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Determining economic efficiency & funding gaps

Manual for the excel based calculation tool

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1 Introduction

With the Excel based *LowTEMP_economic efficiency and funding gaps LTDH_V0-9* tool, hereafter referred to as the tool, users are able to determine the economic efficiency of an investement in a low-temperature district heating (LTDH) system as well as in a conventionell district heating (DH) system. If the investment will not be profitable after a period of 20 years, the tool will calculate a funding gap. This is the amount of the investment that cannot be covered by revenues within the period of 20 years. It can be the basis for applying for funding but the results of the tool do not imply any approval of that.

The following types of investment can be considered with this tool: generating plant only, grid only, or both. The user needs to type in technical and economical data to define the investment. This manual gives guidance on that.

1.1 Purpose of the tool

LTDH has a huge potential to achieve substantial environmental gains while reducing primary energy use and creating possibilities to use surplus energy and distrib-uted renewables as sources in DH networks. Using local energy sources also in-creases flexibility and energy security.

The major challenges when it comes LTDH are not so much related to technical issues but often connected to economic or organisational aspects. Not only, because DH systems are monopolistic by nature, i.e. strictly regulated in terms of prices and tariff models. Also, investments in LTDH seem to be a financial burden in the first realization phase and funding schemes seem to be missing.

Actions like the reduction of primary energy consumption, the introduction of efficient district heating systems with cogeneration plants, the integration of renewable energy supply, the increase of the system flexibility and the reduction of final energy consumption are realized in European (EU) municipalities mostly as specific local investments and not on a large scale. The reason for this is, that looking at these actions under short-term market-oriented aspects, such investments need large upfront capital and may lack profitability and have a funding gap. However, with regard to climate protection targets, the promotion of climate-relevant projects, which do not have sufficient economic viability, is still absolutely sensible and necessary.

In the case of non-prioritized economic viability, it is necessary to demonstrate the economic viability gap in terms of investment and the amount of unprofitable costs. This tool is able to demonstrate this. It is recommended to use it as an assistance during the planning process of (LT)DH systems but not as a final result of the planning.

1.2 Target groups

Target groups of this tool are municipal actors who are responsible for the strategic planning of DH grids and DH suppliers as well as funding authorities and potential investors.

1.3 Structure of the tool

The tool is Excel based and neither has hidden spreadsheet nor is it secured by a password. It does not use Macros or Visual Basic for Applications (VBA) in order to reach a broader audience.

The user has to give inputs to certain topics. Blue cells highlight the input cells or dropdown menues where action is needed by the user.

All other cells as well as the structure of the tool are protected by Excel's "protect workbook command", see figure 1.

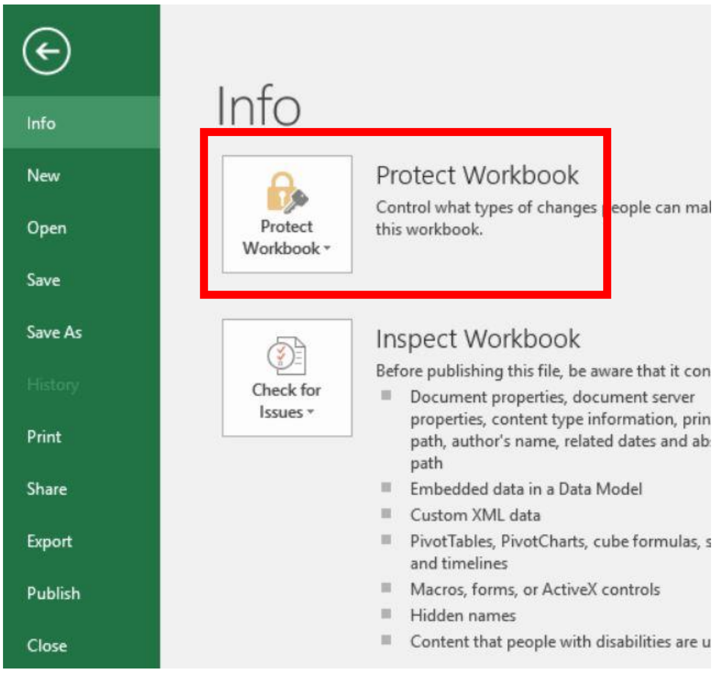

figure 1: protect workbook set-up (own source, 2019)

The tool consists of five spreadsheets that are described in the following subsections. The prerequisites that are needed to fill out the following inputs are described in *3 Prerequisites* as well as their determination.

1.3.1 Input data

The spreadsheet "input data" is the one with the most input required. The following input needs to be given and known by the user:

- Input 1: investment
- Input 2: costs for operating and maintaining
- Input 3: calculated revenues
- Input 4: heat distribution and other system data

All economical data needs to be given without VAT, net values are needed.

Input 1: investment

figure 2 shows the input cells for the investment. In here, the user needs to type in the amount of the investment that is needed to achieve the project objective and the discount rate.

figure 2: input 1 - investment (own cource, 2019)

Input 2: costs for operating and maintaining

figure 3 shows the required input for costs that occur after the initial investment during operating and maintaining: costs for fuel or purchased heat, costs for maintenance, and general operating costs.

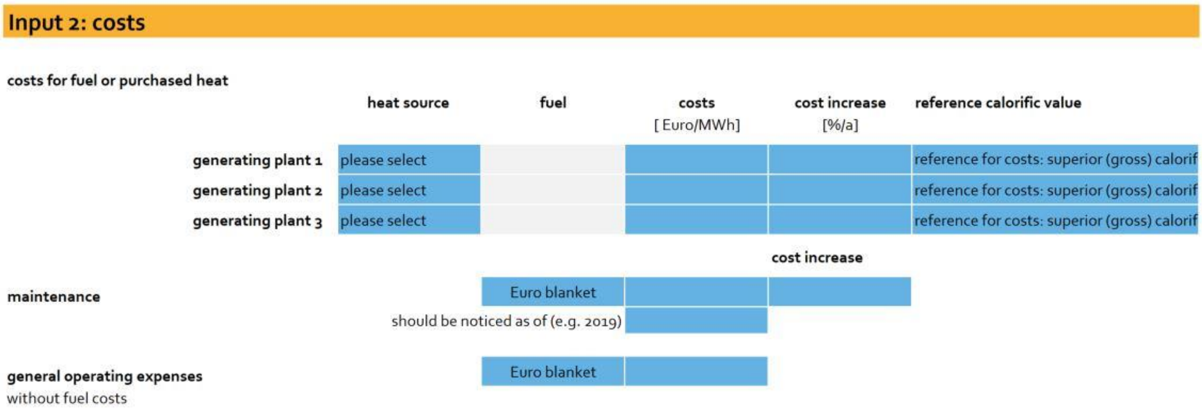

figure 3: input 2 - costs (own source, 2019)

The user can specify up to three different generating plants for DH. Via a dropdown menue in each cell, the user can select from a wide range of different types of generating plants or heat sources:

- Boiler: natural gas, biogas, biomethane, oil, or wood/pellets/straw
- Cogeneration unit: natural gas, biogas, biomethane, or oil
- Heat pump: brine, air, natural gas, biogas, or biomethane
- Solar collector
- P2H
- External heat

By selecting one, two, or three different generating plants, the tool will automatically select the appropriate fuel. The user has to define the purchase price and the expected cost increase.

Costs for maintenance can be defined by either lump sum or percentage of the investment. The expected cost increase and the point of time as of costs for maintenance should be noticed of has to be given by the user.

General operating costs are all operating costs considering the project objective except of fuel costs, e.g. costs for labour, power, insurance, or imputed taxes.

Input 3: calculated revenues

The user has to define the revenues generated by selling heat and, if CHP is used, electricity, see …

figure 4: input 3 - revenues

Input 4: heat distribution and other system data

In input 4, more information on the DH system and its heat distribution is needed: the number of hours of full utilisation per year, the average heat losses and the increase in heat capacity that is expected thorugh the project over the next 20 years.

Besides that, the thermal efficiency of the generating plant(s) needs to be defined. If CHP is used, electrical efficiency is calculated automatically. If more than one generating plant is part of the investment, the share of plant 2 and/or 3 in the generation of heat needs to be defined.

figure 5 shows these inputs.

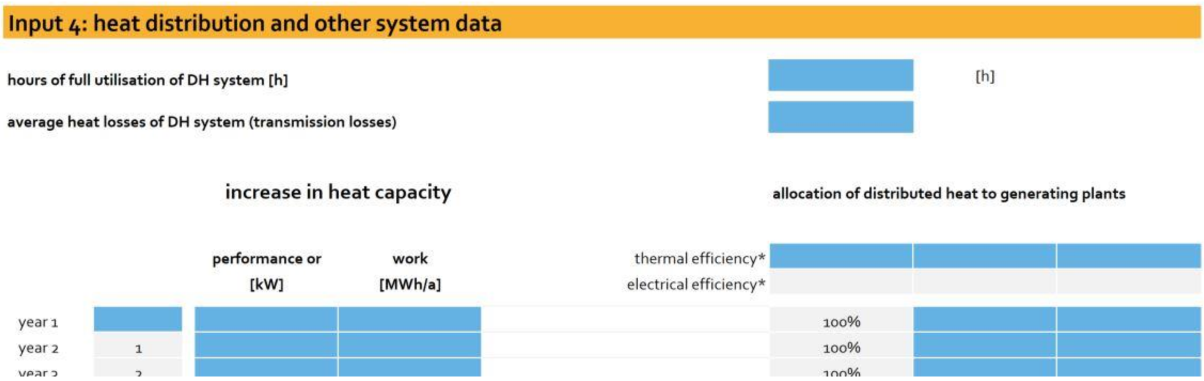

figure 5: input 4 - heat distribution and other system data

1.3.2 Additional calculations

In this spreadsheet, no input is required. In here, the costs for fuel, maintenance and general operating as well as the revenues for the next 20 years are calculated. All cells are visible so that the user is able to understand the calculation. As the spreadsheet is protected, no changes can be made here. Even if the protection of the workbook and of this spreadsheet is deactivated, it is recommended not to change any cells or references to ensure the proper functioning of the tool.

1.3.3 Results

In this spreadsheet the following results are calculated:

- The internatl rate of return (IRR) of the investment and a statement on the efficiency of the project
- If the project is not economic efficient: the amount of the funding gap

These main results are shown in a yellow box, see figure 6.

investment	157,645.51 €
Internal Rate of Return	1.6%
The planned interest rate will not be achieved.	
amount of investment not covered by discounted annuals results	60,682.53 €

figure 6: main results, example (own resource, 2019)

Below, all cash flows over the next 20 years are calculated and discounted to their present value.

There, the user is able to define an optional input, namely the amount of other incomes, e.g. funding. It is recommended to insert other incomes after calculating the funding gap in order to see the effects of them on the whole calculation.

1.3.4 Background data

In this spreadsheet, dropdown menues, references, and text blocks are listed which are used in the spreadsheets before. In here, the user is able to define his or her own types of generating plant, the corresponding fuel and its ratio of superior to inferior calorific value in blue cells, see figure 7.

dropdown menue	*reference*	*reference*	
type of generating plant	**corresponding fuel**	**conversion factor to inferior calorific value (Hi) according to DIN 18599-1 AH B**	
please select		fuel	HS/Hi
boiler_natural gas	natural gas	natural gas	1.11
boiler_biogas	biogas	biogas	1.11
boiler_biomethane	biomethane	biomethane	1.11
boiler_oil	oil	oil	1.06
boiler_wood/pellets/straw	wood	wood	1.08
cogeneration unit_natural gas	natural gas	electricity	1.00
cogeneration unit_biogas	biogas	solar energy	1.00
cogeneration unit_biomethane	biomethane	-	1.00
cogeneration unit_oil	oil		
heat pump_brine	electricity		
heat pump_air	electricity		
heat pump_natural gas	natural gas		
heat pump_biogas	biogas		
heat pump_biomethane	biomethane		
solar_collector	solar energy		
P2H_electricity	electricity		
external heat	-		

figure 7: possibilities of own setups in background data (own resource, 2019)

Although a wide range of different generating plants and fuels are already given, it is possible that new inventions may be used in future case studies. Therefore, the tool offers the option to set up new components. When defining new types of generating plants, a corresponding fuel and a conversion factor have to be given always.

Otherwise, all non-blue cells are protected.

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1.3.5 Version

This spreadsheet shows the current version of the tool. Although tested on one pilot measure, it is still possible that the tool might be adjusted in the future. The author may upload future versions of the tool without notice but will keep the change log up to date. Besides that, author and system requirements are given.

1.3.6 Deactivating and activating the workbook protection

There is no password needed to deactivate the protection of the workbook. To do so, the user has to carry out the following steps:

1. In Excel, go to the tab „File"

2. In "File", go to "Info", see figure 1. If protection is activated, it will be highlighted yellow. In this case, the option "protect workbook structure" and "protect current sheet" is activated, see figure 8. The latter will sum up all protected spread sheets.

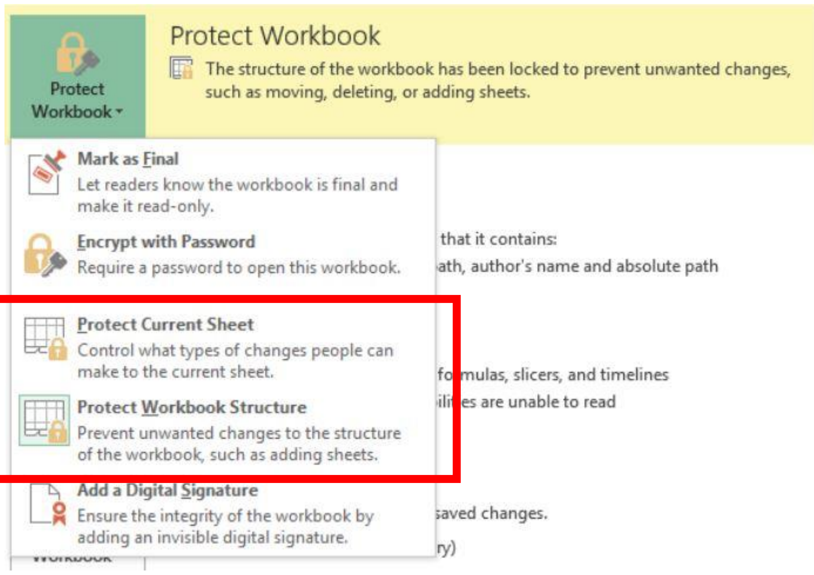

figure 8: activated protection in the tool (own source, 2019)

3. In order to deactivate the protection of a single spread sheet, click on "unprotect" behind each spread sheet.

4. In order to deactivate the protection of the whole file, click on "unprotect workbook structure".

5. After deleting protection, in order to protect either the workbook structure or a single spread sheet, click on either "protect workbook structure" or "protect current sheet".

However, it is recommended to keep it protected in order to guarantee the proper functioning of the tool. If the user deactivates the protection, the tool is used at the user's own risk.

1.4 Limitations of the tool

Energy savings, which occur in LTDH measures, due to investments in already existing systems can be described as a profit and therefore as a positive cash flow. However, it is not possible to describe energy savings as a parameter at this time because of the following:

Investments in already existing systems, which goal it is to increase the efficiency of the DH systems, have no cash-effective revenues against the expenditures but primarily savings due to avoided costs. In general, there are two options on how to assess such savings economically:

- First, it is possible to technically and economically assess the savings on fuel and their impact on costs for operating and maintenance due to the increased efficiency of the system. In practice, this approach is very challenging as all savings have to be technological and economical clearly definable and have to be assigned to the considered investment clearly. In bigger systems, this can be done only by the operator of the DH system and with the help of simulation tools. An assessment from outside is not possible.
- Second, it is possible to determine the release of additional generating capacities due to the increase in efficiency. With this, the operator is able to connect new DH customers to the system. This results in new revenues that are occurring outside the accounting boundaries though. This approach is only possible when the expansion of the system is planned and not just structural adjustments of the generating plant. Costs for the expansion have to be estimated and deducted from the investment as they do not lie within the accounting boundaries.

In view of the above, both approaches have limits and are difficult to implement in the tool. That is why at this time it is not possible to consider energy savings due to investments in already existing systems economically with this tool.

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2 Methodology

The tool is able to determine the economic efficiency and, if present, the amount of a funding gap of a (LT)DH project. These projects involve either the new construction or measures on generating plant(s), grid, or both.

The tool and its result can be used by the target groups mentioned in *1.2 Target groups* while planning (LT)DH measures. Also, it is supposed to support planning institutions while applying for funding and to work as a communication tool between them and funding authorities. The latter are able to see the effects of subsidies on the profitability of the considered project.

2.1 Determination of economic efficiency

For determining the economic efficiency of a project, the tool calculates the Internal Rate of Return of the project after 20 years. It is the "is the value of the discount rate at which the net present value is zero" (Crundwell, 2008, pp. 173–174). Formula (1) shows the mathematical expression of it where the following shall be (Crundwell, 2008, p. 174):

- n = lifespan of the investment of the measure [years]
- t = time index number, a certain year of the investment [w.d.]
- CF_t = cash flow in year t or in other words the difference between costs and revenues in year t [€]
- IRR = internal rate of return [%]

$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1 + IRR)^t} \quad (1)$$

In order to calculate the CF_t in each year, the tool is subtracting all costs from all revenues that are occurring in that year. Both rely on the inputs the user is making in the spreadsheet "input data" and, if applicable, in the spreadsheet "result" if some sort of funding is alreay approved and known:

- Costs
  - Investment costs, occurring in year 0
  - Costs for operating (general and fuel costs) and maintenance, in years 1-20
- Revenues
  - Revenues generated by selling heat and, if CHP is used, electricity, in years 1-20
- Other incomes
  - Funding in years 1-20, only if applicable and known or for testing purposes

2.2 Calculation of funding gap

A funding gap represents that part of an investment that cannot be covered by revenues within the usual amortization period and is the basis for applying for funding (AGFW, 2019). Hence, a funding gap only occurs if a project is not economic efficient, see figure 9.

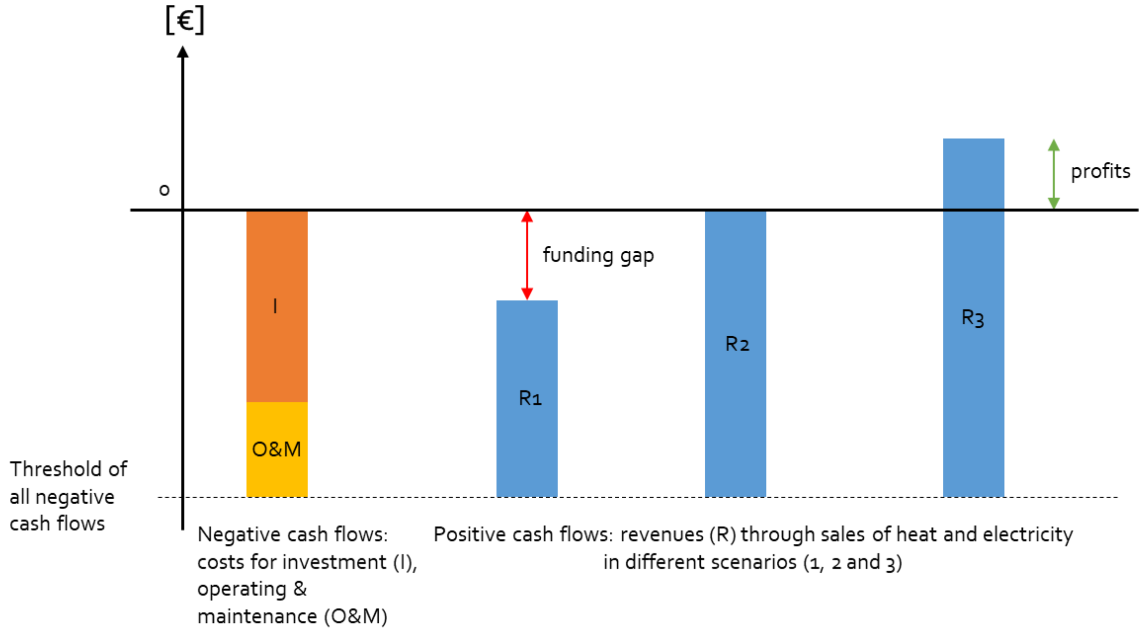

figure 9: principle of funding gaps, positive and negative cash flows (own source, 2019)

In figure 9, the costs (for investment, operating, and maintenance) are set against three different scenarios of revenues that can be made in a project:

- Revenue 1: the sum of all revenues are smaller than the amount of all costs during the considered life span of a project. In the end, a funding gap will be present and the project is not profitable. In order to make to a project profitable, this is the amount of money that is needed and has to come from non-repayable grants.
- Revenue 2: the sum of all revenues is as high as the amount of all costs during the considered life span of a project. In the end, no funding gap will be present but also no profits will be made as the project in this scenario just pays itself off. However, the project will be economically efficient in this case.
- Revenue 3: the sum of all revenues is higher than the amount of all costs during the considered life span of a project. In the end, no funding gap will be present as the project is generating profits. The project will be economically efficient in this case.

Mathematically speaking, the funding gap is the net present value of the whole investment over 20 years or the "difference between the positive and negative cash flows over the lifetime of the investment, discounted to their current value" ((EEAG), point 32). Formula *(2)* shows how to determine this where the following shall be (Crundwell, 2008, p. 169):

- NPV = net present value [€]
- n = lifespan of the investment of the measure [years]
- t = time index number, a certain year of the investment [w.d.]
- CF_t = cash flow in year t or in other words the difference between costs and incomes in year t [€]
- k = discount rate [%]

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t} \qquad (2)$$

2.3 Comparing different scenarios

If different scenarios shall be compared with each other, the tool has to be filled out and saved for each one of them. This can be the case if non-LTDH projects shall be compared with LTDH projects, or different funding scenarios are considered, just to name a few.

3 Prerequisites

In order to use the tool properly and to guarantee correct results, the following prerequsites have to be known to the user prior to using the tool.

3.1 Object of consideration and investment

First, the project objective has to be clear to the user in order to define the object of consideration. It can be measures on either a generating plant, grid or both.

3.1.1 Accounting boundaries

The accounting boundaries have to include everything that is needed to fullfill the project objective. However, this tool only considers measures regarding grid, generating plant, or both. figure 10 shows the largest accounting boundaries possible with this tool.

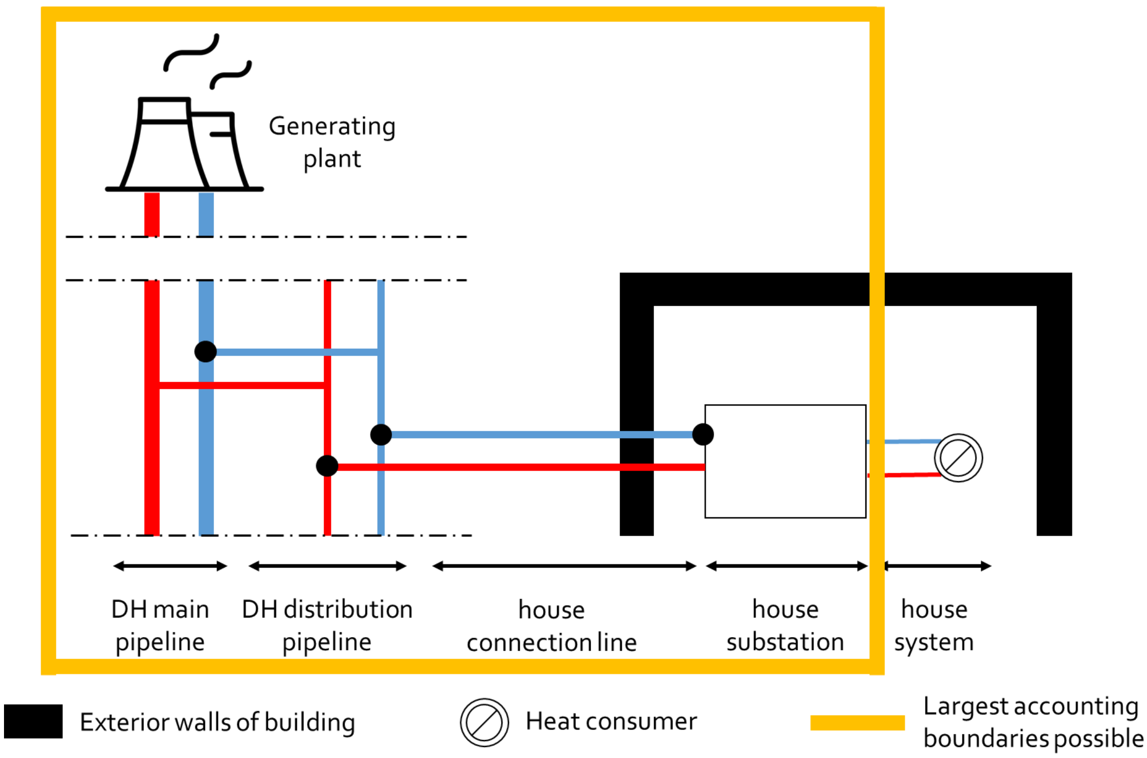

figure 10: largest accounting boundaries possible for the tool (own source following BAFA, 2017, p. 5 and The noun project, 2019)

Everything from generating plant to house house substation can be considered with the tool, as long as it is part of the investment. The house substation is seen as a part of the grid if they are owned by the DH-supplier. If they are not owned by the DH supplier, the accounting boundaries go up to the customer's property line.

3.1.2 Investment costs

Investment costs are the costs that are necessary to build the project objective. Depreciation or financing costs are not considered as part of the investment costs if they are covered by funding.

A detailed list of all (investment) costs parameters is given in *6.2*

Catalogue of cost and revenue parameters. The user can either use this catalogue as a guideline or, if further planning has already been done, use a quote. Investment costs have to be given in € and without VAT.

3.1.3 Discount rate

The discount rate is used for calculating the NPV of all cash flows. It discounts the cash flow of each year to its present value (year 0 of the project). The choice of the right discount rate is important as this has an impact of all cash flows, the NPV and, in the end, on the amount of a funding gap. In general, the following can be said: the higher the risks of a project, the higher the discount rate should be but this demands higher returns as higher discount rates reduce future cash flows more (Frederiksen and Werner, 2014, p. 504). For public investment operations co-financed by European Structural- and Investments Funds (ESI), a discount rate of 4 % is given but exceptions may be made (((EU) No 480/2014), Art. 19).

The user is responsible to consider an appropriate discount rate. On the basis of the information mentioned above, the following recommendation for a discount rate x is given

- 0 % < x > 4 %: for small projects with low costs, low revenues and low risks. The value 0 will not work.
- x = 4 %: for projects that are co-financed by European Structural- and Investments Funds (ESI) or where risks cannot be foreseen
- x > 4 %: for projects with high costs and revenues and high risks

3.2 Costs for operating and maintaining

3.2.1 Operating costs

The following information on operating the planned system and the incurring costs needs to be known by the user:

- Type of generating plant and corresponding fuel
- Fuel costs in €/MWh and their reference to either superior (H_S) or inferior (H_i) calorific value[1], without VAT
- Expected cost increase for fuel costs in %/a
- General operating costs (no fuel costs included), either as a lump sum in €/a or as percentage of the expected revenues in %, without VAT

3.2.2 Costs for maintenance

The following information on maintaining the planned system and the incurring costs needs to be

[1] Fuel costs in €/Mwh relate to the calorific value of the fuel which describes the amount of energy that is released during its complete combustion. The costs can relate to either inferior or superior calorific value. The latter considers latent heat from condensing water vapour in the flue gas as well. Normally, the specification of fuel costs gives information on which calorific value the costs relate to.

known by the user:

- Costs for maintenance, either as a lump sum in €/a or as percentage of the investment in %, without VAT
- Expected cost increase in %/a

3.3 Revenues generated by selling heat and electricity

The user has to give information on the expected revenues that are generated by either selling DH or electricity, the latter only if CHP technology is part of the investment:

- Mixed price for DH that is sold in €/MWh, without VAT
- Expected price increase in %
- Price for generated electricity in €/MWh, without VAT

3.4 Technology data

3.4.1 Heat distribution

The following input concerning the heat disitrbution system of the project is needed:

- Hours of full utilization of the DH system in h/a
- Average heat losses of the DH system (transmission losses) in %

3.4.2 Heat capacity

The tool allows the economical considertation of the project over a period of 20 years. During this time, it is possible to some projects to undergo either an increase or a decrease in installed heat capacity. For example, in year 1, a boiler with 200 kW is installed. Two years later, in year 3, another boiler with 150 kW is installed. This generates an increase in the heat capacity which has a direct influence on the operating costs. Therefor, the user has to know and define any in- or decrease in installed heat capacity per year:

- Year of installation or deinstallation of a generating plant or heat source
- Performance in kW or amount of generated heat as work in MWh/a

If performance as well as work is given by the user, the tool will automatically give priority to work.

3.4.3 Allocation of distributed heat to generating plants

The share in work for each generating plant or heat source of the planned system needs to be defined by giving the follwong information:

- Thermal efficiency in %, e.g. $\eta_{thermal}$ (CHP) = 60 %. If heat pumps are used, the COP[2] or SPF[3] has

[2] COP = coefficient of performance, given by manufacturer.
[3] SPF = seasonal performance factor. Ratio of amount of generated heat to the total amount of electrical energy needed for running the

to be given in %, e.g. if the COP = 4, the input in the tool will be 400 % (same procedure with SPF).

- If CHP technology is used, the electrical efficiency of the plant has to be given as well (same procedure as with thermal efficiency).
- If more than one generating plant is planned, the share in work for each generating plant or heat source has to be defined. In total, all shares sum up to 100 % (the total amount of work produced).

3.5 Funding opportunities (optional)

If funding opportunities for the project objective are known to the user, it is possible to consider them in the calculation as well. Therefor, the following information is needed:

- Amount of funding in €, without VAT
- Year of receiving the funding during the period of 20 years

This input is optional and not necessary to determine the economic efficiency or funding gap of a project.

heat pump.

4 Results

At the top of the spreadsheet "results", an info box gives information on:

- Total amount of investment in €
- IRR in %
- Statement on whether the planned interest rate will be achieved or not
- If present, the amount of investment not covered by discounted annual results or in other words the amount of the funding gap

Intermediate results on costs and revenues as well as their present values are calculated below the infobox, see figure 11.

calculation of unprofitable costs

investment 157,645.51 €
Internal Rate of Return 1.6%
The planned interest rate will not be achieved.
amount of investment not covered by discounted annuals results 60,682.53 €

		costs				revenues			other incomes		result	present value
year	investment	maintenance	operating costs		sum	sales revenues		sum		sum	sum	present value of sum
			general	fuel costs		heat	electricity					
	€	€	€	€	€	€	€	€	€	€	€	€
0	-157,646										-157,646	-157,646
1 2019		-500	-3,905	-42,712	-47,117	53,610	0	53,610	10,941	10,941	17,434	16,294
2 2020		-510	-3,905	-43,566	-47,981	54,683	0	54,683		0	6,701	5,853
3 2021		-520	-3,905	-44,438	-48,863	55,776	0	55,776		0	6,913	5,643
4 2022		-521	-3,905	-45,326	-49,762	56,802	0	56,802		0	7,130	5,439

figure 11:example of info box in spreadsheet "results" (own source, 2019)

4.1 Statement on economic efficiency

The IRR gives information on whether the investment will be profitable after a period of 20 years or not.

If the IRR is positive and higher than the discount rate set at the beginning, the tool will highlight the cell of the IRR green, see figure 12.

investment 157,645.51 €
Internal Rate of Return 1.6%
The planned interest rate will be achieved, the investment is profitable.
amount of investment not covered by discounted annuals results 0.00 €

figure 12: profitable investment with positive IRR (own source, 2019)

If the investment is not profitable, the IRR will be highlighted in red. This can happen in one of the following two cases.

- The IRR is positive but does not reach the discount rate set at the beginning. This shall illustrate the fact that the investment will pay itself off but does not reach the interest rate the user has set, see figure 13.
- The IRR is negative. The investment will not pay itself off after 20 years, see figure 14.

investment	157,645.51 €
Internal Rate of Return	1.6%
The planned interest rate will not be achieved.	
ered by discounted annuals results	60,682.53 €

figure 13: positive IRR does not reach interest rate (own source, 2019)

investment	300,000.00 €
Internal Rate of Return	-4.1%
The planned interest rate will not be achieved.	
ed by discounted annuals results	203,037.01 €

figure 14: negative IRR (own source, 2019)

As soon as the IRR is negative or smaller than the discount rate, a funding gap will be calculated.

4.2 Funding gap in case of non-economic projects

If a funding gap is present, it will be calculated and shown in the info box at the top of the spreadsheet "results", see figure 15.

investment	157,645.51 €
Internal Rate of Return	1.6%
The planned interest rate will not be achieved.	
amount of investment not covered by discounted annuals results	60,682.53 €

figure 15: funding gap as a result (own source, 2019)

5 Glossary

Discount rate: interest rate used in discounted cash flow techniques to calculate the present value of future cash flows.

Economic efficiency: is given when the sum of all revenues is higher than the sum of all costs. Sometimes called “economic fesibility” or “profitability”.

Funding: money in form of a non-repayable grant given by an institution for a project

Funding gap: “difference between the positive and negative cash flows over the lifetime of the investment, discounted to their current value” ((EEAG), point 32)

Internal Rate of Return: the value of the discount rate at which the present value equals zero

Net present value: sum of all cash flows (negative and positive) discounted to their present value

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6 Appendix

6.1 Example of calculation: Gulbene pilot measure

As a guidance, the tool is used on a pilot measure from the LowTEMP project and shown in this section. All information is taken from a questionnaire that Gulbene municipality has answered during the testing phase of the tool. Unless specified differently, the following information is gathered from this questionnaire (Kalmane and Kalniņš, 2019).

6.1.1 Description of the pilot measure

In Gulbene, Latvia, a local heating system was installed in 2019. It provides heat for three municipal buildings, generated by a biomass boiler and distributed in a small local heat grid. Besides that, a smart metering system within the three existing buildings has been installed in order to allow the residents to analyse their heat consumption. (atene KOM GmbH and Thermopolis Ltd., 2019)

6.1.2 Input 1: investment

Accounting boundaries

First, accounting boundaries are defined. According to the description of the pilot measure above, the installation of a local heating system is the goal of the project. Therefore, the following components can be considered as necessary for achieving this goal:

- Biomass boiler
- Small local heat grid

The smart metering system is not considered as necessary for achieving the goal of the project, namely the installation of a local heating system, as it would run without the smart metering system as well. Besides that, this component falls outside the accounting boundaries according to figure 10.

Investment costs

For this, the project partner from Gulbene provided a compilation of all components and services that were necessary to achieve the project objective, see table 1.

table 1: costs overview according to (Kalmane, 2019)

Component / service	Price incl. VAT (21 %) [€]
Designing the construction plan and author supervision	4 756.00
Construction district heating system and boiler house	190 751.07
Construction supervision	968.00
Construction design author supervision	992.20
SUM	197 467.27

As seen in table 1, the investment costs that are necessary to achieve the project objective amount to 197 467.27 €. As the tool requires all prices without VAT, the investment costs required for the input amount to 163 196.09 €.

Discount rate

In this example, the discount rate was set to 4 % but a smaller discount rate can be possible here as the project is rated as a small project.

6.1.3 Input 2: costs for operating and maintaining

Operating costs

In this pilot measure, the biomass boiler is fired with wood pellets which cost 40.00 €/MWh[4]. Their price is expected to rise by 2 % per year.

Besides that, general operating costs are set to 3 905.05 € per year.

Costs for maintenance

Costs for maintaining are set to 500 € per year and should start in 2019. They are expected to rise by 2 % per year.

6.1.4 Input 3: expected revenues

The biomass boiler produces heat that can be sold for 63.26 €/MWh. Its price is expected to rise by 2% per year.

As there is no generating plant running that can produce electricity as well, no electricity can be sold.

6.1.5 Input 4: heat distribution and other system data

The local DH system is expected to run 4 258.60 h per year in full utilisation mode. The average heat losses of the system are estimated at 5 %.

The boiler is installed and put into operation at once at right at the beginning. Therefore, the increase in heat capacity starts with 199 $kW_{thermal}$ in year 1. Its thermal efficiency amounts to 90 %.

6.1.6 Results

Depending on whether other kinds of incomes, e.g. funding, are considered, the following results are calculated.

[4] This price refers tot he superior calorific value of the wood pellets.

Results without any other kinds of income

Without any additional incomes, the tool calculates the following results:

figure 16: results for Gulbene's pilot measure without additional incomes (own source, 2019)

According to figure 16, the IRR amounts to 0.6 %. Hence, the project will pay itself off but does not reach the discount rate set at the beginning, namely 4 %. As a result, a funding gap is still present which amounts to 48 940.87 €.

Results with other incomes considered

The project partner from Gulbene municipality will receive funding for the construction of DH system of 10 941 € incl. VAT (Kalmane, 2019). Without the VAT, the funding amounts to 9 042 € and can be considered in the calculation, see figure 17.

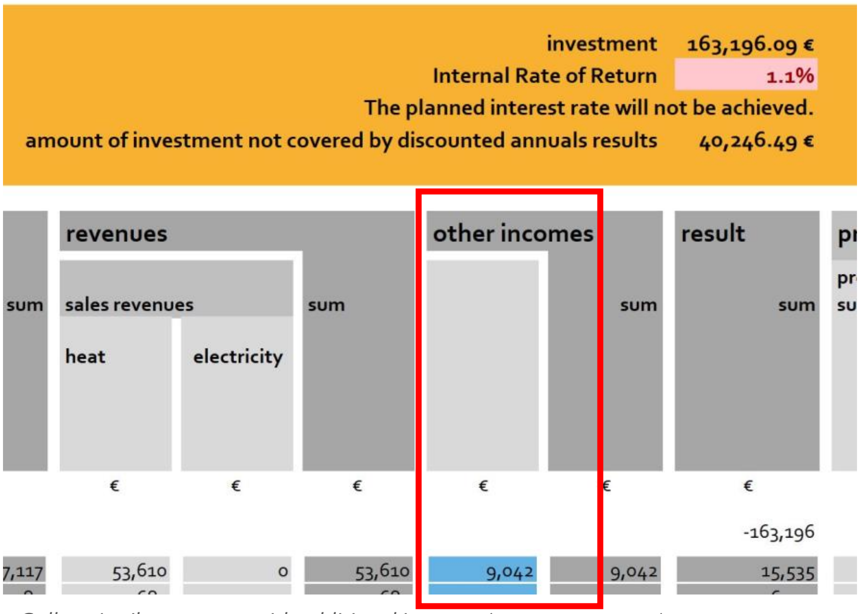

figure 17: results for Gulbene's pilot measure with additional incomes (own source, 2019)

According to figure 16, the IRR amounts to 1.1 %. Hence and in this case, the project will pay itself off but still does not reach the discount rate set at the beginning, namely 4 %. As a result, a funding gap is still present which amounts to 40 246.49 €.

6.2 Catalogue of cost and revenue parameters

The following catalogue gives information on what kind of costs and revenues the user can consider with this tool. The parameters are given in form of a list and without any specific values as these vary from country to country or sometimes even from region to region.

The catalogue works as a guideline. However, the author of this manual does not give any guarantee for completenes. The user of the tool has to check relevant standards and the state of the art in his or her country as well.

6.2.1 Costs

In general, all costs that are necessary to achieve the project objective and lie inside the accounting boundaries shown in figure 10 can be considered here. The following cost categories exist:

- Investment costs (input 1)
- Costs for operating an maintaining (input 2)

Investment costs

table 2 shows cost parameters that are based on groups of cost types defined in the German norm DIN 276: building costs, unless specified differently. Although used in structural engineering, some values of this norm can be taken as a guideline for planning DH projects.

table 2: investment costs parameters according to DIN 276, table 1

parameter	explanation
Building plot	Costs incurring for the plot provided for the object of consideration.
Plot price (value)	This parameter needs separate consideration as a plot usually does not diminish in value over a period of 20 years. Hence, this parameter needs to be considered in year 20. However, the tool is not able to consider investments in different years as it sums up the whole investment in year 0 and takes the time value of money into account. At this stage of development, the user needs to add the plot price manually in year 20 in a separate calculation.
Incidental costs of ownership	Costs that are associated with the purchase and ownership of the plot
Third party rights	Costs incurring for repealing third-party rights in order to dispose freely over the plot
Preparatory measures	Preparatory measures in order to carry out construction work

	on the plot
Preparation	Preparation of the plot
Provision of public services	Costs for buying the public service area Costs for establishing or adapting technical facilities of collective use Costs for establishing or developing areas for public traffic, green spaces, and other open spaces for public use
Provision of non-public services	Costs for traffic areas and technical facilities for non-public use
Compensation measures and compensatory levies	Measures and levies that arise one time and additionaly to provision costs due to public law regulation and by reason of the planned project
Temporary meausres	Temporary measures of structural or organisational nature maintaining utilisation and operation of the object of consideration during construction period
Building - construction	Construction work and supply needed for the completion of the building without technical installations. If conversion or modernization of the building is done, costs for partially demolishing, repairing, safety work, and dismantling are also included.
Pit / earthmoving	Work on soil and topsoil, earthmoving, pits, dams, cuttings, ramparts, slope stabilization
Foundation, base	Measures for foundation and base of the project of consideration
Exterior walls, vertical exterior construction	Bearing and non-load bearing vertical constructions that are located on the exterior face of the building
Interior walls, vertical interior construction	Bearing and non-load bearing vertical construc-tions that are located inside the building
Ceilings & floors, horizontal constructions	Bearing and non-load bearing constructions for ceilings, stairs, ramps, and other horizontal constructions
roofs	Bearing and non-load bearing constructions for flat and inclined roofs and other horizontal constructions that close the building to the top

Infrastructural installations	Independent constructions for infrastructural installations for traffic, energy supply and waste disposal
Structural installations	Installations that are directly attached to the building but without use-specific installations and process-related systems (see below)
Other measures related to construction	Constructions and overarching measures that cannot be allocated to one of the parameters named under "building - construction" or "building - technical installations", e.g. site set-up, scaffold, disposal of materials.
Building - technical installations	Construction work and supply needed for the completion of technical installations of the building. If conversion or modernization is done, costs for partially demolishing, repairing, safety work, and dismantling are also included.
Waste water, water, and gas installations	Primarily sanitary installations
Heat supply installations	Generating plants, distribution grids, room heating, and heating systems for traffic spaces
Ventilation and air conditioning installations	Installations with and without ventilation function
Electrical installations	Electrical installations for power current including fire resistant grommets
Installtions for telecommunication, safety-related installations, and information technology systems	Including necessary terminal blocks, cables, circuits, and fire resistant grommets
Installations for transportation	Elevators, escalators, transport and crane systems, façade lifts, and hydraulic systems
Use-specific installations and process-related systems	Installations that are directly attached to the building and fulfil a specific use, e.g. for kitchens, laundries, laboratories
Building and plant automation	monitoring, controlling, and optimising installations to automatically execute technical processes
Other measures for technical installations	Technical installations and overarching measures that cannot be allocated to one of the parameters named under "building - technical installations", e.g. site set-up, scaffold, disposal of materials.

Additional costs / expenses	Services besides construction works and supplies that are necessary for the project. If additional costs are not known to this level of detail, a fixed percentage of 12 % of costs for materials and construction can be used instead (AGFW, 2015, p. 10).
Principal's tasks	Duties that are performed by the owner or assigned to someone else
Preparation of building planning	Examinations, valuation, services for urban development or landscaping, and competitions
Building planning	Planning and construction supervision
Specialist planning	Planning and construction supervision
General additional building costs	Costs for expert opinions, permits, inspections, operating costs, sampling, provisionally operating, and insurances
Other additional building costs	As-built documentation

Costs for operating and maintaining

table 3 shows parameters for costs incurred during operating and maintaining the object of consideration.

table 3: parameters for operating and maintainance costs

Parameter	explanation
Operating costs	
Fuel costs	Costs for fuel [€/MWh]. Referring to either superior (gross) or inferior (net) calorific value of the considered fuel.
General operating expenses	Costs for operating the object of consideration, including costs for electricity (not to be understood as fuel), insurance, taxes, and staff costs. Can be given as a lump sum or as percentage of annual revenues.
Costs for maintainance	
Maintenance	Costs for keeping the object of consideration running. Can be given as a lump sum or as percentage of the investment.

Costs that are not to be taken into account

Depreciation or financing costs cannot be taken into account, if these are covered by the investment aid / funding.

6.2.2 Revenues

table 4 shows all parameters for revenues that can be generated by the object consideration.

table 4: revenue parameters

Parameter	explanation
Revenues by selling heat	
Mixed price for DH that is sold	Mixed price for DH can consist of contracting price (price per kWh), power price (kW), and metering price
Revenues by selling electricity	
generated by sale of electricity	Only if CHP is part of the DH system

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