Procurement process of small scale CHP in a public procurement context – Case study of Mekrijärvi small scale CHP

Teemu Vilppo & Lauri Sikanen

Abstract

As energy prices are increasing and pressure towards renewable energy sources is global, wood based fuels also in electricity production have been in focus. Heat only solutions are well known but combined heat and power (electricity) production in small scale is just developing. Mekrijärvi Research Station of the University of Eastern Finland has produced its' heat by woodpellets and by local heat grid since 2006. Current project replaces older 700kW_h boiler with small scale CHP unit. Small scale CHP unit produces heat for local district heating and replace some or all of power (electricity) consumption of station. In this study procurement procedure in Finnish public procurement environment [1], major factors affecting price and utilization are considered and the whole process is evaluated in order to help directors and project managers to implement their small scale CHP-projects .

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Abbreviations:
CHP – Combined Heat and Power
kW_h – kilowatts of heat
kW_e – kilowatts of power (electricity)

Cover photo: Sami Lamminen, Finnish Forest Research Institute

1. Introduction

Small scale combined heat and power (electricity) production, also called small scale CHP, is one of the most interesting topics under development in renewable energy business in early 2010's. It is studied a lot in Europe, but the niche of such installations is even more in countries, where heat and electricity is produced in off-grid communities in the middle of forest resources with subsidized oil or gas. That kind of places can be found especially in Canada and Russia. Nevertheless, pioneering installations are located mostly in Europe.

Mekrijärvi Research Station is a part of University of Eastern Finland. It is located in Ilomantsi municipality near Russian border. The role of the station is to support university in ecological research and field education. In addition to laboratory facilities, the station has premises for accommodation, restaurant and catering, lecture rooms and group work rooms as well as offices. Total amount of heated space is about 10 000 m^3 (Figure 1).

Figure 1. Mekrijärvi research station from aerial perspective.

Mekrijärvi research station has produced heat required by Mekrijärvi research station local district heating by pellet boiler since 2006. The aim of the station is to study wood based energy production in the natural size scale for the station and to have research connected to facilities as much as possible.

Current project is to replace older 700kW boiler with small scale CHP unit. Small scale CHP unit produces heat for local district heating and replace some or all of power (electricity) consumption of station.

2. Aim of the study

In this study procurement procedure in Finnish public procurement environment is described. The whole process is also opened so that factors affecting to solutions and selections made are presented and discussed. Major factors affecting price and utilization are considered. The primary aim of the report is to make further investment decisions and building processes more fluent and less risky.

3. Why CHP

3.1. Electricity market in Finland

Finnish electricity market is a part of Nord Pool electricity exchange. Nord Pool covers electricity markets of Finland, Sweden, Norway and Denmark and it is established 1993. Nord Pool deals with the electricity amounts produced and consumed in four member countries but Nord Pool has connections also to Central Europe and Russia. Price is varying a lot concerning the season of the year (Figure 2).

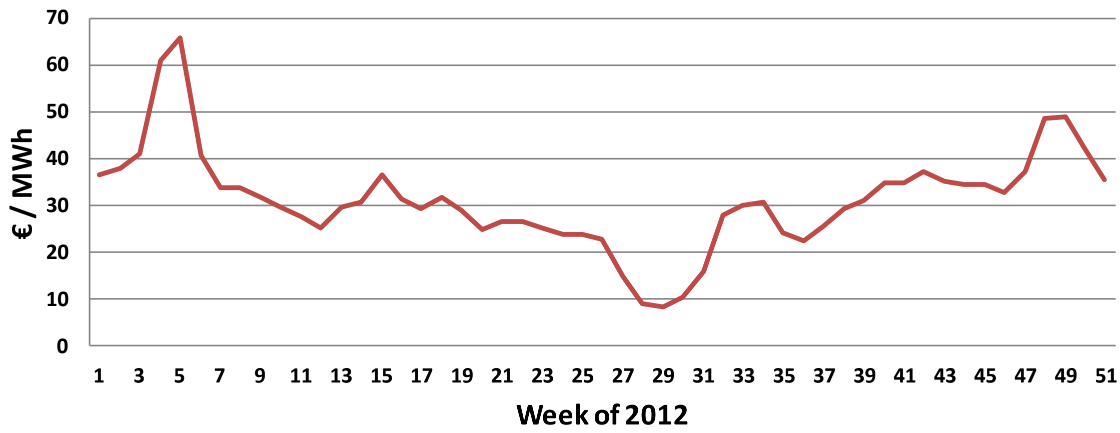

Figure 2. *Electricity price in Nord Pool in 2012 (www.norpoolspot.com).*

In Finland consumer electricity is supplied as 240V/50Hz one phase and 400V / 50Hz 3-phase power. Typical heating setup in cities and municipality center is District heating supplied by boilers of large scale CHP plants with improved emission control due to more strict regulation of large scale plants than household appliances. Finnish electricity prices are relatively low if compared with the rest of Europe (Figure 3).

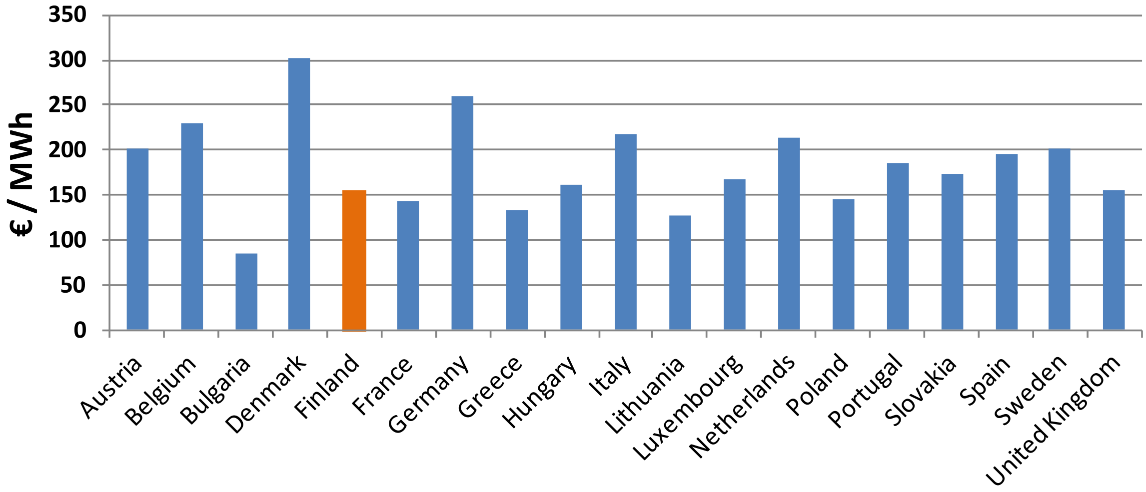

Figure 3. *Electricity prices of households in selected European countries including grid fees and taxes in November 2012 (www.energy.eu).*

Finnish feed-in tariff system for renewable electricity is not well developed but it exists (www.energiamarkkinavirasto.fi). The guaranteed price for wood based electricity is 83.5€/MWh and qualifications are relatively tight. Minimum power limit is 0.1MW. When compared the price of electricity and the feeding tariff, it can be seen that the price is about 40€/MWh higher than the tariff in Finland. It means that the best economic benefit is achieved if electricity produced is replacing the electricity bought from the grid. Price of electricity varies year by year, but general trend is upward, including taxation. Electricity in Finland is about 70 €/MWh more expensive than woodpellets and 95 €/MWh more expensive than woodchips in 2012 (Figure 4). The difference in Finnish electricity price compared to figure 3 comes from the selection of slightly different user group.

In Finland heat entrepreneurship has been expanding rapidly during last 10 years. The number of entrepreneurs was about 300 in 2012 and they took care of about 600 installations. The limit of growth is close, good spots are already occupied and the business need to find other ways to develop. Due to this, heat entrepreneurs are interested to make small combined heat and power units instead of heat only installations [15].

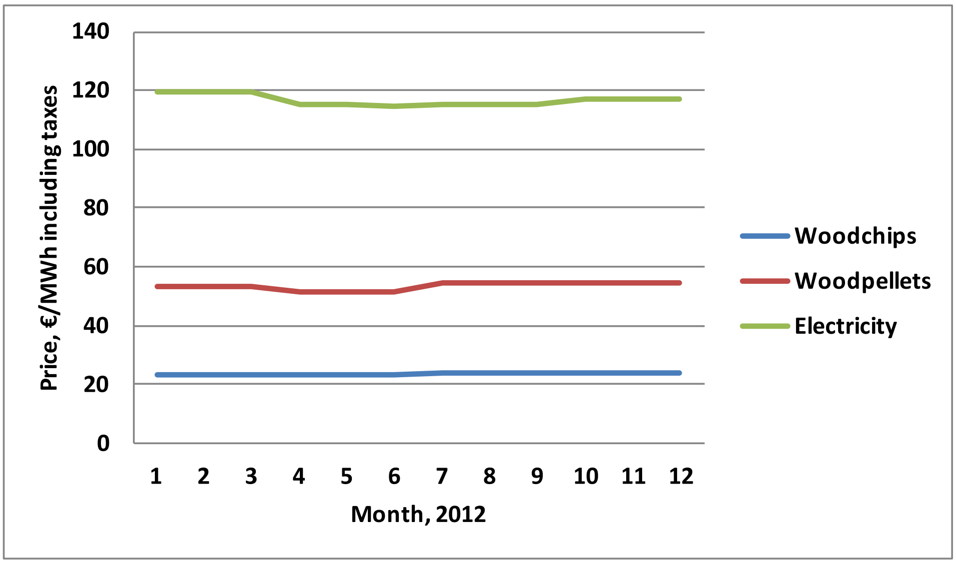

Figure 4. Prices of woodfuels and electricity in 2012 including taxes.

Initial background was laid by procurement of 1st pellet boiler plant at 2006 in Ilomantsi Model Forest project to replace light petroleum oil boilers (LPOB) in district heating environment and to enable biomass combustion experiments. This initial boiler was not deemed completely successful due to restricted turndown ratio, especially lowest usable heating power was too high for summer, when only water heating was needed and required use of reserve LPOBs instead. Preliminary surveys on gasifier based CHP application was made during Mekrijärvi bioenergy R&D environment project 2009-2010 where combining separate gasifier and small scale boiler procurement were considered, but dropped in favour of original plan. Small scale CHP procurement was realized in ongoing (2010-2012) Mekrijärvi Bioenergy R&D environment – new production methods –project.

3.2. Heat entrepreneurship in transition

In Finland, heat entrepreneurs are running about 600 places

4. The procurement process

4.1. Initial survey

Initial survey was made based on maximum heat requirement for Mekrijärvi research station local district heating (around 150kW$_h$ to 300kw$_h$ during winter). Technologies deemed viable in scope of available knowhow and maintenance were considered and gasifier based piston and turbine applications, direct combustion hot air or other turbine applications, and ORC as retrofit on older 700kW pellet boiler. Survey of potential providers were charted nationally on gasifier fueled piston engine applications and EU wide on other applications. Relevant suppliers were listed according to web-search and related research (Table 1).

Table 1. List of relevant technology suppliers listed in initial survey.

Provider	Technology	Retrofit	Scope
Volter	Gasifier-piston engine	No	30kWe/80kW$_h$
GasEK	Gasifier-piston engine	No	50kW$_e$/100kW$_h$
Entimos	Gasifier-piston engine	No	300kW$_e$/700kW$_h$
TurosTeam	Gasifier-piston engine	No	120kW$_e$/320kW$_h$
Recycling Energy	Gasifier-piston engine	No	?kW$_e$/200kW$_h$
RMV-Tech	Compressed combustion gas turbine	No	30kW$_e$/80kW$_h$
EkoGen	Direct combustion hot air turbine	Maybe	100kW$_e$/300kW$_h$
Turboden	ORC-Turbine	Maybe	600kW$_e$/?kW$_h$
Adoratech	ORC-Turbine	Maybe	300kW$_e$/1335kW$_h$
General Electric	ORC-Turbine	Yes	125kW$_e$/1000kW$_h$
Polytechnik	ORC-Turbine	Maybe	200kW$_e$/?kW$_h$

All listed potential provider were sent queries, but not all queries got response.

Overall ORC, were out of scope by order of magnitude of intended application. Gasifier applications were generally in lower end or below initial scope intended heat production. Based on these findings preparation of invitation to tender were initiated.

4.2. Preparation of tendering

Mekrijärvi local district heating heats premises with 11 buildings with total area 3000 m^2 and volume 10 000 m^3, including Experimental Ecology Laboratory with 256 m^2 specialized greenhouse space. Premises are mainly, with exceptions directly owned by UEF, owned by Yliopistokiinteistöt Oy, which purchases heat from UEF boiler(s).

Electricity is supplied from national power grid by air lines from local 20 kV grid with transformer to 400V on station premises. Power to Mekrijärvi research station premises is supplied by 3 supply points, two 3x200A at 400V 3 phase, one for Mekrjärvi research station housing and office facilities and second for Experimental Ecology Laboratory and one 25 A at 400V 3 phase for pellet boilers and attached containers.

Mekrijärvi boilers are configured to use wood pellets as fuel, but also wood chips can be used. In addition to this, Mekrijärvi Research station has focused biofuel research to pellets and major function of pellet boilers is to allow utilization experiments for pellets produced in experimental pellet facility [2]. Same function was in scope for Small scale CHP plant.

Technical standpoint

Heat consumption at Mekrijärvi follows quite well the average Finnish situation. Winter months are cold and heat is needed 5-7 times more than during summer (Figure X). Electricity consumption is different because of the remarkable demand for cooling in summer (Figure 5). Cooling is needed to cool down large greenhouses, where ecological experiments are implemented during the growing season.

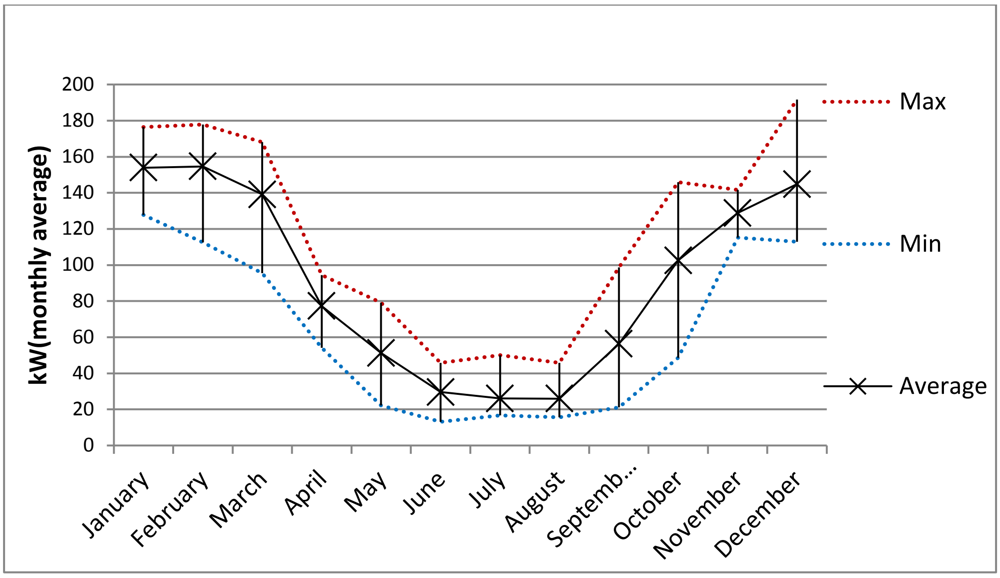

Figure 5. Heat consumption monthly average, minimum and maximum from period 11/2006-10/2012

Heat consumption varies by season from around 25 kW_h during summer consisting hot water heating and above 300kW_h peaks during winter.

Electricity power at Experimental Ecology laboratory at peak hours are around 100kW_e and 5 year average hour consumption 22,9 kW_e and for housing and office facilities 60kW_e peak and 5 year average hour consumption 21,7 kW_e and for pellet boiler 1,9kW_e 5 year average hour consumption (Figure 6).

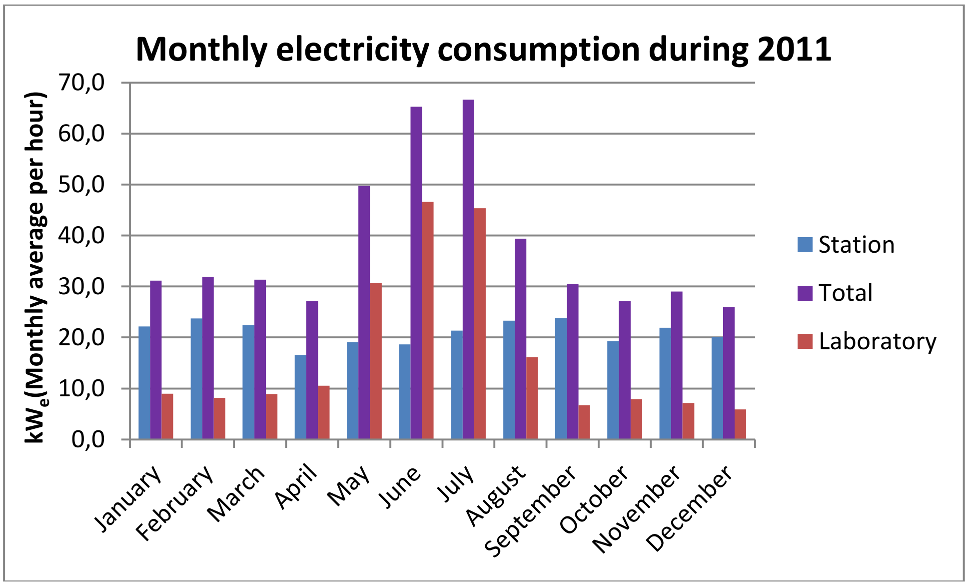

Figure 6. Electricity consumption during 2011 from station general and laboratory 3x200A supply points.

With these consumption figures initial requirement was set up to 20 kW_e to 100kW_e and 80 kW_h to 300kW_h with minimum requirements of 150kW_h maximum output as heating plant only and power to heat ratio (structural ratio) of 0,25.

To better prepare invitation to tender, two specialists, on small scale CHP and local district heating, were consulted regarding invitation to tender.

Major change to draft of invitation to tender from consultation, in addition to minor revisions, additions and corrections, was in requirement of maximum electricity power. Change was due to difference between feed-in tariff lower limit of 100kW and electricity exise tax extempt upper limit of 50kW. It was deemed that range from 50kW to 100kW where electricity has exise tax, but without feed-in tariff option is not cost and management efficient in research oriented application.

Legal standpoint
Finnish legislation, legally binding in Finland. As member of European Union (EU), legislation in Finland has been harmonized with EU directives. Finnish legislation is available in Finlex http://www.finlex.fi/ database and also partially in available English at http://www.finlex.fi/en/ and several other languages. In scope of this procurement, electricity and small scale production thereof, following acts and sections are prominent.

Electricity Market Act (http://www.finlex.fi/en/laki/kaannokset/1995/en19950386.pdf, http://www.finlex.fi/fi/laki/ajantasa/1995/19950386)
3 § *Definitions* (1172/2004)
9 § *Obligation to develop and obligation to connect* (1172/2004)
10 § *Obligation to transmit* (1172/2004)
14 b § *General provisions on the sale conditions and pricing of system services* (1172/2004)
N.B. section 14b is not available in translation. It regards small scale electricity production.
28 § *Obligation to unbundle operations* (1172/2004)

Excise tax act on electricity and various fuels (English translation not available, in Finnish: http://www.finlex.fi/fi/laki/ajantasa/1996/19961260)
5 § Obligation to electricity excise duty

Act on subsidiary to electricity produced by renewable energy sources (English translation not available, in Finnish: http://www.finlex.fi/fi/laki/alkup/2010/20101396)
5 § Definitions
6 § Feed-in tariff scheme
8 § Special grounds for forest chip power plant
11 § Special grounds for wood fuel power plant

Public procurement legislation and EU-project restrictions
Estimated expense of this purchase was above national and European Union thresholds and applicable requirements apply.

Act on Public Contracts (http://www.finlex.fi/en/laki/kaannokset/2007/en20070348.pdf, http://www.finlex.fi/fi/laki/ajantasa/2007/20070348)
15 § National thresholds
16 § EU thresholds
25 § Negotiated procedure

4.3. Tendering

Invitation to tender was published in HILMA (www.hankintailmoitukset.fi) procurement publication channel maintained by Finnish Ministry of Employment and Economy and it fulfils national and EU publicity requirements of invitation to tender[3]. Invitation to tender was open 49 days (including opening and closing days), which met EU legislation requirement minimum 40 days. Invitation to tender was in Finnish which is one of official languages in EU (http://ec.europa.eu/languages/languages-of-europe/eu-languages_en.htm).

Technical specifications
Invitation to tender was call for Turnkey contract of small scale CHP and limited to guaranteed nominal efficiencies with design fuel from 20kWe to 50kWe connected to Mekrijärvi Research Station 400V electricity grid and operate on grid and in case of power failure in grid as island powering limited part of Mekrijärvi Research Station premises and 80kWh to 200kWh connected to district heating. Structural ratio requirement was 0,25 (kW_e/kW_h), with possibility to produce 150kW_h for peak hours, even without power production. Invitation to tender also defined connections for additional measurements, analyzer connections and data collection from automation. Potential provider was required to visit and inspect Mekrijärvi Research Station infrastructure regarding to invitation to tender before leaving tender. This site visit was assumed to be very important, because if tenderer is not aware what is needed and which kind of limitations exist, tender can be confusing and making official decision making difficult. This is the case especially in places, where new system is retrofitted to existing systems and infrastructure.

Procurement specifications
In addition to technical specifications invitation to tender defined commissioning requirements, uptime requirements, guaranteed nominal efficiency measurement period, delivery times, installation site options and requirements and respective scoring for evaluating tenders and penalties if values guaranteed in tender or required in invitation to tender are not reached.

Evaluation criteria
Tenders were evaluated according to total price (0-20 points), technical details (0-16 points) and variable costs of maintenance (0-4 points). Technical details contained: assembly availability into old boiler house, electricity generation technology, kWe/kWh –ratio, possibility to use pellets as a fuel and automated cleaning option.

Tenders received and not received
Total 2 tenders was received by closure of invitation to tender. Tender from Volter Oy was formally, but technically not completely conforming. Tender from Volter Oy received score 11 by scoring laid down in invitation to tender.

Another tender was titled budgetary quote and it lacked requested documentation and had serious technical deficiencies to such degree, that no evaluating score could be calculated due to missing information.

One potential provider told that they will not sell Small scale CHP unit due to proprietary security reasons and they will only lease their plant for CHP production.

One potential provider only visited site as required, but did not leave tender.

Negotation procedure and technical challenges

Due to lack of tenders fully conforming to invitation to tender, 25 § of Act on Public Contracts was ivoked. As invitation to tender was open over minimum period (40 days) required and at least one formally conforming tender was received, all tenders which had formally conforming and addressed key issue of invitation to tender were called to negotiation procedure. Key issue being appliance to produce electricity and heat from solid biomass fuel. In this case only tender from Volter Oy qualified.

Volter Oy offered 30kW$_e$ / 80 kW$_h$ Omasähkö-CHP plant. Key factors which did not conform to invitation to tenders were following:
Tender did not offer turnkey solution in respect of connection to existing infrastructure
Required peak heating power solution (maximum power offered was standard 80 kW$_h$)
Fuel silo / hopper solution
Extra drier container

Negotiation proceeded technical level (technical solutions) and managerial level (budget) and included outsourced technical consultation regarding district heating. Managerial negotiation procedure included fitting technical requirements and available budget together, which limited available options and solutions on technical level.

Turnkey solution was requirement, agreed on and technical modifications in small scale CHP, and to limited degree to existing infrastructure, was agreed.

Fuel storage and handling
In tender one of existing pellet silos were intended to be modified to wood chip silo. This was contrary to invitation to tender where separate wood chip hopper or silo was required. Separate storage for wood chips was requirement, because existing boiler uses both pellet silos and in invitation to tender intention to research pellet utilization in CHP fuel was announced. Despite exceptionally low (below 20%) moisture requirement of Volter Oy Omasähkö- CHP plant, extra drier offered in tender was excluded, because it is not currently in scope of university operation to operate industrial scale drier, when dried fuel can be purchased.

Electricity
Island operation was dropped from technical requirements due to other required installations, limited capacity offered and required extensive modifications to cabling and fuse panel infrastructure.

Heat
During negotiation period heat requirement of Mekrijärvi Research Station was reassessed and total independence from reserve oil heating in form on alternate 150kWh burner was dropped due to saved expense and estimation of very limited time when oil heating will be needed.

In invitation to tenders district heating temperature ranges were not specified, which caused major negotiation, due to higher temperature in network than tender set for small scale CHP input-output range. Mekrijärvi Research Station district heating was designed in "boiler setup" where circulation outgoing and returning water temperatures increase as load increases. Boiler water outgoing temperature can be as high as 105 °C and heat exchangers are scaled to use minimum +85 °C water as input and output as +60 °C where as small scale CHP in tender produced +65 °C - +70 °C outgoing water and returning water temperature was assumed to be even as low as +45 °C highest. For benefit of kn owhow for future installations in existing boiler systems, Volter Oy agreed to increase output temperatures of CHP-plant with technical solution likely causing slight loss of heat output. Future tests will show, how this solution will perform in peak consumption situations.

All in all, all points noted at begining of chapter were addressed, either as technical solution or dropped out due to budgetary considerations.

Major deviations to original invitation to tender setup are lack of island function during power shortage and lack of maximum $150kW_h$ heat output option.

Other considerations
For Volter gasification application, nominal fuel moisture is below 20%, where as typical wood chips on market have moisture content from 30% to 35% and pricing is based on net energy value. In addition to rigorous moisture requirement, amount of fines is strictly restricted to <1% below 3.15mm sieve. Particle size of chips is defined to 8 mm < x < 68 mm. These fuel quality requirements are to ensure tar free operation of gasifier. In principle, as initial invitation to tender stated, high quality pellets fill dimensional and fines requirement, but are not included in nominal fuel, due to fact that pellets will break up to dust in case fuel flow is interrupted and pellets are retained in moisture releasing zone of gasifier.

Because drier was not included in purchase, additional contract is required to procure artificially dried fuel to meet requirement described above. In commercial or municipal context drier may be viable solution, if woodchips are produced by operator or also purchased for other applications which do not need as low moisture.

5. Results

5.1. Time consumption

The process and time consumption can be described by following flowchart (Figure 7).

Figure 7. Time consumption of the Mekrijärvi chp-investment project.

Initial survey and preparation of tendering could be speeded up but other phases would be staying about the same if the procurement is repeated.

5.2. The final set up and the price

The basic set up finally purchased was including following parts:

- Gasifier unit
- Sisu diesel engine tailored for wood gas
- 30 kW generator
- Glycol unit for emphasized cooling
- Control unit for running the plant and for regulating the produced electricity
- Fuel silo, 50 m^3 with tipping roof and ramp.

The price for basic set up was 220 000 euros (excluding VAT).

In addition, additional measurement unit was purchased to enable research level monitoring and data supply (24 000 euros excl. VAT).

5.3. Key points to improve future procurement process in similar appliances

From public procurement standpoint most important factors are careful budgeting, consultancy, choice of procurement procedure and description of core requirements.

Preliminary survey should include potential technologies, but also careful review of infrastructure where appliance is intended, so that all relevant facts can be included in invitation to tender. To this end technical consultancy, preferably from instance familiar with infrastructure and intended technologies is important, so that key issues will be addressed. Procurement and legal consultancy is advisable, so that invitation to tender complies with national and EU directives. Negotiation procedure, despite being slower, and equal treatment of potential suppliers being challenge, will more likely produce ideal solution, where as in open invitation to tender all key facts must be laid down at once, and any lapses may lead to new round of tenders, and in worst case legal action and expenses and even in, or addition to, unsuitable appliance.

For either negotiation procedure or to open invitation to tender clear, short description to intended Core function of appliance (purpose of purchase) should be described in single sentence. This will clearly define what provider should offer, and in case open invitation to tender falls back to negotiation procedure, it defines tenders which are technically applicable.

- Careful budgeting; total budget easily double of coreunit price due to infrastructure, especially when infrastructure has been built in several stages over decades and not received total overhaul at some point
- Technical, procurement and legal consultation from experienced party strongly recommended
- Iterative or negotiation procedure recommended.
- Describe core requirements, it simplifies tender selection to negotiation procedure

From provider standpoint, key factor in tender would be such basic thing, as leaving tender. If you will not leave tender you are out of competition. The tender you leave, should be formally compliant, so include all documentation, legal and financial data requested. From technical standpoint, tender should offer only what you can deliver, regardless of whether it complies requirement of invitation to tender. In case none tenders comply with invitation, there is not necessary new invitation round, as act on public contracts section 25 allows negotiation to be opened with providers whose tender is formally conforming and technically address intention of purchase.

Providers standpoint

- Even with strict terms in invitation to tenders, it is feasible to leave tender
- Make your tender formally conforming (requested attachments, economical and legal data, etc and supply solution to core requirement of tender)
- Offer in tender what you can (technically) provide even if it falls short of terms in invitation to tender. If there is not any tenders conforming to invitation to tender, it's possible for procurer to open negotiation procedure with parties who have left tender which are formally conforming and supply technical solution to core requirements.

6. Discussion

Small scale CHP-production from biomass is increasing rapidly in EU and some installations exist already in Asia and North-America. Still the topic is new and technological solutions are not matured yet. Depending on technology, several dozens of suppliers exist on markets but it is not easy to recognize already serious operators with proven solutions and more experimental set ups under vigorous development to meet requirements of reliable commercial product.

At least two supplier philosophies were recognized during the process. Some companies are eager to tailor their solutions and fulfill customers' needs by adapting their technology to meet different preconditions and requirements. Another approach is to pick up customers which have the case where existing supplied solution is fitting perfectly. Both philosophies have benefits and drawbacks, the latter needs more work for customer search but finally there might be less technical challenges. The selected Volter ltd. In this case followed the latter philosophy.

Act on public contracts do not only touch public operators, but can touch private operators if they receive public subsidiaries. For example, company receiving funding from TEKES is, regarding project funded, subject to Act on Public Contracts when funding is above 50% and value of purchase, without fat, is above 30 000 euros[14].

Gasification needs high quality fuel. Especially the moisture content is required to be under 15%. This is basically impossible with natural drying in Finnish conditions. For Mekrijärvi, original idea was to make contract with local heat entrepreneur building the chip dryer at the same time with our CHP-investment. Unfortunately the dryer project failed (or at least got postponed) and the entrepreneur was not able to supply dried chips. Alternative options to get dry chips have been laborious.

Economical sustainability of the small scale chp-investment is dependent on the subsidy level for the investment itself, annual running hours and the fuel price. In Finland, feeding tariff is not giving any economic support for small scale schemes. In the case of Mekrijärvi, heavily supported investment is economically feasible from the university point of view even without research benefits. Still, profitability could be improved especially by finding cheaper fuel chips with reasonable transportation distance.

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