Guidelines for the Feasibility Study of APPR VC

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

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ABBREVIATIONS

APPR	Agrarian Pruning and Plantation Removal
CAPEX	Capital Expenditure
FS	Feasibility Study
IRR	Internal Rate of Return
LHV	Low Heating Value
NPV	Net Present Value
OPEX	Operating Expense
PP	Payback Period
PrMov	Prime Mover
VC	Value Chain
VCA	Value Chain Actor

DEFINITIONS

APPR biomass value chain	The set of activities and stakeholders involved in the preparation and use of biomass products obtained out of Agricultural Pruning and Plantation Removal wood (APPR wood).
Prime mover	A stakeholder who has a strong interest and willingness to start a new APPR biomass value chain. It is the main actor in the value chain, the actor who engages the others and who makes the things happen. It is generally the more active actor and usually, the stakeholder taking the most of the risk when investing in the new value chain.

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1 INTRODUCTION

The present guidelines show how to perform feasibility study in order to evaluate the economic performance of each APPR value chain. Via these guidelines, the partners will follow a common methodology in which they will collect economic data from the demonstrations and perform economic evaluations. The methodology described below, will calculate some economic indicators such as NPV, IRR and payback period that present the economic feasibility of each demonstrated value chain. The common methodology aims to perform an economic evaluation on the activities of the APPR value chain from the point of view of each economic actor that participates in each step of the chain.

2 ECONOMIC INDICATORS

From the feasibility study, three economic indicators will be calculated. Firstly, the NPV (Net Present Value), the IRR (Internal Rate of Return) and lastly the PP (Payback Period). Via these three economic parameters, the economic performance of the APPR value chain can be evaluated.

NPV is the difference between the present value of cash inflows and the present value of cash outflows.

The following is the formula for calculating NPV:

$$NPV(i) = -C_0 + \sum_{j=1}^{n} \frac{C_j}{(1+i)^j}$$

Where,

C_j = net cash inflow during the period j

C_o = total initial investment costs

i = discount rate, and

j = number of time period

A positive net present value indicates that the projected earnings generated by a project or investment (in present money) exceeds the anticipated costs (also in present money). Generally, an investment with a positive NPV will be a profitable one and one with a negative NPV will result in a net loss. The discount rate i is calculated as the average company investment return rate.

If NPV > 0, the project yield exceeds the chosen discount rate. The project is economically acceptable for the chosen discount rate.

Another way to calculate faster the NPV is via the NPV function in Microsoft Excel as it is done in the current tool.

IRR is another metric commonly used as an NPV alternative. Calculations of IRR rely on the same formula as NPV does, except with slight adjustments. IRR calculations assume a neutral NPV (a value of zero) and one instead solves for the discount rate. The discount rate of an investment when NPV is zero is the investment's IRR, essentially representing the projected rate of growth for that investment. Because IRR is necessarily annual – it refers to projected returns on a yearly basis – it allows for the simplified comparison of a wide variety of types and lengths of investments. IRR is the minimum discount rate at which the project yield or NPV is positive. Hence it is the annual return rate of the investment. The calculation is as follows.

$$NPV = -C_0 + \sum_{j=1}^{n} \frac{C_j}{(1+IRR)^j} = 0 \text{ => IRR}$$

The IRR can be calculated by setting the NPV=0 in NPV equation and by calculating the rate, or simpler by using the IRR function in Microsoft Excel as done in the current tool.

Payback Period (PP) shows the time required after an investment to recoup the initial costs of that investment. To calculate the Payback Period, it is needed to calculate the cumulative net cash flow for each period and then use the following formula:

$$Payback\ Period = A + \frac{B}{C}$$

Where,

A is the last period with a negative cumulative cash flow;

B is the absolute value of cumulative cash flow at the end of the period A;

C is the total cash flow during the period after A.

Generally, the PP is calculated without considering the time value of cash flows.

3 OPERATIONS IN APPR VALUE CHAINS

In order to perform the economic evaluation we firstly have to define the operations that may participate in each step of the value chain. However, each value chain varies from each other, thus it is difficult to examine each combination of different operations. In this light, a general scheme of group of operations is depicted in Figure 1 and based on these operations, the feasibility of the value chain based on the actor/ activity will be defined.

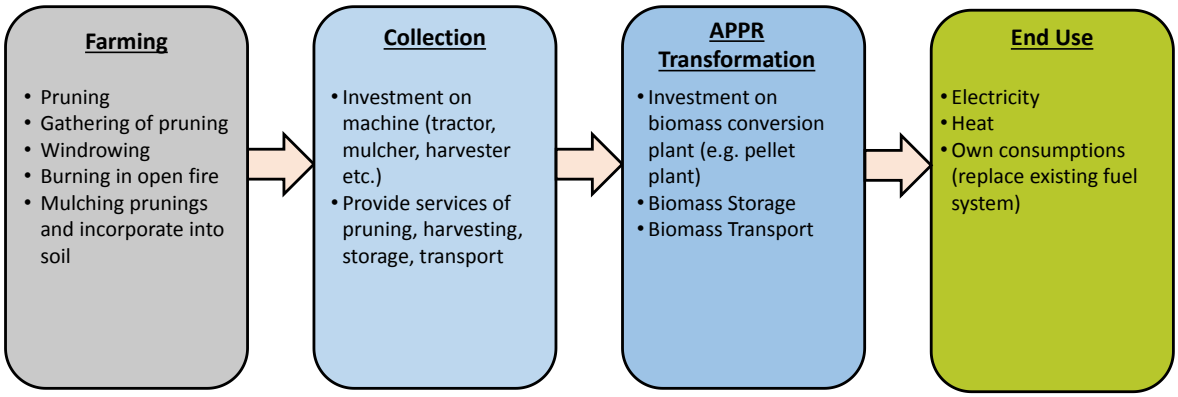


Figure 1. Group of operations that take place in an APPR Value Chain

3.1 Farming

One category of operations that can be clearly identified in any APPR value chain is that of the Farming activities. Farmers are the starting point of each APPR value chain. The activities of this category along with the corresponding costs can be: pruning, collection of pruning, windrowing, mulching prunings and incorporation into soil or transfer and burn prunings in open fire.

3.2 Collection

The second group of operations that can take place in an APPR value chain is that of the Collection activities that include contractors of harvesting machinery, agro-cooperatives or agro-service companies that mainly deal with the treating, collection and transport of APPR from the field. Several costs are attributed to this group of activities like purchase/ rent of the harvesting machine, purchase of the tractor, operational costs of the machineries (e.g. maintenance costs of the machineries, wages of the drivers, etc.), storage costs of APPR and logistic costs.

3.3 APPR transformation

The APPR transformation group includes actors which receive the APPR biomass from previous steps and produce an “upgraded” fuel that can be sold in the market or forwarded to other end-users for the final transformation to energy products such as heat and/or electricity. The typical example of an actor in the APPR transformation group is a pellet plant, but it can also be a case of a plant that is receiving branches or uprooted trees and produces wood chips in a centralized location.

For these activities, the main costs that need to be considered are the following:

- Investment costs for the APPR upgrade process (e.g. static chippers, dryers, pellet presses, etc.)
- Operational costs for the APPR upgrade process (e.g. consumption of fuels for drying, electricity consumption, wages of personnel, etc.)

The income of an APPR transformer is generated from selling the upgraded fuel to the market or a specific end-user. The transportation / logistics costs of APPR to the market selling place or final consumer can be included in these types of economic actors or handled to an additional contractor, depending on the case.

3.4 End use

The final stage of an APPR value chain is that of the market or end use of the final form of the treated biomass. The typical cases is when APPR biomass is used to produce heat, electricity or both (co-generation). Usually, the case of electricity or co-generation implies a specific end-user with particular requests. For the case of APPR biomass for heat, the end-user could also be specific (e.g. a greenhouse, a boiler in a winery, etc.) or the domestic market for biomass fuels, which consists of numerous small-scale end-users.

For this group of operations, the main costs that need to be considered are the following:

- Investment costs for the equipment used in the APPR final energy production process (e.g. a biomass boiler / stove, a biomass gasifier / power plant, etc.) OR the investment cost required for the retrofit of an existing bioenergy system in order to handle APPR biomass (e.g. new feeding line, new cleaning equipment, etc.)
- The operational costs for the APPR final energy production process

Two cases can be discerned:

- Installation of new unit for bioenergy production from APPR biomass. For example, construction of a biomass power plant (selling electricity to the grid) operated by APPR biomass exclusively
- Fuel switch, e.g. replacement of an existing fuel source.

In this sector, it is defined how the APPR is exploited at its end-phase. It is highlighted whether the APPR or part of it is used for self-consumptions or sold as fuel in the market (B2M). Via the current feasibility study, various selling prices of the final product can be examined and conclude for which the value chain is most viable.

Table 1. Costs and Incomes of each Group of Operations in APPR Value Chain

Costs and Incomes of each Group of Operations in APPR Value Chain				
	Farming	Collection	Transformation	End use
Investment costs	Usually zero	Harvesters, tractors, trailers, etc.	Static chippers, dryers, pellet production lines, etc.	Boiler / stoves, power plant, retrofits to existing facilities
Operational costs	Wages for windrowing of prunings, costs for external contractors	Fuel for operation, wages, maintenance, etc.	Fuels / electricity for production, wages, maintenance, etc.	Wages (if applicable), maintenance

Income	Usually zero	From selling APPR biomass with mark-up, providing services to farmers	From selling APPR biomass with mark-up	From selling electricity to the grid, heat to a DH network or final consumer, etc.
Savings	Reduced cost of pruning management compared to alternatives (e.g. mulching, open-field burning)	N/A	N/A	From cost reduction compared to alternative solutions, e.g. natural gas / oil heating, etc.

It should be noted that in a particular APPR value chain, some of the economic roles can be performed by a single actor. For example, it may be a single farmer that decides to invest in harvesting equipment (hence acting as contractor in collection operations), a small scale pellet press (hence acting as transformer in transformation operations) and a new boiler (hence acting as end-user) in order to switch the heating fuel from oil or another type of biomass to APPR. Another example if a farmer takes on the role of contractor and invest in harvesting machines for himself and sell the biomass to a pellet plant. Examples of different make-ups of value chain can be found in the uP_running Observatory, the sector analysis of WP2, etc.

4 FEASIBILITY METHOD

In this section the Excel tool for the economic feasibility of the APPR value chain will be presented.

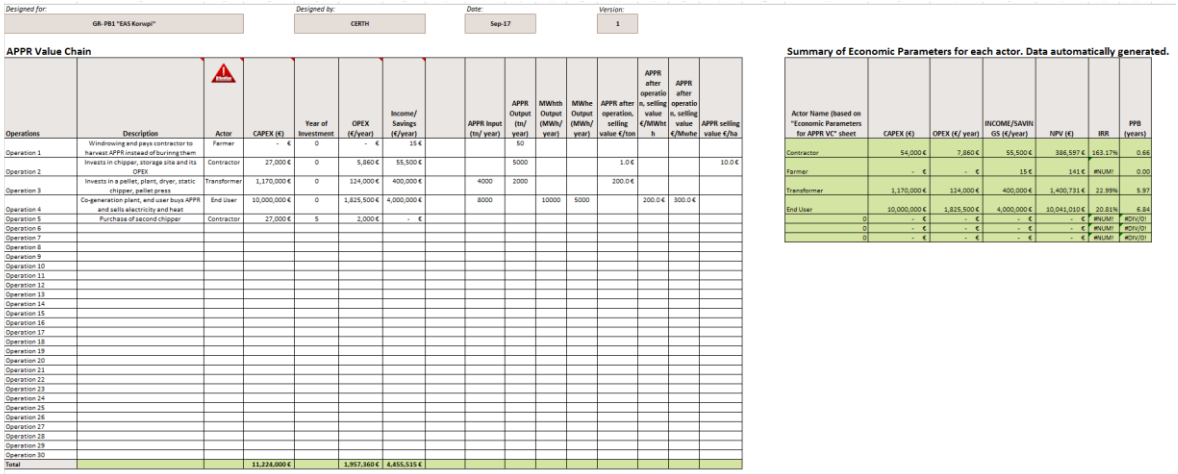
To start with, in all Excel sheets, colored green cells are automatically calculated whereas cells with no color need a value from the user.

The excel file has 7 Sheets:

- “APPR value chain overview”: main sheet of the tool
- “Economic Parameters for APPR VC”: sheet where all the cash flows and economic parameters (NPV, IRR etc.) are calculated
- “FarmingOperations”: auxiliary sheet to aid the user in estimating the costs of the farming operations
- “CollectionOperations”: auxiliary sheet to aid the user in estimating the costs of the collection operations
- “TransformationOperations”: auxiliary sheet to aid the user in estimating the costs of the APPR transformation operations
- “End Use-Green fieldOperations”: auxiliary sheet to aid the user in estimating the costs of the End-use operations when APPR is consumed to produce and sell heat/ electricity
- “End Use-Replace fuel.Operation”: auxiliary sheet to aid the user in estimating the costs of the End-use operations when APPR is consumed for self-needs.

4.1 APPR Value chain overview

The first sheet "APPR value chain overview" is the main sheet of the excel file and is shown in Figure 1. It presents in brief a list of operations that take place in the examined APPR value chain.



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APPR Value Chain

Operations	Description	Actor	CAPEX (€)	Year of investment	OPEX (€/year)	Income/ Savings (€/year)		APPR Input (tn/ year)	APPR Output (tn/ year)	MWhth Output (MWth/ year)	MWhe Output (MWh/ year)	APPR after operation, selling value €/ton	APPR after operation, selling value €/MWhth	APPR after operation, selling value €/MWhe	APPR selling value €/ha
Operation 1	Windrowing and pays contractor to harvest APPR instead of burning them	Farmer	- €	0	- €	15 €			50						
Operation 2	Invests in chipper, storage site and its OPEX	Contractor	27,000 €	0	5,860 €	55,500 €			5000			1.0 €			10.0 €
Operation 3	Invests in a pellet, plant, dryer, static chipper, pellet press	Transformer	1,170,000 €	0	124,000 €	400,000 €		4000	2000			200.0 €			
Operation 4	Co-generation plant, and user buys APPR and sells electricity and heat	End User	10,000,000 €	0	1,825,500 €	4,000,000 €		8000		10000	5000		200.0 €	300.0 €	
Operation 5	Purchase of second chipper	Contractor	27,000 €	5	2,000 €	- €									
Operation 6															
Operation 7															
Operation 8															
Operation 9															
Operation 10															
Operation 11															
Operation 12															
Operation 13															
Operation 14															
Operation 15															
Operation 16															
Operation 17															
Operation 18															
Operation 19															
Operation 20															
Operation 21															
Operation 22															
Operation 23															
Operation 24															
Operation 25															
Operation 26															
Operation 27															
Operation 28															
Operation 29															
Operation 30															
Total			11,224,000 €		1,957,360 €	4,455,515 €									

Summary of Economic Parameters for each actor. Data automatically generated.

Actor Name (based on "Economic Parameters for APPR VC" sheet	CAPEX (€)	OPEX (€/ year)	INCOME/SAVINGS (€/year)	NPV (€)	IRR	PPB (years)
Contractor	54,000 €	7,860 €	55,500 €	386,597 €	163.17%	0.66
Farmer	- €	- €	15 €	141 €	#NUM!	0.00
Transformer	1,170,000 €	124,000 €	400,000 €	1,400,731 €	22.99%	5.97
End User	10,000,000 €	1,825,500 €	4,000,000 €	10,041,010 €	20.81%	6.84
0	- €	- €	- €	- €	#NUM!	#DIV/0!
0	- €	- €	- €	- €	#NUM!	#DIV/0!
0	- €	- €	- €	- €	#NUM!	#DIV/0!

Figure 2. Overview of the main sheet of the feasibility study of APPR Value Chain

In this sheet, the user has to write down for each operation (or group of operations performed by same actor) i) a brief description of it; ii) insert the name of the actor that performs the operation (either names e.g. Sergio, Daniel, Adeline etc. or farmer, contractor etc. or simply Actor 1, Actor 2…); iii) CAPEX costs of the investments needed for the corresponding operation; iv) Year on which the investments will be performed (if they are from the start, default value=0); v) OPEX costs €/year of the corresponding operation and finally vi) Incomes that come from the corresponding operation €/year. In case of a farmer or end user that replaces his heating system, it is savings for them instead of income. This table is made in order to allocate each APPR VC operation to the actor that performs it. Each operation can include either a single operation or a group of operations if only they are performed by the same actor. E.g. Actor "X" invests in a tractor, a mulcher, a trailer, a storage site. These CAPEX costs along with their OPEX and final income that they bring can be included in one operation row in this sheet. This group of data is the data on which the economic calculations that follow depend on.

Furthermore, some auxiliary columns are introduced that refer to the input/ output of APPR (form of APPR varies for each operation) before and after the corresponding operation (e.g. an operation of a pellet plant: input 2000 tn/year of APPR, output 1000 tn/year of "upgraded" APPR-pellets). Moreover, there are some other columns referring to the selling price of APPR (form of APPR based on each operation) after being treated by each operation. These columns appear so as to have an overview of each APPR value chain operation. No data inserted in these columns participate in the following economic calculations.

Finally, there is another table on this excel sheet. This table includes the main economic parameters and main economic results (CAPEX, OPEX, Income) of each actor that participates in the APPR value chain. The table is generated automatically and presents in brief, the main economic aspects of the operations in the value chain based on the actor that performs them.

4.2 Economic Parameters for APPR VC- Cash Flow Analysis

The second sheet "Economic Parameters for APPR VC" consists of the economic calculations performed. Economic calculations are performed for each actor that participates in the APPR value chain. The calculations consider all activities/ operations performed by the actor. Most of this sheet works automatically. The user has to insert the name of the actor as exactly written in the first sheet "APPR value chain overview" and automatically the total costs and incomes appear in the table (Figure 3). The user just has to insert the Economic years for which the calculations will run (max 30 years), insert a discount rate (default 10%), insert a tax rate for the income and finally insert a value for which the working capital is calculated (10-35% of OPEX, by default 22.5%) Working capital is spent at the start of the investments, and retrieved at the end of the economic years of the business.

Actor 1- Economic Feasibility of actor in APPR Value Chain

Actor	CAPEX (€)	Income/ Savings (€/year)	OPEX (€/year)	Economic Years for calculations	Discount Rate	Tax	Working capital (10-35% of OPEX)
transformer	1,224,000 €	455,500 €	131,860 €	20	10%	0%	22.50%

Figure 3. Main table requesting name of actor for starting cash flow calculations

After the user has inserted these values, a discounted cash flow is run automatically which calculates the NPV, IRR and Payback period as shown in Figure 4. In this sheet there are 7 tables where these calculations can be performed up to 7 different actors participating in the APPR value chain simultaneously.

Discounted Cash Flows

Year	Investments	Revenues	Operational Costs	Mixed Revenues	Depreciation	Net Income pre-tax	Tax	Net Income	Net Cash Flows	Discount factor	Present Values	Cumulative Discounted Cash flows	For calculation of Payback Period/ don't change
0	1,226,669 €								- 1,226,669 €	1.00	- 1,226,669 €	-1226668.50	-
1	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.91	294,218 €	-932450.32	-
2	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.83	267,471 €	-664979.24	-
3	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.75	243,156 €	-421823.72	-
4	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.68	221,050 €	-200773.25	-
5	27,000 €	455,500 €	131,860 €	296,640 €	61,200 €	235,440 €	- €	296,640 €	269,640 €	0.62	167,425 €	-33348.02	-
6	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.56	182,686 €	149338.32	0.182542498
7	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.51	166,078 €	315416.81	0.899203252
8	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.47	150,980 €	466397.26	2.089123577
9	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.42	137,255 €	603652.22	3.398035935
10	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.39	124,777 €	728429.45	4.837839528
11	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.35	113,434 €	841863.29	6.421623481
12	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.32	103,122 €	944984.97	8.163785829
13	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.29	93,747 €	1038731.95	10.08016441
14	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.26	85,225 €	1123956.48	12.18818085
15	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.24	77,477 €	1201433.32	14.50699894
16	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.22	70,433 €	1271866.81	17.05769883
17	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.20	64,030 €	1335897.26	19.86346872
18	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.18	58,209 €	1394106.76	22.94981559
19	- €	455,500 €	131,860 €	323,640 €	61,200 €	262,440 €	- €	323,640 €	323,640 €	0.16	52,918 €	1447024.49	26.34479715
20	- 29,669 €	455,500 €	131,860 €	353,309 €	61,200 €	292,109 €	- €	353,309 €	382,977 €	0.15	56,927 €	1503951.58	25.41890809
21	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.14	- €	1503951.58	#DIV/0!
22	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.12	- €	1503951.58	#DIV/0!
23	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.11	- €	1503951.58	#DIV/0!
24	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.10	- €	1503951.58	#DIV/0!
25	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.09	- €	1503951.58	#DIV/0!
26	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.08	- €	1503951.58	#DIV/0!
27	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.08	- €	1503951.58	#DIV/0!
28	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.07	- €	1503951.58	#DIV/0!
29	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.06	- €	1503951.58	#DIV/0!
30	- €	- €	- €	- €	- €	- €	- €	- €	- €	0.06	- €	1503951.58	#DIV/0!
										NPV	€ 1,503,952		
										IRR	26%		
										Payback Period	5.18		

Figure 4. Cash flow calculations

Thus, these are the main sheets of the excel file. To aid the user who fills it, we have made the other 5 sheets that helps the user define the costs for each actor (Operations/ Actors Sheets). These sheets aim to identify the majority of the costs in the operations performed by the actor and

estimate the total CAPEX, OPEX, INCOME of the actor and then insert them to the first sheet "APPR value chain overview".

These 5 sheets work in the same way. The colored cells are calculated automatically while the non-colored cells need a value by the user.

These auxiliary sheets aim to identify the costs performed by actors that can participate in an APPR value chain such as: a farmer, a contractor (services to farmers, mulchers, treat/harvest APPR etc), transformer (pellet company), end user (heat/power generation plant) or end user that replaces his heating system to consume APPR. The sheets are divided by the operations of each actor. However, that doesn't mean that one actor can't perform other actors' operations. If for example a transformer (pellet company) invests in a mulcher, tractor and performs the operations of a contractor, the user should firstly identify and estimate the OPEX/ CAPEX costs and revenues from the corresponding sheets (ContractorOperations and TransformerOperations) and then when the costs are inserted in the first sheet: "APPR value chain overview", the actor name should be the same for both group of operations as they are performed from the same actor= transformer.

4.3 Farming Operations FS

In order to perform a feasibility study regarding the farming operations, we should deal with the activities of the farmers that are influenced from the new APPR value chain and not costs of farmers that don't participate in the value chain. For example, costs like plow, pruning, and sprinkling aren't needed to be recorded during the demonstrations. These costs exist independently of the proposed APPR value chain, thus not influencing the value chain's feasibility.

In the case of the farmers, it doesn't make sense to calculate any of the aforementioned economic indicators (NPV, IRR, PP). However, it is interesting to calculate and compare the costs and profits from the activities of the APPR value chain that substitute the current activities of the farmer. For example, the benefits of the farmers when the contractors of machineries enter their field and harvest the APPR than collected by the farmer himself and burned in open fires.

Firstly, some initial data is needed to be filled regarding the field (Figure 5). The requested information regards the field size, the pruning frequency and an average estimation of APPR productivity in wet tons per hectare. Then, automatically the annual APPR productivity is calculated.

Farm's conditions	
Field Size (ha)	5
Pruning frequency (times/ year)	1
avg estimation (tons APPR/ha)	10
APPR productivity (wet tons/ year)	50.00

Figure 5. Initial Information on Farm's Conditions

Continuously, each partner should record the costs of the current activities of the farmer that will be influenced from the proposed APPR value chain activities. These activities refer to the AS-IS

activities of the farmer (Figure 6). The user is requested to write for each activity: i) number of workers needed, ii) hours needed in hr/worker, iii) wage in €/hr/worker. After having completed this data for each activity, the annual cost and the cost of each activity in €/ha will be automatically calculated. It should be noted, that the costs of farmer's activities must be expressed in €/ha, as this type of measurement unit is comprehended and used by the farmers (they are more fond on using costs per hectare). In case you know the cost of the activity in €/ha, you can directly fill it without completing the rest of cells.

"AS-IS" Operations

Operation	Nr of workers	hours needed (hr/worker)	Wage (€/hr/worker)	Cost (€/year)	Cost (€/ha)
Hauling APPR	2	5	5.00 €	50.00 €	10.00 €
Preparing firewood piles	2	4	5.00 €	40.00 €	8.00 €
Executing fire	1	5	5.00 €	25.00 €	5.00 €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Total				**115.00 €**	**23.00 €**

Figure 6. "AS-IS" Farming Operations

After having recorded the current "AS-IS" activities, it is time to record the activities of the proposed APPR value chain ("TO-BE" situation, see Figure 7) that will influence the farmer's businesses. For example, when a contractor comes to the fields of the farmer and collects the APPR and transfer it to the next step of the APPR value chain. In the following example, the cell referring to the cost of harvesting and treating APPR by a contractor is not colored as it is not calculated automatically. Note that the cost for the harvesting of the APPR by the contractor may have a "±" value. This is because, in most cases the farmer pays the contractor to come into his fields and collect the APPR. However, there is a chance that the contractor will have to pay the farmer in order to get to his fields (not very likely). In this case, the cost should be recorded with a "-" as the farmer gets an income from the contractor for harvesting his APPR.

"TO-BE" Operations in the new APPR value chain

Operation	Nr of workers	hours needed (hr/worker)	Wage (€/hr/worker)	OPEX/ Cost (€/year)	Cost (€/ha)
Windrowing	2	5	5.00 €	50.00 €	10.00 €
Harvesting and treating APPR (payed to contractor/actor 2)				50.00 €	10.00 €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Other				- €	- €
Total				**100.00 €**	**20.00 €**

Figure 7. "TO-BE" Farming Operations

After the identification of the "AS-IS" and "TO-BE" activities along with their costs, the savings from the farmer's point of view are automatically calculated (Figure 8).

Farmer's Savings (€/ha)	**3.00 €**
Farmer's Savings (€/year)	**15.00 €**

Figure 8. Farmer's Savings from the proposed APPR VC

This parameter is expressed in €/ha and if it is positive, it means that the farmer gains that amount of money from the new activities and if it is negative, it means that the farmer will be damaged if he applies the new activities proposed. The red colored cell is what is needed to be copied-pasted in the main sheet "APPR value chain overview" regarding the farming operations.

4.4 Collection Operations FS

In the uP_running value chains that will be demonstrated, there is a group of actors who come to the fields and treat the APPR. This group of actors may contain contractors, agro-service companies, agro-cooperative etc. The corresponding activities may include treating the APPR, harvesting the APPR and transfer it to the next actor in the value chain (e.g. pellet plant). In order to accomplish these activities, the economic actors of this step have several costs and possible investments. Investments such as purchase of tractors, treating machine (e.g. shredder, mulcher, chipper, baler), trailers etc. Furthermore, operational costs as wages, fuel costs, logistics costs etc. also occur.

First of all, some initial parameters should be defined as in Figure 9.

Volume of sales to be achieved		
tons APPR/year	5000	
ton/ha of APPR	10	(we expect 15 t/ha, but we evaluated 10 t/ha to be more secure)
ha/year	500.0	
LHV of collected APPR (MJ/kg)		
Moisture content of collected APPR (%)		
Nr of economic years (max 30 years)	10	

Figure 9. Initial information on Collection Operations

The annual volume of APPR that will be sold from the contractor should be estimated in order to define the scale of the sales and investments that have to be made. In addition, the productivity of the crops on which the actor is interested into, has to be defined. The information of how much APPR is produced from a hectare of field, will also result to the number of land that is needed to achieve the estimated amount of APPR. A general assumption is that each hectare produces 10 tons of APPR, mainly for olive groves and stone trees. Furthermore, the input of the heating value of the collected APPR (LHV- Low Heating Value) along with the initial moisture of the APPR will be needed for the Environmental Assessment that follows (however not for the current feasibility study). Finally, the user can put the number of economic years for which the investment costs can be expressed in €/year.

The next step is to record the equipment related costs that are relevant to the collection operations as presented in Figure 10.

Equipment-Related Costs	A	B	C	D	E	F	G	H
Machine/ Investment/ Activity	If equipment is purchased (€)	Percentage of usage (%)	Total CAPEX (€)	If equipment is rented instead of purchase (€/year)	If equipment is rented to other people and brings income (€/year)	Total CAPEX (€/year)	Total CAPEX (€/ton APPR)	Maintenance Costs (€/year)
Shredder		100%	- €		500 €	- €	- €	200 €
Chipper	15,000.00 €	100%	15,000 €			1,500 €	0.30 €	
Mulcher		100%	- €			- €	- €	
Baler			- €			- €	- €	
Tractor	10,000.00 €	100%	10,000 €			1,000 €	0.20 €	500 €
Trailer			- €			- €	- €	
Lift			- €			- €	- €	
Storage Site	2,000.00 €	100%	2,000 €			200 €	0.04 €	100 €
Biomass transfer			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Total			27,000 €	- €	500 €	2,700 €	0.54 €	800.00 €

Figure 10. Equipment- Related Costs of Collection Operations

At the first column, all the investment costs are recorded (machines, buildings, equipment etc.). The white cells are cells where the user manually gives input whereas the green cells are automatically calculated. After having defined the equipment that is needed for the new APPR value chain, the costs of them should be listed in the following columns described below:

Columns:

A: The equipment/ machinery cost that is needed to purchase.

B: Percentage of how much time is each equipment used for the scope of the APPR value chain (e.g. a tractor that is used half of the year to harvest the APPR from the field and the rest of time is used for other activities like plowing= 50% usage).

C: The total cost of purchasing the item based on the time that is used for the APPR value chain (C= A*B).

D: If the machine is rented instead of purchasing it, fill the cost of rent/year that will be taken into consideration as OPEX.

E: If the machine is rented to other actors during idle times for the APPR value chain, fill the cost of rent/year that is considered as income for the economic feasibility of the collection activities.

F: The total CAPEX expressed in €/ year, normalized for the number of years that were considered for the economic study.

G: The total CAPEX expressed in €/ ton of APPR collected annually.

H: Maintenance cost for each equipment in €/year. This cost is considered in the OPEX costs. However it is on this table as it refers to each equipment.

The next step for the economic feasibility study of the collection operations is the identification and recording of the OPEX. The data that needs to be recorded is shown in Figure 11 and explained below.

Operational Costs

	A	B	C	D	E	F	G	H	I	J
Machine/Activity	Fuel Type	Unit	Price Purchased (€/unit)	Annual Fuel Consumption (Unit/ year)	OR Fuel Consumption (€/ha)	Fuel Consumption (€/year)	Operator/ Personnel Cost (€/year)	Other OPEX costs (€/year)	**Total OPEX (€/year)**	Total OPEX (€/ton APPR)
Shredder						- €			- €	- €
Chipper	Diesel	Litre	1.30 €	600		780 €	1,000 €		1,780 €	0.36 €
Mulcher						- €			- €	- €
Baler						- €			- €	- €
Tractor	Diesel	Litre	1.30 €	600		780 €	1,000 €		1,780 €	0.36 €
Trailer						- €			- €	- €
Lift						- €			- €	- €
Storage Site	Electricity	KWhe	0.05 €	10000		500 €	1,000 €		1,500 €	0.30 €
Biomass transfer						- €			- €	- €
Other						- €			- €	- €
Other						- €			- €	- €
Other						- €			- €	- €
Total									5,860 €	1.01 €

Figure 11. Operational Costs of Collection Operations

As in the investment costs, the white cells need to be filled by the user whereas the green cells are calculated automatically. The first column presents the machine/ activities of the actor for which the operational costs will be recorded (e.g. shredder, mulcher, storage site etc.). The rest of the columns are described below:

A: In this column, the fuel type consumed for each equipment/ activity is specified. For example, you specify if a tractor consumes Diesel, oil, LPG fuel or a storage site that consumes electricity for its power demands.

B: The units of the fuel based on which the consumptions and costs will be calculated. For example, Litres for fuels or KWh_e for electricity, Nm^3 for Natural gas etc.

C: The price of fuel purchased per each fuel's unit.

D: The annual amount of fuel that is needed in order to cover the demands for each activity/ equipment.

E: If the fuel consumption is known in €/ha instead of €/year.

F: The annual fuel consumption cost in €/year.

G: The annual personnel cost paid for each activity.

H: Other OPEX costs that the user want to insert in a different column that is not presented at the current form of the table.

I: The total annual OPEX costs expressed in €/year for each activity/ equipment.

J: The total annual OPEX costs expressed in €/ton of APPR harvested.

After having recorded the OPEX costs, the next step is to identify and record the incomes of Collection activities as it can be seen in Figure 12.

INCOME			
Incomes	**€/ha**	**€/ton**	**€/year**
Selling APPR	100.00 €	10.00 €	50,000 €
Harvest and treat APPR from farms (payed by **farmer**)	10.00 €	1.00 €	5,000 €
Other			
Other			
Other			
Other			
Other			
Total Income			55,500 €

Figure 12. Income of Collection Operations

The first column includes the incomes of collection operations. The main income of these activities is from selling the APPR. Another possible income, is the amount of money payed by the farmer to the Contractor in order for the latter to come to the fields and harvest and treat the APPR. This activity in most cases is considered as income. The rest columns present each income in euros per hectare, per ton of APPR and finally the total annual income. The income, colored in yellow, accounts for the cost payed by the farmer to the Contractor and is inserted based on the price calculated from the previous sheet. If there are any other incomes, they should be recorded on the table.

On this sheet, three cells are colored red. These cells represent the total amount of CAPEX, OPEX and INCOME of the collection operations. These values are what is needed to be copied-pasted to the corresponding cells in the main sheet “APPR value chain overview” in order for the economic calculations to be performed.

4.5 APPR Transformation Operations FS

Transformation operations deals with the import of APPR and transformation into “upgraded” fuel. The “upgraded” APPR is then forwarded to an end-user from where heat/ power is produced. As it is aforementioned, an example of APPR Transformer is a pellet plant.

The methodology for the identification of the costs of APPR Transformation operations is similar with that of the Collection operations.

Firstly, information on the volumes of “upgraded” fuel that need to be achieved have to be defined, as shown in Figure 13. Additionally, the amount of APPR needed to produce the upgraded fuel has

to be estimated. For both raw and "upgraded" APPR, the LHV and Moisture content should be defined as these parameters will be needed for the forthcoming environmental assessment.

Volume of sales to be achieved of "upgraded APPR"		
tons of "upgraded" fuel (e.g. pellet, wood chip etc.) tons/year	2000	
LHV (as received) of "upgraded" APPR (MJ/kg)		
Moisture content of "upgraded" APPR (%)		
tons of APPR needed tons/year	4000	(Estimation: 2 kg of APPR produces 1 kg pellet)
LHV (as received) of incoming APPR (MJ/kg)		
Moisture content of incoming APPR (%)		
Nr of economic years (max 30 years)	10	

Figure 13. Initial information on APPR Transformation Operations

Continuously the Equipment related costs along with the Operational Costs need to be identified and recorded, as shown in Figure 14. The logic for filling the tables is the same with the Collection Operations. For example, equipment costs for a dryer, pellet press or even the whole pellet plant (for more generic cost estimation with no detailed equipment) can be recorded. Moreover, operational costs for the transformation process (e.g. in case of pellet plant) such as power consumptions, heat consumptions, personnel costs, consumables etc. have to be filled. One operational cost that should be highlighted is that of buying APPR (probably from a contractor). This operational cost has to be the same with the selling price of APPR recorded in the Collection Operations for the same APPR value chain.

Equipment-Related Costs

Machine/ Investment/ Activity	If equipment is purchased (€)	Percentage of usage (%)	Total CAPEX (€)	If equipment is rented instead of purchase (€/year)	If equipment is rented to other people and brings income (€/year)	Total CAPEX (€/year)	Total CAPEX (€/ton "upgraded" APPR)	Maintenance Costs (€/year)
Pellet Plant	1,000,000 €	100%	1,000,000 €			100,000 €	50.00 €	20,000 €
Static Chipper	40,000 €	100%	40,000 €			4,000 €	2.00 €	1,000 €
Dryer	100,000 €	100%	100,000 €			10,000 €	5.00 €	2,000 €
Pellet Presses	30,000 €	100%	30,000 €			3,000 €	1.50 €	1,000 €
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Total			1,170,000 €	- €	- €	117,000 €	58.50 €	24,000.00 €

Operational Costs

Machine/ Activity	Fuel Type	Unit	Price Purchased (€/unit)	Annual Fuel Consumption (Unit/ year)	Fuel Consumption (€/year)	Operator/ Personnel Cost (€/year)	Other OPEX costs (€/year)	Other OPEX costs (€/year)	Total OPEX (€/year)	Total OPEX (€/ton "upgraded" APPR)
Buying APPR from Contractor	APPR	kg	10.00 €	4000	40,000 €				40,000 €	20.00 €
Power Consumptions	Electricity	KWhel	0.05 €	300000	15,000 €				15,000 €	7.50 €
Heat Consumptions	NG	NM3	1.00 €	5000	5,000 €				5,000 €	2.50 €
Personnel					- €	30,000 €			30,000 €	15.00 €
Consumables					- €		10,000 €		10,000 €	5.00 €
Other					- €				- €	- €
Other					- €				- €	- €
Other					- €				- €	- €
Other					- €				- €	- €
Other					- €				- €	- €
Other					- €				- €	- €
Other										
Total									124,000 €	62.00 €

Figure 14. Equipment-Related and Operational costs of APPR Transformation Operations

After having recorded the Equipment related costs along with the Operational costs, the income of the APPR Transformation Operations should be recorded in €/ton of "upgraded APPR" as shown in Figure 15.

INCOME		
Incomes	**€/ton "upgraded" APPR**	**€/year**
Selling upgraded APPR	200.00 €	400,000 €
Other		
Other		
Other		
Other		
Other		
Total Income		400,000 €

Figure 15. Income of APPR Transformation Operations

Again, the red colored cells indicate the values that should be copied-pasted in the main sheet "APPR value chain overview".

4.6 End Use Operations FS

For the End Use operations two main cases have been considered:

- Green Field Operations: Where the stakeholder invests on a new unit for bioenergy production from APPR biomass.
- Replace Fuel Operations: Fuel switch, e.g. replacement of an existing fuel source for using APPR for own consumptions.

4.6.1 End Use- Green Field Operations

To help users identify and record the costs of operations for using APPR, e.g. biomass power plant, the current excel sheet has been created. Similar to the previous auxiliary sheets, it starts with filling data as shown in Figure 16. The first requested data is the net heat and/or electricity production by using APPR as fuel. In case of a co-generation plant, the user has to fill both values (electricity and heat production). In other case, if only heat or electricity is produced, fill the cells accordingly. Continuously, it is requested to estimate the necessary amount of APPR for producing this amount of energy. Lastly, the heat content of feedstock (APPR) is requested for the environmental assessment.

MWh to be achieved from APPR		
Net Heat Production from APPR (MWhth/ year)	10000	
Net Electricity Production from APPR (MWhel/ year)	5000	
APPR consumed (tons/year)	8000	(Estimation:1 kg of APPR generates 0.75 Kwhel/ or 3 KWhth)
LHV (as received) of APPR consumed (MJ/kg)		
Nr of economic years (max 30 years)	10	

Figure 16. Initial information on End-Use Operations (case 1)

Moreover, the user has to identify and record the costs related to these end-use operations as shown in Figure 17. The logic is similar to the previous auxiliary sheets. Here the equipment related costs could include more detailed equipment/ investment or the investment as a whole (e.g. co-generation plant etc.). Furthermore, the operational costs are also recorded in the usual way. Of course one main operational cost is that of purchasing APPR for which the price derives from the previous sheet.

Equipment-Related Costs

Machine/ Investment/ Activity	If equipment is purchased (€)	Percentage of usage (%)	Total CAPEX (€)	If equipment is rented instead of purchase (€/year)	If equipment is rented to other people and brings income (€/year)	Total CAPEX (€/year)	Total CAPEX (€/MWhth)	Maintenance Costs (€/year)
Co-generation Plant	10,000,000 €	100%	10,000,000 €			1,000,000 €	100.00 €	20,000 €
Dryer			- €			- €	- €	1,000 €
Other			- €			- €	- €	2,000 €
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Total			**10,000,000 €**	- €	- €	**1,000,000 €**	**100.00 €**	**23,000.00 €**

Operational Costs

Machine/ Activity	Fuel Type	Unit	Price Purchased (€/unit)	Annual Fuel Consumption (Unit/ year)	Fuel Consumption (€/year)	Operator/ Personnel Cost (€/year)	Other OPEX costs (€/year)	Total OPEX (€/year)	Total OPEX (€/MWhth)
Buying APPR from Transformer	"upgraded" APPR	ton	200.00 €	8000	1,600,000 €			1,600,000 €	160.00 €
Power Consumptions	Electricity	KWhel	0.05 €	10000	500 €			500 €	0.05 €
Heat Consumptions	NG	NM3	1.00 €	2000	2,000 €			2,000 €	0.20 €
Personnel					- €	150,000 €		150,000 €	15.00 €
Consumables					- €		50,000 €	50,000 €	5.00 €
Transfer					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Total								**1,825,500 €**	**180.25 €**

Figure 17. Equipment-Related and Operational costs of End Use Operations (case 1)

Lastly, the income of the related operations have to be recorded as shown in Figure 18. For example in the case of a co-generation plant, there is the income of selling heat and electricity. Other incomes can be added when applicable.

INCOME

Incomes	€/Mwhel	€/MWhth	€/year
Selling electricity from APPR	200.00 €		1,000,000 €
Selling heat from APPR		300.00 €	3,000,000.00 €
Other			
Other			
Other			
Other			
Other			
Total Income			**4,000,000 €**

Figure 18. Income of End Use Operations (case 1)

4.6.2 End Use- Replace Fuel

This auxiliary sheet helps the user identify and record the costs for an investment intended to replace the existing fuel system with one for APPR consumption in order to cover its energy demands. Firstly, the heat demands of the existing system, along with the APPR needed to cover this demand and the heat content of APPR consumed is requested as shown in Figure 19.

MWhth to be achieved

Heat demands of existing system (MWhth/year)	3000
APPR consumed (tons/year)	1000 (Estimation:1 kg of APPR generates 3 KWhth)
LHV (as received) of APPR consumed (MJ/kg)	
Nr of economic years (max 30 years)	10

Figure 19. Initial Information of End Use Operations (case 2)

Continuously, the user is asked to record the costs of the existing fuel system which will be avoided when its replacement to an APPR system will occur. For example, the fossil fuel that is needed to be purchased annually. These costs should not include costs that will continue to occur with the APPR fuel system.

Costs to be avoided from Existing Fuel System

Costs	Fuel Type	Unit	Price Purchased (€/unit)	Annual Fuel Consumption (Unit/ year)	Fuel Consumption (€/year)	Other OPEX costs (€/year)	Total OPEX of current fuel system (€/year)
Fuel Consumptions of existing system	NG	NM3	1.00 €	300000	300,000 €		300,000 €
Other					- €		- €
Other					- €		- €
Other					- €		- €
Other					- €		- €
Other					- €		- €
Other					- €		- €
Total							300,000.00 €

Figure 20. Costs of existing Fuel System (case 2)

Furthermore, the equipment-related costs on which the stakeholder will invest in order to replace his fuel system has to be recorded in the same way as described in the previous sheets. For example, the purchase of a biomass stover along with its maintenance cost and the retrofits of the existing system that are needed. In addition, the operational costs of the NEW APPR system have to be identified and estimated. Of course these costs may include the purchase of APPR (the price derives from the previous sheets of the value chain), ash disposal etc. After identifying the costs of the previous and new fuel system, the savings of the end user are calculated automatically as shown in Figure 21. End users that replace their fuel system, don't have income but savings. The savings derives from the calculation of the operational costs to be avoided from the existing fuel system minus the operational costs of the NEW APPR system. Thus, this value is considered for the calculation of the economic parameters that shows the feasibility of the APPR value chain for the stakeholder. Again the red colored cells show which values are needed to be copied-pasted to the main sheet "APPR value chain overview" for the economic calculations.

Note: In this case, the cell with the OPEX costs of the NEW system is not colored red as it doesn't need to be put in the main sheet. This is because the OPEX costs of the NEW system are already taken into consideration for calculating the savings, thus, it is not needed to put this value again for the economic calculations.

Equipment-Related Costs For Replacing existing fuel source

Machine/ Investment/ Activity	If equipment is purchased (€)	Percentage of usage (%)	Total CAPEX (€)	If equipment is rented instead of purchase (€/year)	If equipment is rented to other people and brings income (€/year)	Total CAPEX (€/year)	Total CAPEX (€/MWhth)	Maintenance Costs (€/year)
Biomass Stover	40,000 €	100%	40,000 €			4,000 €	1.33 €	1,000 €
Retrofits	20,000 €	100%	20,000 €			2,000 €	0.67 €	1,000 €
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Other			- €			- €	- €	
Total			60,000 €	- €	- €	6,000 €	2.00 €	2,000 €

Operational Costs of NEW System

Machine/ Activity	Fuel Type	Unit	Price Purchased (€/unit)	Annual Fuel Consumption (Unit/ year)	Fuel Consumption (€/year)	Operator/ Personnel Cost (€/year)	Other OPEX costs (€/year)	Total OPEX (€/year)	Total OPEX (€/MWhth)
Power Consumptions	Electricity	KWhel	0.05 €	50000	2,500 €			2,500 €	0.83 €
Ash disposal					- €		2,000 €	2,000 €	0.67 €
Purchase of APPR	APPR	ton	200.00 €	1000	200,000 €			200,000 €	66.67 €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Other					- €			- €	- €
Total								206,500 €	68.17 €

Savings

End User Savings (€/year)	93,500 €

Figure 21. Equipment-Related and Operational costs and Income of changing the existing fuel system into a new APPR system (case 2)

Again, the 5 sheets are auxiliary and aim to support the user identify and record in a more detailed way the costs of the operations performed by each actor in every step of the value chain. The goal of the excel is to fill the costs in the main sheet "APPR value chain overview" in order to perform the feasibility calculations for the proposed APPR value chain. There are three ways to fill it.

1) Directly fill the main sheet "APPR value chain overview" manually with the operations that take place and their costs (if known in total)
2) Firstly, fill the auxiliary sheets to identify the activities and their costs and then copy paste the total CAPEX, OPEX, INCOME to the main sheet for each (group of) operation
3) Combine the two previous options. Use the auxiliary sheet to calculate the operations and copy paste them in the main sheet. Then, add any extra operation manually in the main sheet when the investment for the operation occurs in different year. For example, in case "A" actor who is a contractor buys a chipper and a tractor at year 0. The user fills the auxiliary sheet regarding the Collection Operations with the corresponding operational costs and incomes and copy pastes the costs to the main sheet "APPR value chain overview" for year 0. However, actor "A" also plans to buy a second chipper in 5 years (for replacing the first one because of damages). Then the user has to insert in another operation raw in the main sheet the CAPEX of the second chipper but with the investment year set to 5. Note, that the OPEX costs of the second chipper are already included from the first chipper, thus no need to put again OPEX costs for the second chipper. Then when the calculations will be performed for actor "A" in "Economic Parameters for APPR VC" sheet, the economic parameters will be calculated for all the activities of the actor.