TCP/CRO/3101 (A) Development of a sustainable charcoal industry

ECONOMIC ASPECTS OF CHARCOAL PRODUCTION IN CROATIA

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This project was launched in July 2006 within FAO Technical Cooperation Programme withthe objective to assess the current status of the charcoal production in Croatia, in order to develop a programme for the revitalisation of this industry.
Apart from recommendations and best solutions for the technological modernisation, the programme will provide guidelines for the production improvement and amplification with a holistic approach.
Ministry of Agriculture, Forestry and Water management is responsible for the project execution on behalf of the Government of the Republic of Croatia.

ECONOMIC ASPECTS OF CHARCOAL PRODUCTION IN CROATIA

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Executive summary

International charcoal market reports increased demand for charcoal that changed from seasonal good to all-year-round good at higher and rising prices. The current production of charcoal in Croatia in respect of its production and availability of feedstock as well as vicinity of the EU market indicates that investment in modernisation of charcoal production is a worthwhile investigation. Namely, about a half of domestic charcoal production is produced in a single industrial plant while the rest of charcoal is produced by numerous medium to small producers that employ traditional charcoal production techniques. The situation of the traditional charcoal producers is rather blurry with unclear legal background where majority of charcoal producers are using illegal channels to sell charcoal at dumping prices. As such, those producers that are registered are pushed away from the market and on the verge of closing down their business. However, while talking to the registered small and medium producers which are experienced in charcoal production through generations, one could identify the incentive to advance from the traditional charcoal production in one way or another.

This report addressed the economics of traditional charcoal production which was examined to detail since the charcoal production technique varies from kiln to kiln, both by days of carbonisation process and efficiency ratio of conversion of wood to charcoal. The economics are given on a highly efficient example whose parameters were provided by one of the producers itself – a 27.51 m^3 of wood were converted to 4 680 kg of charcoal. The purpose of this chapter was to provide guidelines for the traditional producers in order to estimate their costs of production (including/excluding price of the labour) and estimate the relation between the effort and income – in the example, the producers are earning about 560 € per month which is very close to the national average net monthly salary obtained in Forestry, logging and related service activities sector and more than double than the minimum net monthly salary of 240 € in Croatia during 2006.

In order to investigate investment possibilities for modernisation of charcoal production in Croatia, Carbo Twin Retort System (CTR) and CML Carbonisation (CML) System have been chosen as the best practice technologies upon the feedback from both charcoal experts and FAO consultants. After investigating the base case scenarios of 1 000, 3 000 and 6 000 tons of charcoal production per year and applying the sensitivity analysis with changes in main parameters' prices ± 25 percent, it has been concluded that both investments are indicating positive investment opportunities while the decision on which technology to employ depends on the investment environment. Namely, when focusing on the investment costs - carbonisation technology - the CML technology dominates with IRRs achieved range between 25 and 38 percent, depending on the plant size while their counterparts by capacity reach 23 and 29 percent IRR, respectively. The investment costs in the carbonisation line of the CTR technology are 1.7 times more expensive than the CML technology. On the other hand, when focusing on cash flow, the CTR shows more stability since it has higher efficiency of carbonisation. It is more robust to price changes in general and especially to price changes in feedstock. Moreover, the CTR technology has 1 000 tons capacity modules that could be easily added or removed according to the feedstock availability while the CML has 12 kilns unit without straightforward possibility to extend or decrease its production capacity.

Modernisation of a traditional activity, such as charcoal in Croatia, also needs a context to be placed in. For that purpose, socio-economic background is investigated

from macro and micro perspective. The main macro contribution of modernisation of charcoal production is generation of value added from natural resources and waste which would otherwise be left aside and reducing governmental losses from illegal charcoal sales. In addition to that, an overall social welfare is increased since the production, now as a legal business, would have to contribute not only in regular wages to the employees but also by paying their pension fees as well as social and health security fee. Another issue that will have its effect on micro level is occupational health of employees that would be improved according to already existing laws enforced in the usual business practice. In that case, charcoal production might mitigate one of its current problems which are labour deficiency. All these issues are directly influencing the rural depopulation, improving the living conditions in the rural areas. Business-wise, the modernisation of charcoal production will improve the position of small and medium producers that are already registered by securing a stable supply of charcoal of a homogeneous quality in sufficient quantities that would empower their position in the market.

Table of contents

1 Introduction

In Croatia, production of charcoal is unevenly distributed between numerous traditional and one industrial producer. Namely, while the producers that employ traditional carbonisation techniques in kilns (or, to lesser extent, in pits), count around 400, they contribute with almost the same amount as the single industrial producer to the domestic charcoal production. There are two subgroups of traditional charcoal producers. They both emerged from family tradition but one group remained part-time producers while the other group have registered charcoaling as their business activities. The part-time producers are provoking grey economy disturbances in the charcoal market by offering the charcoal at price lower at least for the VAT difference that a registered producer has to pay. Trapped between the industrial producer that is dominating the market with higher quality charcoal, reliable supply in large quantities and part-time producers that are taking a large share of the market with dumping prices, the registered producers are placed in position which is unsustainable. Moreover, due to their relative small production and large number, the registered producers are locked-in from both supply and demand side. However, charcoal, as international good, records positive changes in demand as well as in prices which is especially true for the EU market. Due to the vicinity of the EU market, existing national charcoal production and feedstock availability, it seems that investment in modernisation of charcoal production is a worthwhile investigating.

In order to understand the economics behind most of the Croatian charcoal producers, the first chapter delivers the example of calculations for traditional charcoal production. The production is presented with and without shadow prices in order to give the guidelines of the difference in production costs between the registered and non-registered producers.

The next chapter provides investment options for modernisation of the charcoal production. The FAO technical assistance provided best technologies examples, such as Carbo Twin Retort system and CML, for investment appraisal. In each technology's investment appraisal, sensitivity analysis is exercised with a special emphasis on the feedstock prices and availability.

The third chapter addresses socioeconomic issues from macroeconomic point of view at national and regional (local) level as well as micro level. In order to make the complex socioeconomic drivers closer to the reader, each level is divided according to the contributions of the producers' type, whenever it was possible.

The conclusion, followed by recommendations, summarise the economic aspects of charcoal production in Croatia together with possible solutions for upgrading the production and improving the position of already existing producers.

2 Economic assessment of traditional charcoal production

In Croatia, traditional charcoaling is currently dominant production technique, the domination of which is not expressed in quantities of charcoal produced but in the number of people engaged in the production. The quantity of traditionally produced charcoal, where more than 800 people are engaged, is more or less equivalent to that produced in a single industrial charcoal plant, which has 26 employees.

The traditional charcoal production mostly occurs in rural areas in the vicinity of the resources (forest areas). There are two subgroups of traditional producers. They both emerged from family tradition but one group remained part-time producers while the other group have registered charcoaling as business activities. The part-time producers are provoking grey economy disturbances in the charcoal market by offering the charcoal at price lower at least for the VAT difference that a registered producer has to pay. The following section is delivering state-of-the-art economics of traditional charcoal production with indication of shadow prices for labour in order to emphasise the starting cost difference between the registered and non-registered producers. Traditional charcoal production in brick kilns is labour intensive activity. The small producers tend to focus their production on manual labour originating from their own household. Therefore, the earnings aftermath does not represent the real cost structure which is full of shadow prices. Although this cost difference increases further at the expense of registered producers with adding administration cost, taxes and VAT, those costs are not included in the analysis.

The economic analysis presented here is made in such a way that shows estimated shadow prices for labour along the assumption that the charcoal production is the only activity for which the equipment is used. The idea is to separate costs per production process following the logic of calculations provided by the small-charcoal producers whenever it was possible. All data are originating from the experiences of traditional charcoal producers[1] and represent substantial guidelines for cost estimations for charcoal producers that employ traditional carbonisation techniques since they vary significantly by number of days needed for carbonisation as well as in the conversion wood to charcoal ratio. It has to be said that a significant number of individual improvements of kiln have been recorded. The improvements were aimed either to improvement of carbonisation efficiency or shortening of the charcoal production process (down to 3 days). Nevertheless, the detail cost description and calculations on annual, monthly and daily basis provide basis for a traditional charcoal to evaluate the true cost that are occurring while producing charcoal in different kilns.

❖ Production phases

The traditional producers suggested dividing the economics of traditional small and medium scale charcoal production into four main parts:

- building a brick kiln,
- collecting and preparation of wood,
- carbonisation,

[1] Project team would like to thank Mr Dubravko Medarac, independent charcoal producer for sharing his practical knowledge on traditional charcoal production. Some results presented here are taken from his bachelor degree thesis done at Faculty of Forestry University of Zagreb. Our thanks also go to Mr Branko Keglevic and Mr Bozidar Zrinski, both private charcoal producers for their valuable inputs and comments.

- finishing with packaging and sale.

Medium scale production in this report understands actually that one producer produces charcoal in more than one brick kiln. In other words, there is always the same technology employed with absence of economies of scale.

❖ **Building the brick kiln**

Kiln is built out of old full bricks, steel net, concrete iron, iron doors and cover plate, cement, lime, gravel, sand and clay, total costs 675 €. Based on the experience of traditional charcoal makers, the brick kiln is estimated to have a life time of 8 years with one production process per month. Wood inputs per kiln are approximated on 27.51 m^3 and the charcoal output on 4 680 kg. Thus, the cost estimations of a kiln are the following:

- Annual costs: 84.42 €[2]
- Cost per carbonisation process: 7.03 €
- Cost per kg of charcoal: 0.0013 €

❖ **Collection and preparation of wood and transport of charcoal**

The reason for linking pre and post process of carbonisation is in utilisation of same equipment for transporting of wood from the forest to the kiln and charcoal from the kiln to the storage facility.

The charcoal is produced from various wood, very often beech and hornbeam. It is interesting to emphasize that the non-registered producers are aware that if they make charcoal from beech and hornbeam only, they will get the highest quality charcoal. With optimisation, they mix those two wood species with others in ratio 70:30 to get the charcoal of market quality.

Further, the input wood is mixed by shape, too, in order to develop fire with desired characteristics. The usual mixture is shown in a table 2.1 together with the quantity described in both solid and bulk cubic meters.

Table 1 The usual mixture of wood input per kiln

Wood input	m^3s	m^3b
Branches	3.02	5.50
One meter logs	18.28	26.50
Stumps	6.21	9.00
Total	**27.51**	**41.00**

The wood is either bought on a public bid from the Hrvatske šume d.d. or it is collected from the forest with permission of forester.

In the case when the wood is bought on the public bid, it is easy to attribute the costs to the wood type according to the official price list (Table 2.2).

Table 2 Cost calculations for wood input per kiln

Wood input	m^3s	m^3b	Unit	Total

[2] Croatian National Bank exchange rate on 20th April 2007 was 1 € = 7.40 HRK:

			price (€)	(€)
Branches	3.02	5.50	2.03	6.12
One meter logs	18.28	26.50	11.89	217.29
Stumps	6.21	9.00	12.16	75.50
Total	**27.51**	**41.00**		**298.91**

In that case, the wood input set on an annual basis gives the following cost calculations:

- Annual costs: 3 586.88 €
- Cost per carbonisation process: 298.91 €
- Cost per kg of charcoal: 0.0615 €

And when added with transportation costs of charcoal to the storage, the cost calculations are:

- Annual costs: 3 900.20 €
- Cost per carbonisation process: 324.82 €
- Cost per kg of charcoal: 0.0689 €

When the wood is retrieved from the wood, it represents a regular part of forest management practice where charcoal producers are cleaning the forest after selection cut in young forests (20-30 years). The compensation for their work is usually collected wood, free of charge. The process can be divided in two parts: wood sawing and wood preparation and transport. The table below shows material costs of wood sawing with most frequent tool – chain saw Stihl 038 at price of about 675 € and estimated lifetime of 10 years. It takes four days and two workers to make amount of wood necessary for one kiln (table 2.3)

Table 3 Material costs of wood sawing

Item	**Effective utilisation days**		**Purchasing price (€)**	**Life time**	**Cost per carbonisation process (€)**	**Cost per kg of charcoal (€)**
	Per year	**Per carbonisation process**				
Chain saw Stihl 038	48	4	675.39	10		
	Unit	**Normative, annually**	**Unit price (€)**	**Annual cost (€)**		
Fuel	Litre	58	1.15	66.59	5.55	0.0012
Lubricant	Litre	29	1.35	39.17	3.26	0.0007
Chain	Piece	1.2	16.21	19.45	1.62	0.0003
Slide	Piece	0.3	58.08	17.43	1.45	0.0003
Cycle chain	Piece	1.2	10.27	12.32	1.03	0.0002
Spare parts-other	% am	30%		20.26	1.69	0.0004
Maintenance costs	% am	20%		13.51	1.13	0.0002
Total operation cost				**188.73**	**15.73**	**0.0034**

Amortization	% purchasing price	10%		67.54	5.63	0.0012
Material costs of wood sawing				**256.27**	**21.36**	**0.0046**

For the next phase, the main tool is tractor with different attachments such as towing with towing winches and splitters and semi-trailer for transportation of prepared wood from the forest to the kiln. The table 2.4 gives detailed overview of annual costs as well as cost per carbonisation process and per kilogram of charcoal produced.

Table 4 Costs outlines for wood preparation and transport

Item	Effective utilisation days		Purchasing price (€)	Life time (years)	Cost per carbonisation process (€)	Cost per kg of charcoal (€)
	Per year	Per carbonisation process				
Tractor IMT 539	96[3]	7	4727.74	20		
Towing winch Tajfun EGV 1x40kN	24	2	1350.78	15		
Splitter	24	2	270.16	15		
Semi trailer	48[1]	3	540.31	20		
Item	**Unit**	**Normative, annually**	**Unit price (€)**	**Annual cost (€)**		
Spare parts	Piece	2	33.77	67.54	4.92	0.0011
Fuel	Litre	1650	0.57	936.09	68.26	0.0146
Lubricant	% of fuel	20%		187.22	13.65	0.0029
Spare parts-others	% am	30%		70.92	5.17	0.0011
Pneumatics	Piece	2	33.77	67.54	4.92	0.0011
Maintenance costs	% am	20%		47.28	3.45	0.0007
Total operation cost				**1 376.58**	**14.34**	**0.0007**
Amortization (tractor)	% purchasing price	5%		236.39	17.24	0.0037
Amortization (towing winch)	% purchasing price	7%		90.10	7.51	0.0016
Amortization (splitter)	% purchasing price	7%		18.02	1.50	0.0003
Amortization (semi-trailer)	% purchasing price	7%		36.04	2.25	0.0005
Total fixed annual costs				380.54	28.50	0.0005
Total material costs of wood preparation				**1 757.12**	**128.87**	**0.0275**

The usual net wage for retrieving woods from the forest is 2.53 €/hour. The table 2.5 gives detailed overview of labour costs by activity for collecting and retrieving the woods from the forest.

Table 5 Labour costs for wood retrieving and preparation followed by transport of charcoal to the storage

Item	Hours per workin g day	No of workin g days per kiln	Wag e per hour (€)	Numbe r of worker s	Total annual cost (€)	Cost per carbonizatio n process (€)	Cost per kg of charco

[3] Here is added 12 days that the tractor with the semi-trailer will be used for transportation of charcoal from the kiln to the storage.

							al (€)
Sawing	6	4		2	1458.84	121.57	0.0260
Towing	6	2		2	729.42	60.79	0.0130
Splitting	6	2	2.53	2	729.42	60.79	0.0130
Transport (forest-kiln)	6	3		2	1094.13	91.18	0.0195
Transport (kiln-storage)	5	1		2	303.93	25.33	0.0054
Total labour costs for wood preparation					**4 315.75**	**359.65**	0.0768

When expressed on the annual basis, per carbonisation process and per kilogram of charcoal, total costs for wood preparation and transportation to and from a kiln, are (the values in the parenthesis present costs without shadow prices of labour):

- Annual costs: 6 072.87 € (1 757.12 €)
- Cost per carbonisation process: 488.52 € (128.87 €)
- Cost per kg of charcoal: 0.1044 € (0.275 €)

Namely, the charcoal producers prefer collecting woods from the forests over purchasing it on public bid since the labour employed is not perceived as expenditure. If they were to pay the average net wage per hour, the public bid prices of wood would make about 61 percent of the wood price from forest cleaning. However, the charcoal producers are considering only material costs as investment to the production which is only 26 percent of the total costs. Thus, the pre and post carbonisation phases make 0.0275 € per kilogram of charcoal amount of a kiln.

- **Carbonisation**

The process of carbonisation lasts for 10 to 15 days, depending on the wood type and moisture content. The cooling process lasts 7 to 8 days and sometimes, producers are using water to speed up the cooling which significantly decreases on charcoal quality. The only material cost of carbonisation is utilisation of brick kiln since the wood was ensured in the previous stage (Table 2.6).

Table 6 Material costs of carbonisation

Item	**Effective utilisation days**		**Purchasing price (€)**	**Life time (years)**	**Cost per carbonisation process (€)**	**Cost per kg of charcoal (€)**
	Per year	**Per carbonisation process**				
Brick kiln	365	30	675.39	8		
Item	**Unit**	**Normative, annually**	**Unit price**	**Annual cost (€)**		
Amortization (kiln)	% purchasing price	12.50%		84.42	6.94	0.0015

Total material costs of carbonisation	**84.42**	**6.94**	**0.0015**

In 5 hours, two workers are able to prepare and load the kiln. Carbonisation itself lasts for 12 days; each day two workers are monitoring and refilling the kiln for 2 hours (Table 2.7).

Table 7 Labour costs of carbonisation

Item	Hours per working day	No of working days per kiln	Wage per hour (€)	Number of workers	Total annual cost (€)	Cost per carbonization process (€)	Cost per kg of charcoal (€)
Preparation of kiln	5	1	2.53	2	303.93	25.33	0.0054
Monitoring	2	12		2	1458.84	121.57	0.0260
Total labour costs of carbonisation					**1 762.77**	**146.90**	**0.0314**

Total costs of carbonisation process itself are (the values in the parenthesis present costs without shadow prices of labour):

- Annual costs: 1 847.19 € (84.42 €)
- Cost per carbonisation process: 153.84 € (6.94 €)
- Cost per kg of charcoal: 0.0329 € (0.0015 €)

Since the material costs and labour costs ratio is roughly 5:95, charcoal producers are recognizing costs excluding shadow prices of labour.

❖ Packaging and sale

The main tool for packaging of charcoal is elevator transporters which make, together with paper bags, total material costs of packaging (Table 2.8).

Table 8 Material costs of packaging

Item	Effective work day	Per carbon process	Purchasing price (€)	Life time	Cost per carbonisation process (€)	Cost per kg of charcoal (€)
Transporter	12	1	405.23	10		
Item	**Unit**	**Normative, annually**	**Unit price (€)**	**Annual cost (€)**		
Paper bags	Piece	3120	0.14	421.44	35.12	0.0075
Amortisation (transporter)	% purchasing price	10%		40.52	3.38	0.0007
Total material costs of packaging				**461.97**	**38.50**	**0.0082**

The process of taking out the charcoal from the brick kiln lasts a day if the work is organised and divided between 5 workers with assigned tasks. One for shovelling the charcoal from the kiln to the elevator transmitter that continues on a riddle (1.5 cm holes) and wheelbarrow for collecting smaller pieces of charcoal and dust. Two workers are employed for filling the bags with sieved charcoal. The fourth worker tides the bags and the last one is loading the bags on a trailer, drives the full load to the storage (Table 2.9).

Table 9 Labour cost of packaging

Item	**Hours per working day**	**No of working days per kiln**	**Wage per hour (€)**	**Number of workers**	**Total annual cost (€)**	**Cost per carbonization process (€)**	**Cost per kg of charcoal (€)**
Empting and packaging	5	1	2.53	5	759.82	63.32	0.0135
Total labour costs of packaging					**759.82**	**63.32**	**0.0135**

The total costs overview for packaging and sale are (the values in the parenthesis present costs without shadow prices of labour):

- Annual costs: 1 221.78 € (461.97 €)
- Cost per carbonisation process: 101.82 € (38.50 €)
- Cost per kg of charcoal: 0.0218 € (0.0082 €)

Summing the production stages of traditional charcoal making, it is possible to observe the calculations from both non-registered and registered producers' perspective. Table 2.10 gives summarized cost outlook by way of obtaining the wood input as well as costs of production with and without labour costs.

Table 10 Cost estimations for traditional charcoal producers

	Without shadow prices		**With shadow prices**	
	Purchasing wood on public bid	**Retrieving wood from a forest**	**Purchasing wood on public bid**	**Retrieving wood from a forest**
Annual costs (€)	4142.67	2303.51	6969.18	9141.85
Costs per carbonisation process (€)	345.13	174.31	580.67	744.17
Cost per kg of charcoal (€)	0.0734	0.0372	0.1237	0.1590

It has been mentioned, non-registered producers are depreciating the price of charcoal for registered producers. While household expenses for charcoal could be as low as 0.04 €/kg of charcoal, the registered producers would have to put up with at least 0.12 €/kg of charcoal since the wage per hour is calculated on the net basis and without any taxes that a legal entity has to pay. The non-registered producers are selling charcoal to the restaurants or wholesalers at price of 6.08 € per 18 kg bag, meaning 0.34 kn per kilogram of charcoal.

In that perception, the traditional charcoal producers are earning as much as 0.30 €/kg charcoal, depending on the way of obtaining woods and family labour force (table 2.11).

Table 11 Profit estimations for traditional charcoal producers

	Quantity of charcoal	Unit	Price per kg (€)	Income (€)	Profit (without shadow prices)		Profit (with shadow prices)	
					Purchasing wood (€)	Retrieving wood (€)	Purchasing wood (€)	Retrieving wood (€)
Per year	56160	Kg	0.34	18964.97	14822.31	16661.46	11995.79	9823.13
Per carbonisation	4680			1580.41	1235.29	1406.10	999.75	836.24
Per kg of charcoal	1			0.3377	0.2647	0.2999	0.2134	0.1783

Being on the safe side, the classical calculations (NPV; IRR) were made including the shadow prices for labour (net value) and using the averaged equipment discount rate of 8 percent. The calculations did not include “number of effective utilisation days” having the assumption that all of the equipment is solely purchased and utilised for charcoal production purposes and that the wood input originates 6 times per year from public bids and 6 times from retrieving woods from the forests. As expected, the production cost increased to 0.17 € per kilo of charcoal. Nevertheless, the IRR showed admirable 107 percent even when the conservative assumptions were made. Decreasing the sale price from 0.34 €/kg of charcoal to 0.31 €/kg (supermarkets' price) decreased the IRR to 90 percent, which is, however, still more than promising for an investor.

Naturally, these results would be realised very rarely in the reality. These results would be obtained if the producer produces charcoal all year around which is difficult to pursue due to the winter conditions and lack of labour, to say the least. The high IRR is also inflated by paying the labour at lower price (2.53 €/hour net) than the average labour price recorded in the forestry sector which is 3.13 €/hour net (4.24 €/hour gross).

In this highly idealistic example, the charcoal producers (assuming two persons engaged per a kiln) would earn, in average, about 560 € per person, which is below the average monthly salary in Croatia and close to the average net monthly salary for forestry sector[4] but without pension fund and social and health security.

[4] In July 2007 the average monthly paid off net and gross earning per person in paid employment in legal entities in the Republic of Croatia amounted to 4 855 kuna (665 €) and 7 067 kuna (968 €) while the average net and gross salary in Forest, logging and related service activity in 2005 were 4 179 kuna (565 €) and 5 985 kuna (809 €) (source: Croatian Bureau of Statistics www.dzs.hr)

3 Economic assessment of industrial charcoal production

This section questions the viability of modernisation of the charcoal production in Croatia through testing economic performance of industrial systems. In order to detect the charcoal producing technologies available at the market, several technologies and equipment producers were contacted. The information on producers and their contact details were provided by FAO consultants and added at the workshop/expert consultation on Sustainable Charcoal Production, Trade and Use in Europe, (May, 2007, Zagreb). Carbo Twin Retort System (CTR) and CML Carbonisation (CML) System have been chosen as the best practice technologies upon the feedback from both charcoal experts and FAO consultants.

The CTR and CML technologies will be examined as investment possibilities in the present market conditions of Croatia. The input data are aggregated and rounded as here is not the aim to find exact investment gain or to provide exact value of charcoal produced but to provide guidelines for potential investors whether investing in modernisation of charcoal production in Croatia is viable or not. Furthermore, the investment will be increased from its base capacity to production of 3 000 and 6 000 tons of charcoal so as to evaluate the role of economies of scale in the investment opportunities. Both technologies will be levelled at the same foot and subdued to the same assumptions in order to make the comparison as realistic as possible.

The first part of economic analysis will describe the investment viability of each technology with three analytical parameters: internal rate of return (IRR), net present value (NPV) and simple payback period. The analysis will continue with a sensitivity analysis to examine the investments' behaviour in different market conditions. A special attention will be given to the feedstock behaviour due to the raising competition at biomass market. The economic assessment of industrial charcoal production will end with a comparison of parameters and performance of both technologies pinpointing the issues and trade offs on which the investor has to decide according to ones interests and market conditions at the time.

Although the analysis here will be focused on economic outcomes, environmental issues are covered too in order to minimize external costs of the environment.

3.1 Description of technology

There are many ways of carbonisation of woods that depend on the tradition, local environment, type of feedstock, climate conditions, availability and price of labour, available technologies, the purpose of charcoal made, market demands, etc. Nevertheless, all carbonisation techniques could be divided according to the three basic principles (Gronli, 2005) which are:

a) Internal heating
b) External heating
c) Heating with recirculated gas principle

All these techniques differ among each other according to their efficiency and length of the carbonisation process.

The efficiency of charcoal production describes the weight ratio between the feedstock used (input) and charcoal produced (output).

The carbonisation process involves preparation of feedstock (drying), carbonisation and cooling of charcoal.

The internal heating principle is used in traditional charcoal production in pits and kilns where a part of the feedstock is burnt under controlled air flow in order to provide heat for the carbonisation of the remaining wood. The expected efficiency is up to 30 percent and the length of the production process varies from 6 to 30 days. The CML process improves the internal heating principle with decreasing the production process to 22 to 24 hours.

The external heating principle is often called retort carbonisation since the carbonisation occurs in a retort which is heated from the outside and no oxygen enters the reactor. The basic model usually goes in pairs where the first vessel is heated using the external energy source. After the pyrolysis has started, the pyroligneous vapours are conveyed to the combustion chamber and burnt, to give energy for heating the second vessel which has been placed. After the initial ignition from external energy source, the process is utilising its own energy – the extracted vapours from one vessel are burnt to be utilised in the carbonisation process of the other vessel. External heating carbonisation is a continuous carbonisation process.

The second technology to be examined from the investors' point of view is Carbo Twin Retort system that utilises the external heating principle in its carbonisation process. The efficiency is up to 32 percent and the carbonisation process lasts 24 hours. The only existing industrial charcoal producer in Croatia, Belišće Jsc., is using retort carbonisation, too. Its efficiency is around 20 percent and carbonisation process takes 24 hours.

The last principle of carbonisation – the heating with recirculated gas principle – directs the pyroligneous vapours burnt in an external combustion chamber into the reactor where it is in direct contact with the feedstock. The efficiency could be as high as 34 percent and the carbonisation process of 16 to 20 hours. The most prominent examples of this technology is Degussa and Lambiotte continuous carbonisation processes.

Another aspect to be brought to investors' attention is the environmental effect of the charcoal production since "polluter pays" principle could be, if not already, enforced and significantly jeopardise the future incomes. The focus here is on the economic aspects of the investment and there is just a brief overview of the environmental effects with emphasise that the technology chosen for this analysis is in compliance with the European regulation concerning the air emissions and the thermal treatment of polluting molecules.

However, the investors should be informed that, apart of the sustainable forest management, the most significant environmental effect of the charcoal production process is the emission of gaseous substances and particulate matter into the air and workspace. Namely, the by-products of charcoal production are pyroacids, primary acetic acid and methanol, tars, heavy oils and water, the majority of which is emitted into the environment with the kiln exhaust. The emissions into the air include gaseous emissions of carbon monoxide (CO), carbon dioxide (CO_2), methane, ethane and volatile organic compounds (VOC); emissions of the particulate matter (PM) coming from the uncombusted tars and charcoal dust, and pyroacids that may form aerosol emissions. The level of emissions depends highly on the technology used for the production, the temperature developed during the pyrolysis as well as on the moisture content of the wood.

The use of flue gas to heat the combustion chamber, which contributes to higher temperatures in combustion chambers, and improved environmental performance of equipment, such as cyclones and filters for removal of particular matter and use of pre-drying of feedstock, make possible to lower the levels of air emissions considerably. Afterburning of flue gases causes oxidation of methane, thus lowering its emissions by more then tenfold. It can also reduce emissions of PM, CO and VOC by at least 80%, while it also considerably reduces emissions of tars and nitrogen oxides. Furthermore, tests conducted on charcoal production management showed that the incineration of flue gases at about 1 000°C allows destruction of 99% of the mass of pollutants apart from CO_2 (Halouani & Farhat, 2003). At the same time, employment of the described practice and equipment increases the production efficiency, thus covering the investment costs for the equipment and bringing additional revenue.

3.1.1 The Carbo Twin Retort

The Carbo Twin Retort (further CTR) is a semi-continuous production module that utilises external heating principle for carbonisation of wood. Its basic carbonisation unit, consisted of two retorts (vessels) has capacity of 1 000 tons of charcoal per year. However, CTR's production capacity can be easily extended by adding additional carbonisation units.

After the initial external ignition, the pyrolysis vapours released from one hot carbonizing vessel are combusted to heat-up another vessel freshly loaded with wood. Several hours later, the vessel with fresh wood reaches the carbonization temperature and emits pyrolysis vapours suitable for combustion which are utilised for the carbonisation process in the another vessel which is reloaded with fresh wood in the meantime. Namely, when the charcoal in the first vessel is ready, the vessel is removed and replaced by another that has been filled with fresh wood. The direction of gas flows is switched by making use of valves.

In order to be continuously operated, one vessel is to be removed every 4 hours (6 vessels per 24-hours) from the CTR. The process is to be repeated interminably. Carbonisation of one vessel takes 8-12 hr, depending on wood properties.

The hall, in which the kilns are mounted, is provided with a monorail and overhead crane that enables to lift the vessels into and out of the carbonisation kilns. The hot charcoal vessels are placed outside the hall in a sand lock and left for a 20-24 hours (natural) cooling period before emptying. This means that spare vessels are needed to keep the carbonisation system running.

The CTR yields on average 33 percent weight of wood input with 30 percent moisture content. Naturally, the yield varies among wood species (hardwood and softwood) and moisture content.

The internal combustion of the pyroligneous vapours lowers the emission levels significantly. In other words, all harmful pyrolysis gases are completely combusted internally and the vapours are completely oxidized into CO_2 and H_2O. Thus the emissions of other polluting gases, such as CH_4, CO and higher C-compounds are minimized. It is also worth to mention high thermal (energy) efficiency of the CTR system. After start-up with external heat source, the system is operating auto-thermally.

One plant with 12 vessels, run on a 24-hours basis, has a production capacity of 6-7 000 tons per year of charcoal and needs 3 workers per shift (Gronli, 2005).

3.1.2 The CML carbonisation system

The CML process is based on a conventional partial combustion system and is coupled with specific gas treatment unit allowing the combustion of the pyrolysis gas produced from wood carbonization. The CML process can be automatically controlled by a continuous control command system. With a standard unit of 12 kilns, the total production capacity is about 3 000 t of charcoal per year, and the energy content in the carbonization gas is 3.6 MW_{th}. The basic unit needs 4 to 5 workers per shift (Gronli, 2005). Once the carbonisation plant is built, it is difficult to increase its capacity since they are lined with refractory concrete and connected to a central combustion chamber through ductings. In practice, the number of steel retorts fluctuates from 4 to 12.

The process module consists of 12 cylindrical connected kilns, each with 16 m^3 of volume capacity. The carbonization air of each furnace is controlled with manual valves located at the bottom part of the kiln. The pyrolysis vapours are sucked out from the top.

The wood is loaded through the top of each kiln with a forklift. After loading, the reactor is closed with a lid. A discharge trap is located on the base of the furnaces and ensures the charcoal unloading into wagon. The unloading can be carried out at relative hot temperature which reduce the duration for kiln cooling and allow a higher temperature in the furnaces for new carbonization cycles. This will induce a higher yield as well as a higher productivity. The discharge mode is done with metallic boxes moving in an excavation located at the centre of the two battery lines. The metallic boxes are then rapidly closed and moved to a park for a cooling period (at least 24 hours). The cooled charcoal is then sent to the packaging house before storage or transport.

In general, the total cycle time for one batch is 22 to 24 hours, with 1 hour for (dis)charging, 6 to 8 hours for carbonisation and 14 to 15 hours for cooling.

The efficiency of the CML process is between 22 and 24 percent, depending on the feedstock characteristics (dimensions, humidity, cleanliness etc) and quality (debarked, moisture content, type of wood, etc.). With wood under 20% humidity a complete production cycle of loading, carbonization, cooling and discharge is completed in 24 hours for each kiln. For example, using oak or beech with humidity between 20 and 25%, the daily production levels for 12 kilns is 8.75 tons of charcoal. The basic 12 units CML process has a production capacity of 2 to 3 000 tons per year, depending on the organisation of the site.

A specific gas treatment unit for carbonization processes has been developed. It is designed to treat the fumes produced by 4 or 5 kilns in simultaneous operation, with staggered firing up of the carbonization line and a wood of which the moisture rate does not exceed 20%.

At the bottom of the incinerator, a natural gas burner is fixed and used for the preheating. The burner is switch off when the heating value of the pyrolysis gas is high enough for combustion. The natural gas burner can be used in case of additional energy requirements when wood moisture content is very high.

The composition and calorific value of the polluted discharges varies considerably from non-combustible to very combustible, depending on the stage of pyrolysis. By recovering and mixing the fumes from several kilns operating simultaneously, provided the firing up of each kiln is suitably staggered, an effluent mixture is obtained which is almost constant in composition and rate of flow, and burns without assistance. This situation, properly exploited by the CML process, allows self-combustion of the fumes by means of an optimized fume collection and incineration system. This working method achieves a statutory de-pollution for all rates of carbonization. Pipes extract the gases from the top of the kiln and are connected to two horizontal chambers where a first combustion stage takes place. The two chambers are connected to a vertical incinerator which assures a secondary combustion stage for a complete pyrolysis gas treatment.

Under normal conditions, the gas treatment unit is designed to respect the European regulation concerning the air emission and the thermal treatment of polluting molecules.

3.2 Basic assumptions of the model

Due to aggregated input data and rounding numbers, the assumptions have been chosen to deliver conservative results and keep the investors' guidelines on the safe side. All data used in the analysis were taken either from the technology manufacturer or expert data. The prices of wood and charcoal sales prices are taken from the current Croatian market conditions. The gross wages are taken from Croatian Bureau of Statistics. The detailed explanations of economic and technical parameters used in for the calculations are given in the Annex 2.

The assumptions used could be divided to those economy related and to those technology related. The economy related assumptions are those that define the economic model of the investment analysis. The technology assumptions relate to feedstock, capacity factor, operation and maintenance etc.

For given prices of inputs (feedstock), output (charcoal), labour employed, the assumptions are the following:

a) Economic assumptions:

- The price of feedstock is 20 €/t bulk at 50% moisture content.
- The charcoal sales price is 315 €/t.
- Discount rate of 10 percent is for 2 percentage points higher than those suggested by the World Bank for conventions and risk stratification of doing business in Croatia and Standard and Poor's country credit rating.
- Project lifetime has been estimated at 10 years.
- Salvage value is assumed to be 30 percent of the end of the project lifetime since the expected technological lifetime of the equipment is 15 years.
- The average monthly net salary according to the level of qualifications is given in the annex.
- Cost of civil works were estimated by civil engineers as 500 €/m^2 for construction costs.

- Operation and maintenance costs were estimated as a sum of 2 percent of the carbonisation equipment, 25 percent of the working capital and the annual labour costs
- Packaging and marketing costs were excluded from calculations as they will increase the operating costs of each module proportionally. It is left to the investor to add those cost to the cash flow according to the purchasing conditions on packaging material.

Before performing the analysis, it would be beneficial to the reader to understand why the period of 10 years was examined while the expected technical lifetime of the equipment is 15 years. Net present value analysis is the usual way to assess the profitability of an investment with showing the difference between the present value of cash flows and the present value of cash outflows. It discounts the future cash flows to arrive at their present value. As such, it is rather sensitive to the reliability of future cash inflows that the examined investment will yield and the longer the time of the project, the harder is to come up with a realistic estimate of the cash flows. However, the shortcomings of the NPV analysis are going to be met firstly by SPP which is the period of the return of the investment. The longer the payback period, the investment seems less appealing, especially if the payback period exceeds 10 years. Secondly, the sensitivity analysis will be performed with changes in prices ± 25 percent to identify the most vulnerable investment parameter. Thirdly, given the present input price of 20 €/t and its upward going trend where in the period from 2002 to 2007 the input price increased 25 percent, it has been investigated how much the input price can raise to keep the investment at least at the neutral level, without gains but without losses, too.

b) Technology assumptions:

- Due to heterogeneous types of feedstock that varies by moisture content, preparation requirements (de-barking, sawing, cutting in smaller pieces etc.), the feedstock preparation costs were not calculated.
- The same type of feedstock (beach or oak) will be purchased for both technologies: density of wood at 0 percent moisture content is equal to 655 kg/m^3, and the average raw feedstock moisture content is 50 percent (0.85 t/m^3 bulk and 1.31 t/m^3 solid).
- Capacity factor or the efficiency level has been assumed at 85 percent of the nominal capacity as suggested by FAO consultants.
- The loads are as homogeneous as possible: one species, one moisture content level, the same piece of wood size per kiln.
- The moisture content of the feedstock is the highest possible according to the technology (20 percent for CML and 30 percent for CTR).

The choice not to include feedstock preparation costs in the analysis represents the strongest assumption among the technology assumptions. In order to mitigate the possible effects on downsizing the economic analysis results, other technical assumptions were quite rigid. The capacity factor is set at 85 percent, meaning, for example, that the base model of 1 000 tons per year capacity is producing 850 tons of charcoal only. Furthermore, the best moisture content is used for the related technology which increases the costs of production. Namely, the producer is buying wood in bulk tons with 50 percent of moisture content. The weight of wood decreases with removing the water content which means that the producer has to buy more tons of wood than the efficiency ratio would suggest.

3.3 Investment possibilities in charcoal modernisation with varying capacities[5]

The analysis starts with the basic modules of each technology which is 1 000 t and 3 000 t per year for the CTR and CML, respectively. In order to make the results of the analysis comparable, the CTR will be increased to 3 000 t, too. Furthermore, the production capacity is increased to 6 000 t per year which is the current charcoal production in Croatia. The detailed calculations are shown in the corresponding tables in the Annex 3.

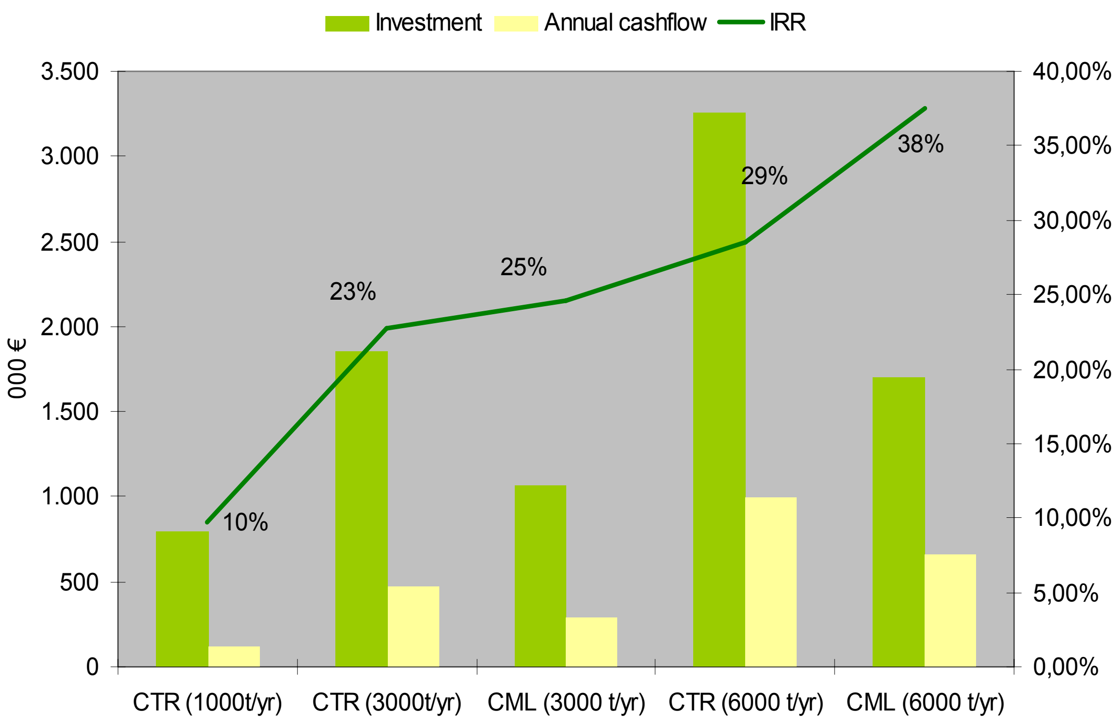

Figure 0.1 The comparison of investment possibilities according to the production capacity

The figure above shows selected indicators of the investment analysis in two different technologies with different production capacities. Both technologies prove the benefits of economies of scale where the IRR and cash flow improve together with the increase of the production capacity. The observer could easily conclude that the best option to invest is the CML technology with 6 000 t per year capacity. The IRR of stunning 38 percent is mostly due to favourable combination of low investment costs (equal to the half capacity CTR plant) and second best cash flow.

Simple payback period confirms the dominance of the CML technology over the CTR technology when investigating the overall investment since both capacities of the CML technology demonstrate better results. However, all payback periods fit within 6.6 and 2.6 years, decreasing as the capacities are increasing.

[5] Comprehensive calculus of all investment cases as well as sensitivity analysis are given in the Annex 2

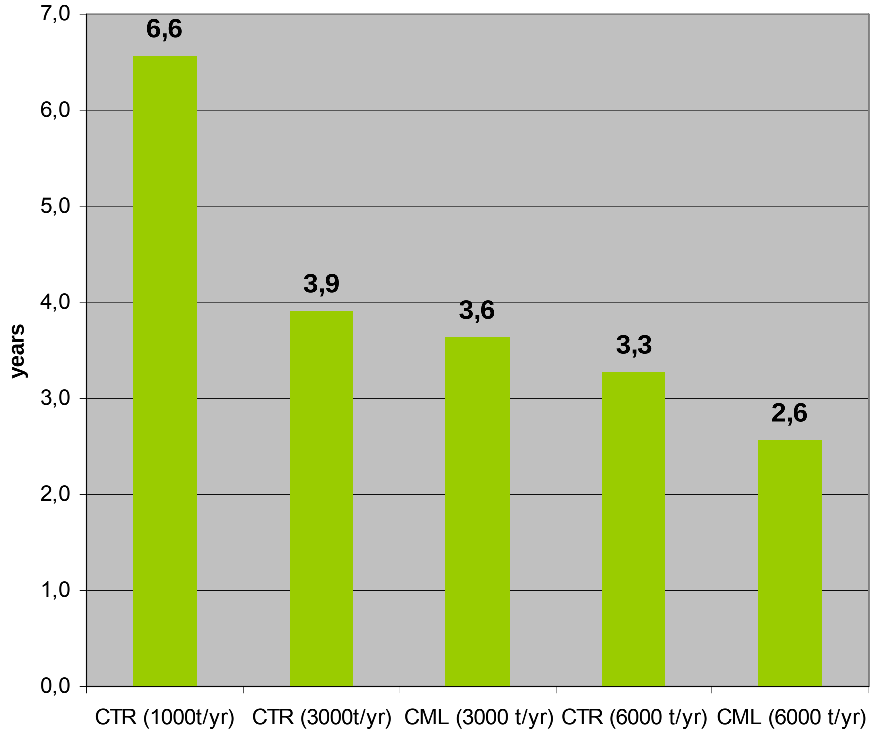

Figure 0.2 Payback period for the base case investment options

However, in economics, there are very few straightforward answers and one should look behind the numbers. The figure below investigates the structure of the investment costs.

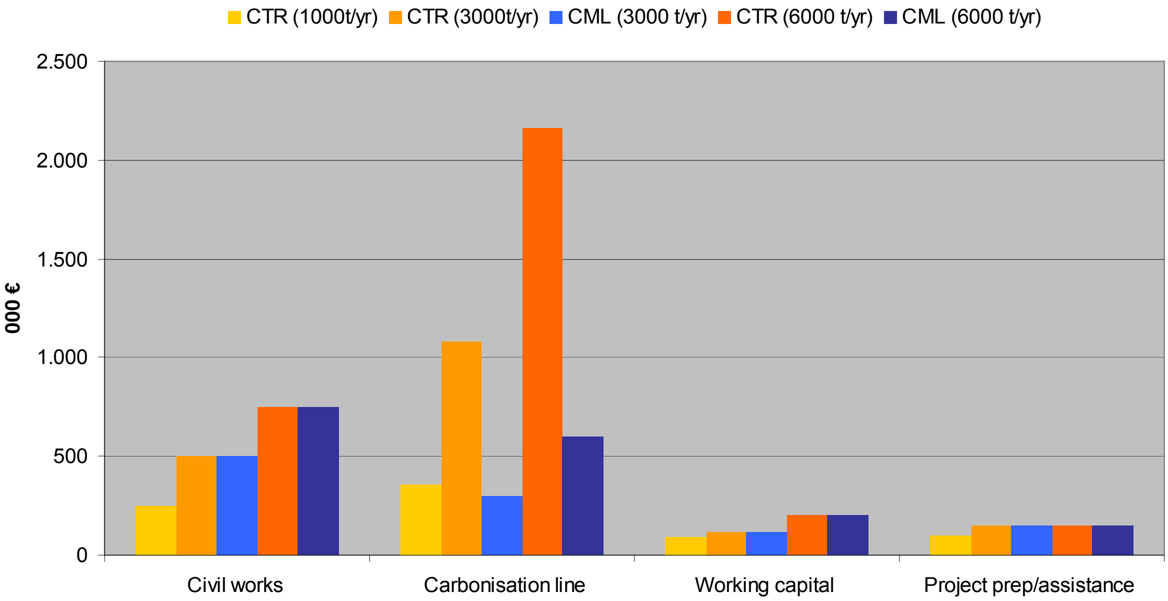

Figure 0.3 Investment parameters according to the technology and corresponding production capacity

The figure clearly visualises the reasons for favourable returns of the investment for the CML technology – the carbonisation plant of the CTR system is 3.6 times more expensive than CML technology for both 3 000 and 6 000 t capacity.

However, it is necessary to investigate the production process and its outcomes. The figure below compares the annual inputs of feedstock (in bulk cubic meters with 50 percent moisture content) and annual outputs of charcoal in tons as well as in monetary units for each investment possibility.

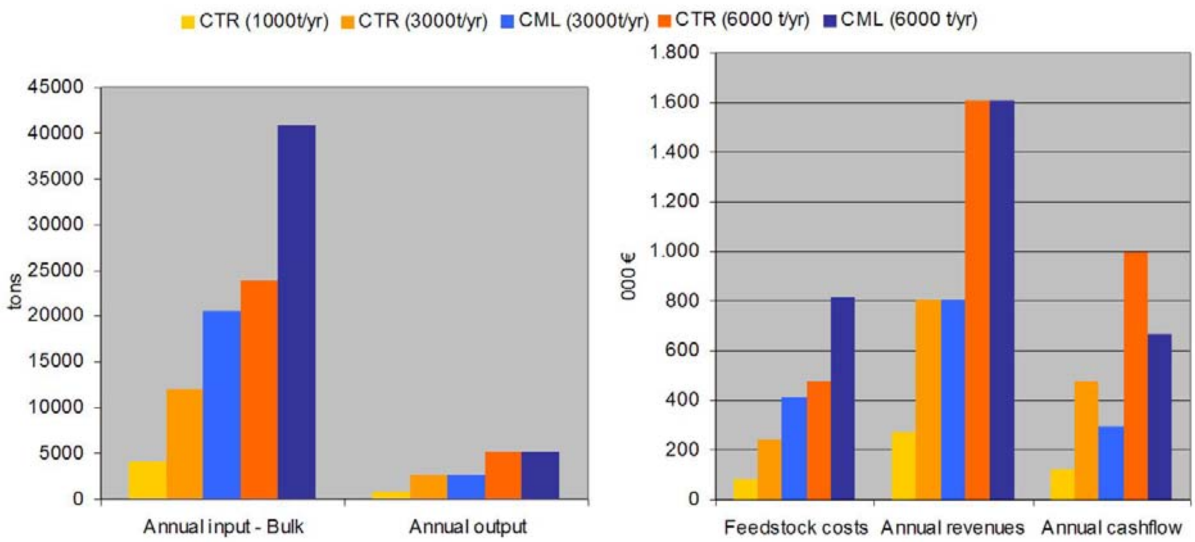

Figure 0.4 Cash flow parameters (without investment) in mass and monetary units according to the technology and corresponding production capacity

The investment now changes its view - the CTR dominates over the CML technology due to its higher efficiency of carbonisation (30 percent compared to 20 percent of the CML). The annual revenues are the same for both investments since they are levelled at the production capacity. However, the cost of charcoal per ton in respect to feedstock cost is 93 € and 160 € for the CTR and CML technology, respectively, which makes the CML technology 1.71 times more expensive in respect to the feedstock costs for all capacities compared. The calculations are visualised on the right part of the figure where the annual cashflow is better for both cases of CTR technology then the same capacity of CML technology.

3.4. Sensitivity analysis

This section will investigate the behaviour of the investments if the prices of their parameters change for ± 25 percent. The sensitivity analysis applied investigates each parameter changes separately, although they are visualised in one figure. The reader should be aware of the possible consequences if the price change happens in more than one parameter.

The minimum capacity CTR system will be the first to be examined and the results are shown it the figure below:

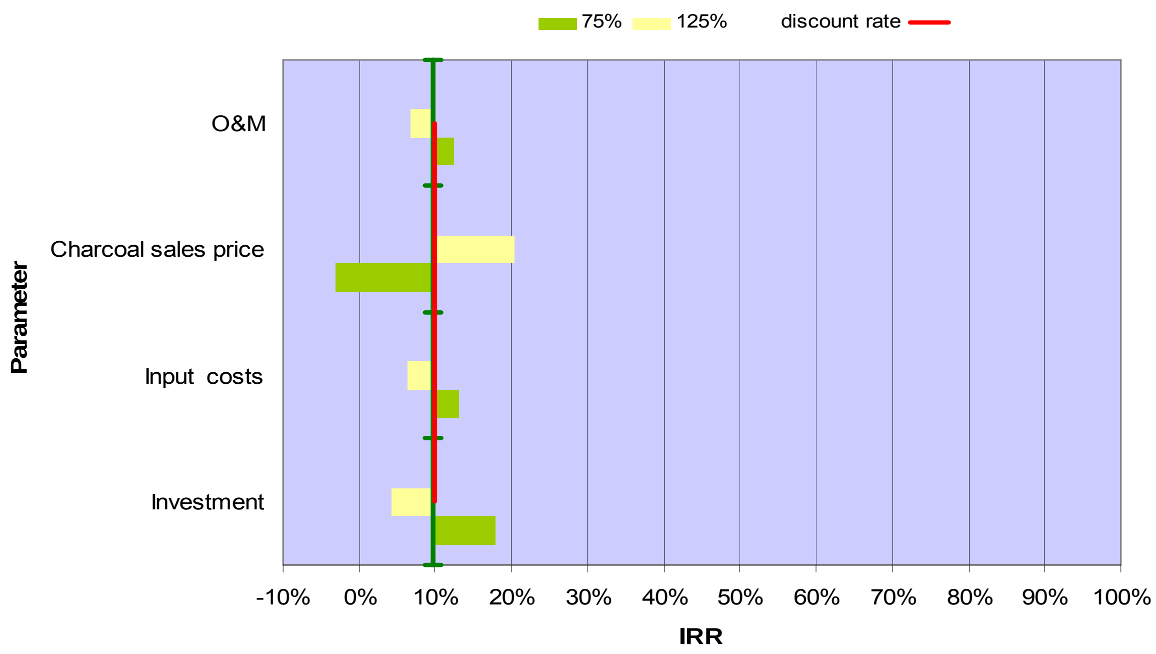

Figure 0.5 Sensitivity analysis for the CTR system of 1 000 t production capacity

Considering that the vertical green line represents the IRR calculated in the previous chapter and the red vertical line the discount rate used, it is obvious that the investment in the basic CTR system is rather vulnerable to all negative changes in prices since the calculated IRR in the basic case is overlapping the discount rate. In other words, the investment is not showing profitability if the charcoal sales prices drop by 25 percent or if the investment, O&M costs and feedstock price increases for 25 percent.

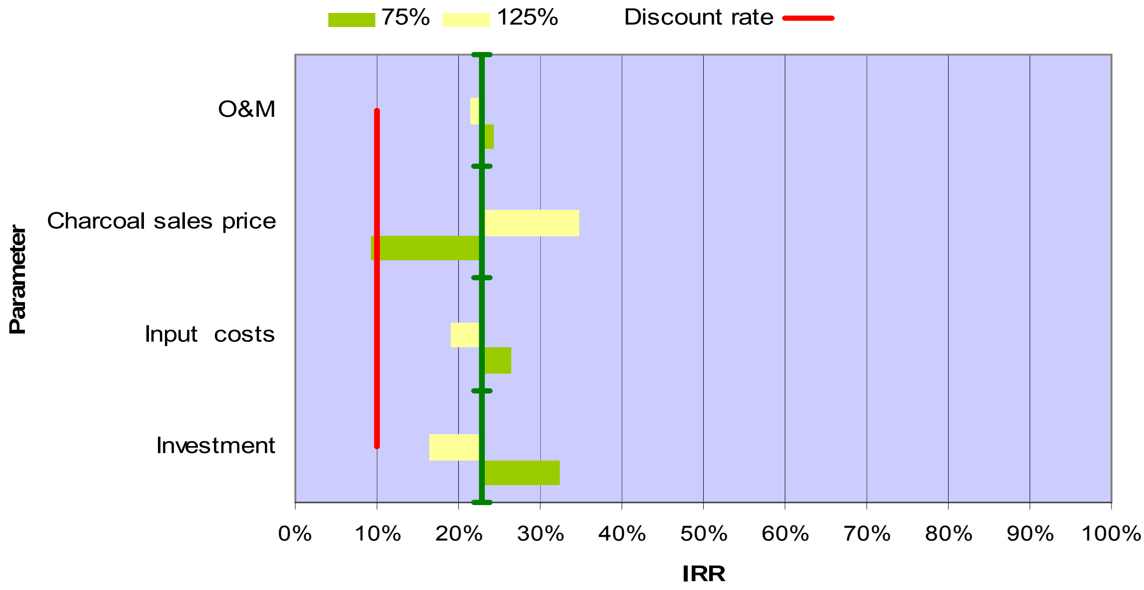

Figure 0.6 Sensitivity analysis for the CTR system of 3 000 t production capacity

Increasing the production capacity from 1 000 t to 3 000 t per year makes the investment in the CTR system less vulnerable, although the drop of 25 percent in charcoal sales prices jeopardises investment's approval since the green bar is crossing the discount rate's line. The figure below shows the sensitivity analysis of the same production capacity but with the CML technology.

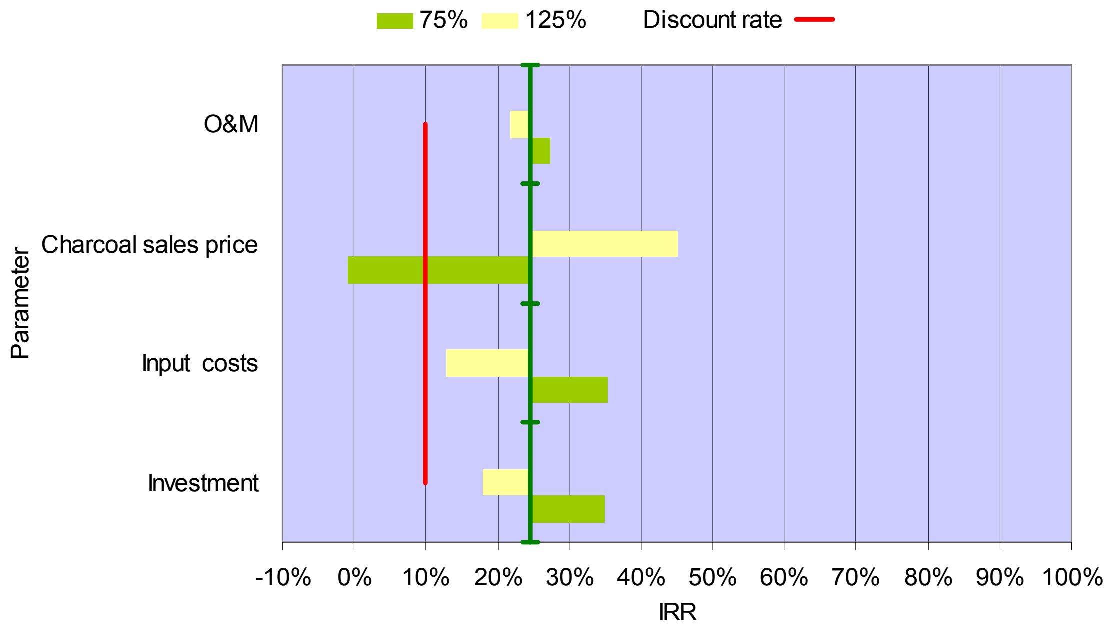

Figure 0.7 Sensitivity analysis for the CML system of 3 000 t production capacity

Although both investments in 3 000 tons of production capacities for both technologies deliver very close IRRs, a 25 percent drop in the charcoal sales prices seriously jeopardises the profitability of the CML investment. To the difference of the CTR system, the investment here is more reactive to price changes in market prices of feedstock and charcoal. Namely, a ± 25 percent change in charcoal sales prices moves the IRR from -1 to 45 percent while the same change in the CTR system covers the range from 9 to 35 percent. The same could be said for the feedstock prices even though a 25 percent increase in feedstock prices does not push the investment below the profitability line.

The following two figures demonstrate the benefits of economies of scale where investments in both technologies have higher original IRRs which help them to improve their results.

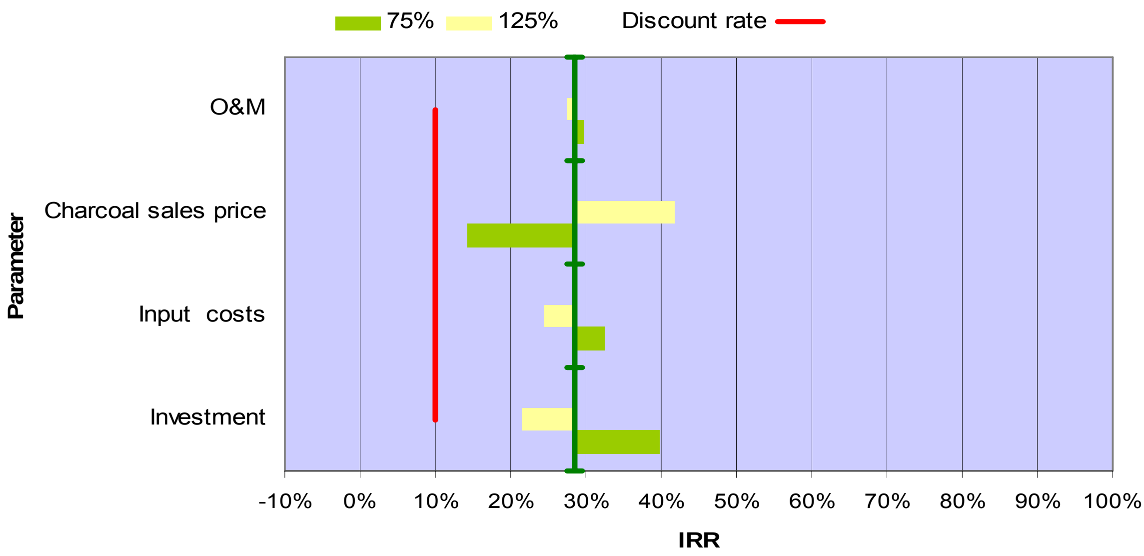

Figure 0.8 Sensitivity analysis for the CTR system of 6 000 t production capacity

However, the sensitivity analysis properties of the 3 000 t capacities plant are repeated on both technologies regardless on the increase of the production capacity – the CTR system is more robust to price changes despite its lower IRR (29 percent and 38 percent for the CTR and CML technology, respectively) while the CML system is showing a wider range of fluctuations due to the price changes. Namely, the vulnerability to annual price changes of the CML technology is again demonstrated where a ± 25 percent change in charcoal sales price provokes a change of IRR from 10 to 62 percent while change the same results with 14 to 42 IRR change for the CTR technology. Here is important to stress that the discount rate of 10 percent used for this analysis is 2 percent higher than the one recommended by international financial institutions for investments in Croatia. Thus, the 8 percent IRR of the CML in the case of a 25 percent plunge in charcoal sales prices should be considered carefully.

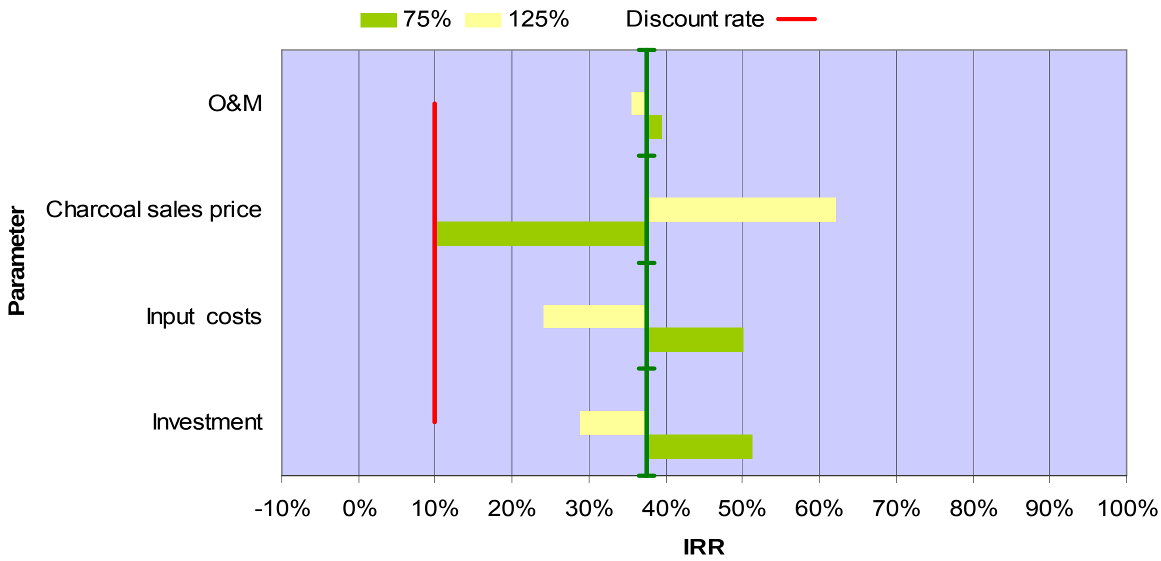

Figure 0.9 Sensitivity analysis for the CML system of 6 000 t production capacity

The sensitivity analysis confirms the implications from the basic economic analysis from the previous chapter and they are: the CTR system is more investment orientated and the CML system is more feedstock orientated. Both systems have charcoal sales price as the most influential parameter of the success on their business operations. However, they differ in the second most important parameter of the overall business venture. For the CTR system, it is the size of the total investment costs (including both sunk costs and carbonisation plant) that is the second most influential parameter. The second most important parameter for the CML process is input costs. It is up to the investor to assess which one of the technologies is more suitable to invest to, weighting the sources and costs of capital versus the availability of feedstock and the situation on the biomass market.

3.4.1 Financing possibilities

As stated before, the purpose of this chapter is to provide guidelines for investing possibilities in modernisation of charcoal production in Croatia. Thus, it is fair to inform an investor about financing possibilities of the investment in Croatia and provide a framework for deciding on the feasibility on the investment since two important steps (feedstock preparation and packaging) of the investment are not incorporated in the calculations.

Let’s assume that the investor will take a loan at HBOR (Croatian Bank for Development and Reconstruction) which offers a special Loan Programme for the Financing of Projects of Environmental Protection, Energy Efficiency and Renewable Energy Sources. In principle, HBOR will finance up to 75 percent of the estimated investment value, VAT excluded. It offers grace period up to 2 years and up to 12 years of repayment period, including grace period. For the purpose of this simple financial analysis, the loan will be signed at 5 years (half of the project lifetime). The interest rate is 6 percent to be on the safe side, although there is a possibility to get a

4 percent interest rate. The figure below shows how the investments' IRR change when the cost of capital is included.

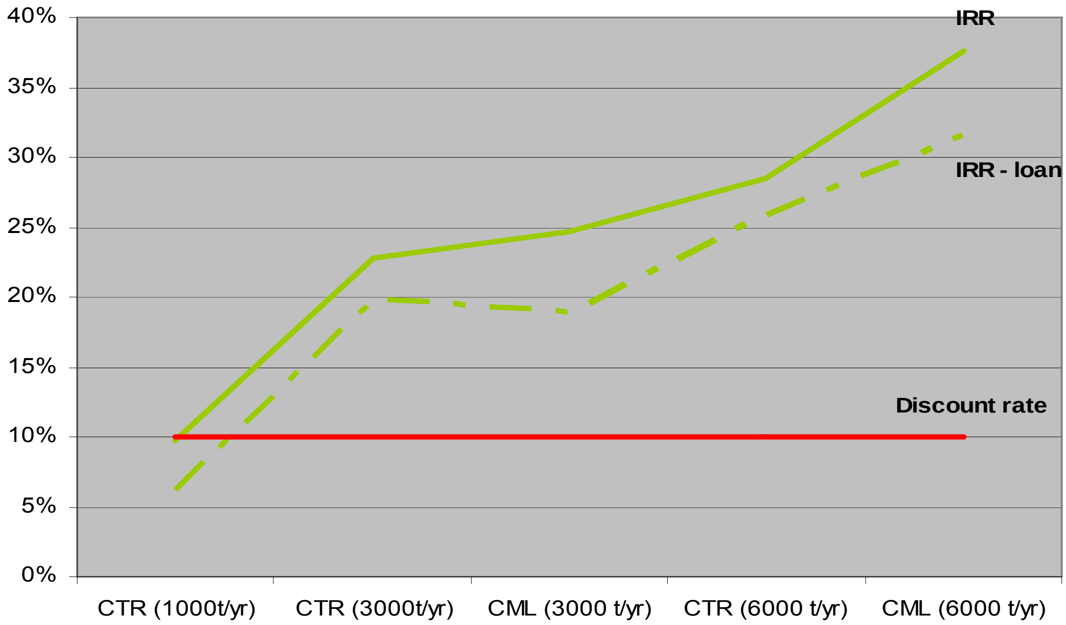

Figure 0.10 Comparison of the IRR and cost of capital

The cost of capital is decreasing the IRR around 3 percent for the CTR technology and 6 percent for the CML technology, starting with 6 percent for the smallest capacity of 1 000 tons to 32 percent for the CML technology of 6 000 tons. Only the investment in the basic CTR system has changed from neutral to negative investment opportunity. All other investment possibilities are remaining at the positive investment side.

3.5 The role of feedstock in the investment

Given the present input price of 20 €/t and its upward going trend where in the period from 2002 to 2007 the input price increased 25 percent and considering the emerging biomass market, it is important to investigate how much the input price can raise to keep the investment at least at the neutral level, without gains but without losses.

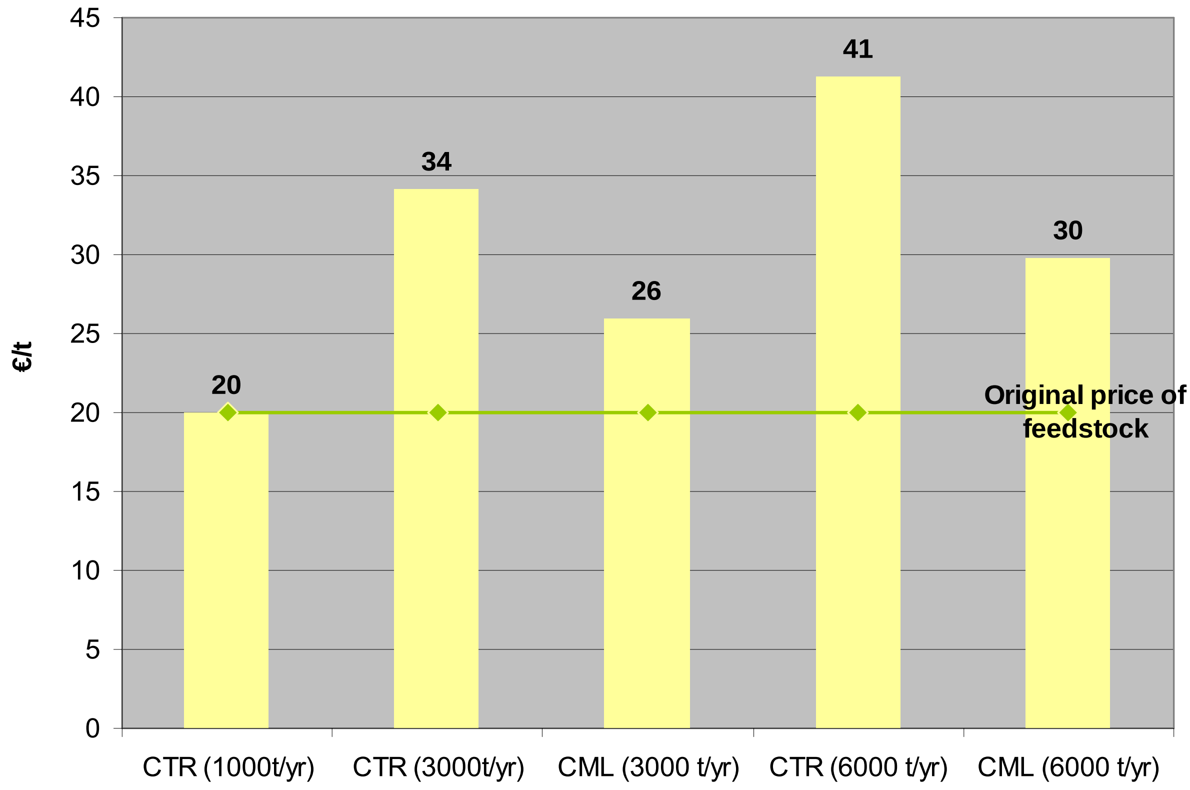

Figure 0.11 The maximal input price to keep the investment neutral

The CTR technology shows more flexibility to biomass price increase since it has higher wood to charcoal conversion efficiency than the CML process. Naturally, the larger the capacity is, the more price increase it can sustain. From the point of the feedstock availability, it is important to notice that the CML process with 6 000 tons per year capacity can sustain less feedstock price increase even than the CTR process with 3 000 tons per year capacity.

Current disturbances at the national biomass market caused by demand from a biomass cogeneration plant in Hungary are indicating the possible price increase trend steeper than the one experienced in previous years. The plant is buying the wood at 35 €/t at the border. Including that price in investment appraisal, the results are shown in the figure below which could be, roughly speaking, met only by the CTR technology.

3.6 Comparison of the best practice technologies

The economic analysis indicates two important characteristics of the best practice technologies. When focusing on the investment costs, namely carbonisation technology, the CML technology dominates. On the other hand, when focusing on cash flow, the CTR shows more stability since it has higher efficiency of carbonisation.

First, when focusing on the investment costs, namely carbonisation technology, the CML technology dominates if taking ceteris paribus in cash flow. The IRRs achieved range between 25 and 38 percent, depending on the plant size while their counterparts by capacity reach 23 and 29 percent IRR, respectively. The investment costs in the carbonisation line of the CTR technology are 1.7 times more expensive than the CML technology.

Second, once the investment is done, the CTR technology performs better results due to its higher wood/charcoal ratio. It is more robust to price changes in general and especially to price changes in feedstock. Moreover, the CTR technology has 1 000 tons capacity modules that could be easily added or removed according to the feedstock availability while the CML has 12 kilns unit without straightforward possibility to extend or decrease its production capacity.

4 Socio-economic issues

Socio-economic issues are giving the context where to place the financial calculus in as well to evaluate the local, regional and/or national implications of implementing particular development decisions. Typically, these implications are measured in terms of economic indices, such as employment and monetary gains, but in effect the analysis relates to a number of aspects, which include social, cultural and environmental issues. The problem lies in the fact that these latter elements are not always tractable to quantitative analysis and, therefore, have been precluded from the majority of impact assessments in the past, even though at the local level they may be very significant. In reality, local socio-economic impacts are diverse and will differ according to such factors as the nature of the technology, local economic structures, social profiles and production processes (Domac, 2002).

The above mentioned holds true for charcoal production. Charcoal, being one of the many bioenergy carriers, delivers three most important socio-economic issues which are regional employment, economic gains and mitigation of rural depopulation. Unlike in the third world countries, in Croatia charcoal is perceived as a luxury energy type dominantly used for preparation of food in terms of barbeques or grilled menu in restaurants. As such, charcoal is related more to the percentage of personal consumption (average per household) available for food (food and beverages category have a dominant share in personal consumption in Croatia of 31.5 percent) and leisure (recreation and culture category are at the 6^{th} place with 6.54 percent) goods than to energy consumption. In that respect, charcoal contribution to the society should not be perceived as a typical bioenergy source that provokes positive economic effects on stability of energy supply and energy price stabilisation but it should be focused on job, income opportunity and generation of value added. On the other hand, charcoal production delivers some negative side effects such as development of grey economy and occupational risk. The influence of both positive and negative effects of charcoal production and their magnitude vary from macro to micro level of the economy. The following chapter will identify those socio-economic issues according to the level of the economy they influence the most. In addition, there would be a hypothesis placed in order assess the possible socio-economic impact if there would be a change from the state-of-the-art.

Before segregating the socio-economic impacts by levels, it is important to briefly describe the overall context of charcoaling in Croatia. The charcoaling is closely linked with the less developed rural areas where social changes are adopted at slower pace. If one connects the average life expectancy of a Croat, which is 75 years, and changes of Croatian economy in that same life span, it could be possible to understand the position of charcoal producers which has been dominantly family run business in less developed areas where social changes are accepted in slower pace. Namely, in a century, Croatia has changed five government-legal frameworks: Austrian-Hungarian Empire until 1918, Kingdom of SHS/Yugoslavia 1918-1941, Independent Croatian State (NDH) 1941-1945, Socialist Federation of Yugoslavia (Social Republic of Croatia) 1945-1990 and independent Republic of Croatia since 1990. Each of the periods had a leading characteristic which is dramatic rejection of the previous system. Croatia has started that turbulent century with characteristics of a feud society with more than 90 percent share of agriculture in the economy. In 1921, 78.6 percent of population was employed in agriculture (Obadić, 2003). The early development of capitalism was cut off by planned economy and fast industrialisation that transited, after a clear cut, again to capitalism some 17 years ago. Today's structure of GDP is 8 percent agriculture, 35 percent industry, 57 percent services (CBS, 2005) which are almost characteristics of a post-industrial economy. In other words, the structure of economy changed from dominantly agricultural economy to third sector economy within period less than the average life expectancy which had severe influence on agriculture and forestry related traditional activities in terms of migration to urban areas, lack of skilled labour, ageing of the rural population etc. Current employment structure is 63.2 percent in services, 31.2 percent in non-agriculture and 5.4 percent of labour force is employed in agriculture (HZZ, 2007). The production techniques remained the same while the charcoal utilisation changed dramatically. Charcoal production used to be a significant income from sales to rural areas as well as energy input for households. Over time, the main market, blacksmiths and related crafts, has disappeared and energy became available either as district heating, electricity or natural gas. Charcoal production has been changed the status from an important "business as usual" activity to a traditional activity on the margins of economy. One of the evidences is that the latest legal document in terms of laws was in 1949 and, at present, the legalisation of charcoal production in kilns or pits is rather non-transparent.

4.1 Socio-economic issues at macro level

From the macroeconomic point of view, charcoal production is significantly related to the following socio-economic issues:

1) Generation of additional value added from natural resources and waste,
2) Rural depopulation,
3) Loss in governmental revenues ('grey economy'),
4) Health (improved living standard).

It is true that charcoal production, as any other business activity, has backward and forward linkages which are, apart of the feedstock, rather negligible to induce significant multiplier effect. The macro level socio-economic issues are rather similar at the national and local level although their impact is felt more at the local level.

Generation of additional value added from natural resources and waste

One of the major characteristics of charcoal is its link with forestry. Exploitation of natural resources is perceived as "new money" in the economy which boosts the GDP. Most countries have experienced GDP jump rate due to their natural resources and ending up with lower GDP after the resource was exploited than that at the beginning of the exploitation. Luckily, this is not the case in Croatia since Hrvatske šume has already been managing forests with well established sustainable practice.

Hrvatske šume are crucial source of feedstock supply for traditional charcoal producers. At present, Hrvatske šume allow to the producer to collect the remainings after their regular forest activities at price range from 1.35 to 6.76 €/bcm. From the point of earnings, the income received from those remainings is negligible, from the Hrvatske šume's point of view, considering that the lowest quality of wood for chipping sold on a public bid reaches price from 10.41 €/bcm to 12.70 €/bcm (although this price contains production costs and trade margin). However, from the forest management point of view, producers are helping sustainable forestry practice by reducing the surplus biomass in the forest ecosystem. In that spirit, charcoaling should be understood as beneficial for the forest management practice and, consequently, could be integrated in that practice.

Generated value added from 1 t of biomass collected after forest harvest way amounts to 60 € (see annex 1, Table 1) and 55 € if the biomass is purchased at public bid (annex 1, Table 2) if the biomass is carbonised in traditional way (carbonisation efficiency 20%). If this value added is multiplied with estimated amount of charcoal produced in traditional way in 2006 which is 6 110 tons, this would mean that traditional charcoal production generates additional value between 867 000 and 929 000 € to the economy (Annex 1, Table 3). If Croatia is about to became self sufficient in charcoal and keep the foreign markets in 2006, the additional production would require some 13 500 t of biomass and generate additional 753 000 to 806 000 € depending on the biomass source (Annex 1, Table 4). Naturally, the higher the efficiency, the greater the value added is.

The estimated potential for value added above is a significant indicator for the government to give a sustainable boost the national GDP from own natural resources. Having in mind that Hrvatske šume is a public company, there is political will only needed for integration of charcoaling together with the already implemented sustainable forest management.

Feedstock availability per each forestry unit should be the base for the implementation. Namely, each forestry unit can estimate with sufficient precision from already available data and usual forestry practice what are the amounts of biomass suitable for charcoal production. Charcoal producers should register at the local forestry unit which would allow them unrestricted and free of charge access up to the estimated sustainable feedstock quantity. They would receive a confirmation form for the quantity retrieved. The confirmation form is an evidence for parties, charcoal producers and foresters, of the possible quantities of charcoal produced. The charcoal producer is giving up a percentage of his profit in the name of the feedstock supplier – the forestry unit of Hrvatske šume, regardless of where the production occurs. In present circumstances, this percentage is (if considered the average wood price and present sales price of charcoal) 1.81 percent.

Integration of charcoal production would cause so called piggy bagging of policies since it addresses many issues of charcoal production, and not only feedstock supply. The most important issues are:

- charcoal producers are having steady access to the feedstock without depending on the personal perception of the chief forester
- charcoal production is getting regulated since each charcoal producer has to be identified in order to get access to the feedstock
- improvement of the small and medium size producers' position in expense to the unregistered producers
- government is generating value added from natural resources which represents "new money" in the economy
- government is gaining VAT otherwise lost in grey economy
- producers are getting full time employed with all the benefits of health insurance and pension fund

- producers are obliged to implement protection at work regulations which is covering the occupational health hazard
- improved health of the forests
- reduction of personal involvement of the local forester
- simplifies the process of certification of origin.

Here, it is fair to mention emerging biomass market since the wood residues for charcoaling are appropriate for production of wooden pellets, too. Hrvatske šume have recently established a daughter company, Šumska biomasa ltd., with biomass and bioenergy as core business. It has already been planned to open a cogeneration unit per each forestry unit. It is also true that production of wood pellets would generate more value added to the economy since there is no loss in the mass from conversion. However, these activities do not have to be perceived as competition to the charcoal production but more like complimentary activities. Namely, if assuming that Croatia wants to be self sufficient in charcoal, there is market demand for additional 2 700 t of charcoal (keeping the same production, together with export but replacing the imports for 2006). The biomass needed is equivalent to 13 500 t which is some 0.06 percent of the estimated technical biomass potential. Charcoal production is already there and the pellet market is about to be developed. When and if the feedstock demand for charcoal production collides with the demand for pellets production, Hrvatske šume still have the power to adjust the feedstock supply to their interests in sense of reducing the available feedstock per forestry unit giving the advantage to its daughter company or/and the wood pellets producers.

Wood waste is the secondary feedstock source for traditional producers but the primary one for the industrial charcoal production. Despite the higher competition for the wood waste, there are still examples of wood processing industries that, for various reasons, pile up their wood waste instead of either utilising (sale or recycling) it or appropriate disposing. This brings an issue of enforcement of already existing legislation on Waste Disposal and Recycling. There should be stronger penalties and stricter inspections for those industries since the wood waste represents environmental problem in many ways: pollution of underground waters and soil, GHG emissions (methane), habitat for rodents and other pests, risk of self ignition to number only a few. The benefits of the existing legislation of waste disposal and recycling in respect to the feedstock supply do not have to be elaborated separately and they affect charcoal production neither directly nor especially but biomass market in general where charcoal belongs to.

Rural depopulation

An issue that would drive a local community to consider involving in supporting charcoal production in its area is social cohesion and stability in terms of mitigating rural depopulation, regional development and rural diversification. Charcoal has been recognised as a significant source to gain additional income of a household. It has been estimated that there are some 800 people engaged in traditional charcoal production and very few of them, if any, apply measures to prevent occupational risk, namely inhaling of smoke during the carbonisation process. In that respect, unregistered charcoal producers are exceptionally sensitive matter: they do generate income from a business activity but they do not pay taxes to the government and their health and the health of community is deteriorating, meaning decreasing the standard of living despite the additional income generated. On the other hand, they are living on the edge of poverty and charcoaling helps their stay in the village.

Health (improved living standard)

It is believed that approximately one third of the total charcoal production in Croatia originates from the “grey economy” that engages about 800 workers (2 persons per a kiln). The workers are not receiving any benefits from registered employment such as steady salary, health insurance, pension fund and/or workers’ rights. In addition, the workers engaged in this activity are not familiar of possible occupational health hazards and risks and, consequently, do not exercise any protection measures.

The kiln owners participating in the “grey economy” do not comply with any standard in respect to the existing environmental laws. The effect of the smoke during the carbonisation depends solely on the conscience of the kiln owner how far is he going to build the kiln from the community. It is true that, on the national scale, the GHG emissions and other pollutants are not contributing with a significant share, but on the local scale the negative consequences are rather visible.

Although individual health is an issue that could be placed under the “micro level”, government has to strive to improve the social welfare of its citizens and thus, occupational risk and health issues of the community are issues to be addressed at the national level, too, by organising a system that would provide sustainable charcoal production with consideration of both present and future generations.

Loss of government income

Apart of the socially handicapped charcoal producers, this “grey economy” producers generate a loss in government revenues from taxes of 120 000 €/year if considered VAT (22 percent) only without considering other losses from income tax, profit tax, etc.

On the other hand, the government is providing rights to the unemployed persons in terms of financial compensation, pension fund, financial aid and compensation of cost due to the education, one-time financial aid and compensation of travel and moving expenses (HZZ, 2007). It is difficult to assess the true amount of benefits received by unregistered charcoal producers but it is highly suggestive that the unregistered charcoal production is not only the source of government income loss but also it increases the government expenditures designated for socially unfavourable groups.

Possible modernisation of charcoal production could address all the above stated issues but a special care has to be addressed in the implementation phase. A hypothetical large-scale charcoal production would gradually push the traditional producers out from the market while the government would collect designated amount of revenues, GHG and volatile particles emission would be easier to control and the employees would be instructed and forced to apply occupational safety measures. The third socio-economic issue, additional income generation and, thus, mitigation of rural depopulation cannot be addressed by founding a modern charcoal production plant directly. Nevertheless, if the modernization of charcoal production techniques is followed by organisation of a system for production, all aforementioned social issues could be met without jeopardizing the income driver. What seems to be crucial is to develop implementation strategy to bring the modernization of charcoal production closer to its beneficiaries. Traditional charcoal production is labour intensive and it is logical that there would be some job losses. But those losses could be minimized by employing the (ex)producers in collecting the feedstock from the wood, for example, that would sustain generation of additional value added to the national GDP from natural resources.

4.2 Socio-economic issues at micro level

Micro level of charcoal production is consisted of one industrial producer and traditional producers divided into two groups: registered and part-time producers. Registered small scale producers kept the habit of having the charcoal production as a secondary income source while just two of the registered producers (located in Istria and Sv. Ivan Žabno) have registered its craft for charcoal production only.

One industrial producer, Belišće, gives an example of possible benefits of large-scale charcoal production. It produces little over a half of the national charcoal production with 115 t of charcoal per employee while the traditional producers make 3-4 t of charcoal per year. Industrial charcoal production holds a well established position in the market due to large scale production that ensures standardized quality and continuity of supply as well as bargaining power. The position is flexible from the market point of view where industrial charcoal producer is able to sell its charcoal at both domestic and international markets.

In the terms of formal-scale employment opportunities which include both direct employment, comprising jobs involved in biomass (wood) supply, construction of a pit or kiln, operation and maintenance of carbonisation process, packaging and transport of wood from a forest to a pit or kiln and from a pit or kiln to the consumer; and indirect employment comprising jobs generated within the economy as a result of expenditures related to charcoal cycle (Faaij, 1997), there is little to add to the already known number of engaged people which is two persons per a kiln.

Apart of the job generation, the most important socio-economic issues of the micro level mostly address traditional producers and they are:

1) Pareto optimum position of part-time producers
2) Lock-in position of registered producers
3) Stable quality and supply of charcoal
4) Deficiency of manpower and unfavourable working conditions
5) Pollution.

Those issues are greatly interrelated and, thus, they will be addressed jointly with other contributing issue. It should be noted that at the local level charcoal (bioenergy) production and use may have other significant implications besides employment and monetary gains (social, cultural and environmental) which are not tractable to quantitative analysis and are therefore omitted from most of impact assessments.

Pareto optimum position of the part-time producers

If an economic system is Pareto efficient, then it is the case that no individual can be made better off without another being made worse off. Traditional small-scale charcoal production represents a significant income source for the rural communities. Well established personal connections between the producer and buyer would be difficult to change since both of the parties in the market do not have incentive to move from the obtained positions. Namely, most of the small scale producers have network of customers based on personal relationships where incentive to cheat is low due to the family ties build for generations. Non-registered or part-time producers organise their production according to the demand since the charcoal production is the secondary income source. Increasing the production means stepping out from the familiar network of customers and personal sale into retail sale via supermarket chains which requires registration. If a small scale producer is to register charcoal production as a craft, he has to pay certain amount of taxes to the government for its economic activity, keep the inventory records of inputs and outputs, upgrade packaging, meet quality standards etc. which increases the cost of production from one side and decreases the flexibility of production as well as negotiation power, on the other side. In total, small charcoal producers end up working more for less profit.

Small unregistered charcoal producers employ mostly family members with no actual wages being paid for their labour, only “sweat equity” (Hector, 2000). The reported selling price of small-scale producers (0.34 €/kg at the production site) is higher than the reported buyout price from the retail market chains (0.31 €/kg at the supermarket). Restaurants (the consumer) and small-scale producers (the producer) have established a market equilibrium price: the restaurant purchases charcoal directly from the producer, saving significantly in omitting the storage costs and supermarkets’ trade margins while having continuous supply and quality (face-to-face sales). The small-scale producers that sell directly to restaurants do not have incentive to approach the wholesalers or enter supermarkets. The wholesalers would be the second best option while the supermarkets are not viable as market not because the buyout price of 0.31 €/kg but due to the small quantity and inadequate packaging.

The issue of occupational risk and pollution at local level has been discussed in the previous section.

Lock-in position of registered producers

Lock-in position is commonly used to describe the position of a small farmer in relation to the supply and demand market. Although large by number, the individual size of farmers is relatively small in comparison to the high concentration ratio in the agriculture input industry (supply side) and wholesalers (demand side). The consequences are higher production prices inflated by input side and true earnings of the production are transferred from the farmer to the wholesalers or retail chains. The usual solution for small farmers is to form a cooperative that would improve their market position transforming them from price takers to a price leader (and preferably, market leader) and, hence, cost leader and efficient (Van Dijk, 1997). In many ways, farmers’ lock-in position is applicable to the position of the traditional charcoal makers. But, before describing the lock-in position of charcoal producers, it is necessary to give a brief insight of their situation.

Small and medium size charcoal producers emerged from traditional, part-time producers into legal business entities designated for production and sale of charcoal. Most of them emerged in early 1990s at the beginning of transition period. They often recall on the “golden period” of charcoal where retail market was still young and charcoal demand was inflated by UNPROFOR troops that had to have once per week grilled menu. They could dictate the conditions of sale to the immature retail sector. However, the golden period came to the dead end street with an overall insolvency of Croatian economy that peaked in 1998 with 93 percent of outstanding debts (Družić, 2003). The economic restructuring strengthened more the fast turnover business activities such as trading than production and processing industries.

Placing the charcoal producers in the described environment, together with their inefficient production, lack of (adequate) labour, bargaining power, to name only few barriers of small and medium traditional charcoal producers, it becomes obvious that they represent the most fragile segment of the production side with lock in situation similar to that of small agriculture farmers. Unlike in the classical economic terms, the charcoal producer is so dependent on the customer (retail chain) for sales that cannot move to another customer without having significant switching cost, either realistic or perceived. The registered small and medium size producers have the least favourable position in the market among the charcoal producers. As described above, traditional non-registered small scale producers have established Pareto optimum and neither they nor their customers (restaurants) have an incentive to move. The industrial producer has power over customer by choosing where to sell, either at domestic or international market and its power is exercised in 15 percent higher selling price. To reach the biggest share of the market, individual charcoal consumers – barbeque consumers – they have to go through retail shops and supermarket chains or, another usual place to buy charcoal, gas stations.

The registered small scale producers do have incentive to increase the market. The phone survey revealed that they are struggling with meeting the conditions of the largest market share held by supermarket chains. There are several possibilities to address the socioeconomic position of the registered producers are employing traditional charcoal production techniques and they are:

- Concentration of charcoal producers
- Modernisation of the carbonisation techniques
- Improvement of efficiency
- Vertical associations.

<u>*Concentration of charcoal producers*</u> could be achieved either through forming associations the farmers' cooperatives example or increasing the production to gain the benefits of economies of scale. Concentration via associations provides collective bargaining power but also requires *adoption of certain quality standards of charcoal* in order to get unique price and commodity of homogeneous quality. If the producers are going to retain the same production technique, organisation in some form of *horizontal alliances* would empower their market position. The agricultural cooperatives could serve as an example for organization structure. Many small agricultural producers are forming cooperatives towards either feedstock (better conditions when ordering bigger quantities of woods such as lower price or priority purchasing right or lower transportation costs) or market (joint processing facilities, marketing and packaging, delivery chains etc.). If the small and medium charcoal producers were to organize themselves in post production activities, they would gain both better negotiation power in respect to the supermarket chains and decrease post production costs. They could share the costs of packaging and distribution by optimizing delivery points which would decrease the costs. Marketing of a *Croatian charcoal brand* would be significantly lower if spread over the producers. However, the producers are those to decide what is the type and form of their association(s).

<u>*Vertical integration*</u> of charcoal producers with feedstock supplier and wholesalers or clustering with wood processing industry would *decrease the exogenous risks* of

charcoal production mostly together with other benefits of cooperatives and partnerships described above for horizontal associations.

Traditional charcoal producers can simultaneously *decrease* both costs of production and *pollution* by *increasing the carbonisation efficiency* through utilisation of hot smoke emitted during the carbonisation in kilns. There are some technologies[6] suggest that current efficiency of up to 21 percent could be doubled. However, the issue of labour deficiency still remains. Namely, traditional charcoal production in kilns is labour intensive activity with unattractive public perception which is not a national issue only.

A *modern production of charcoal* that employs retort gas in the carbonisation process covers all the issues stated above. The production process requires the same quantity of labour as the traditional charcoal production while the *labour conditions are significantly improved*. The workers' exposure to hazardous emissions and particles is minimized. The modern production techniques are usually having larger production capacities[7] with *better carbonisation efficiency* that are bringing benefits of economies of scale in terms of *decreasing the marginal costs of production*. The *stable quality of charcoal* is easier to achieve in those large scale systems then per each kiln. Finally, the large scale production is *improving the position of the charcoal producer,* with or without participation in a charcoal production association, in the market towards supply – from negotiation power to exporting power.

Labour deficiency

In 2006, the registered unemployment rate for Croatia was 16.6 percent (DZS, 2007) or 11.8 percent according to the ILO and EUROSTAT methodology[8]. Despite the large unemployment rate in the rural areas (sometimes rising above 30.1 percent[9]), charcoal producers cannot find adequate labour force. The main complaint of the registered producers that they could have found market to sell more charcoal if they could rely on the working force. Charcoal production is not perceived as a comfortable employment as it involves forest works, staying in modest accommodation while monitoring the kiln or pit during the carbonisation process. Unloading the charcoal from the kiln or pit is dirty and unpleasant. The competing work of unskilled labour is on construction sites which are more reliable, cleaner and more secure source of employment. In addition to that, Croatia is facing a negative trend in rural population, high migration rate to urban areas and ageing of rural population. The labour force that stayed in the village is mostly of low quality with, often, alcohol issues.

To conclude, the charcoal production survived in those areas where family tradition was sustained. Small scale charcoal production in one or two family owned pits, taken as part-time job and additional income activity, is run by family members. Most of attempts to increase the production and employ a non-member of a family did not turn out to be successful due to unfavourable perception of charcoal production and lack of adequate labour force.

[6] Chris Adam and his partners have developed a low cost retort kiln (ECO-Charcoal) that claims 30 to 42 percent efficiency

[7] Carbo technology suggests 1000 t/yr as starting size for their vessles.

[8] The ILO and EUROSTAT methodology includes reaches to„grey economy“

[9] The unemployment rate for Vukovarsko-Srijemska County serves as indicator since it has 40 percent share of agriculture in its GDP involving 36 percent of households. In addition, 61.8 percent of its land is registered as agricultural land and 28.3 percent as forest land.

Modernisation of charcoal production: socio-economic issues of supply and demand of charcoal production

As a luxury good, charcoal demand is following the fluctuations of GDP growth – the higher the GDP is, the society is converting its consumption towards luxury goods. The position of charcoal demand is even better since the consumer does not perceive charcoal as unreachable luxury good.

Charcoal achieves higher prices at the Croatian market than abroad and, thus, the producers are primarily orientated towards the domestic market. *Domestic market position* could be addressed in a way that the charcoal producers, either through an association or, if big enough to bare the expenses, could obtain *Hrvatska kvaliteta (Croatian Quality) sign* that informs the consumer of the charcoal origin. Croatian Chamber of Economy has developed a project called "Visual identification of Croatian products" with intention to support domestic companies and producers in their positioning in both domestic and international markets: "…the intention is to assist first to Croatian economy to recognise clearly its advantages by identifying the goods of highest quality in Croatia. The next step would be to offer those goods, with full confidence and assurance, to the international market…". The Hrvatska kvaliteta project is linked with the issues of *certification* and development of *Croatian charcoal brand*. The world charcoal market reports on unfair competition between producers that domestic legislation does not require sustainable charcoal production standards and those producers that have to comply with strict and expensive environmentally friendly legislation. The issues related to certification are rather complicated and go beyond the scope of this report. However, mentioning certification here emphasises the necessity to protect domestic producers that are contributing to the sustainable development and, thus, sell charcoal at higher prices from those who have different practice.

Another important fact rose from the survey of traditional charcoal producers – Belišće was not perceived as their competition but as a dominant player at the charcoal market. This finding is crucial for the future investor in charcoal production as it points out where and how to enter the charcoal market. Given that the catering sector is saturated and entangled with personal ties, the market where a new entrant would participate is the supermarkets and other retailers. While small scale producers are struggling with the supermarkets, Belišće is able to sell charcoal at prices even 15 percent higher. The key advantage of Belišće is its negotiating power which lies in the quantity of charcoal produced and stable production flow. That is why an investor should focus on large scale industrial production of charcoal to succeed.

Modernisation of charcoal production means transfer of knowledge for production of charcoal production line (i.e. twin retorts) where domestic heavy metal and packaging paper industries could find income. Industrial production makes charcoal production less labour intensive while it improves working conditions for employees. In other words, due to the diseconomies of scale, larger production with more sophisticated production techniques tend to generate less employment opportunities (BIOSEM – Biomass Socio-economic Multiplier, 1998). But, taking into the account the inadequate working conditions in traditional techniques, health issues both for personal health and local community would improve with modernisation of production techniques. Modernisation of charcoal production could change the scornful attitude/perception towards charcoal production through improving the working conditions, decreasing visual and other pollution and still contribute to the rural development.

The last but not the least, another social issue arises from modernisation of charcoal production: modernisation might provide solution for unfavourable position of small and medium size producers described above.

5 Conclusions

From the economic point of view, charcoal production represents a lucrative business opportunity regardless of the carbonisation technique employed. The economic calculus of traditional charcoal producers identifies that traditional charcoal producers are earning from self-employment a net monthly salary of 560 € close to the average of the sector and getting the IRR as high as 90 percent when supermarket's price considered (without transportation costs). The results are inflated since the labour employed is underpaid (2.53 €/hour in total while the average is 3.13 €/hour net and 4.24 €/hour gross). Furthermore, these admirable results are deflated when placing the traditional charcoal production in the context of socio-economic issues; the businesses venture of charcoal production losses its appeal. Fragmentation of traditional charcoal production as well as significant part of grey economy involved weakens their position at the market, both from the demand and supply side. One industrial producer, Belišće, gives an example of possible benefits of large-scale charcoal production. It produces little over a half of the national charcoal production with 115 t of charcoal per employee while the small-scale produce 3-4 t of charcoal per year with traditional carbonisation technique. Industrial charcoal production holds a well established position in the market due to large scale production that ensures standardized quality and continuity of supply as well as bargaining power. The position is flexible from the market point of view where industrial charcoal producer is able to sell its charcoal at both domestic and international markets.

The investment opportunities have indicated guidelines for modernisation of charcoal production. The project appraisals of both production capacities together with the corresponding sensitivity analyses indicate lucrative investment opportunities in modernisation of charcoal production.

The IRRs in the base case scenarios are ranging from 10 to 38 percent and simple payback period lasting from 6.6 years to 2.6 years. However, the technologies investigated are showing two complete opposite investment opportunities. The CML technology performs better overall results while the CTR technology is having better cashflow and business performance. In other words, it is upon the investor and investment environment to decide which of the two technologies investigated are more appropriate to undertake. If the investor finds biomass supply to be instable or decreasing, the CTR technology would be safer choice. On the other hand, in the environment with scarce financing sources, the choice would be the CML technology since it would be paid off in 2.6 years (in the 6 000 tons capacity). Naturally, the final shaping of the investment would be after understanding the costs of feedstock preparation which differs from the wood processing industry and forest residues, to say the least.

The base scenarios of charcoal production were further explored with sensitivity analyses changing O&M costs, input costs, charcoal sales price and total investment for 25 percent in both directions. While the variations of investment, input costs and O&M costs were negligible, the project feasibility is mostly influenced by charcoal sales price that pushed the profitability of the project either below the discount rate in the case of the CML system of 3 000 tons production capacity or very close to it, when capacity was increased to 6 000 tons. The CTR technology performed more robustness to negative price changes in all capacities than the CML technology.

Because the charcoal sales price has a relevant impact on the economic performance of the project, and the last few years a charcoal sales price rose significantly (in the five years period, from 2002 to 2007, sales price rose for about 7 percent), one could also say that project is feasible from that point of view.

Apart from the charcoal sales price, the applied changes in the parameters do not cause the IRR of the project to drop below acceptable levels. Only if multiple of these changes occur simultaneously, and to the full extent, the project feasibility may drop below acceptable levels.

Therefore a reliable market (domestic and foreign) and reliable technology are essential criteria to develop a good charcoal project.

In the respect of the input prices, due to the increasing demand for biomass, the investments were tested for the maximum price increase in feedstock. The best performance was 41 €/ton in the CTR technology with the highest production capacity of 6 000 tons. The CTR technology performed better results in both sensitivity analysis and feedstock analysis in the respect of feedstock.

Does charcoal provides earnings that are high enough to make it worthwhile to mobilize local resources to improve it? It is assumed, and possibly generally true for rural conditions, that some of the required resources (e.g. labour, machines, forests or forest residues, land infrastructure and management capacity) would otherwise not be fully utilised. Moreover, the work is generally not performed under wage contracts, but by self-employed farmers, forest owners or local contractors whose interest is to get adequate earnings regardless of the source (whether personal labour, rental of machines or sale of charcoal). However, by establishing a system for charcoal production, the government can generate “new money” in the economy since charcoal production is directly linked with forestry and utilise wood residues that otherwise would not be economically valued. If Croatia is to become self-sufficient in charcoal (taking 2006 as the base year) the additional value added from charcoal production would be 753 000 to 806 000 €/year depending on the biomass source. In that sense, the integration of charcoal production within the usual forest activities would boost the GDP of 60 € per ton of wood residues that are collected from the forest (given the present prices and carbonisation efficiency).

Modernisation of charcoal production could tackle most of the socio-economic issues of traditional charcoal production such as locked-in position in the market for the registered traditional producers, downsizing of grey economy with improvement of standard of living both at the employee’s level and local community as well as generate income from taxes.

The implementation of charcoal production modernisation has to be carefully executed in order to minimise negative socio-economic issues since, despite the old-fashioned way of charcoal production in kilns employed among small scale charcoal producers, charcoal production still maintains its significance in the rural areas with low income or job opportunities. In villages, generations of families were dependable, and they still are, on the “charcoal production trade” which is transferred from a father to the son.

However, if the small and medium charcoal producers do not recognise the advantages of charcoal modernisation, they have to form some form of vertical and horizontal associations in order to survive at the market. This would not be the long-term solution, since the main issues are still present such as labour intensity and lack of manpower, uneven quality of charcoal produced etc. It is fair to expect, if the current trends of international charcoal markets continue, that the traditional charcoal producers will be swept away by the low price charcoal from imports.

6 Recommendations

The previous chapters have shown how complex the situation of charcoal production in Croatia is. In order to make comprehensive comments for improvement of that situation, the recommendations are organised according to the point of focus which are:

1) feedstock supply
2) charcoal production and sale.

Nevertheless, the reader should bear in mind that the proposals listed below could be taken as single recommendation or a combination of any.

Feedstock supply

While the traditional charcoal producers prefer remained wood in the forest after the regular forest activities, the industrial producer prefers wood waste from wood processing industries as feedstock for charcoal production. In that respect, the recommendations strive towards these two main feedstock sources:

a) woody biomass from usual forestry activities:
    a. *Integration of charcoal production together with forest maintenance*
    b. *Formation of a charcoal inputs association to avoid the lock-in position of charcoal producers from the feedstock side*

b) wood waste from wood processing industries:
    a. Enforcement of legislation on Waste disposal and recycling

Charcoal production and sale

The recommendations related to charcoal production reflect greatly on the sales position and thus the recommendations here will be joined for both production and sale. The recommendations are aimed at:

a) Transparency of the legal environment that describes to the detail conditions for:

- location of charcoal production,
- emissions limits from charcoal production,
- occupational safety

b) Way out for lock-in position of small and medium size producers

- Concentration of charcoal producers
- Modernisation of the carbonisation techniques
- Improvement of efficiency
- Vertical associations

c) Quality of charcoal

- Adoption of quality standards
- Developing a Croatian charcoal brand
- Gaining ‘Hrvatska kvaliteta’ (*Croatian quality*) sign

d) Labour deficiency

- Improvement of working conditions

e) Air pollution

- Reutilisation of retort gases

The stated issues could be tackled with either one or various combinations of the following suggestions although they are numbered separately.

A <u>*modern production of charcoal*</u> that employs retort gas in the carbonisation process covers all the issues stated above. The production process requires the same quantity of labour as the traditional charcoal production while the *labour conditions are significantly improved*. The workers' exposure to hazardous emissions and particles is minimized. The modern production techniques are usually having larger production capacities with *better carbonisation efficiency* that are bringing benefits of economies of scale in terms of *decreasing the marginal costs of production*. The *stable quality of charcoal* is easier to achieve in those large scale systems then per each kiln. Finally, the large scale production is *improving the position of the charcoal producer,* with or without participation in a charcoal production association, in the market towards supply – from negotiation power to exporting power. At the end, the *governmental income is increased* from VAT otherwise lost in the grey economy and from sustainable exploitation of national natural resources.

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Annex 1

Value added

If one multiplies the charcoal price with production efficiency and reduced it by biomass price, the one obtains the value added from charcoal production.

Table 12 Added value from 1 ton of biomass (harvest remainings) used for charcoal production

Item	Value	Unit
Biomass price	2.44	€/t
Charcoal price	311	€/t
Production efficiency	20	%
Added value from charcoal production	**60**	**€**

The biomass price taken here represents the mean of the minimum and maximum price (1.35 and 6.76 €/bcm) for forest harvest remainings which is 4.06 €/bcm and convert it to tons (2.44 €/t) while the charcoal price is actually the supermarkets' buyout price for charcoal.

The next table shows the value added from charcoal production when the biomass represents the lowest quality wood purchased at a public bid.

Table 2 Added value from 1 ton of biomass (lowest quality wood) used for charcoal production

Item	Value	Unit
Biomass price	6.93	€/t
Charcoal price	311	€/t
Production efficiency	20	%
Added value from charcoal production	**55**	**€**

Table 3 Added value from the charcoal produced in traditional way in 2006

Item	Value 1[1]	Value 2[2]	Unit
Biomass price	2.44	6.39	€/t
Charcoal price	311	311	€/t
Feedstock	15500	15500	t
Production efficiency	20	20	%
Added value from charcoal production	**928 680**	**867 257**	**€**

[1] Biomass originates from harvest remainings
[2] Biomass is purchased at public bid and represents the lowest quality of wood

Table 4 Added value if the imports of charcoal in 2006 were to be replaced by domestic production

Item	Value 1[1]	Value 2[2]	Unit
Biomass price	2.44	6.39	€/t
Charcoal price	311	311	€/t
Feedstock	13500	13500	t
Production efficiency	20	20	%
Added value from charcoal production	**806 249**	**752 924**	**€**

[1] Biomass originates from harvest remainings
[2] Biomass is purchased at public bid and represents the lowest quality of wood

Annex 2

Explanation of parameters used for economic analysis

Density of Wood (at 0% MCw)	Physical property of a certain wood species
MCw1 (m. content on wet basis)	Moisture content of fresh wood, physical property of a certain wood species in a certain area
MCw2 (m. content on dry basis)	Moisture content of dried wood, physical property required by technology
Weight of wet wood (50% MCw) - Bulk	(Density of wood/(1-MCw1)*0,65)/1000
Weight of dry wood (30% MCw) - Bulk	(Density of wood/(1-MCw2)*0,65)/1000
Weight of wet wood (50% MCw) - Solid	(Density of wood/(1-MCw1)/1000
Weight of dry wood (30% MCw) - Solid	(Density of wood/(1-MCw2)/1000
Yield	Efficiency by which 1 ton of wood is converted to 1 ton of charcoal
Average production time	Time needed for carbonization
Average cooling time	Time needed for carbonized wood, charcoal, to cool down and be prepared for packaging
Capacity	Quantity of charcoal that can be produced annually
Capacity factor	Possible production hours in one year of production period
Investment	Sum of 1 to 4 below
1. Civil works	Annual gross salary of all employed, full and part time employees, plus cost of work on construction
2. Kiln	Cost of technology, defined by manufacturer - includes all technology needed for carbonization
3.Working capital	All tangible assets that are used in production process, cranes, forklift, conveyer for packaging surveillance system, computers for offices and running business
4.Project prep/assistance	Licenses for opening business, licenses for building, cost of lot for plant, technical preparation before building
Annual input	Quantity of wood needed for production of certain amount of

Annual input - Bulk	charcoal= annual output / yield ((1-MCw2)/(1-MCw1)/Annual input)
Annual input - Solid	(Annual input bulk/ Weight of dry Solid wood)
Annual output	Tons of charcoal produced, input times yield (efficiency) - **nominal capacity times capacity factor**
Wood (mc 50%) costs - (bulk)	Contemporary market price
Charcoal sales price	Contemporary market price
Annual costs	Raw material + O&M
Raw material	Cost of inputs needed for production, price of input times input needed (bulk or solid)
O&M	Cost of operation and maintenance:10 % of value of kiln plus 25% of value of working capital plus labour
Depreciation rate	Rate at which tangible assets loses its value by being in use
Salvage Value	The estimated value that an asset will realize upon its sale at the end of its useful life
Annual revenues	Revenues generated through selling produced output
Annual cash flow	Difference between annual revenues and annual cost
Simple payback	The length of time required to recover the cost of an investment
Discount rate	Financial concept based on the future cash flow in lieu of the present value of the cash flow
NPV	Measures the excess or shortfall of cash flows, in present value (PV) terms, once financing charges are met.
IRR	Rate of growth a project is expected to generate, annualized effective compounded return rate which can be earned on the invested capital

Table 1 Average monthly salary according to the level of qualifications

Level of qualification	Net salary (€)
Qualified	505
Highly qualified	528
Engineer	672

Annex 3

Economic analysis of investment in the CTR plant

Table 1 Technology specific assumptions

MCw_2 (moisture content on dry basis)	[%]	30%
Weight of dry wood (30% MCw) – Bulk	[t/m^3]	0.61
Weight of dry wood (30% MCw) – Solid	[t/m^3]	0.94
Number of kilns		1
Capacity of kiln	[m^{3}s wood/vessel]	3
Yield	[kg of charcoal/kg of wood]	0.3
Average production time	[hours]	12
Average cooling time	[hours]	24

Table 2 Economic analysis of the CTR plant with varying capacities

Parameter	Unit	1000 t/yr capacity	3000 t/yr capacity	6000 t/yr capacity
Nominal capacity	[ton/year]	**1 000**	**3 000**	**6 000**
Capacity factor	[production hours/total hours]	85%	85%	85%
Capacity	[ton/year]	**850**	**2 550**	**5 100**
Project time	[years]	10	10	10
Investment	[EUR]	**800 000**	**1 850 000**	**3 260 000**
Civil works	[EUR]	250 000	500 000	750 000
Kiln (Carbo Twin Retort)	[EUR]	360 000	1 080 000	2 160 000
Working capital	[EUR]	90 000	120 000	200 000
Project prep/assistance	[EUR]	100 000	150 000	150 000
Annual input	[tons wood 30%/yr]	2 833	8 500	17 000
Annual input - Bulk	[tons wood 50%/yr]	**3 967**	**11 900**	**23 800**
Annual input - Solid	[m^{3}s wood 50%/yr]	**3 028**	**9 084**	**18 168**
Annual output	[tons charcoal/yr]	**850**	**2 550**	**5 100**
Wood (mc 50%) costs - (bulk)	[EUR/ton]	20	20	20
Charcoal sales price	[EUR/ton]	315	315	315
Annual costs	[EUR/yr]	145 932	330 507	610 107
Raw material	[EUR/yr]	79 333	238 000	476 000
O&M	[EUR/yr]	66 598	92 507	134 107
Salvage Value	[30% of base value]	108 000	324 000	648 000
Annual revenues	[EUR/yr]	267 750	803 250	1 606 500
Annual cashflow	[EUR/yr]	121 818	427 743	996 393
Simple payback	[year]	**6.6**	**3.9**	**3.3**
Discount rate	[%]	10%	10%	10%
NPV	[EUR]	**-8 946**	**1 072 470**	**4 928 642**

IRR	[%]	**9.73%**	**22.79%**	**28.54%**

Economic analysis of investment in the CML plant

Table 3 Technology specific assumptions

MCw_2 (m. content on dry basis)	[%]	20%
Weight of dry wood (20% MCw) – Bulk	[t/m^3]	0.53
Weight of dry wood (20% MCw) – Solid	[t/m^3]	0.82
Number of kilns		12
Capacity of kiln	[m^{3}s wood/vessel]	16
Yield	[kg of charcoal/kg of wood]	0.20
Average production time	[hours]	12
Average cooling time	[hours]	24

Table 4 Economic analysis of the CML plant with varying capacities

Parameter	Unit	3000 t/yr capacity	6000 t/yr capacity
Nominal Capacity	[ton/year]	3 000	6 000
Capacity factor	[production hours/total hours]	85%	85%
Capacity	[ton/year]	2 550	5 100
Project time	[years]	10	10
Investment	[EUR]	1 070 000	1 700 000
Civil works	[EUR]	500 000	750 000
CML Kiln System	[EUR]	300 000	600 000
Working capital	[EUR]	120 000	200 000
Project prep/assistance	[EUR]	150 000	150 000
Annual input	[tons wood_30%/yr]	12 750	25 500
Annual input - Bulk	[tons wood_50%/yr]	20 400	40 800
Annual input - Solid	[m3s wood_50%/yr]	15 573	31 145
Annual output	[tons charcoal/yr]	2 550	5 100
Wood (mc 50%) costs - (bulk)	[EUR/ton]	20	20
Charcoal sales price	[EUR/ton]	315	315
Annual costs	[EUR/yr]	509 695	943 695
Raw material	[EUR/yr]	408 000	816 000
O&M	[EUR/yr]	101 695	127 695
Salvage Value	[30% of base value]	90 000	180 000
Annual revenues	[EUR/yr]	803 250	1 606 500
Annual cashflow	[EUR/yr]	293 555	662 805
Simple payback	[year]	3.6	2.6
Discount rate	[%]	10%	10%
NPV	[EUR]	698 606	2 220 043
IRR	[%]	24.63%	37.54%