjusted to the required needs. They depend on the local possibilities to gain biomass and further renewable energies, the local need for energy (power and heat), the existing infrastructure and the existing experience in operating plants.

2.6.1 Operator Model for citizen cooperative

In this operation model the citizen cooperative finances, implements and operates the renewable power and/or heat station. The renewable energy can be used by the members of the cooperative themselves and from other consumers. Since the electric power surplus can be fed into the power network, the revenues come back to the cooperative.

The decisive advantage of a citizen cooperative is that the concept is developed by the local population and strives for their interests. They can invest in their own project and the profit stays with them. This creates an increased acceptance for the project, fosters the sense of community and establishes identity with the area. In the operation phase the members of the cooperative have to manage the complete operation of the technical devices, repairs and maintenance, measurement and verification, the contracts with the energy users and suppliers, the risk assessment and the quality assurance, the billing and accounting which might be challenging for cooperatives without any experience.
The foundation of a citizen cooperative keeps all the profit in the community which strengthens the local value chain. Since an “informal pressure” is generated through the publicity of the project, involved farmers and people in charge on the project will push it to ensure a satisfying performance. Additionally, the cooperative can be a very successful platform to sensitise their members in terms of an efficient use of energy. Aside from the cooperative model, other legal structures for citizen participation are possible in the operation period as described in chapter 2.7.1.

2.6.2 ESCO-Model

Energy Service Companies (ESCOs) offer customized energy service packages, provide guarantees for all-inclusive costs and results and take over the commercial and technical implementation and operation risks over the whole project period. There are different ways to involve an ESCO. First, the result of the feasibility study and the citizens can be a recommendation to transfer the complete project to an ESCO. Second, the municipality recognises the high potential of the village itself, but cannot initiate or manage the project in the municipality. Then, the municipality will look for a competent third party within a tendering procedure. Thirdly, ESCOs themselves contact municipalities and convince local decision-makers to promote the project carried out by the ESCO. ESCOs have experienced staff or cooperate with sub-contractors who can apply lessons learnt from different energy efficiency and biomass projects. In addition, ESCOs have access to more favourable purchase conditions and cooperate with financing institutions for many years. Managing contracts, accounting the revenues and expenses, ensuring the supply of biomass and fossil fuels, negotiating contracts, expanding the district heating systems including the economic calculation is part of their daily business.
Furthermore, the efficiency of the implemented machinery will probably be better than in the citizen projects. However, as appropriate ESCOs are often not available in rural areas, the generated turnover does not stay within the community. Nevertheless, local companies are sometimes involved in this model, e.g. as biomass suppliers or the HVAC companies which are responsible for services like the implementation or the maintenance of the technical equipment. Having local tradespeople in charge of this also keeps the response times short in case of emergency.

Plus, ESCO also often find additional energy saving potentials during the operation time since they are deeper involved in the project. Considering tapping these additional potentials requires further economic calculation. Further adjustments are necessary in case of building demolitions, changes in the use of the buildings or new legal requirements. ESCO can deal with these challenges in a capable way.

### 2.6.3 Cooperation between a citizen cooperative and an ESCO

Another operator model is a successful cooperation between a citizen cooperative and an experienced ESCO which combines advantages for both parties. The citizen cooperative organizes the financing with citizens funding. Members of the cooperative take over partial tasks within the operation period according to their knowledge and their capacities. Thus, the cooperative earns a share of the profit and can extent the operation experience. The interfaces between both parties differ with the local situations. For instance, the cooperative can manage the heat supply contracts including the billing and accounting. The ESCO implements and optimises the technical plants, whereas the cooperative acts as owner of the plants and pays the ESCO for its services.
The interfaces should be clarified in the contract between the cooperative and the ESCO. Mostly, the cooperative as the owner of the technical plants has to bear all operation-related risks. However, the cooperative can transfer risks, e.g. the default risk, to the ESCO using its experience and knowledge. Though, subsidy regulations or financing contracts might require that a single party is in charge of operation.

The operating models are closely connected with the requirements emerging from the chosen legal entity and the ownership models. Therefore, these issues are explained in the following chapter.

2.7 Legal structures, ownership models and governance rules

2.7.1 Legal structures

According to the national framework conditions, there are different options in regard to the choice of the legal structure of the company that is in charge for the implementation, financing and operation of the bioenergy village. Basically, this is to differentiate between an association with exclusively local stakeholders and the integration of a third party for implementing and operating the installation as described in chapter 4.2.

On the national level, legal regulations relevant to the respective private association forms must be considered. Below are the main legal structures that have been successfully practiced in implemented bioenergy projects in Germany and Austria.
When choosing the structure of the organisation, the liability and other risk factors, the minimum capital, and the decision-making authority must be considered. The possible legal structures can be classified as legal partnerships where mostly individuals agree to cooperate to advance their mutual interests, and as corporations. In some of the bioenergy villages, the legal structure also depends on the operating and ownership model. Hereinafter, the most common legal structures for the citizen ownership model are explained.

The Limited Liable Company (LLC) / LLC & Cooperative Limited Partnership are the most common legal structures for bioenergy villages in Germany (35%). Furthermore, 25% of the bioenergy villages are organized as energy cooperative and 19% as Company Constituted under Civil Law (FNR, 2014-1).

**Limited Liable Companies (LLC)**

The Limited Liable Company is characterized as a separate legal personality. The CEO and the shareholders meeting are the bodies of this form. Other institutions can be involved in this stakeholder meeting, but the number of stakeholders should be limited in order to ensure a constructive decision-making process.

The limited Liable Company & Limited Partnership is a special type of this structure. It’s a combination of the limited partnership and the LLC. In the LLC & Cooperative Limited Partnership, the partner(s) must take the responsibility for liabilities only with their own deposits; therefore, this form is interesting for citizens who wish to participate financially without great risk. The LLC is complementary in this partnership, but the liability is limited to the capital contributions, so that unlimited liability is excluded. Since the full liability is excluded, this may bring disadvantages in the creditworthiness. In addition, the two different groups of shareholders and the obligations of the LLC may be sources of dissent for management. However, this form is very interesting if one already experienced company is incorporated as a limited company and other co-financers are incorporated as limited partners.

**Most important governance rules for Limited Liable Companies:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>EUR 2,670 (HRK 20,000)</td>
<td>Limited partners: liability is limited to the amount of invested capital Complementary: Fully liable (the personal assets of the members are protected)</td>
<td>Voting rights correspond to amount of capital contributed</td>
</tr>
<tr>
<td>Macedonia</td>
<td>EUR 5,003 (MKD 308,000)</td>
<td>liability is limited to the amount of deposit</td>
<td>Voting rights mainly correspond to amount of</td>
</tr>
</tbody>
</table>
BioVill – D5.1 Guideline on business models for bioenergy villages

Energy Cooperative

In an energy cooperative, both private and commercial or municipal actors can contribute with a very manageable financial outlay and be held liable for only their contributions. This legal structure is beneficial for all when a community business is the focus and the cooperative is operated for the members above all else. Nevertheless, equity procurement is limited and banks often evaluate the legal structure of the cooperative as riskier than other types because of the limited liability and the participation rules. However, it is possible that more capital can be raised via the possibility of dividend payment.

Table 5: Specific requirements on Limited Liable Companies & Limited Partnerships in partner countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romania</td>
<td>EUR 44 (RON 200)</td>
<td>Limited only up to the limit of their contributions to the shared capital</td>
<td>Voting rights correspond to the amount of capital contributed</td>
</tr>
<tr>
<td>Serbia</td>
<td>EUR 0.80 (RSD 100)</td>
<td>Liability limited to the amount of deposit and defined by Founding Act</td>
<td>Voting rights correspond to amount of capital contributed and founding act</td>
</tr>
<tr>
<td>Slovenia</td>
<td>7,500 Euro</td>
<td>Limited partners: liability limited to the amount of own property. Complementary: not liable for the obligations of the company.</td>
<td>Voting rights regardless of the amount of capital contributed.</td>
</tr>
</tbody>
</table>

Most important governance rules for energy cooperatives:

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>min. EUR 133 (HRK 1,000) per founder (min. EUR 934 = HRK 7,000 because it has to be min. 7 founders á HRK 1,000)</td>
<td>Liability limited to the amount of invested capital/stake/share</td>
<td>Equal across all members (The cooperative assembly is democratic body and the absolute majority of votes is understood as more than one half of the votes)</td>
</tr>
<tr>
<td>Macedonia</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Romania</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Serbia</td>
<td>EUR 0.80 (RSD100)</td>
<td>Defined by adopted Cooperative Rules</td>
<td>Equal across all members</td>
</tr>
<tr>
<td>Slovenia</td>
<td>None</td>
<td>Liability limited to all its property.</td>
<td>Voting rights equal across all members.</td>
</tr>
</tbody>
</table>

Table 6: Specific requirements on energy cooperatives in partner countries

Stock company

A stock company or corporation is brought together via the equity shareholders. Both local players and foreign buyers can participate with the main advantage being the relative ease in raising capital. Because the distribution of voting rights is based on capital shares in a stock company, this can lead to conflicts, even if the issue of non-freely tradable registered shares can be set in the stock company. In addition, a stock company focuses on a high expected return, which is often contrary to the fundamental goal of a bioenergy village. A corporation’s credit rating may also be limited from the perspective of the banks.

Most important governance rules for stock companies:

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>EUR 26,709.40 (HKR 200,000.00)</td>
<td>Liability in the amount of the shares (The personal assets of the shareholder are protected)</td>
<td>According to the amount of capital contributed</td>
</tr>
<tr>
<td>Macedonia</td>
<td>EUR 5,003 (MKD 308,000)</td>
<td>Only in the amount of the shares</td>
<td>One layer (Board of directors) or two layer decision making process (Management and Executive Board)</td>
</tr>
</tbody>
</table>
The shareholders are only liable towards the creditors to the limit of their contributions to the share capital.

According to the amount of capital contributed

Voting rights equal across members of management or supervisory body.

Table 7: Specific requirements on corporations in partner countries

**Company Constituted Under Civil Law**

This legal structure is only considered for small projects, since the shareholders have unlimited liability for the corporate and private assets. On the other hand, it provides a lot of freedom because few formalities are necessary.

**Most important governance rules for Company Constituted Under Civil Law:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Assembly</td>
</tr>
<tr>
<td>Macedonia</td>
<td>No limit</td>
<td>Liable to the founders of the company based</td>
<td>Based on the Statute of the Company</td>
</tr>
<tr>
<td>Romania</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Association Assembly Executives or defined by Statute of Association</td>
</tr>
<tr>
<td>Serbia</td>
<td>EUR 0</td>
<td>Defined by Statute of Association</td>
<td>Association Assembly Executives or defined by Statute of Association</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Is not determined.</td>
<td>All partners liable for all private assets (without limit and jointly).</td>
<td>Voting rights equal across all members.</td>
</tr>
</tbody>
</table>

Table 8: Specific requirements on a company under civil law in partner countries

**Registered association**

A registered association is legally functioning as a corporate body on the basis of the Civil Code (Germany).

**Most important governance rules for registered associations:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>not needed/required</td>
<td>Liability limited to the amount of property</td>
<td>Assembly</td>
</tr>
<tr>
<td>Macedonia</td>
<td>EUR 0</td>
<td>Liability limited to creation of profits</td>
<td>Executive Director or Executive Board</td>
</tr>
<tr>
<td>Romania</td>
<td>EUR 320 (RON 1,450)</td>
<td>Liability limited to the amount of property</td>
<td>Association Assembly Executives or defined by Statute of Association</td>
</tr>
<tr>
<td>Serbia</td>
<td>RSD 0</td>
<td>Defined by Statute of Association</td>
<td>Association Assembly Executives or defined by Statute of Association</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Administrative fee of 31.72 Euro</td>
<td>Association liable for its obligations with all its assets.</td>
<td>Voting rights equal across all members.</td>
</tr>
</tbody>
</table>

Table 9: Specific requirements on associations in partner countries

**Foundation**

A foundation is considered if there are actors who donate the endowment. The foundation may not use the assets itself, but rather only the income of the assets (e.g. interest) and donations. Therefore, this legal
structure is suitable only when correspondingly high capital is available or can be expected later. The founders firmly decide the foundation’s purpose; it cannot later be revoked or amended.

Most important governance rules for foundations:

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Capital</th>
<th>Liability</th>
<th>Decision-Making Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>not needed/required</td>
<td>...</td>
<td>Board of the foundation is deciding based on the proposals from the Executive Director</td>
</tr>
<tr>
<td>Macedonia</td>
<td>EUR 10,007 (MKD 616,000)</td>
<td>Liability limited to the annual or multiannual programme defined and approved by the Board</td>
<td>Board of Directors</td>
</tr>
<tr>
<td>Romania</td>
<td>100-times the Romanian minimum gross salary EUR 32,017 (100 x EUR 320 (RON 1,450))</td>
<td>Liability limited to the amount of property</td>
<td>Board of Directors</td>
</tr>
<tr>
<td>Serbia</td>
<td>EUR 29,807 (RSD 3,680,000)</td>
<td>Defined by Founding Act</td>
<td>Defined by Founding Act</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Is not determined.</td>
<td>Liable for all initial capital.</td>
<td>The Management Board takes decisions by a majority vote of the members.</td>
</tr>
</tbody>
</table>

Table 10: Legal environment of foundations

2.7.2 Ownership models

All above listed models imply that the legal entities own the technical equipment. That means, the legal entity finances, implements and operates heating centers, district heating systems, solar thermal plants, photovoltaic cells or wind turbines that are their own property and accept all the linked obligations. In particular, if the legal entity supplies heat to the consumers, it is classified as a professional ESCO.

However, if ECMs on the demand side are integrated in the project, using devices that are often not portable, the ownership model can differ. In most of these cases, the energy efficiency measures are carried out from the bioenergy village entity and will be pre-financed and calculated as other investments for the heating system. Then, the base price will cover the ECMs and the property will be transferred to the building owner at the agreed end of the contract.

If a professional ESCO is managing the complete project, it is the exclusive owner of the technical equipment. A transfer of the property is not foreseen in the contracts in comparison to common heat supply contracting.

The shared ownership model can also be a solution pertaining financing, implementing and operating of measures in bioenergy villages. In this model, public or private building owners finance a share of the measures, e.g. the ECM in their buildings. The heat generation measures can be funded and implemented from the local citizens company or the ESCO. Or, these owners deliver an additional payment to the operation company that covers the investment costs of the ECMs. Depending on the agreements with the selected financing institution, the ownership on the implemented devices can be on the building owner or on the operating company.
2.7.3 Governance rules

Besides the typical governance rules for the legal structures, general governance rules should be taken into account from stakeholders in order to implement the bioenergy project successfully. These rules are essential in the preparation process as well as in the operation phase:

<table>
<thead>
<tr>
<th>Governance rules</th>
<th>Preparation process</th>
<th>Operation phase (Contractual regulations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent structures and processes</td>
<td>Open and transparent communication, clear and traceable structures strengthen the trust of the stakeholders in the process and the acceptance of decisions and procedures.</td>
<td>Contracts define project partners, deputy regulations, services of the partners and accounting methods considering the specific objects of the agreement.</td>
</tr>
<tr>
<td>Availability and transfer of all relevant information</td>
<td>Although, bioenergy projects are complex and much information has to be collected and compiled, all relevant facts, arguments, data and experiences should be available for the relevant stakeholders. On the over hand, stakeholders can hardly handle all information that will be provided within the process. Therefore, a well-structured preparation phase, clear interfaces between all stakeholder groups and a professional management are crucial for bioenergy villages.</td>
<td>The contract includes clear regulation about information needed from the partners and the timeframe of delivery.</td>
</tr>
<tr>
<td>Cooperative and faire relationships between stakeholders</td>
<td>Formal and informal decision-makers focus on an open and respectful communication, especially in situations of conflict. The relationships between the stakeholders are set up on jointly-set rules.</td>
<td>Contracts are agreed on the basis of a fair partnership and mutual benefits.</td>
</tr>
<tr>
<td>Clear decision-making procedures and responsibilities of stakeholders</td>
<td>Democratic rules for decision-making are used and votes, e.g. of citizens meetings, are documented thoroughly.</td>
<td>Services of both partners are agreed in the contract as well as accounting rules and further arrangements.</td>
</tr>
<tr>
<td>Adaptability of the process and managing errors</td>
<td>Since the preparation phase varies in its duration between one and three years, many external or internal changes can happen. Stakeholders should be able to adapt their inputs and to be open-minded in the process. If faults are detected, e.g. in the data base or in the calculation, a correction has to be realized.</td>
<td>Algorithm for adaptation of invoices, e.g. in case of changed legal regulations, are foreseen in the contract in order to avoid additional risk for the partners.</td>
</tr>
<tr>
<td>Taking into account local circumstances</td>
<td>Projects cannot be &quot;copied and pasted&quot; since the local environment always differs. Thus, the particular framework conditions are evaluated and appropriate models are derived in each bioenergy village.</td>
<td>All relevant facts such as locations and quality assessment (e.g. in the biomass supply contract) are included in the contract.</td>
</tr>
<tr>
<td>Monitoring, controlling and accountability</td>
<td>Stakeholders agree on a monitoring mechanism regarding the task-fulfillment and clear commitment to rules.</td>
<td>The contract comprises regulations for monitoring (e.g. heat consumption) and timeframes.</td>
</tr>
<tr>
<td>Conflict management</td>
<td>Opposing intentions and interests of the stakeholders might lead to conflicts</td>
<td>Processes of mediation/arbitration and the eligible court are described in the contract.</td>
</tr>
</tbody>
</table>
which should be discussed in an open process and if necessary be solved with external experts.

| Respect of rules and agreed sanctions | Rules for decision-making, discussion, responsibilities and further interpersonal activities are developed in a democratic process. | Regulations, e.g. for the interruption of heat supply, bad biomass quality, are included in detail. |

Within the operation phase, different types of contracts are agreed (see chapter 3). The above mentioned governance rules (Ostrom, 2011) are the basis of all contracts in order to realize the project successfully. These rules can be used as a template in order to check the ongoing processes during the preparation of new bioenergy villages.

2.8 Economic assessment and key performance indicators

2.8.1 General information

- Since bioenergy projects can be considered as community projects that often include neighborhood concepts, the economic assessment of the projects have to capture the complete bundles of measures including all costs and revenues. Taking into account that possible measures in bioenergy villages range from ECMs on the demand side, which can involve single measures and complex building refurbishments, to heating generation measures (mostly on the basis of biomass and power generation measures) with renewable energies (solar, wind or CHPs), the economic calculation is influenced by many factors: The way that the economic and ecological goals are set will influence the efficiency and effectiveness through an appropriate design which considers the economic analysis, in particular the life cycle analysis.
- The existing energy prices have a strong influence on the pay-back calculation. Lower energy prices lead to less viability of the projects. On the other hand, the low biomass prices or the use of by-products (slurry, waste-heat) improve the economic outcome. In order to reduce the price risk for the operator, price adjustment clauses are applied for heat and power supply.
- Operation costs over the life-cycle of a building are a multiple of the initial construction costs (Bogenstätter, 2010). Decisions in the early stage of design process influence life-cycle costs in terms of space, the quantity of structural elements, technical and mechanical service equipment and the choice of materials.
- The investment costs mainly depend on the availability of the technical plants and devices, on the specific material and labor costs for the implementation of the technical equipment, on removal and disposal costs of existing devices, on calculated business profit and on the individual quality requirements. Considering bioenergy villages as the long-term projects that they are, quality standards that are at least in accordance to technical regulations should be applied. Results of a life cycle cost calculation clarify whether more cost intensive products should be used in order to reduce maintenance costs during the life time of the technical devices.
- In addition, land prices have to be calculated (e.g. for the heating centre of a district heating system). Regional differences have to be considered. Negotiations with land owners are recommended.
- The level of the capital cost depends on the specific contract conditions (interest rate, fixed interest period, contract duration, flexibility of changes) with the financing institution.
- The operation costs are influenced by the labour costs from the maintenance companies, chimney sweeps and others and by the inflation rate for the replacement of technical components during their life-time.
- Revenue sources can be very different: In district heating systems, the revenues come from the agreed baseload price in combination with the revenues depending on the heat consumption and the agreed heating price. Feed in tariffs or additional payments for power production depends on country-specific
regulations. Often, they are limited in time and legal changes of the relevant regulations have an important impact on the calculation.

- In addition, available subsidies and grants should be always included in the projects as they often have a big influence on the economic outcome of the project.
- Aside from these issues, more monetary and non-monetary influences resulting from the implemented measures should be taken into account, in order to assess the project comprehensively.

Furthermore, the economic calculation depends on the stage of the project. Within the initial phase and after the first survey, a rough cost and revenue calculation will be enough. The more the project is developed the more detail in calculations are necessary.

The economic assessment should follow the procedure described in the following chart:

![Figure 18: Procedure of the economic calculation](image)

This described procedure focuses on the project outputs, and more over the local or regional added values can be considered. Within the planning period, green building certifications are often provided, that are the basis for the assessment of the financial performance assessment.

### 2.8.2 Key performance indicators (Lohse, 2017)

The acceptance of bioenergy villages is related to the cost-benefit calculation, which means first of all cost-effectiveness. Depending on the types of measures, the cost effectiveness is usually calculated in different ways.

However, there are some elemental instruments that can be applied to assess the cost effectiveness of single measures or complete bundles of measures depending on the stage of the process. There are varieties of static and dynamic key performance indicators, the most common KPIs are:

- Static Amortisation
- Net- and Gross Return on Investment (ROI)
- Annuity method
- Net present value (NPV) combined with a cash flow calculation
- Internal rate of return (IRR)

The static amortization and the ROI are used at the beginning of the project and the more complex calculation methods such as the annuity method, NPV and IRR are applied in detail in the context of the life cycle analysis.
The payback period is the length of time required to refinance the costs of an investment. The payback period of an investment is a determinant of whether to undertake the measure or the project, as longer payback periods are typically not desirable for investment positions. Planners should note, that the payback period ignores the time value of money, unlike other methods of capital budgeting, such as net present value, internal rate of return or discounted cash flow (see below).

A rough thumb rule for the calculation of ECMs is the coefficient of:

\[
\text{Static Amortization} = \frac{C_{\text{Investment}}}{C_{\text{savings}}} \quad (1)
\]

The static amortisaion corresponds to the simple payback period that is only in use for first estimations of measures.

**Net- and Gross Return on Investment (ROI)**

The ROI is applied to evaluate the efficiency of an investment or to compare the efficiency of a number of various investments. It determines the benefit to an investor resulting from an investment or, in other words, the ROI considers the profits in relation to the capital invested. It provides a quick check of the profitability of a project. A high ROI shows that the investments are very attractive.

The return on investment is calculated over a specific period of time, such as a year.

\[
\text{ROI} = \frac{\text{profit}}{\text{complete capital}} \times 100 \quad (2)
\]

The gross rate of return is the total rate of return on an investment before the deduction of any fees or expenses. The net return on investments includes the net profit and the net capital or investment of the project.

**Annuity method**

The annuity method – taking into account replacements - is exactly described in the German VDI 2067 – Economic efficiency of building installations / Fundamentals and economic calculation).

The annuity calculation combines non-recurring payments, regular payments and incomes with the aid of an annuity factor during the observation period.

The following categories of costs are given:

- Capital related costs: these costs comprise all financing costs including the net book value and replacement costs in the observation period.
- Requirement (consumption)-related costs
- Operation related costs
- Other costs
- Incoming payments

The annuity of the capital related costs can be determined using the following equation:

\[
\text{Annual annuity of capital payments} \quad A_K = (A_o + A_1 + A_2 + \cdots + A_n + R_w) \times a + \frac{f_k}{100} \times A_o \times ba_{\text{IN}} \quad (3)
\]

- \(A_o\): Investment premium
- \(A_{1...n}\): Cash value of the 1st, 2nd, \(n\)th replacement
- \(R_w\): Net book value
- \(a\): Annuity factor
- \(f_k\): Factor for repairs in % of the investment premium per year
- \(ba_{\text{IN}}\): Price-dynamic annuity factor for repair payments

The net book value is calculated by straight-line depreciation of investment premium until the end of the observation period and discounted at the beginning of the observation period.
The annuity factor is determined as follow:

\[ a = \frac{q^T \times (q-1)}{q^T-1} = \frac{q-1}{1-q^{-T}} \]  

(4)

q: Interest factor
T: Observation period

If price changes to the regular payments for maintenance during the observation period are expected, a price-dynamic annuity factor can be used.

The annuity of the requirement / consumption–related costs \((A_V)\), the operation-related costs \((A_B)\), the other costs \((A_S)\) and the revenues \((A_E)\) are also calculated with the price-dynamic annuity factors.

\[ A_V \text{ or } A_B \text{ or } A_S \text{ or } A_E = A_{V1} \text{ or } A_{B1} \text{ or } A_{S1} \text{ or } A_{E1} \times ba_{V \text{ or } B \text{ or } S \text{ or } E} \]  

(5)

ba: Price-dynamic annuity factor for repair payments

The difference between the revenue annuity and the annuities of all costs gives the total annuity:

\[ A_N = A_E - (A_K + A_V + A_B + A_S) \]  

(6)

Net Present Value (NPV) calculation

The NPV is a measurement of the profitability of the investments by subtracting the present values (PV) of cash outflows from the present values of cash benefits over a period of time. The present value of revenue is the amount needed today to yield the same revenue from the bank, including interests. The present value of expenses is the amount needed on the present day to pay upcoming expenditure. The NPV is the sum of all present values: the costs (or payments, e.g. the investment) are negative, and the revenues are positive. Present values are comparable as they refer to the same point in time.

The NPV is the total gain of the investment, when all lifetime costs and revenues are taken into account. Therefore, a positive or non-negative NPV means that the investment is economic. As long as capital (incl. debt) is available, it is economically profitable to make any investment down to a NPV of 0.

A positive NPV means that

\[ NPV = -I + \text{SUM}(n; t) \times \frac{ct}{(1+i)^t} + \frac{RV}{(1+i)^n} \]  

(7)

NPV = Net Present Value function
I = Investment in year \(t = 0\)
N = Life time in years
Ct = Cash flow in year \(t\)
I = Interest or discount rate
RV = Residual value in the year \(n\)

Cash-flow analyses are often combined with NPV calculations. For simulation purposes, the net present value (NPV) of a cash-flow analysis of each ECM measure bundle should be individually calculated.

In the cash-flow analysis the annual costs and benefits are displayed under assumed price increase rates. If the Net present value of the costs and benefits are higher than the total investment costs, then the project is attractive:

NPV – Investment costs > 0

Internal rate of Return

The Internal rate of return (IRR) is a metric used in capital budgeting that measures the profitability of potential investments. IRR is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. IRR calculations rely on the same formula as NPV. IRR are utilized to compare several measures within bioenergy villages, e.g. types of heat generation systems.
\[-I + \sum(n; t) \frac{Ct}{(1+i)^t} + \frac{RV}{(1+i)^n} = 0 \]  
\[(8)\]

NPV = Net Present Value function
I = Investment in year \( t = 0 \)
n = study life in years
Ct = cash flow in year \( t \)
i = interest or discount rate
RV = residual value in the year \( n \)

2.8.3 Rough economic calculation

In the first phase of the project, a rough comparison between different technological options can be carried out in the following way:

**How can you calculate the heating price in the first year roughly?**

**Example:**

Useful energy demand: 9,215 MWh/a
Total investment and planning costs: 5,55 Million € (1.12 Million € equity) for heat center (biomass plant and peak load boiler, district heating system)
Interest rate: 3.6%, 20 y

<table>
<thead>
<tr>
<th>Annual capital costs (annuity)</th>
<th>314,846 €/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable operation costs (Annual repair- and maintenance costs, staff costs, administration, insurances)</td>
<td>402,178 €/y</td>
</tr>
<tr>
<td>Energy costs</td>
<td>244,986 €/y</td>
</tr>
<tr>
<td>Sum</td>
<td>962,010 €/y</td>
</tr>
<tr>
<td>Heat price (excl. VAT)</td>
<td>104,4 €/MWh</td>
</tr>
</tbody>
</table>

2.8.4 Life-cycle costs approach

Life cycle costs are the total costs over the building life time, discounted according to the year when they occur. Life Cycle Costs in buildings are defined by the standards on Life Cycle Cost Analysis [ISO 14040-44], the European standards [EN 15804] and [EN 15978] and other reference documents of the ILCD 2010a,b and c. In the bioenergy village decision making process however, the focus point is the assessment of Part- LCC; Part- LCC only considers the construction and usage phase of the building and leaves the de- construction phase out of the focus.

The technical life time of the relevant technologies has to be taken into account. National standards often list life times for main technologies:

<table>
<thead>
<tr>
<th>Appliance bundle (selected samples)</th>
<th>VDI 2067/B 1 (DE) (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler/furnace</td>
<td>20</td>
</tr>
<tr>
<td>Air Handling Unit (without distribution)</td>
<td>20</td>
</tr>
<tr>
<td>Cooling (water cooled rotary compressor)</td>
<td>18</td>
</tr>
<tr>
<td>Control (hybrid with pneumatic, electric and digital signal)</td>
<td>12</td>
</tr>
<tr>
<td>District heating pipes</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 11: Life- time of ECM according to German Industry Standard VDI 2067.1
During the calculation process, modelling of measures and building simulation is included. The modeling process includes the “baseline”, the “base case” with the national minimum requirements for building refurbishments and one or more refurbishment scenarios.

The simulation and modeling processes for the main measures or the complete bundles of measures are work intense, complex and have to be carried out and documented appropriately with regard to the quality assurance and the re-use of data sets in the detailed design process. The calculation of estimated savings for projects of the scale anticipated must be based on “open-book” calculation methods or tools and will be used to perform verified savings calculations as part of the M&V effort. Estimated energy savings should be compared to empirc data such as previous energy savings estimates or M&V data from accomplished projects for reasonableness (=> rebound effect).

With regard to the transformation of results to other buildings, it has to be considered that the results of modeling will always be related to the individual investment and LCA cost and demand structures, the data inventory and utilization of the building.

Investment cost calculation

Investment costs are the initial investment costs to set up the ECM and supply measures. To prepare the assessment of the economic validation of the different combinations of ECM and supply measures, the investment costs have to be identified and analyzed. For decision making it is important to present the investment and annual costs at the first place. To compare different energy efficiency scenarios it is usual to focus on the “delta- cost” which are the incremental investment and annual costs for a better energy standard than the basic requirements. Most of the countries databases provide specific investment costs per floor space unit or per external wall and window area unit (windows, roofing, roof insulation, wall insulation, perimeter insulation), per load unit (boilers, CHP units, biomass boilers); these costs comprise in most cases the average material and labor costs and can be used for the preliminary planning. In order to make sure that the cost calculation is correct, price offers for the main components of the bioenergy village can be requested.

Operating costs

ECM measures and energy supply measures are linked with energy savings (better energy efficiency). Energy costs in the post-refurbishment phase will be available from the energy balance of the modeling process; the energy savings will be calculated from the comparison with the baseline energy costs. With regard to the reliability of the energy saving calculation, the “rebound effect” as an energy efficiency paradox has to be considered carefully. This effect describes the fact that ECMs induce an increase in the usage of the corresponding technologies and thus can possibly increase energy consumption.

Since biomass often replaces fossil fuels in bioenergy villages, the specific price differences and the linked revenues are part of the economic calculation. However, the fuel or biomass costs often have the main impact on the operating costs. Therefore, the quantity on biomass material / fossil fuels, its specific price, revenues (e.g. feed in tarifs) and the efficiency of the heating generation system are the main factors that influence the energy costs.

Operating costs include costs for maintenance and refurbishment (m&r) of the building and its components (also called secondary investment costs). Usually bioenergy projects will be established for long time periods that are exceeding the technical life time of some moving parts like pumps, electric valves and control systems. These may have to be replaced in parts or in total. Operating costs consider these spare parts or complete replacement in the time frame. These investments, which will take place in the future, will have to consider increasing investment costs which are usually adopted by investment cost indexes on a national level. An investment in 10 years is then the value of the investment today multiplied by the cumulated investment cost index from year 1 to 10.

\[ \text{Invest (ten= 10a) = } \sum \text{Index (yr 1-10) } \times \text{invest. (Basic year)} \quad (9) \]

Figure 19 shows a typical maintenance cost chart of a condensing boiler heating station (straight line). Looking at the measures carried out over a time period of 10 years it shows that a short time period would provide inaccurate (i.e. too low) cost data.
According to the industry standards in some European countries (e.g. German Industry Standard VDI 2067, B1) maintenance costs are estimated as an average percentage value of the primary investment over the technical life time of this investment. The increasing maintenance and replacement costs over the technical life time of a heating station are documented in the following chart.

As mentioned before, the economic calculation has to take into account many factors. This guideline considers the most often used technologies and approaches, having regard to the calculation tools for these technologies. The tools involve a technical and an economic LCC assessment of the planned measures. An assessment compares the profitability of a fossil fuel based reference energy conversion system with a bioenergy based one. Bioenergy pathways that can compete with fossil fuels are the ones to start with for becoming a bioenergy village. Biomass ovens in southern European countries might be among these fuel-switch options. Within the different loops of calculation in the planning phase, the impacts on dimensioning and selecting the technical measures and plants should be taken into account carefully and also harmonized with the objectives of the project. A sound technical implementation is e.g. given with the fulfilled economic criteria over the lifetime of the main components of the technical system:

- optimized economics and lowest possible emissions
- high annual energy efficiency (high plant utilization, boiler efficiency, low grid losses, high spread between flow and return temperature etc.)
- low investment, maintenance, repair and fuel costs
- low fuel handling and storage costs.

Biomass plants are characterized by a high investment and usually low biomass fuel costs. Based on a thorough and qualitatively high value conceptualization, planning and implementation it is feasible to achieve,

- an optimized technical plant configuration,
- an energy efficient operation,
- technical-economical sound and successful biomass utilization.

For the economical assessment it is necessary to conduct a full LCC approach. This means that for both the biomass plant and the alternative investment all capital-bound and operation-related costs and revenues within the defined time frame must be taken into consideration. The following cost categories shall be considered:

<table>
<thead>
<tr>
<th>Capital-bound costs</th>
<th>Demand-related costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital costs investments for installation systems and</td>
<td>Fuel costs,</td>
</tr>
<tr>
<td>their respective building components, including renovation</td>
<td>Costs of misc. energy, costs of operating materials,</td>
</tr>
<tr>
<td></td>
<td>cash disposal, concession fees etc.</td>
</tr>
<tr>
<td>Operation-related costs</td>
<td>Other costs</td>
</tr>
<tr>
<td>Costs of servicing (personnel), cleaning, maintenance,</td>
<td>Costs of insurance, general levies and charges, administration costs etc.</td>
</tr>
<tr>
<td>repair, inspection, trouble-shouting, rent, chimney</td>
<td></td>
</tr>
<tr>
<td>sweeping, flue gas analyses</td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Cost categories (Aigner)

The German VDI Guideline 2067 gives more details on the methodology of considering the cost categories listed above.

2.8.5 Application of the economic assessment

The BioVill project provides Excel tools developed/adapted for assessing the economic profitability of various biomass energy conversion systems; all take into account the above mentioned cost categories. The BioVill assessment tools are listed in chapter 5, the published ones can be downloaded for free via the documented links.

Tools are available for the following biomass energy conversion systems

- Heat cost comparison of small in-house ovens (briquettes, soft and hard log wood, pellets, extra light fuel oil, hard coal), developed for the IEE project “Bioheat” and modified for BioVill
- Heat cost comparison of small in-house boilers (Wood chips (P16), soft and hard log wood, pellets, extra light fuel oil, natural gas), developed for the IEE project “Bioheat” and adapted for BioVill
- Heat cost comparison of medium-scale district heating plants and micro grids (comparing Wood-chips or pellets or straw with natural gas or fuel oil or coal); i.e. the “B4B BioHeat Profitability Assessment Tool” developed within the H2020 project Bioenergy4Business
- The CHP plant assessment tools (for biogas CHP plants, solid biomass CHP steam turbine and biomass gasification CHP gas motor/turbine plants) are provided by the Austrian Energy Agency (AEA) for the BioVill partners and for their usage only, as the tools are property of AEA

The application of the economic assessment is illustrated for a new biomass boiler and district heating system (see tool “B4B BioHeat Profitability Assessment tool”):

Step 1: Calculation of the energy demand
   All relevant facts are described in the Summary report: Techno-Economical assessment of bioenergy value chains and their potentials in the target village (pending at the time of finalising this guideline)

Step 2: Design of the biomass boiler and the district heating system
   All relevant facts are described in the Summary report: assessment of opportunities to set-up biomass based CHP plants and small district heating networks (pending at the time of finalising this guideline)

Step 3: Cost calculation
   - Investments in the district heating system
   - Investments in ECM
• Investments in biomass boiler and fossil fuelled boiler
• Construction and development investments (heating centre and others)
• Other investments
• Planning costs, approval costs
• Replacement costs

Step 4: Calculation of revenues
• Calculated heat price (sale)
• Subsidies
• CO₂-certificates
• Other revenues

Step 5: Calculation of consumption-related costs and operation related costs
• Costs of biomass, fossil fuels and power
• Staff costs
• Repair- and maintenance costs
• Land costs
• Other annual costs

Step 6: Compiling economic parameters
• Subsidies / grants
• Share of equity / loans
• Interest rate for both equity and loans
• Period under consideration
• Annuity
• Weighted average costs of capital (loans and equity)

Step 7: Deriving results
Outputs of the dynamic cash-flow-calculation are:
• Dynamic time of amortisation
• Net present value,
• IRR
• Calculated heat generation costs (€/MWh)

These outputs are given for both, the biomass system (option 1) and the reference system (option 2 - mostly on basis of fossil fuels).

Example: Calculated life cycle costs for two heat generation options

<table>
<thead>
<tr>
<th>Year</th>
<th>Option 1: wood-pellets with fossil fuel peak boiler</th>
<th>Option 2: fossil fuelled reference system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual payments [€]</td>
<td>Annual payments [€]</td>
</tr>
<tr>
<td>2017</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>2018</td>
<td>25,000</td>
<td>35,000</td>
</tr>
<tr>
<td>2019</td>
<td>20,000</td>
<td>30,000</td>
</tr>
<tr>
<td>2020</td>
<td>15,000</td>
<td>25,000</td>
</tr>
<tr>
<td>2021</td>
<td>10,000</td>
<td>20,000</td>
</tr>
<tr>
<td>2022</td>
<td>5,000</td>
<td>15,000</td>
</tr>
<tr>
<td>2023</td>
<td>0</td>
<td>10,000</td>
</tr>
<tr>
<td>2024</td>
<td>0</td>
<td>5,000</td>
</tr>
<tr>
<td>2025</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
2.9 Financing instruments

The following chapter will briefly present financing instruments with regard to the specific needs of an operating company responsible for a bioenergy village. A financial instrument in general terms is “any contract that gives rise to a financial asset of one entity and a financial liability or equity instrument of another entity” (International Accounting Standard, 2014).

Financing instruments are used to raise capital in order to realise technical measures and related services. This chapter focuses on external financing instruments that can be classified as assets, liabilities and off-balance products. Off-balance instruments (leasing) do not influence the economic balance sheet of a company, whereas all other instruments change the assets or the liabilities of a company.

Figure 21: Calculated life cycle costs for two heat generation options

Figure 22: Financing instruments – connections between the financing institution and the recipient
The specific demand of a bioenergy village is related to the characteristics of the technical execution of the bioenergy village. Bioenergy villages are typically established in smaller villages or districts with a heterogeneous building stock. Therefore, the need of demand side measures is highly variable across the buildings. However, this chapter focusses on the financing of complete bundles of measures, starting with ECMs on the demand side up to heat generation systems and electricity generation systems (see items 2.4 and 2.5).

Furthermore, the financing instruments can be classified regarding their target areas: There exist instruments on a European level such as the European efficiency fund that can be used for many projects in the EU member states. Nevertheless, most of the financing instruments are available on national or on regional levels such as subsidies. The conditions of conventional loans depend on the rating of each financing institution itself, thus interest rates for these loans can differ within one municipality.

The suitable financing instruments depend on different framework conditions that should be taken into account. The risk assessment carried out by the financing institutions result from technical as well as economic criteria of the project.

From the customer’s point of view, the financing instruments can be selected on the basis of the following criteria:

- **Conditions**: (fixed) interest rates, fees, provisions, extent of the financing / which measures are financed, compatibility to subsidies, contract duration, flexibility, requirements of the financing institutions (properties of the investments..)

- **Securities**: cash-flow assessment (financing on the basis of the project), equity of the investors (contractor, citizen initiative..), insurances, bank guarantees, land registry, ..),

- **Financing related supports**: tax exemption, tax limits, ..

For the financing institutions, the most important criteria for the project assessment (rating) are (Energy Agency Northrine-Westphalia, 2014):

- Can the project cover the obligations based on the cash flow?
- Are the securities quickly available and for low costs?
- How is the credit rating / the creditworthiness of the project / the company?
- Are additional securities necessary? Which ones?
- Is the customer able to pay back the loan on basis of the agreed conditions?

Therefore, the financing instruments are described in the following way:

- **Investment volume**: The extent auf the available capital is very different. Therefore, some of the financing instruments can be applied separately, whereas other financing instruments cover only small investments and have to be combined in order to fulfil the need for capital.

- **Flexibility**: This criterion means both the flexibility of time schedule for the payment of the credit amount to the debtor and the flexibility to increase (or decrease) investment cost and to extend the borrowed amount of money. In addition, the flexibility takes also into account whether the financing instrument can be combined with other financing instruments.

- **Risks for the obligor and for the creditor**: Every external financing instrument bears risks for both the obligor and the creditor which have to be assessed.

- **Requirements and necessary securities**: In order to minimize the risks, the creditor requires de-risking measures that need additional effort from the debtor.

- **Cost effectiveness**: Often, transaction costs are necessary to prepare the financing agreement. In many financing instruments the transaction costs of the projects still are above- average as the number and size of such projects is still comparably small and the due diligence process cannot refer to numerous well evaluated reference projects.
2.9.1 Loans/Soft Loans/Dedicated Credit Lines

Loans are the mostly applied financing instrument for energy investments. Soft loans are subsidized loan programs with no interest or a below-market rate of interest, or loans made by multinational development banks and government agencies to developing countries that would be unable to borrow at the market rate. Soft loans have lenient terms, such as extended grace periods in which only interest or service charges are due, and interest holidays. Soft loans typically offer longer amortization schedules and lower interest rates than conventional bank loans. A dedicated credit line is providing low-interest loans to reduce capital costs.

Bank loans are a very common financial instrument for the financing of bioenergy projects. This is often a challenge, as banks and other financing institutions are still sceptical regarding the validity of the planned measures and cash flow calculations, and therefore rate the risk of financial involvements in the projects relatively high, in particular when the operating company applying for a loan is new in the market and lacks experiences in bioenergy villages or comparable projects.

The financing of Energy Efficiency investment in conventional loans is often combined with preferential loans provided by national or multinational institutions at preferential conditions. The retail distribution is provided by market banks. Best practice examples are in the European context: German KfW’s “Renewable Energies programme - Premium” related to ambitious technical requirements (KfW). In the assessment of KfW preferential loan programs the major steering instruments for the usage of renewable energies and energy efficiency are reduced interest rates, longer maturities and repayment bonuses.

The combination of a repayment bonus with decreased interest rates obviously increases the ambition; the leverage effect of public funds is usually between 4 and 10 which is higher than traditional grants. An important topic is that a preferential loan scheme allows 1:1 refinance to market banks (Basel III compliant).

A weak point of the soft loan system is that the risk adversity of commercial banks towards the technical measures in bioenergy projects is served with public money without creating a necessary improvement of experience on the side of the commercial banks; instead of this, commercial banks delegate the majority of risks to the soft loan bank (Energy Efficiency Financial Institutions Group, 2015). With the margins being small the commercial banks often consider soft loans/dedicated loans not as a priority in their loan distribution strategy. Overall this strategy may contribute to a first market development.

### Investment volume

Normally, loans cover a wide range of investments. If soft loans or dedicated credit lines are used, the loan programmes are often dedicated to specific measures or the defined energy efficiency targets. Then, the delivered capital depends on the planned measures in the bioenergy village.
### Flexibility
The flexibility of soft loans is limited but higher than in normal loans. The soft loan amount is fixed in the loan agreement. Often a “floor limit” (maximum loan amount) is settled at the hand of a first detailed investment cost calculation and includes, if possible a cushion for contingencies. However, the volume of these agreements is limited to the capacities of the bioenergy village finance plan.

### Risks for obligor
The bank is providing an assessment of the project to de-risk the bioenergy village performance risks. The interest rate may be capped over time; the loan term however is fixed, reducing the term would require only small extra payments. Bank loan is providing high risks for the obligor as the flexibility (total amount and time schedule) is low, performance risk of the DER investment has to be taken by the obligor and is not considered in the creditor’s due diligence.

Soft loans may reduce some of the obligor’s risk as they provide more flexibility in terms of redemption, lower interest rate risks.

### Risks for creditor
In particular, the bank assesses the risk of insolvency and bankruptcy of the lender and the risk of delay or cease of payment of annuities.

### Requirements and necessary securities
The major de-risking instrument for the creditor is the creditworthiness check of the obligor which is taking into account the balance sheet comparing liabilities and incomes over time. The economic benefits of the investments are not accounted but assessed by the soft loan bank. Risks from defaulting obligors will be mitigated by the assessment of the subsidized project and the number of different projects.

In order to reduce the risks and to ensure their financing, banks require agreements in land registries of the building owners.

### Cost effectiveness
Transfer costs and interest rates are low as soft loan programs do refer to the creditworthiness of the applying company. For new companies, the transaction costs can be higher because of deeper economic assessment of the companies.

2.9.2 Subsidies and Grants
Subsidies are handed out to reduce the investment costs of equipment and installations over a certain period of time, i.e. broadening the market approach of a quasi-mature product. National or regional programmes offer different types of subsidies, often managed by a public bank or institution.

Grants are targeted at the owner or the operator of the technical devices such as the municipality, private building owners, contractors and others to pay for a part of the incremental costs of introducing ECMs or renewable energy systems in the market – such as wood chip boilers.

Grants or subsidies are financed directly through the state or local authority budget or hypothecated taxes (also known as ring-fenced or ear-marked tax).

### Investment volume
Subsidies are applied to support specific technical measures. Since a large variety of measures is implemented in bioenergy villages, subsidies only cover a part of the measures as well as only a part of the complete investment costs.

### Flexibility
Subsidies often are given as a grant after the installation of the technical equipment, depending on the extent of the investment costs. Some programmes include specific limitations (limited time of installation, limited supported investment costs and others).

### Risks for obligor
If the obligor is aware of the specific programme requirements, the risks for the obligor are low.

### Risks for creditor
In particular, the bank assesses the risk of insolvency and bankruptcy of the lender and the risk of delay or cease of payment of annuities.

### Requirements and necessary securities
The institutions that are offering subsidies are obliged to check de-minimis regulations and to ensure that technical standards are respected.
Cost effectiveness
Transaction costs are normally low. Often different programmes can be combined, the related regulations have to be determined.

2.9.3 Leasing
In general, lease means a contractual arrangement between the lessor (owner) and the lessee (user), who pays for use of an asset at a fixed rental fee per period. Property, buildings or technical equipment are assets that can be leased in bioenergy villages. The lessor is the legal owner of the asset and the lessee obtains the right to use the e.g. technical equipment in return for regular rental payments. There are two common types of lease: the operate leasing and the finance or capital leasing. An operating lease is chosen for short use of the asset being leased. Finance leasing is focused on longer contract durations. The most important differences of the models are described in the following table:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Operate Leasing</th>
<th>Finance Leasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract duration</td>
<td>Short-term</td>
<td>Medium-term, long-term</td>
</tr>
<tr>
<td>Period of notice</td>
<td>Always</td>
<td>Only at the end of the contract</td>
</tr>
<tr>
<td>Risks bearing by</td>
<td>Lessor</td>
<td>At least partially by the lessee</td>
</tr>
<tr>
<td>Maintenance by</td>
<td>Lessor</td>
<td>Lessee</td>
</tr>
</tbody>
</table>

Table 7: Overview about leasing models (FNR, 2014-1)

Lessors not just have a comprehensive knowledge over the planning of the projects, but also have experience with the implementation and operation of the leased equipment depending on the realised type of leasing. However, leasing is only applicable for portable goods, since the lessee must return the leased equipment to the lessor in good condition (consistent with its maintenance and repair obligations under the lease).

Investment volume
Leasing is used for financing special equipment with clear defined interfaces. Depending on the extent of the planned central or decentral measures in the bioenergy village, leasing can used to finance heating biolers and others, but mostly this do not cover the complete volume of the project.

Flexibility
The flexibility depends on the contract and the type of leasing. Termination of the contract can be possible, but the lease payments are normally fixed.

Risks for obligor
Often, the delivery of the leased property is at the risk of the lessee. Lessee’s failure to comply with or perform any of the terms or conditions or rules and regulations under this lease will be considered a default and grounds for early termination of the lease.

Risks for creditor
In premature termination of the lease contract, e.g. through default by the lessee or a total loss of the equipment – the lessor will require the outstanding capital costs of the equipment to be paid as a lump sum. It is unlikely, that this “second-hand value” at the date of termination will be high enough to eliminate the outstanding capital costs. The creditors (leasing companies) obtain the same information regarding the credit standing of prospective lessees as banks and other financial institutions do for loan applications. On the other hand, it may be easier for a lessor as owner to repossess leased equipment following a default by the lessee than it would be e.g. for a mortgage.

Requirements and necessary securities
Two major de-risking instrument for the creditor:
- a) the creditworthiness check of the obligor which in the public sector is taking into account the balance sheet comparing liabilities and incomes over time.
- b) The DER benefits are assessed and considered as a revenue.

Cost effectiveness
Transfer costs are higher because of the deeper project assessment from the creditor.
2.9.4 Project finance

In comparison to a loan program the project finance (also: cash-flow funding) does take into account the creditworthiness of the obligor AND the transactions in which the project is financed based on its own merits. The financed project is often implemented in a project company. The assessment of the project finance is carried out by evaluating the quality of the obligor and whether the cash flow generated will be sufficient to cover the debt-service (interest plus repayment). This is done by using key performance indicators (KPIs) such as the debt service ratio (Net-cash flow/debt service) and the life loan coverage ratio (net present value of cash flow available for debt service divided through the outstanding debt in the period).

The following basic types of project finance exist and are often combined:

a) Pure cash flow related finance will only take the future cash-flow as security, whereas
b) secured debt finance is additionally safeguarded by all of the project assets, including any revenue-producing contracts.
c) In recourse financing a collateral is available which puts the creditor in a stronger position.

### Investment volume
Project finance is applied for the complete investments of the project, whereas the share of the necessary equity has to be taken into account.

### Flexibility
The flexibility is comparable to normal loans. Especially in refinancing the companies a “floor limit” (maximum loan amount) is settled at the hand of a first detailed investment cost calculation and includes, if possible a cushion for contingencies.

### Risks for obligor
The bank is providing an assessment of the bioenergy village project to reduce the performance risks. The interest rate is capped over time. The obligor takes the performance risk.

Project finance combines the creditworthiness of the obligor with the quality of the DER project cash-flow.

### Risks for creditor
In particular, the bank assesses the risk of insolvency and bankruptcy of the lender and the risk of delay or cease of payment of annuities. Therefore, the performance risk is checked intensively by using the KPIs.

### Requirements and necessary securities
Two major de-risking instrument for the creditor: a) the creditworthiness check of the obligor which in the public sector is taking into account the balance sheet comparing liabilities and incomes over time. b) The DER benefits are assessed and considered as a revenue.

### Cost effectiveness
Transfer costs are higher because of the deeper project assessment from the creditor.

2.9.5 Energy efficiency funds
Energy efficiency funds are available on European and on national level. The requirements, the project sizes and the eligibility criteria distinguish and they depend on the objectives of the funds. Often, the funds finance bigger projects because of the lower transaction costs, whereas bundling of projects is one option to finance smaller projects by energy efficiency funds.

The Environmental Protection and Energy Efficiency Fund (EPEEF) in Croatia is an instrument for investing projects of environmental and nature protection, energy efficiency and use of renewable energy sources.

In the system of management and control of utilization of EU structural instruments in Croatia, the fund performs the function of Intermediate Body level 2, for the specific objectives in the field of environmental protection and sustainability of resources, climate change, energy efficiency and renewable energy sources.

The activities of the Fund comprise the financing of the preparation, implementation and development of programs and projects and similar tasks in the field of conservation, sustainable use, protection and improvement of the environment, and in the field of energy efficiency and use of renewable energy sources.

The Environmental Protection and Energy Efficiency Fund is implementing energy retrofit programs that were adopted by the Government of the Republic of Croatia, and it is co-financing ECMs in buildings, with a view to reducing the consumption of energy at national level and reducing CO₂ emissions. The Fund grants financial resources to legal and natural persons for the purpose of financing the programs, projects and other activities,
set out in the Act on the Environmental Protection and Energy Efficiency Fund through loans, subsidies, financial assistance and donations. The financial resources are granted on the basis of a completed public tender. Appropriations of the fund are used primarily to finance the programs, projects and similar activities set out in accordance with the National Environmental Strategy and the National Environmental Action Plan, the Energy Development Strategy and the Implementation Programs for the Energy Development Strategy and national energy programs.

Example on European level:

The European Energy Efficiency Fund (eeef) was established as a joint initiative of the European Commission and the European Investment Bank. It started in 2011 and aims to support the goals of the European Union to promote a sustainable energy market and climate protection. The eef is a public-private partnership open to investments from institutional investors, professional investors and other well informed investors.

Eeef contributes with a layered risk/return structure to enhance energy efficiency and foster renewable energy in the form of a targeted private public partnership, primarily through the provision of dedicated financing via direct finance and partnering with financial institutions. Investments should contribute significantly towards energy savings and the reduction of greenhouse gas emissions to promote the environmentally friendly use of energy. Maximizing its impact, eef facilitates investments in the public sector, which offers an enormous potential, but in which projects are often hindered or decelerated due to budget restrictions and lack of experience with this kind of investments.

The eef targets investments in the member states of the European Union. To reach its final beneficiaries, eef can pursue both direct investments and investments into financial institutions. Direct investments comprise projects from project developers, energy service companies (ESCOs), small scale renewable energy, energy efficiency services and supply companies that serve energy efficiency and renewable energy markets in the target countries. Project investment in energy efficiency and renewable energy projects range between 5 million € to 25 million €. The Fund can (co-)invest as part of a consortium and participate through risk sharing with a local bank (EnPC INTRANS, 2015).

### Investment volume
Energy efficiency funds often focus on bigger projects and require a minimum amount of investments.

### Flexibility
The capital amount financed by the fund and the interest rate are fixed in the agreement. The interest rates are often higher than the rates of normal loans, in particular in private energy efficiency funds.

### Risks for obligor
The contract conditions such as the interest rate are agreed over the complete contract duration, thus the risks for the obligor are low.

### Risks for creditor
In particular, the bank assesses the risk of insolvency and bankruptcy of the lender and the risk of delay or cease of payment of annuities.

### Requirements and necessary securities
Also funds administrators carry out the creditworthiness check of the obligor and a project assessment that includes a cash flow calculation including a check of liabilities and incomes over the contract time.

### Cost effectiveness
Transfer costs are normally low, they depend on the creditworthiness of the company.

2.9.6 Green Bonds

Green bonds are relatively new assets that are used to raise investors’ capital at environmental projects such as renewable energy plants, climate emission mitigation projects or ECMs. Green bonds are issued by governments, (multi-)national banks (World Bank, European Investment Bank, European Bank for Reconstruction and Development, national development banks), corporations (e.g. EDF, DGF Suez) or public entities (e.g. Ile-de-France; Paris, Göteborg) (Climate Bonds Initiative ). Small local authorities and municipalities do not offer green bonds because of the high requirements to issue a bond, and of the constraints of reporting the results. The NRW.BANK in Germany also issues green bonds for sustainable projects in the Federal State of North Rhine-Westphalia (Zentrum für Bioenergie ). All the issuing institutions guarantee to repay the bond over a certain period of time, plus either a fixed or variable rate of return.
Investment volume
Green bonds are used to finance smaller and bigger projects depending on the regulations of the issuing institutions. Regional entities offering green bonds support smaller projects more often than European or multinational institutions.

Flexibility
Normally, the interest rates are fixed in the partners’ agreement and the contract time is limited. Therefore the flexibility of this financing instrument is considered as lower than in normal loans contracts.

Risks for obligor
The contract conditions such as the interest rate are agreed over the complete contract duration, thus the risks for the obligor are low.

Risks for creditor
The issuing entity assesses the solvency of the lender and the viability of the project.

Requirements and necessary securities
These requirements are the same as the requirements on debtors of normal loans. In addition, the project has to meet the sustainable criteria set up from the creditor.

Cost effectiveness
Transfer costs are high because aside from the creditworthiness-check of the company the sustainable criteria are checked and ecological or energy-related benchmarks have to be proven from the obligor.

2.9.7 Crowd funding
Crowdfunding platforms are innovative instruments where people are able to jointly invest an amount of money starting at small budgets (e.g. 50 €) in energy efficiency projects of established enterprises, contractors or citizens. This instrument can also be considered as a marketing instrument for these stakeholders to promote their services to the crowd to an account of betterves. The project partners, who will perform the energy efficiency or bioenergy projects, get the necessary investment capital afterwards. Then, the ECMs will be implemented and the project partner pays back the annual annuity rates to bettervest that transfers the money minus a service fee to the crowd. Thus, crowdfunding can be also considered as a PR activity of the building owner and building owners accept higher interest rates counted on the crowd.

Investment volume
Crowdfunding is suitable for small bioenergy projects and the amount of investments is limited.

Flexibility
The flexibility of the instrument is higher than the flexibility of the traditional financing instruments because of the connection of financing and marketing.

Risks for obligor
Since the interest rate in crowd funding projects is often higher than the rates of normal loans, the obligor has to generate more incomes or to improve the economic outcome of the project.

Risks for creditor
Investors have also to take into account that the crowd funding is subordinated. In case of bankruptcy of the project partner, the crowd receives money only after the higher ranked creditors.

Requirements and necessary securities
In order to minimize this risk, the project owner’s solvency is checked by a credit reference agency working for the crowdfunding platform.

Cost effectiveness
In general, the transaction costs are low. Taking into account the promotion activities carried out from the obligor who addresses the crowd, additional efforts and cost are necessary. On the other hand, promotion is not mandatory, but it is the obligor’s interest in order to create more awareness for his services or products.

2.9.8 Other funding by citizens
Citizens can support bioenergy projects by delivering the equity for the legal structure, such as an energy cooperative or an association. All these models do not only unleash investments in bioenergy villages they lead also to higher acceptance of energy efficiency and they facilitate regional engagement for the energy transition. There are different types of funding by citizens, two of the successful examples are:
The German project “Steinfurt Material Flows” (Steinfurter Stoffströme) focuses on maximising synergy effects in the area of regional materials flow. The project is embedded in the Bio Energy Park, which hosts seven wind turbines, a solar power park, a biogas plant and a biomass composting plant. Behind the Climate Community Saerbeck is a tight cooperation between the municipal department of Energiemanagement Saerbeck, which is responsible for the project management, and the climate advisory/steering committee that consists of 12-14 individuals from the local community. In addition, a booster club of the citizens of Saerbeck is supporting the project. The working of the Climate Community is also supported by the Förderverein, a booster club of the citizens of Saerbeck. Local and regional investors and citizens spent an investment amount of 70 million € on the Bioenergy Park. Additional financial support came from different sources and parties such as grants from the federal state of North Rhine Westphalia (NRW), the staff cost of a project manager financed by the Federal Environmental Ministry and subsidies from the European Union. The local citizen cooperative “Energie für Saerbeck” also invested in the solar park and in one wind turbine at the bioenergy park site (Cityinvest, 2015).

The ECO Watt GmbH & Co KG has been founded with the aim to finance (and implement) ECMs in a public school in Freiburg (Germany). Interested citizens gave financial contribution to this project that was realised as contracting project. The registered association FESA acted as a trustee for the gathered capital from citizens. The minimum investment was set at 511 € for parents and teachers, and 2,556 € for external investors. In addition, the Öko-Bank contributed the remaining amount of money. The project was very successful, since the involved citizens received an interest rate of 6% /y through the savings and the school also received money from the annual savings (Seifried, 2007).

. Since the PR activity is a basic element of this instrument, these project partners accept higher interest rates that have to be counted on the crowd. The crowd (investors) receives annual interests within a defined time period generated by the savings or revenues through the implementation of ECMs. Therefore, crowdfunding platforms act with venture capital and investors do not have the status of shareholders.

Bettervest, one of the crowdfunding platforms in Germany, finances in particular energy efficiency projects that are examined by an experienced energy advisor before. The capital from the crowd is transferred

<table>
<thead>
<tr>
<th>Investment volume</th>
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<tbody>
<tr>
<td>The extent of the available capital depends on the existing financial resources of citizens and their willingness to support the project. Aside from the citizens, regional companies and others can be involved to increase the funding of a relevant investment volume.</td>
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<table>
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<tr>
<th>Flexibility</th>
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<tr>
<td>Since citizens are more involved in the projects that they finance, they also accept changes of the financing conditions on basis of a statement of reasons. Therefore, this instrument can be considered as flexible.</td>
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<table>
<thead>
<tr>
<th>Risks for obligor</th>
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<tr>
<td>Citizens as investors are very motivated to support the projects and to improve their economic outcomes. Therefore, citizens do not expect high interest rates and high profits from the projects.</td>
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<tr>
<th>Risks for creditor</th>
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<tr>
<td>Investors have also to take into account that the funding by citizens is subordinated. In case of bankruptcy of the obligor, citizens receive money only after the higher ranked creditors.</td>
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<tr>
<th>Requirements and necessary securities</th>
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<tr>
<td>Often, citizens cooperate with experienced experts, who can assess the economic calculation of the projects and the project owner’s solvency in order to reduce performance and investment risks.</td>
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<tr>
<th>Cost effectiveness</th>
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<tr>
<td>Citizens have to be informed about the project that they are interested in financing of the investments. In addition, the money has to be gathered and individual agreements prepared. This requires a high preparation effort by the creditor whereas the transaction costs by the obligor are lower.</td>
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### 2.10 Risks, de-risking strategies and quality assurance

Stakeholder risks in bioenergy villages can be classified as economic risks, technical risks and administrative risks. The relevance of the different risks for the different stakeholders who are involved in a bioenergy village depends on the phase of the project too.

#### Initial phase

The risks for the involved stakeholders are relatively low in the initial phase, because the focus is more on creating awareness and interest and convincing people to take energy from the bioenergy plant operator in future. Nevertheless, depending on former experience or bad examples, the initiators of the bioenergy village...
have sometimes to struggle with mistrust, doubts and lack of interest from the citizens and possible heat and power consumers, from the municipal administration or from the farmers, agriculture companies or forest owners. Since a lot of questions need answers at this stage, inter alia questions about the suitable legal framework, about the economic viability of the project, about the revenues from feed in tariffs and the availability of the technologies, the initiator group thereby risks wasting time with rejection of the project at the end. Concerns about availability of feedstock at a competitive price may arise from potential providers or utilities, too. Therefore, it is essential to form a strong community and to present best practice examples. Moreover, the initiator group should be motivated to organise meetings, workshops and information events and to individually discuss the project with the inhabitants and other relevant stakeholders.

Planning phase

The accurate estimation of the investment costs and a correct economic calculation using reliable data are key issues in the planning stage. Two risks need to be considered to ensure accuracy of investment cost calculation: First of all the design needs to follow the national industry or other design and security standards and must consider recent developments in standardized design solutions and must provide the necessary technical accuracy, avoid unnecessary work and material and also consider a degree of cushioning. Also strict regulations regarding hazardous materials in the buildings or districts have to be considered. The standards and regulations have been changing over time. All this creates certain risks which mainly result from inadequate current technical information which have impacts on the following steps (design, implementation and operation). From the perspective of the implementation of the investment these uncertainties create mainly risks on the time schedule of the bioenergy villages and the investment cost in total.

Accurate cost data should be available e.g. on the national level for all levels of design on a commercial basis. In some countries, there are online tools in commercial use that are useful in this context. The investment costs could also be negatively influenced by an early shortfall (before the end of the considered life time period) of a component or system. This would require secondary investments at an earlier point of time as calculated in the cash flow calculation, a higher write-off and additional capital costs for the secondary investment. However, “floating prices” of investments creates risks for the investor, because the investor (citizens, contractor, building owner) has little influence over the price risk.

To reduce the risks for the calculation of the bioenergy and renewable measures, it is recommended that the planners elaborate and describe the planned measures in detail. Moreover, the investment costs can be calculated and the investment cost optimization can be prepared by modelling of different technologies. Contractors or sub-contractors will calculate their bids referring to this modelling in the tendering process.

Since a lack of consistent policy, e.g. long-term subsidy programmes, exists in many countries, the stopping of these programmes nullifies the calculation of the project. A tight schedule and joint forces in the planning stage can help to reduce this risk.

In order to reduce the re-financing risk, a high number of heat consumers should be involved in the project, because the risk of exiting from the contract can be reduced significantly. Optimizing the investment cost-benefit ratio can be achieved by pulling together a building pool which includes ECMs with short-, mid- and long term pay back periods. In addition, the efficiency of the energy supply can be improved in this way and e.g. in the case of CHP power production the change of power supply from the utility to the plant owner contributes strongly to the cost effectiveness.

The capital costs take into account the likely interest rates. Depending on the financing contract, the interest rate can be fixed or can be flexible. In general, long term re-financing is a risk for all loan takers that are required to calculate with a fixed interest rate. Currently the interest rates increase with longer loan contract period. The company (citizens’ company, contractor, utility or others) bears the investment and financing risks that only can be mitigated by a planning and modelling process according to the technical requirements and to the specific price offers for the technical plants and devices. Sensitivity analyses may help to assess the financing risk better.

Financing contracts often contain repayment penalties which can have a significant impact on the economic outcome of the project. A clear payment plan and contract negotiations with the financing institution may reduce this risk. Bioenergy villages will be established the first time in some countries and the realised measures are not very common. Therefore, the availability of capital may be a problem. Initiators of the bioenergy villages have to convince financing institutions of the technical and economic feasibility of the project. They will assess the solvency of the involved companies and probably do not focus on the cash flow of the project. Investors will need high effort to find acceptable financing partners, thus proven as well as new financing instruments should be checked carefully.

Taking into account the energy costs, the volatile energy prices create risks for the investors and operators of the plants. Heat supply contracts contain price adjustment clauses that normally involve fuel or power
price adaptations. Therefore, this risk can be mitigated by suitable price adjustment factors that are included in these clauses. In addition, the biomass supply contract should include such price adjustment clauses, but often these contracts are only agreed for 2-3 years and then, the procurement process starts again.

In the field of ECMs that are also included in bioenergy village projects, the performance risk has to be considered. Expected energy savings could not be achieved or could drop after some years of performance. One of the major risks regarding the cost effectiveness of the bioenergy village is the reliability of the modelling results, in particular of the energy savings and the energy costs after the refurbishment. The result of the technical planning will be combinations of energy conservation measures and supply measures for the building scenarios. The energy balance of the used modelling process contains the energy costs in the operation phase; the comparison with the baseline energy costs delivers the estimated energy savings. Otherwise, proven calculations of savings for single measures or bundles of measures and M&V results can be used in the economic calculation and, if these facts do not exist, a safety factor for first projects should be included.

In general, involving skilled planners and project developers, local experts and experienced citizens and using sample contracts should be applied carefully in order to mitigate all above mentioned risks.

Implementation phase

An extension of the implementation time that increases the pre-financing costs is the major risk in this phase. The extension can be caused through bankruptcy of a general contractor or sub-contractor, through longer delivery times of the technical equipment, new emerging problems such as a rocky ground, pollutants spread in soil or through an uncoordinated planning process. Therefore, a very detailed planning is the most important precondition in order to avoid such risks. In addition, bank guarantees can be applied to reduce the default risk of a general contractor or of a sub-contractor.

Operation phase

First, the default risk of the technical devices and the involved cost risks have to be considered. The operator of the technical equipment takes the responsibility for the availability, functionality and energy efficiency of the measures that are implemented. The operator can be the citizens (e.g. as energy cooperative), contracted providers or ESCOs (see chapter 2.6).

Manufacturers provide a guarantee or warranty for a limited period depending on the national regulations. But these guaranties do not cover the complete operation time of the technical plants, and the risks normally increase the older the devices become. A building automation system and an emergency management are necessary parts of the complete operation management of the technical plants.

In the contracting model, a trouble-shooting service is included in the ESCO services. ESCOs take over responsibilities for the availability, functionality and energy efficiency of the measures that exceed the “normal” guarantee provided by manufacturers. Moreover, ESCOs know the incorporated risks very well and use available empiric data from successful best practices. However, projects with longer contract periods lead to increased and sometimes unforeseeable risks, because maintenance and replacement costs for the technical devices and the re-financing costs will increase or will at least be difficult to predict. These risks should be limited to one life cycle of larger HVAC parts.

In addition, damages of the technical equipment can be covered by building or hazard insurances:

- Fire & wind damages
- Ice & water damages
- Burst pipes
- Boiler and machinery
- Power failures

During the planning phase it should be clarified which insurances already exist (including adaptation) or which insurances are additionally necessary depending on the operating model. A further risk can be the poor quality of the biomass material, therefore the biomass heating systems do not work efficiently or defaults of the machinery often arise. The quality criteria of the biomass material have to be agreed in the supply contract. In order to mitigate this biomass material risk, a periodic quality assurance system should be also established.

The operation of the biomass techniques and renewables is very complex and sophisticated. Experienced staff is necessary to operate, monitor and maintain the technical equipment. As the efficiency of biomass
plants, CHPs, district heating systems and other devices depends on the optimal operation during the life time of the machineries, the operator should be very competent and proficient. Furthermore, payments depending on the efficiency of the technical equipment are very helpful to motivate operators such as in the contracting model.

Measurement and verification is a main task during the operation time. It will become even more complex as changes of utilization, of the number of heat consumers, the close down of buildings or other changes of energy consumption will occur. The risks which the building user’s behaviour may have on the performance should be considered in detail. Otherwise, measurement and verification experiences from running projects help to understand and manage project performance risks and allocate them among the parties much better.
3. **Contractual issues**

Contract are an important part of an overall business model for bioenergy villages as usually various parties are involved in the implementation and operation of a bioenergy village.

A **contract** is an arrangement between two or more parties that is enforceable at law as a binding legal agreement. It arises when the parties agree that there is an agreement. The Formation of a contract generally requires an offer, acceptance, consideration, and a mutual intent to be bound. Each party to a contract must have the capacity to enter the agreement. A contract is often evidenced in writing or by deed, but a valid contract may be made orally or even by conduct.

In general, it must be highlighted that the most important contracts in bioenergy projects should involve **professional advice** of a lawyer. The evaluation of several biomass project related contracts show that contracts are made in insufficient detail (Valentin, 2009).

Links to public sample contracts are given in chapter 5.

### 3.1 Overview on contracts for bioenergy villages

A bioenergy village is characterized by one or several biomass value chains which may include different types of feedstocks that are converted into different energy services. Thereby, various stakeholders and organizations are involved, as described in chapter 2.2. Depending on the number and size of the value chains as well as on the complexity of the overall bioenergy village concept, various contracts need to be set-up. The following core value chains are frequently implemented in bioenergy villages. Thus, typical contractual issues of these chains are presented in more detail below, as the aspects are similar. However, details of the contracts can differ considerably between the concrete examples.

- Agricultural biogas plants
- Waste biogas plants
- Biomethane plants
- Solid biomass heating plants
- Solid biomass CHP plants
- Biomass trade centres

**Agricultural biogas plants**

Agricultural biogas plants are often owned and operated by one or several farmers. Sometimes, the plant is owned by an investor, but operated by the farmer. Figure 24 shows the contracts of a typical farmer-owned biogas plant.
Waste biogas plants

In waste treatment biogas plants, the business model depends on the type of the waste, as it could be based on municipal solid waste (MSW), agro-industrial waste, food waste, sewage sludge waste, or on a combinations of different waste streams. The owner of the biogas plant could be a public or private entity and include also the collection of the waste or not.

This influences the application of contracts between the different parties. A main difference to agricultural biogas plants is that waste biogas plant operators usually gets a tipping fee for treating the waste, whereas the farmer of an agricultural biogas plant usually pays for the feedstock. Another difference is that usually more health safety and hygienic aspects need to be considered, especially also in relation to the use of the digestate. However, in principle, similar contracts apply for agricultural and waste biogas plants.

Biomethane plants

Larger biogas plants may upgrade the biogas to biomethane which has natural gas quality, and inject it to the natural gas grid or use it directly as transport fuel. In addition to the contracts for the biogas production, further contracts may be needed due to the additional upgrading step in the value chain, as shown in Figure 25.
**Solid biomass heating plants**

Heating plants that supply heat to small district heating grids are often community-based projects. Sometimes, the heating plant and heating grid owners and operators are the same entity, sometimes they are separate entities. In many cases, the heat consumers have the opportunity to participate in the project by holding shares. An overview on the contracts of such a project is presented in Figure 26.

![Figure 26: Example of contracts for a woody biomass heating project (Source: Dominik Rutz, WIP)](image)

**Solid biomass CHP plants**

In case that the solid biomass combustion plant is not only generating heat, but also power (gasification, ORC, steam turbine), additional contracts may be needed. They may include feed-in contracts and electricity grid connection contracts. Besides that, the contracts could be similar to the contracts of a biomass plant that only generates heat. An overview on the contracts of such a project is presented in Figure 27.

![Figure 27: Example of contracts for a woody biomass combined heat and power project (Source: Dominik Rutz, WIP)](image)
Biomass trade centres

A biomass trade centre is a regional entity that organizes the logistics of woody biomass supply. It usually buys woody biomass from producers and sells it to biomass users. Typically, different biomass fuels, such as firewood, woodchips, pellets, energy crops are marketed at guaranteed quality and prices. Services of a biomass trade centre may include the harvesting, drying of biomass, chipping, pelletizing, packaging, delivery, etc. At the same time, the biomass trade centre may be also the operator and owner of a small district heating grid. An overview on the different contracts of a biomass trading centre is shown in Figure 28.

Figure 28: Example of contracts for a biomass trade centre (Source: Dominik Rutz, WIP)

3.2 Contracts with manufacturers

During the planning, construction and operation of a biomass project the investor and operator is usually working in close cooperation with the manufacturers. The manufacturer may be a turn-key service provider that is in charge of the whole construction until commissioning. In this case, the plant operator has to deal contractually only with one other party. It could be also several manufacturers that deliver their equipment to the plant owner. In this case, several contracts are needed.

Depending on the value and complexity of the equipment, contracts may be needed at the different stages of the project implementation:

- Purchase agreement
- Installation contract
- Service and maintenance contract

An important aspect that may influence the decision on the manufacturer selection is the offered equipment warranties which may be extended beyond the legally required duration.

A long-term service and maintenance contract of the manufacturer for expensive equipment, such as the CHP unit or the boiler, reduces risks and helps to maintain the good performance of the plant.

3.3 Contracts with land owners

Depending on the value chain, long-term contracts with land owners for land rental may be needed to mobilize enough biomass for the plant. This is more relevant for agricultural land than for forest land, as land rental for forest land is not very common due to the long harvesting periods. Thus, land rental contracts is mainly applied for the cultivation of annual or perennial energy crops on agricultural land, especially in biogas value chains.

Besides land rental contracts, also service contracts with land owners may be made. They may include the following services:
Besides feedstock-related contracts with land owners, special contracts may be needed to ensure access to land for construction purposes. This applies especially to the installation of small district heating grids whereby the pipes must be installed under public and non-public land, including private backyards, agricultural land, infrastructure such as roads, etc. Thus, the grid owner or operator must agree with the land owner on the conditions to use the land for installation purposes. These easement agreements should be fixed in contracts. An easement is the non-possessory right to use or enter onto the real property of another owner without possessing it.

3.4 Contracts with biomass suppliers

Biomass suppliers may include farmers, forest owners, waste management companies, or industries. The contracts may be related to the following feedstock types:

- Wood chips
- Pellets
- Saw dust
- Logwood
- Forest residues
- Substrate for biogas (silage)
- Organic fraction of municipal solid waste
- Other organic waste
- Straw
- Other agricultural residues

In many biomass plants, especially in biogas plants, a continuous supply with substrates is necessary. If a supply of substrates cultivated by third parties is required, feedstock supply contracts are needed to agree on the supply conditions. The contract may include the following important aspects:

- **Type of the feedstock**
- **Quality of the feedstock:** water content, dry matter content, energy content, ash content, applied standards and specifications, proofs of origin
- **Quality of the feedstock:** in tons, cubic meters
- **Procedure of delivery:** delivery to the plant or delivery at source of origin
- **Monitoring and control measures:** intervals, type and procedures for biomass samples
- **Delivery intervals:** depends on the storability of the feedstock, the storage capacity at the biomass plant and
- **Duration of the contract:** 3-10 years
- **Recycling of residues:** agreements on recycling digestate or ashes as fertilizer
- **Price:** fixed price, index-related prices
- **Conflict resolution:** jurisdiction clauses, penalties, warranties, liabilities, general provisions, etc.

Especially the specification of the quality of the feedstock is an important issue, as this has a direct impact on the technology and efficiency of the biomass plant which could be based on combustion or on anaerobic digestion.

For solid biofuels such as woodchips, pellets, briquettes and logwood the ISO standard ISO 17225-1:2014 on “Solid biofuels -- Fuel specifications and classes” should be applied and referred to in the contract. There are also other related ISO standards for determining the fuel quality and for taking samples.

For wood chips, especially the characteristics that influence the combustion process are important. These are the woodchip size, water content, dry matter content, energy content (heating value), and the ash content, which should be considered. Lower quality fuels are generally cheaper, but the combustion unit (boiler,
CHP unit) has to be suitable for lower quality fuels. This applies especially to non-woody biomass, such as straw, as the combustion of straw is related to some challenges (high chlorine content, low as melting point). In general, the classification of pellets in standardised categories is much simpler, as the production process is more standardised. For pellets, similar aspects are included in the ISO standard as for woodchips.

Agricultural biomass for biogas production is more inhomogeneous and thus, no ISO standard exists. However, it is recommended to include quality aspects in feedstock supply contracts, such as:

- Dry matter content
- Organic dry matter content
- Methane yield
- Size
- Harvest time and storage conditions
- Content of impurities (e.g. sand, stones, mould)
- Legal classification (which may be relevant for the feed-in tariffs)

A general aspect for biomass supply contracts is the duration of the contract. The typical duration of biomass supply contracts is 3-10 years. The longer the contract is, the lower is the risk and the better is the economic planning.

Depending of the system, the feedstock costs are usually a very large share of the overall costs. For example, it accounts for about half of the annual total costs of a biogas plant. Price fluctuations of other fuels, such as fossil fuel prices may impact the bioenergy system, as consumers tend to compare prices for biomass supply with overall energy prices. The price for the biomass is fixed in the contract (fixed price contract), or related to an index (e.g. to fossil fuels) or to a market price (market price contract). Investigations on the price related contracts of biogas plants are made and summarized by (Reise, Liebe, & Musshof, 2012).

Often, contracts also include aspects on the recycling of residues, this means when, how and to which price the residues are given back to the biomass supplier. National and local regulations need to be considered when agreements on the recycling on residues are made.

Digestate from anaerobic digestion is a high quality fertilizer which can be used by the farmer for fertilizing the fields. The quality of waste biogas plants depends on the input material and the treatment technology. Often, the digestate is treated and used in the same way as digestate from agricultural biogas plants. However, regulations on contaminants, such as polymers and heavy metals need to be considered.

The use of ashes as fertilizer or as road construction material depends on the quality of the woody biomass, as well as on the type of the ashes. Thereby, the limiting factor is the concentration of heavy metals which is mainly accumulated in the fly ashes, whereas the grid or bottom ashes usually have lower heavy metals concentrations.

3.5 Contracts with biogas users and biomethane grid operators

If not used by the biogas plant operator himself, non-upgraded (raw) biogas can be sent through biogas pipelines to biogas users. Typically, these users convert the biogas in CHP units to generate heat and power. In this case, a (raw) biogas supply contract should be made. This should include the quality and quantity of the supplied biogas. Important is the sulphur concentration in the biogas which needs to be low in order not to damage the gas engine. Ensuring low sulphur concentrations could be the responsibility of the biogas plant operator, or of the CHP unit operator.

Upgraded biogas to biomethane quality is usually fed into the natural gas grid. Depending on the legislation, a gas grid connection contract may be needed. It should specify the location of the connection point, the quality of the gas and the capacity of the injection. Either the legislation or the contract should furthermore specify who pays for the connection pipelines, who owns the upgrading and the conditioning technology.

Finally, a biomethane supply contract should be made with either the biomethane trader or the end user of the biomethane. In order to record the biomethane supply, the use of biomethane certificates (green certificates) may be required.

3.6 Contracts with heat consumers

In many bioenergy projects, the heat generation and distribution to consumers is a core business activity. The heat is transferred from the heat generator to the consumers through a small district heating grid. For the installation of the pipes, easements must be agreed with the land owners, as described in chapter 3.3.

With the consumer, heat supply contracts are made. Even if there is no dedicated written contract, a contract is made between the heat supplier and the consumer. In this case, existing legislation on district heating...
applies. However, in order to minimize potential conflicts, it is recommended to elaborate and sign dedicated written heat supply contracts.

Furthermore, it should be considered to elaborate and sign a preliminary contract or a memorandum of understanding between the heat supplier and consumer during the planning phase and before the real heat contracts are signed. The purpose of these preliminary contracts is, on the one hand, to provide security for the grid operator in the planning phase to make the overall project economically feasible and to get enough revenues from the heat sales to cover the high investment costs in a certain period. On the other hand, the heat consumer has security to get connected to the heating grid and to get the heat at a certain price (index). This is especially important if the existing heating system is very old and if the heat consumer would have to refurbish the heating system in the near future. However, the details and the commitments in these preliminary contracts can be more or less binding, depending on the conditions. They may even include same or similar articles as the real heat supply contract which is signed during the implementation phase of the grid.

The most important basic content of these heat supply contracts may include (Wagner & Glötzl, 2014)

- **Subject of the contract**: start time, duration, termination clause
- **Heat supply specifications**: capacity, quantity and temperature of heat supply, minimum and maximum supply, details on the heat source (renewables)
- **Grid issues**: map of the grid, location of the heat consumer and heat generator(s)
- **Heat transfer station**: location of the heat transfer station, ownership of the heat transfer station, transfer point
- **Installation costs**: costs for the installation of the connection pipes, energy meter, and transfer station, re-establishment of damages after construction
- **Heat counting and monitoring**: installation and ownership of the heat meter, data transfer and data protection, measurement frequency
- **Maintenance and operation**: responsibilities for maintenance (e.g. heat transfer station) and operation, electricity for the heat transfer station, calibration of energy meters
- **Information**: obligations to inform about maintenance work, failures, price changes
- **Prices**: basic price, connection price, energy price, measurement prices, equipment (rental) prices, heat price calculation
- **Payment**: instalment payments, final revision and payments, accounting period, default of payment, payment type
- **Access right**: for maintenance work, meter reading
- **Liabilities**: in case of disturbance
- **Severability**

The most important aspect of the contract is the price of the heat supply service. Often, the price is differentiated in the following categories, whereas not all categories must be applied:

- **Connection price**: in €/kW or in € per connection point; unique fee only paid at the first connection of the heat transfer station to the grid
- **Basic price**: in €/kW connection capacity to cover the fixed cost
- **Energy price**: in €/MWh heat supplied per year to cover the actual demand related costs
- **Measurement price**: annual fee for the measurement, maintenance and calibration of the energy meter
- **Equipment rental price**: in case that the heat transfer station is owned by the grid operator, he may charge a rental fee for it

Similar to biomass supply contracts, the energy price for the delivered heat can be either fixed or is related to an index. This index calculation must be included in the contract.

The heat price depends very much on the provided service. There are two main different concepts, namely supply of basic heat, and full heat supply, as described by (Rutz, Mergner, & Janssen, 2015) and (Rutz, Doczekal, Hofmeister, & Laurberg Jensen, 2017).

In the concept of basic heat supply, the grid operator supplies only the available fraction of a heating plant to the heat consumer. This model is often used if the heat is supplied by the waste heat from already installed biogas plants or other facilities that have waste heat available. The operator does not guarantee the full
heat supply. Therefore, it is necessary that the heat consumer is also equipped with additional (existing) boilers that can be switched-on in case that insufficient heat is supplied by the biogas plant operator. This mainly occurs in times of peak demand or during system failures and maintenance. In the basic heat supply system, the risk of the heat plant operator is reduced to a minimum. However, the plant operator usually does not receive reasonable prices for this heat. Heat consumers generally benefit from very low heat prices, but have to pay for the installation and maintenance of additional boilers.

In the concept of guaranteed heat supply, the whole heat demand is supplied by the heating plant operator. This is the typical model if dedicated heating facilities and heating grids will be newly installed. This model includes also the supply of peak demand e.g. in cold winters, as well as the supply in case of system maintenance or failure. In many contracts in Germany, the heat supply for temperatures of down to -15°C is guaranteed. In this system, the heating plant operator has higher investment costs, since he has to install and maintain peak or emergency heaters. In this concept, the risk is higher for the plant operator since he has to guarantee continuous heat supply. Since the consumer has fully outsourced the heat supply to the biogas plant operator, higher heat prices can be charged. The comfort for the consumer is higher.

3.7 Contracts with power grid operators and utilities

If the biomass plant is producing power (and heat) which should be fed into the grid, the connection to the grid and the sale of power must be considered. This is often regulated by national legislation, especially if feed-in tariffs apply. Depending on the legislation, power supply and grid connection contracts may be mandatory or voluntary.

If they are voluntary such as e.g. in Germany, and if the issues are well regulated by legislation, dedicated contracts with the grid operator or energy utility may even not be recommended. Often, the power grid operator proposes a contract which shall be carefully evaluated by the biomass plant operator. This can be a main difference to e.g. heat supply contracts which are usually drafted by the plant operator.

In case, that a power supply and grid connection contract is mandatory, the most important aspect is related to the feed in tariffs and its requirements.

3.8 Contracts with electricity consumers

Besides feeding power into the national power grid, new business models for the direct sale from renewable energy generators to consumers are currently being developed. This, however, is again related very much to the national legislation. In some countries, it may be possible to directly sell power to third parties other than the utility; in some countries, it may not be possible due to too high barriers. It may depend on the distance between the supplier and consumer, if the power is transmitted through the public grid or through an own grid, if the consumer is still connected or disconnected to the public grid, etc. In these cases, contracts are important, but it makes no sense to specify this in more detail here in this document. If direct sale is considered, national legislation as well as the grid operator and the energy utility should be contacted and legal advice taken.

3.9 Contracts with shareholders, investors and banks

In general, the investment costs for bioenergy technologies are considerably high. In addition, in bioenergy villages, dedicated new start-up entities with limited equity may be created that own and operate the installation.

The choice legal structure of the new entity influences the needed equity and debt capital. Thus, contracts with banks, investors and shareholders may be needed to collect money for the installation of the technologies. Details on this are described in chapters 2.9.

A good legal structure for a new entity of bioenergy villages may be cooperatives, which means that the energy (heat) consumers and other inhabitants of the village have the opportunity to become shareholders by buying shares. Thereby, they may have dedicated rights to get access to information, to participate in assemblies, or to vote.

Again, this depends very much on national legislation and thus, is not specified in more detail here.
4. **Examples of typical business models for bioenergy villages**

4.1 **The citizen cooperative model**

**Stakeholders**

The citizens are the initiators, drivers and communicators of the project, but they are also in charge of the project planning, of the implementation and of the operation of the technical devices, sometimes with external support. Generally spoken, bioenergy villages set up from citizens have a better starting point to convince the inhabitants than other business models have, because the initiative is locally/regionally embedded. The possibility to partake financially is also in favour of the citizen model, in particular of energy cooperatives. Nevertheless, the responsibilities of the bodies of the legal structure during the complete process and the operation phase need to be clarified.

The municipal administration often plays a crucial role in the starting phase of citizen bioenergy projects. First of all, the municipality mostly is an amplifier for the citizens’ ideas within the community, encouraging local support. If it backs up the citizens ideas, this creates trust among the citizens and they are more willing to join the project. The local government has manifold advantages if the project is successful therefore it is likely to support the project, even at a stage when its outcome is not yet predictable. Its decisions are not solely based on economic factors. Considering the added regional value-chains, the citizen participation and also image reasons are in favour of the citizen cooperative model. On the other hand, it will be very difficult to win citizens without support from the municipal administration. Apart from that, the municipality often helps to promote the cooperative idea by taking part in the project itself. E.g. for district heating projects the municipality often partakes with its own buildings, which make up for a considerable share of the total heat demand.

Customers or energy consumers (heat or power consumers who are not member of the cooperative) are needed to be convinced that it is beneficial for them to partake. This is in many cases a challenging and time-consuming task, since the project’s technical complexity is beyond most customers understanding. The higher the number of involved energy consumers the better is the economic outcome of the project.

Local farmers or agricultural companies provide the feedstock for the bioenergy plants and generate additional revenues. Since the citizen project is promoted and communicated very intensively in the villages, the farmers are key people within the project and responsible for the quality of the biomass material.

Local planners often support the planning and the implementation of the technical plants. Also regional SMEs play often an important role during the planning, implementation and operation phases. Their knowledge of the local environment and the technical background are very helpful and they are very crucial for the optimised operation of the bioenergy plants.

**Used resources and technologies**

The citizen model often has the goal of regionalizing the energy supply, and therefore focusses on the locally available resources. For district heating systems this might for instance be biomass (woodchips) or feedstocks for a biogas plant. Citizen projects often have a strong focus on independence from fossil fuels. In addition to renewable energy sources e.g. solar, geothermal or wind energy, the projects often include biomass boilers, CHP plants in combination with district heating systems and a fossil back-up.

In many projects the value chain of citizen projects is limited to heat-delivery. Depending from the local circumstances, waste heat from the local industry is applied in the projects. In some project’s the scope is wider, integrating locally produced electricity from CHP-plants or solar power into their district heating systems and delivering electricity to customers or using it for other purposes, such as electro-mobility. These citizen projects cooperate with cooperative purchasing groups for power and gas.

**Legal structure and ownership model**

The most common form of citizen projects is in founding an energy cooperative. Such a cooperative is a grassroots democracy: It is open for everyone to join in, the statutory rules apply to all members and decisions are made in an assembly, in which the principle „one man, one vote“ is used. The municipality, the local utility and local companies sometimes partake in the cooperative. The ownership of all technical plants is by the citizens’ cooperative.
Operation model

In many cases operation is provided by the cooperative itself. Depending on the capacity, the knowledge and the experience it can either be done by its own members or in cooperation with utilities or engineers. The cooperation can include maintenance, accounting and/or procurement.

Since bioenergy projects often focus on district heating systems, the cooperative acts as a heat provider to customers. In such a case the cooperative uses the heat supply contracting, that includes the complete planning, implementing, financing and operating of the heat generation systems and the district heating system (see chapter 2.7.2).

Cash Flows and Financing

Financing depends on the availability of local capital and the cost of external capital. The equity capital is contributed by the members of the company. In addition, loan capital is included in the project that is provided by a bank or through a third party financing due to high investment sums or to better financing conditions. If subsidies are available these are of course included into the project.

The members commit to the project through their investment. Since these projects are long-term investments, withdrawing money is not intended. On the other hand, the citizens capital is a subordinated loan, therefore bank loans will covered firstly if the project breaks down. If the project generates surpluses these are distributed to the member’s according to their share. In the citizen cooperative model, the members decide how much dividend is paid, in citizen cooperatives (Germany, Austria) dividends from e.g. 3-5 % p.a. are common. Surpluses can also be used to build up a financial backup, to support social and cultural projects or – in case the members are also customers- to lower the purchase prices.

If the cooperative supplies heat via a district heating system to the customers, than it receives basis payments and consumption-based heat rate.

Risks, Strengths and weaknesses

The citizen model has a good starting point to initiate bioenergy villages. As a local grassroots movement it is open to all citizens. Since everybody can participate and share in the benefits, the citizen model is likely to win public support by the municipal government. The momentum and trust that can be built up by the locally rooted initiative makes things a lot easier to create a “we”-feeling.

However, even if a group of people to initiate the project forms, it needs more than just persuasiveness to implement the ideas. There is a risk that persistence wavers if any obstacles prevent a quick success, since the citizen model is often based on volunteers - people who are willing to invest their free time to push-start the project.

Another risk originates in the lack of professionality. If capacity in project implementation and management is non-existent or if there is a lack of knowledge about approval planning, suitable financing, legal requirement or efficient operation, this might result in a project delay and higher costs. Or the project may fail altogether.

Coupled with external knowledge this potential weakness can be overcome. Cooperating with professional consultants or engineering companies in the planning and implementation phase as well as in operation or outsourcing the services that cannot be delivered within the cooperative (or at least not efficiently).

To sum it up: The basic “ingredients” to success are a municipal back-up, persistence, a good communication strategy, clear responsibilities and professional external partners.

4.2 The integrated energy contracting model

Stakeholders

Often the on-site expertise of building owners or local stakeholders and the existing capital are not sufficient to implement the systems and also operate them efficiently. Therefore, the building owners assign a customized energy service package for the results of the measures taken by an ESCO. The assumption of technical and economic risks by the ESCO constitutes an added value for the customer.

Thus, the Energy Service Company (ESCO) is the key stakeholder in this model. An ESCO offers energy services which may include implementing energy-efficiency measures in bioenergy villages on a turn-key basis. In other word, the ESCOs offer customized energy service packages (consisting of planning, implementing, operation, maintenance, energy controlling, optimisation, fuel purchase, (co-)financing, user behavior ...) and take over commercial, technical implementation and operation risks over the complete project term. Public utilities, engineering companies or other SMEs work as an ESCO in German or Austrian bioenergy villages.
In every case, the ESCO concludes the biomass supply contract with the local farmers or agricultural companies. Since the ESCO has to work very profitable and takes care for many projects, it’s looking for very attractive prices for biomass or other energy carriers using strong price negotiations and pooling agreements with suppliers e.g. pellet suppliers that can be also produced in a wider area. In particular public utilities are very experienced in buying and selling electricity, gas or other fuels that can be also used in the bioenergy villages.

Normally, the ESCOs take over all tasks connected with energy efficient implementation and operation of the technical systems. However, in some cases the ESCO is supported by local tradesmen companies or SMEs that realise installation works, the periodic maintenance or the incident management.

**Used resources and technologies**

Since the expertise of the ESCO is very high, the realised measures comprise the reduction of energy demand through the implementation of energy efficiency measures in the fields of building technology (HVAC, lighting), building envelope and user behaviour and the efficient supply of the remaining useful energy demand, preferably from renewable energy sources. The extent of the measures depends on the economic outcome of the project, on the availability of subsidies and additional payments from the building owners for measures with long pay-back times.

**Legal structure(s) and ownership model**

ESCOs are often organised as limited liable company or stock company. Because ESCOs invest into the technical equipment in third-party buildings, the financing institutions require securities. Therefore, the ESCOs own all devices that they have implemented in the bioenergy village. Sometimes, the ownership of specific investments in ECMs is transferred to the building owner directly after their implementation.

**Operation model**

ESCOs mostly handle the operation of the technical devices more efficiently than unexperienced operators. The integrated approach of the model comprises both a) the operation of the ECMs and b) the operation of the heating generation systems or other renewable energy systems. The building owner bears the responsibility for the operation of the ECMs. In addition, quality assurance instruments secure the functionality and performance of the ESMs (see below). The ESCO is in charge of the technical equipment in the heating cellar and of the district heating system, the heat meters are the interfaces between both the building owners’ and the ESCOs’ responsibility.

The ESCO is managing, controlling and operating the building technology primarily through a web based building automation system that includes goal values and current values of different technical parameters. The operation of the technical devices contains also the maintenance of the implemented equipment, the replacement of defective devices and the periodic controlling of the heat consumption data.

**Cash flows and financing**

The ESCO concludes contracts for its services with every building owner separately, therefore it has to account all services with every building owner.

The remuneration of the ESCO comprises three parts: The consumption-related price that is calculated on basis of expenditures for biomass and fuels and auxiliary electricity. This price will be adjusted every year by using statistical energy price indices depending on the fuel used (e.g. gas or biomass index), which are defined in the contract. The service price is a flat rate for all operation related costs such as the cost for operation & maintenance, personal, insurances, management of the energy supply infrastructure as well as of the ECMs. A monetary assessment of all entrepreneurial risks is also included in the service price. The service prices will be adjusted every year by using statistical indices such as income or investment good indices.

Furthermore, the ESCO gets an annuity-remuneration for its capital costs taking into account grants or cost allowances from the building owner.
ESCOs’ remuneration is calculated on basis of a cash-flow assessment of its expenses and revenues for the complete contractual period (life cycle cost calculation). Normally, the ESCO finances all measures using loans on the capital market in combination with equity.

**Risks, strengths and weaknesses**

The integrated contracting model is linked with outsourcing of functional, performance and price risks to the ESCO that constitutes an added value for building owners. Besides, the integrated energy contracting model includes a quality assurance and simplified measurement and verification procedures for the ECMs installed. The quality assurance instruments can be classified in short-term, medium-term and long-term performances and should be agreed in the contract, possibly with penalties, if quality assurance is not fulfilled. They can e.g. contain an additional controlling of the detailed planning documents, defining of specific requirements such as quality standards or maximum energy indicators or limited deployment of fossil fuels; comparing target and current energy consumption values or one-time verifications after implementation such as performance tests, efficiency measurements and others. However, a reasonable ratio between quality assurance and control, on the one hand, and the expenditures on the other hand, should be taken into consideration and has to be defined pertaining the specific project requirements.

Experienced ESCOs can assure a professional and cost-efficient project and receive a high level of local acceptance of the project.

**4.3 Resource based business model**

Very often there are the local biomass suppliers the most interested stakeholder group for implementing a bioenergy village. This can be a group of farmers, forester or the regional biomass processing industry e.g. food processing industry, saw mills, pulp and paper industry or manufacturer of wood products.

The possibility to use low value biomass, side products and residues for energy production is often seen as an opportunity to increase the added value and diversify the income structure. At the demand side are the citizens and the regional administration. Both sides can win from a regional material, energy and money flow. In order to secure long term stability of the market, energy suppliers and consumers are being called to make a contract, which defines the conditions of energy supply and demand. Such contracting between biomass and energy supplier and the consumer of energy represents the legal basis for supply and demand of energy. Due to this background, the resource based business model is a common variation of an energy contracting company (ESCO).
Biomass produces which produces bioenergy and operates the distribution faces the same framework conditions as described in the integrated energy contracting model (see chapter 4.2). This includes especially the framework conditions for financing and return on investment. Furthermore, the supplier of bioenergy faces similar risks, strengths and weaknesses of the business model such as facilitated long-term planning, risk sharing and the professional service.

Stakeholders

The main challenge in a bioenergy village is to bring supply and demand together. The key stakeholder groups in this process are biomass suppliers such farmers and farmer cooperatives, forest owners, biomass trading companies. At the demand side are local communities, private and public institutions such as schools, hospitals and other public buildings, policy makers, small and medium enterprises, and the citizens. The objective is to use energy contracting to secure long-term stability in demand and supply.

The most important stakeholders are coming from the supply side of biomass. The biomass is primarily harvested by the land owners itself. However, the technical development of the forestry and farming sector results in increasingly outsourcing of harvest and transport of biomass to technical service providers. The produced biomass can be used for food, feed, material and energetic applications. For example, high value wood is sold to the wood processing industry while wood of lower quality and residues remain for energetic purposes. This wood can be used to produce energy wood assortments and sold to regional consumers or utilized in a regional biomass heating plant. Instead residues from farming and food processing can be used in biogas production.

Agricultural products are primarily processed to food and feed. Residues can be used for energy production. Woody biomass is processed in industries such as pulp and paper, saw mill and other wood processing industries. These industries process round wood to high value products. Nevertheless, nearly half of the material remains as by-product which can be used to produce wood chips or pellets for energetic purposes. Against this background biomass processing industries often searches for possibilities to utilize the residues and become an energy supplier. This can be a biogas plant, biomass heating plant or biomass CHP plant.

Neverhless, a functioning market on regional bioenergy requires a sufficient demand. Therefore, local energy consumers and the municipality need be involved as well. It is beneficial to involve this stakeholder at an early stage of the project in order to plan and coordinate supply and demand of energy. Additionally, early involvement of the demand side display reservations and obstacles for implementing bioenergy projects.

Legal structure(s) and ownership model

The legal structure and ownership model can differentiate widely and will depend on local conditions. The most common legal structures are cooperatives and small enterprises. Supply and demand is contractual agreed between the two parties.

In general, cooperatives are autonomous formed and democratically directed by its members. The advantage of a cooperative is the flexible organizational structure of stakeholders with a common interest. In case of bioenergy, biomass suppliers (farmers and foresters) and energy producers, which could also biomass suppliers, organizes the sufficient energy supply. In specific cases, a local cooperative can include energy consumers and the municipality as well. The bioenergy is supplied by farmers and foresters which are mostly shareholders of energy production facilities. An important trigger to form a cooperative is to archive economies of scale. Another driver to form a cooperative can be to bundle know-how, equipment or economic power.

Especially, if the bioenergy village is started by a local biomass processing company (SME), the energy production is mostly owned by that company. Nevertheless, biomass suppliers remain strongly connected to the energy producer and benefit from the new business as well. Contractual agreements between energy producers, biomass supply as well as bioenergy consumers help to ensure stable market conditions. There would be also the possibility that biomass supplier and energy consumers become shareholder of the bioenergy production facilities. This help to ensure the support of the local community and strengthen the financial base of the project.

Operation model

The value chain of bioenergy includes generally the production of biomass, its utilization to energy and the consumption of energy. For coordinating supply and demand, the business model is characterized by contractual agreements. In general, energy contracting is market orientated model and sells the bioenergy one or more users. It is a relatively new opportunity for investments with high added value appropriate for forest owners, farmers, and other target groups in rural areas. Contracting offers the opportunity to sell energy through energy contracting to public infrastructure, industry and households. Depending on offered services, the opera-
tion model can be distinguished between supply of biofuels, energy supply and energy supply with additional services.

Supply of biofuels: The most obvious way for biomass producers to support the development of a bioenergy village is to prepare and provide different biofuels which meet the quality requirements of the combustion systems. The quality of biofuels can vary differentiate. National and international standards such as the EN 17225 help to produce biofuel of a certain quality. Guidance on good practice in wood based biofuel production in different languages is provided by e.g. the biofuel handbook of the Biomass Trade Centres. From the demand market perspective, the biomass producer can primarily serve two markets. The first one includes the regional bioenergy producers or enterprises that require large biofuel quantities. This requires very often long-term contractual agreements between the supply and the demand side. In Austria, for example, forest owner associations guarantee a sufficient biofuel supply for district heating operators by long-term contracts. The second market is the individual biofuel market which demand smaller volumes of biofuel at higher prices. Additionally, the demand can be characterized by seasonal fluctuation.

Energy supply: In order to gain higher added values from the biofuel production, the biomass producer could start to become an energy supplier. This could be done as an individual business, a cooperative or any other legal entity. The organization of fuel and energy production remains within the responsibility of the biomass producer. Usually, the maintenance of the energy production and energy supply facilities is carried out by equipment manufacturer or a specialized company. Dependent on local demand, the operator can focus on different kinds of energy supply such as heat for heating, cooling or for processing e.g. steam or compressed air. The contractual agreement defines the extent of energy delivered and its measurement, usually in Megawatt hours (MWh). At the demand side, the building or other energy consuming facilities remain in the responsibility of the energy consumer. The responsibility of the energy supplier ends usually in the boiler room. This operation model is very common for local micro grids or district heating networks.

Energy supply with additional services: In addition, the energy supplier additionally takes over the responsibility for in-house installations. Professional services such as maintenance, troubleshooting or optimization and energy measures ensure efficient energy supply at lower energy costs. By offering such services, the supplier expands and diversifies the sources of income and reduces the dependency on energy consumption. Additionally, the bioenergy supplier can influence the design of the installed system. For the consumers, the main advantages are

- Reduced expenses through outsourcing to experts,
- Function-, performance and price guarantees,
- Commercial and technical risks take over the energy supplier.

Reliable conditions for demand and supply should be ensured by contracting. This ensures that the energy or service can be marketed for a certain price over a certain period of time.

Please consider:
In order to calculate financial and technical models for the described business models, the same methodology which is described in chapter 2.8 can be applied in the preparation phase of each business model.
Links to suitable sample contracts are listed in chapter 5.
5. **Further information**

**Economic calculation of energy saving measures:**


**Technical information about bioenergy technologies:**

- [www.biofuelstp.eu/](http://www.biofuelstp.eu/)
- [http://www.cropgen.soton.ac.uk/publications.htm](http://www.cropgen.soton.ac.uk/publications.htm)
- [http://www.energetische-biomassenutzung.de/](http://www.energetische-biomassenutzung.de/)
- [http://www.qmholzheizwerke.at in German only](http://www.qmholzheizwerke.at)

**Sample contracts:**

- **Heat supply contracts:**
  - [https://www.edfenergy.com/sites/default/files/sme_fixed_contract_terms_and_conditions_0714_0.pdf](https://www.edfenergy.com/sites/default/files/sme_fixed_contract_terms_and_conditions_0714_0.pdf)
  - [http://sparkenergy.co.uk/documents/spark_energy_supply_contract_terms_sept15.pdf](http://sparkenergy.co.uk/documents/spark_energy_supply_contract_terms_sept15.pdf)
- **Biomass supply contracts:**

Bioenergy:
– https://mediathek.fnr.de/broschuren/fremdsprachige-publikationen/english-books.html

General information about bioenergy villages:

Calculation tools of bioenergy measures:
– http://www.bioenergy4business.eu/services/plant-dimensioning-tool/

Contracts
– https://tinyurl.com/j5m3c5l
6. References


Biovill. (2016a). Local and regional framework conditions to support the establishment of a "bioenergy village". Biovill. (2016b). National framework conditions to support the establishment of "Bioenergy villages" in Croatia, Macedonia, Romania, Serbia and Slovenia.


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### 7. Annex

#### 7.1 Checklists for the development of adapted local technology and infrastructure concepts for heat supply and CHP based on bioenergy models

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<td>kW</td>
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<td>Required room temperature</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Standard outside temperature for dimensioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current energy demand according to invoices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffer available? (Volume?)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy saving potentials determined?</td>
<td></td>
<td></td>
<td>kW</td>
</tr>
<tr>
<td>Reduced heat load after implementation of energy saving measures (room heat, hot water, process heat)</td>
<td></td>
<td></td>
<td>kW</td>
</tr>
<tr>
<td>Reduced energy consumption after implementation of energy saving measures (room heat, hot water, process heat)</td>
<td></td>
<td></td>
<td>kWh</td>
</tr>
<tr>
<td>Concept to cover load peaks developed?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantification of annual fuel demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition of the most suitable type of fuel (own possibilities, costs, availability)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a need for mixing fuels (various wood fuels in the storage area or in a chronological sequence)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In what time slots can the fuel change?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which different fuels can be used?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the fuel specified according to standards and is this information provided to the equipment supplier?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provided the fuel supplier a guarantee for the supply and quality of the desired fuel?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the terms of delivery agreed with the supplier?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were there possible price changes between summer and winter season considered?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the costs for delivery (e.g. Pellets) considered?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the fuel included in guarantee declaration of the plant supplier?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Storage

<table>
<thead>
<tr>
<th>General clarifications</th>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the required or economically reasonable storage volume determined?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A surplus of space has been taken into account when determining the storage space volume?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relevant standards and other possible requirements for storage areas (building regulations, fire protection etc.) are considered?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was there a preliminary exchange of information with the licensing authority?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How should the fuel be filled?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is an outside tank, container or silo required?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a ventilation to remove water vapour or fermentation gases required of planned?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the construction company or the storage / silo supplier informed about the fuel type, quantity and design of filling?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are different offers for internal fuel transfer systems requested?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### For existing storages

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the available storage in the vicinity of the planned boiler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it possible to fill the storage by tank or dump truck?</td>
<td>dump truck</td>
<td>tank truck</td>
</tr>
<tr>
<td>Does the storage capacity correspond to the requirements regarding geometry (room discharge) and approval requirements as well as statics?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are non-removable storage installations (power lines etc.) sufficiently protected?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### For Pellet storages

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can the filling station be reached by truck (distance max. 30m)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the connections protected by covers?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the security advice &quot;CAUTION Prior filling SWITCH OFF HEATING&quot; available?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the filling construction grounded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the impact protection mat correctly installed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the storage door equipped with a surrounding door seal?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the keyhole sealed from inside?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are protective boards attached to the door inside?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are floors and walls dry?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Heating system

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a requirement for authorization or notification of the installation?</td>
<td>authorization</td>
<td>notification</td>
</tr>
<tr>
<td>Is a possible funding considered (state, district, municipality)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the conditions of possible subsidies clarified?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there an approved boiler room?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Is it ensured that the boiler room is suitable? If there is too little</td>
<td></td>
<td></td>
</tr>
<tr>
<td>air, the combustion does not work well (too high energy consumption,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>safety risks).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the chimney suitable for the energy system?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the chimney have to be renovated or replaced?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the energy system offered meet the official safety regulations?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the boiler supplier informed about the purpose of the facility,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the required performance, the fluctuations in demand, the fuel provided</td>
<td></td>
<td></td>
</tr>
<tr>
<td>etc.?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the offer and, subsequently, the order confirmation refer to your</td>
<td></td>
<td></td>
</tr>
<tr>
<td>general requirements?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are different offers checked for comparison (by listing the individual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>items)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a maintenance checklist including execution steps and time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>intervals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the responsible company/person for maintenance tasks selected and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trained?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is a maintenance contract concluded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the warranty statement show which parts of the system are seen as</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobile, immovable or wear parts?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there clarity about the warranty periods for the plant and the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>individual plant components?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there clarity about possible reasons for exclusion from the warranty?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are emission measurements necessary for the approval of the installation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have the costs for measurements been considered?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the disposal of the ash calculated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the combustion efficiency guaranteed for the specified performance?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Financing**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a possibility to outsource the supply of heat to an energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>service company (contracting)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the heat costs for a contracting solution surveyed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is a loan financing preferred?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is leasing possible for e.g. boiler, storage, and installations up to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fuel deliveries?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible subsidies have been checked with regard to the intended</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>financing?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 7.1.1 Template on governance rules that are relevant in bioenergy villages

<table>
<thead>
<tr>
<th>Governance rules</th>
<th>Preparation process</th>
<th>Operation phase (Contractual regulations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent structures and processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability and transfer of all relevant information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooperative and faire relationships between stakeholders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear decision-making procedures and responsibilities of stakeholders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptability of the process and managing errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Considering local circumstances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring, controlling and accountability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conflict management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respect of rules and agreed sanctions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---