FME HighEFF

Centre for an Energy Efficient and Competitive Industry for the Future

Deliverable D4.2_2017.01

Status on surplus heat database

Delivery date: 2017-12-21

Organisation name of lead beneficiary for this deliverable:

SINTEF Energy Research

HighEFF- Centre for an Energy Efficient and Competitive Industry for the Future is one of Norway's Centre for Environment-friendly Energy Research (FME). Project co-funded by the Research Council of Norway and Industry partners. Host institution is SINTEF Energi AS.		
Dissemination Level		
PU	Public	X
RE	Restricted to a group specified by the consortium	

Deliverable number:	D4.2_2017.01
ISBN number:	
Deliverable title:	Status on surplus heat database
Work package:	WP4.2 Surplus heat recovery
Deliverable type:	Memo
Lead participant:	SINTEF Energy Research

Quality Assurance, status of deliverable		
Action	Performed by	Date
Verified (WP leader)	Trond Andresen	2017-12-21
Reviewed (RA leader)	Aud Wærnes	2017-12-21
Approved (dependent on nature of deliverable)*)	Aud Wærnes	2017-12-21

*) *The quality assurance and approval of HighEFF deliverables and publications have to follow the established procedure. The procedure can be found in the HighEFF eRoom in the folder "Administrative > Procedures".*

Authors		
Author(s) Name	Organisation	E-mail address
Vidar Skjervold	SINTEF Energy Research	VidarTorarin.Skjervold@sintef.no

Abstract

This memo gives an update on the status of the surplus heat database developed in WP4.2. The work is progressing well. However, a lot of work remains before it is finished. By the spring of 2018, the goal is to finish the database for the metals and materials sector. By the end of 2018 we aim at extending the database to either the food and chemicals or oil and gas sector.

Table of Contents

1 Introduction

The industrial partners in HighEFF represent 41 % of the total energy consumption in Norway, as shown in Figure 1. Metal production and refined petroleum, chemical and pharmaceutical products are the main contributors. One of HighEFF's goals is a 20% to 30% reduction in energy consumption in the industry. In order to reach this goal, improvements in several areas are required. For example, a larger extent of capture, conversion and utilization of industrial surplus heat will be crucial.

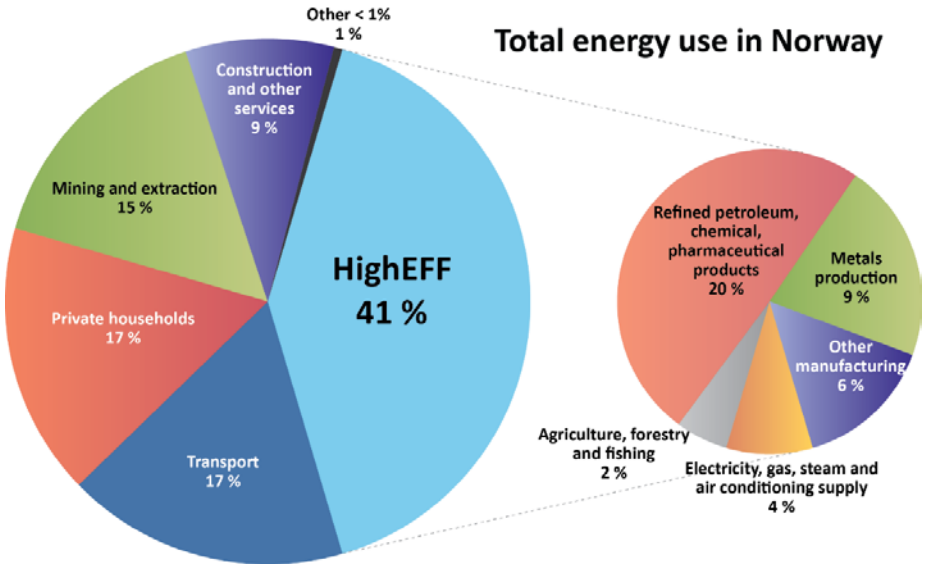


Figure 1: Energy consumption in HighEFF industrial partners related to the total energy use in Norway.

One of the aims of WP 4.2 in HighEFF is to create a database of significant surplus heat sources in the partner industries. This is a quite ambitious activity that most likely will take time to complete. The aim is to assemble a database of the thermodynamic potential remaining in exhaust, waste streams, and by-products, organized by industry sector, partner/plant, and sub-process/process stage. In addition to the direct use of a surplus heat characterization, this data can be used to identify processes and sub-processes with high impact on energy performance, as well as exergy losses between core process and waste streams. A screenshot of the database is shown in Figure 2.

This database can serve many purposes in HighEFF, across many research areas and WP's. Examples are design of heat recovery technologies, feasibility studies in energy exchange and heat-to-power conversion, *process improvements*, and *future processes*.

Plant	Process stage	Input/output	Process flow	Type	Material	Process flow temperature – annual average [°C]	Minimum allowable [°C]	Temperature location specification	Core process temperature [°C]	Annual production/consumption [tons/year]	[Nm³/h]	Annual hours of operation [h/year]	Energy per year [MWh/year]	[MJ/year]
Alcoa Mosjøen	Anode bakeing	Input	Natural gas		Methane				1250	13500		8760	186300	670626
		Input	Coke						1250	2644			24589	88514
		Input	Pitch						1250	43174			479231	1725095
		Output	Exhaust	Gas	"Air equivalent"	190	90	Facility exterior wall	1250		185000	8760		
		Output	Anodes						1250	299735				
	Electrolysis	Input	Electric energy	-	-	-						8760	2996717	10787318
404 pots		Input	Carbon		Coke					80485		8760	748510	2694422
		Output	Primary Aluminium		Al					196786				
		Output	Pot gas	Gas	"Air equivalent"	130	80	Cell outlet	960		1600000	8760		
		Output	Sidewall	Surface	Steel	300		Cell exterior	960			8760		
		Output	Other surface heat loss	Surface	Steel	250		Cell exterior	960			8760		
	Casting furnace	Input	Natural gas		Methane				720	6000			82800	298056
		Input	Primary Al		Al				720	196786				
		Input	Other Al		Al				720	36161				
		Input	Other materials		Si				720					
		Output	Aluminium alloy		Al				720	232947				
		Output	Exhaust		"Air equivalent"	1000		Gas outlet, 6 furnaces	720		0 - 100000			
		Output	Other heat loss	Surface	Steel	200		Furnace exterior	720					
	Casting bed	Input	Aluminium alloy						720	232947				
		Output	Cooling water	Liquid	Water	25		To sea	720		350	8760		

Plant	Process stage	Input/output	Process flow	Type	Material	Process flow temperature – annual average [°C]	Minimum allowable [°C]	Temperature location specification	Core process temperature [°C]	Annual production/consumption [tons/year]	[Nm³/h]	Annual hours of operation [h/year]	Energy per year [MWh/year]	[MJ/year]
Alcoa Lista	Electrolysis	Input	Electric energy	-	-	-						8760	1725236	6210352
		Input	Carbon		Coke					34008		8760	316274	1138496
Søderberg		Input	Pitch							12577			139604	502536
		Output	Primary Aluminium		Al					93294		8760		
		Output	Pot gas	Gas	"Air equivalent"	300	80	Cell outlet	960		150000	8760		
		Output	Sidewall	Surface	Steel	300		Cell exterior	960			8760		
		Output	Other surface heat loss	Surface	Steel	250		Cell exterior	960			8760		
	Casting furnace	Input	Natural gas		Methane				720	3123			43097	155138
		Input	Primary Al		Al				720	93294				
		Input	Other Al		Al				720	34377				
		Input	Other materials		Si				720					
		Output	Aluminium alloy		Al				720	127671				
		Output	Exhaust		"Air equivalent"	900		Furnace outlet	720		0-70000			
		Output	Other heat loss	Surface	Steel	200		Furnace exterior	720			8760		
	Casting bed	Input	Aluminium alloy						720	127671				
		Output	Cooling water	Liquid	Water	25		To sea	720		300	8760		

Figure 2: Screenshot of surplus heat database. Alcoa's plants are used as example.

1.1 "Workflow"

To complete the database, we rely on in-kind contributions from the industry, which means that gathering data takes time. The workflow of collecting data is described below.

1) Search literature and previous projects for data
    a. Some relevant previous projects for the material sector
2) Create model process sketch and identify main sub-processes. Example in Figure 3.
3) Request data from industry – start direct cooperation/discussion
4) Create energy/ exergy loss process flow diagram. Example in Figure 4.
5) Use data in several work packages in HighEFF, e.g. thermal energy storage, process improvements, design of novel heat recovery concepts.

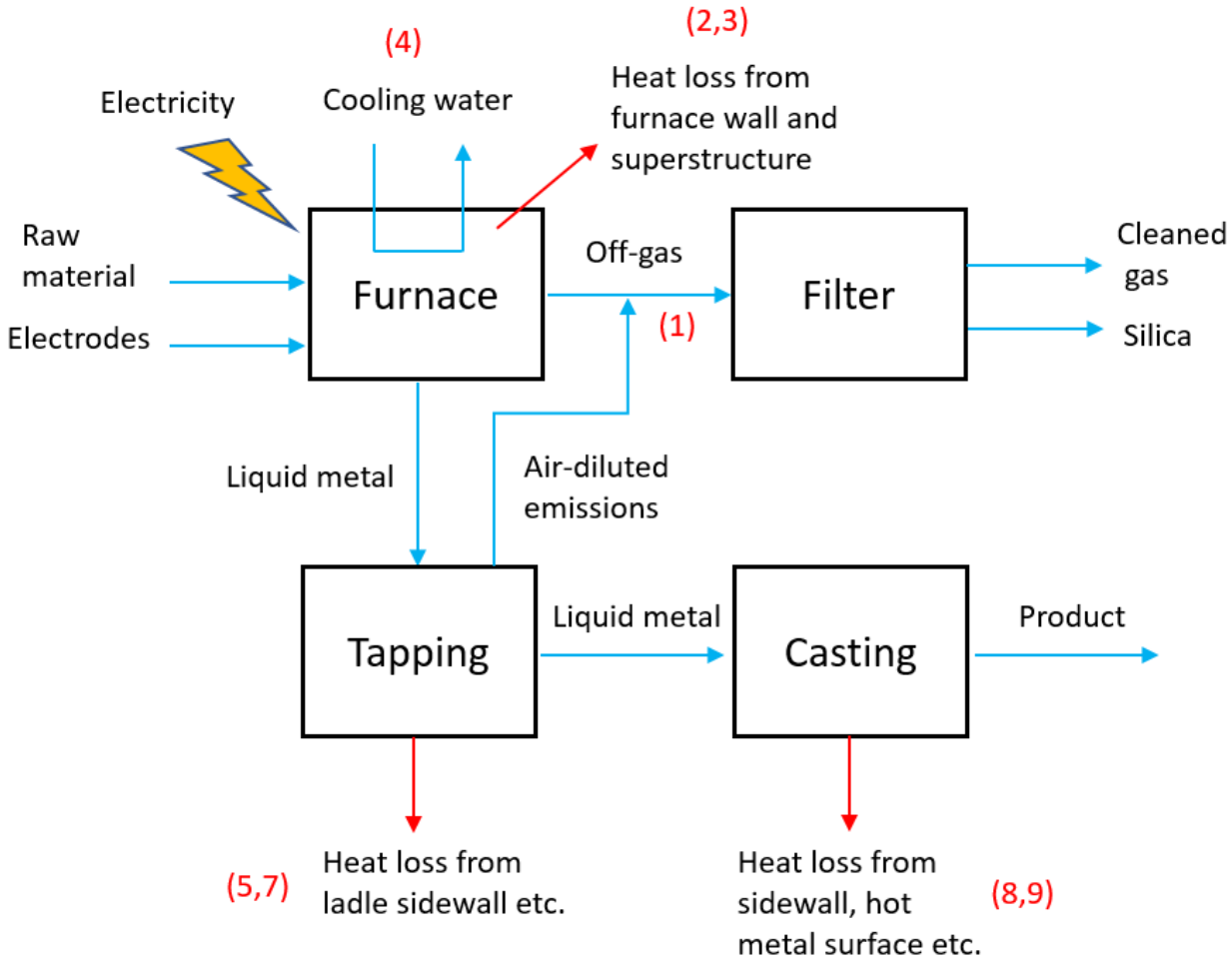


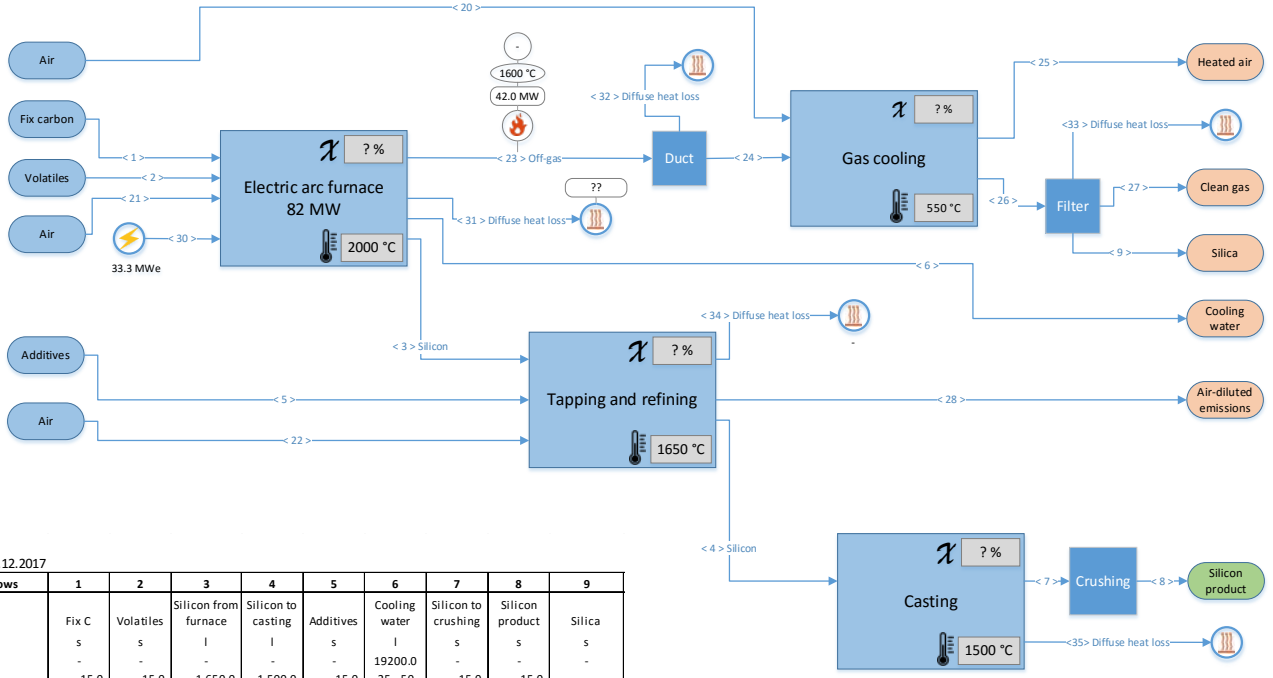
Figure 3: Example of process sketch divided into sub-processes for Wacker's plant at Holla.

2 Status on data acquisition

The HighEFF centre covers three industries: metals and materials, food and chemicals and oil and gas. The metals and materials sector was chosen as the starting point for the database. Contact has been established with all partners except Glencore, and work still remains before the database is complete for metals and materials. In Table 1, the progress on data acquisition for this sector is summarized.

Table 1: Status on data acquisition for the metals and materials sector.

Partner	Status	List of plants	Data from literature or previous projects	Sketch w/ sub processes created	Data provided from partner	Diagram w/ energy and exergy losses
Alcoa	Data for both Mosjøen and Lista has been acquired, some refinement required	Lista, Mosjøen	None	No	80%	No
Elkem	Idea was discussed at the HighEFF autumn workshop in October. Follow-up e-mail was sent in November, but Elkem has not responded yet.	Bjølvefossen, Bremanger, Rana, Salten, Thamshavn	[1], [2], [3], [4]	No	0%	No
Eramet	Initial contact in October, but we agreed on delaying the work to the middle of November. Follow-up e-mail has been sent, but Eramet has not responded yet.	Porsgrunn, Sauda, Kvinesdal	[1], [2]	Yes	0%	No
Finnfjord	Finnfjord was contacted in November, but no answer has been received yet. Will be followed up after Christmas.	Finnfjord	[1], [2], [3], [4]	No	0%	No
Glencore	Work has not started	Kristiansand (Ni), Mo i Rana (Mn)	None	No	0%	No
Hydro	Data for all primary Al plants has been acquired, some refinement required	Husnes, Høyanger, Karmøy, Sunndalsøra, Årdal	[1]	Yes	80%	Begun
Wacker	Data for the Holla plant has been acquired. Some additional information might be needed, this will be discussed in plant visit on the 15th of December 2017.	Holla	[2], [3], [4], [5]	Yes	70%	No



Wacker Holla
Updated 14.12.2017

FLOW ID - Material flows		1	2	3	4	5	6	7	8	9
Description		Fix C	Volatiles	Silicon from furnace	Silicon to casting	Additives	Cooling water	Silicon to crushing	Silicon product	Silica
State		s	s	l	l	s	l	s	s	s
Flow rate	t/d	-	-	-	-	-	19200.0	-	-	-
Temperature	°C	15.0	15.0	1 650.0	1 500.0	15.0	25 - 50	15.0	15.0	-
Energy (chem)	MW	28.2	20.5	-	-	-	-	-	28.7	-
Energy (thermal)	MW	-	-	-	-	-	8.2	-	2.0	-

FLOW ID - Gas flows		20	21	22	23	24	25	26	27	28
Description		Air for gas cooling	Draft air in furnace	Air mixed with tapping gas	Furnace off-gas	Off-gas	Heated air	Cooled off-gas	Filtered off-gas	Air-diluted emissions from tapping
State		g	g	g	g	g	g	g	g	g
Flow rate	kNm³/h	-	-	-	200.0	200.0	-	200.0	-	25
Temperature	°C	15.0	15.0	15.0	1600.0	-	~20?	220.0	-	30 - 150
Energy (chem)	MW	-	-	-	-	-	-	-	-	-
Energy (thermal)	MW	-	-	-	42.0	-	-	36.0	-	-

FLOW ID - Other		30	31	32	33	34	35			
Description		Electricity to furnace	Diff heat loss furnace	Diff heat loss ducts	Diff heat loss filter	Diff heat loss tapping	Diff heat loss casting			
State		Electric	Heat	Heat	Heat	Heat	Heat			
Energy	MWe	33.3	-	-	-	-	-			
Energy	MWth	-	-	-	-	-	-			

Figure 4: Early draft of energy/exergy loss flow diagram for Wacker Holla.

3 Conclusion

The work with the surplus heat database is progressing well. However, a lot of work remains before it is finished. By the spring of 2018, the goal is to finish the database for the metals and materials sector. By the end of 2018 we aim at extending the database to either the food and chemicals or oil and gas sector.

References

[1] "KMB Roma, confidential report," 2009.

[2] M. Tangstad, *Metal production in Norway*. Trondheim: Akademika publishing, 2013.

[3] N. E. Kamfjord, "Mass and Energy Balances of the Silicon Process," NTNU, 2012.

[4] M. T. Børset, "Energy Dissipation and Recovery in the Context of Silicon Production: Exergy Analysis and Thermoelectricity," NTNU, 2015.

[5] Z. Borkowska, "Silicon production process: energy and exergy analysis for Holla silicon plant," NTNU, 2012.