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EFFICIENCY OF
INDUSTRIAL PROCESSES

A Bottom-up analysis of energy efficiency improvement and carbon dioxide emission reduction potentials in the Swiss basic metals and fabricated metal products industry

By
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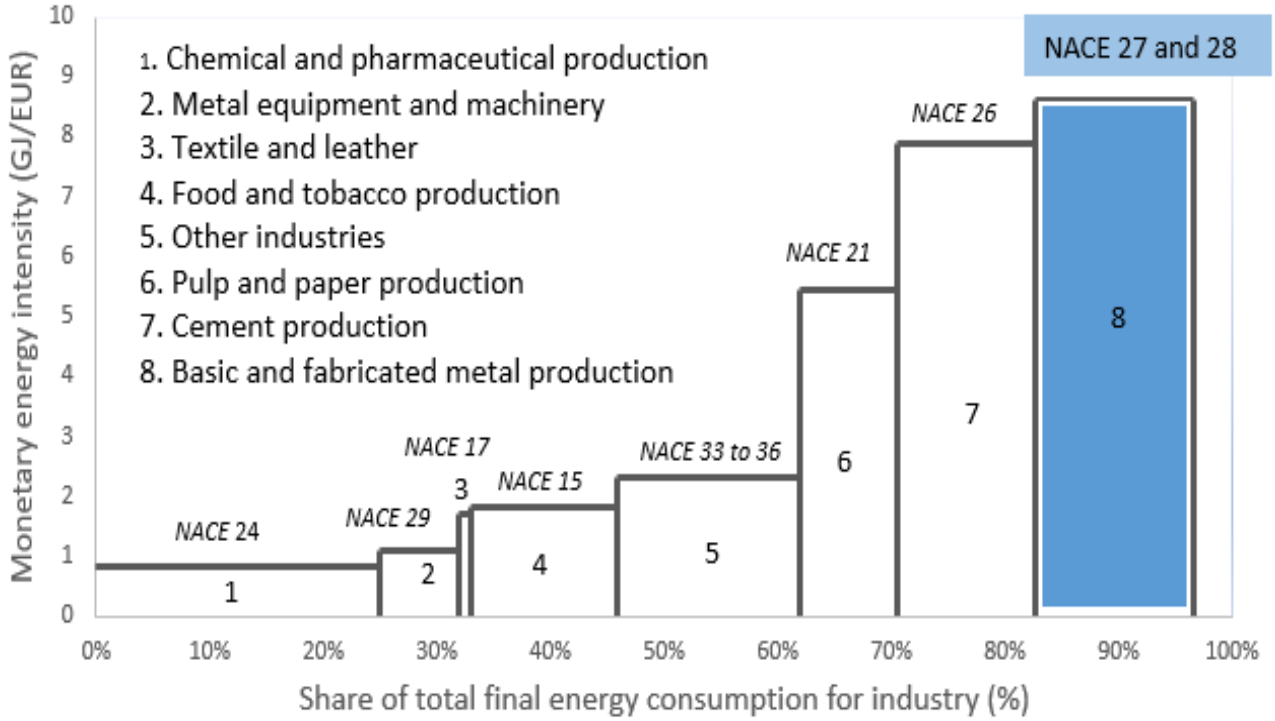
Introduction

Background

- Metal processing sector: 14% of total final energy demand of Swiss industry
- Switzerland's Energy Strategy: 35% reduction in total final energy demand of the sector by 2035 (structural change, activity change and EE improvement)

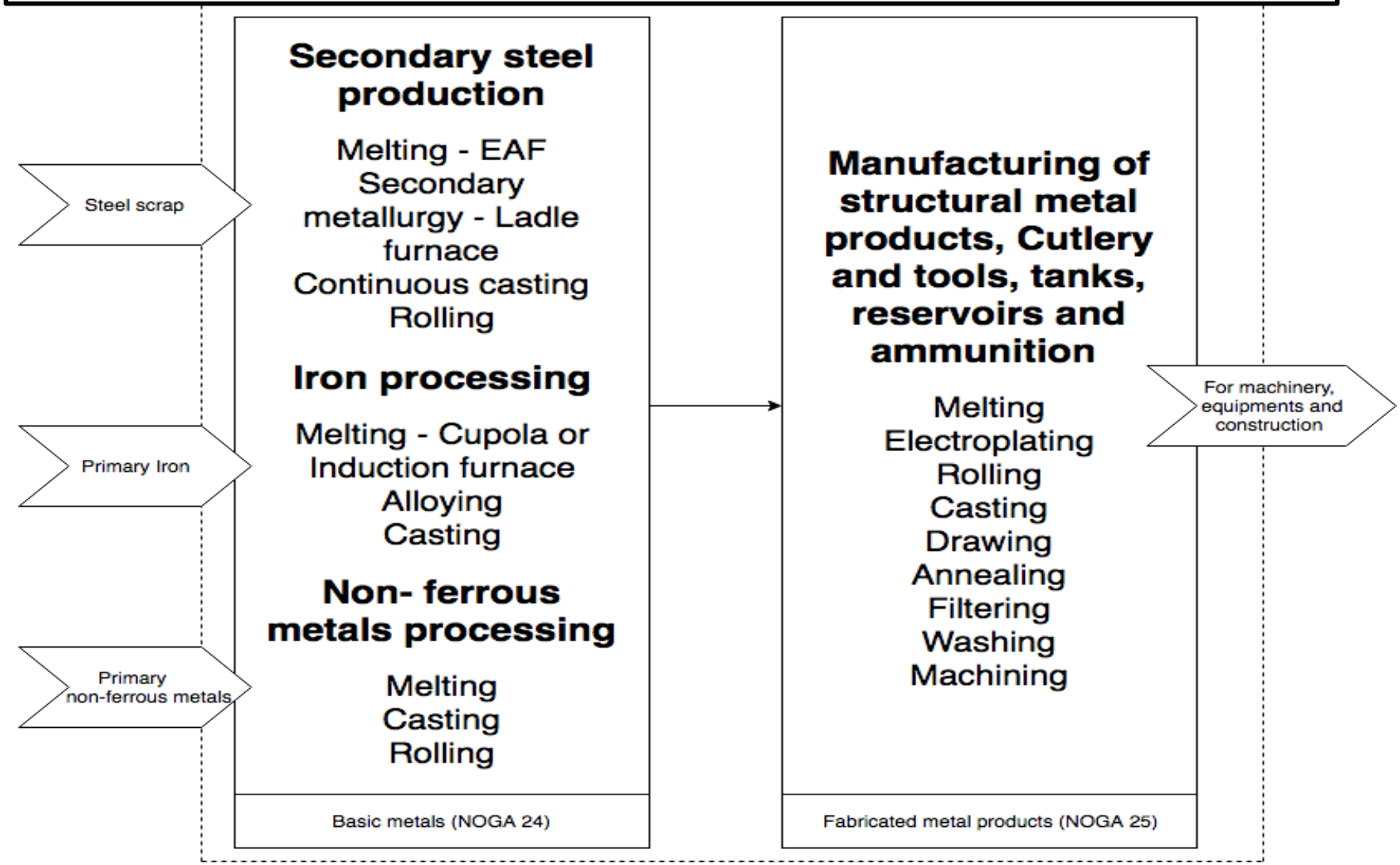


Sources: SFOE;FSO, 2017

Objective

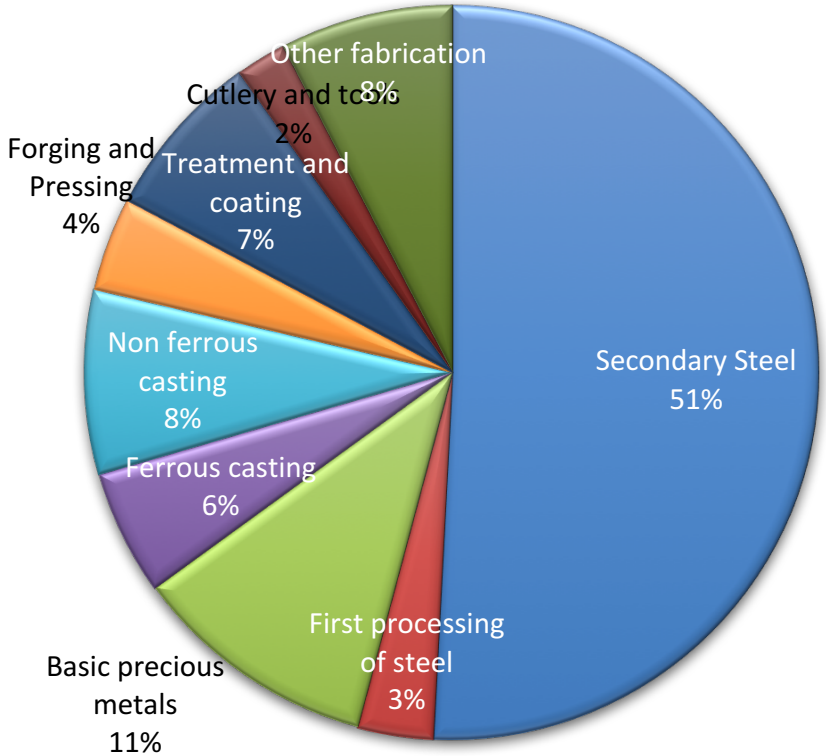
Estimation of cost-effective EE and CO_2 emission reduction potential in Swiss basic metals and fabricated metals production sector using Bottom-up energy efficiency cost curves

Sector profile for Swiss basic and fabricated metal manufacturing - Processes

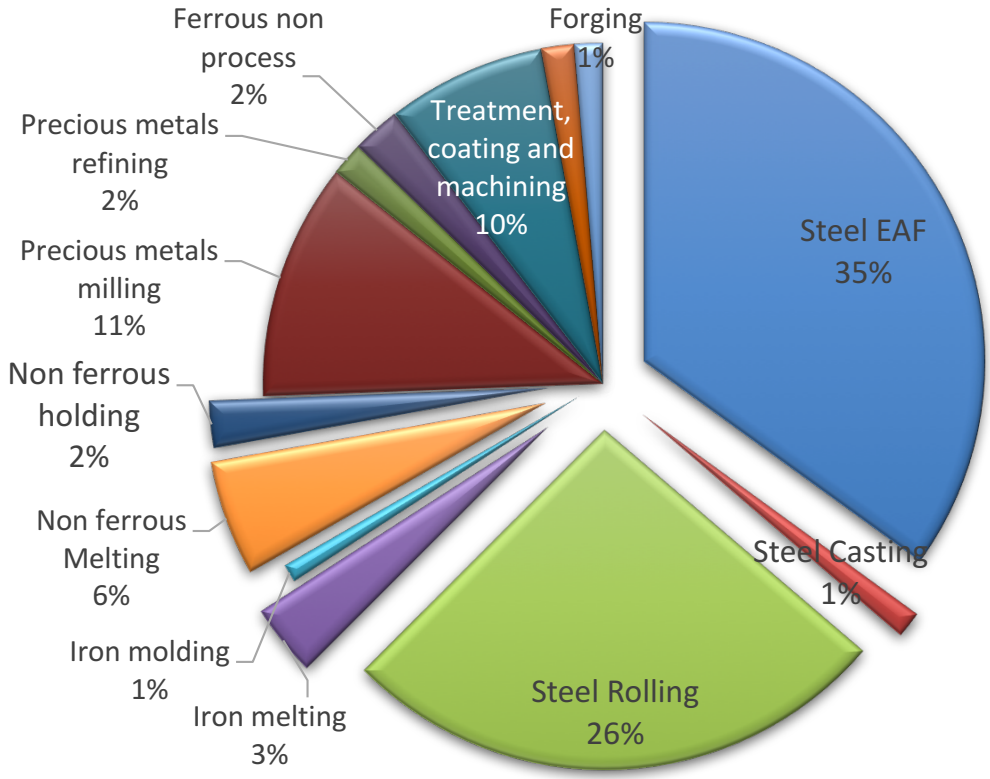


Source: Input/output table for Swiss industry and PROGNOS

Energy profile - Energy consumption by end use and production steps



Total final energy consumption of Swiss metal processing by sub sector 2016
(*Source: Based on analysis of EnAW database, 2016*)



Energy consumption for individual production steps
(*Source: Based on analysis of EnAW database, 2016*)

Data sources

Data	Source
Cost – Initial investment, Operation and maintenance	• International literature and database of EnAW* (*International values adapted to Swiss francs using price level indices.*)
Energy saving potentials	• International literature and database of EnAW (*Measure specific Energy savings from EnAW database are averaged to specific savings potentials for measure categories*).
Energy prices – Fuel, Electricity, CO2	Prices are estimated from energy price projection for household sector (*Zuberi, 2017*)
Discount rate	Value generally used for private perspective obtained from literature

** Energie-Agentur der Wirtschaft* OR *Energy Agency of the Swiss Private Sector (EnAW)*

Data estimation

CO_2 emissions data from Swiss ETS and CO_2 emission factors

EnAW database

Physical production estimate (site specific)

Energy consumption (site specific)

Specific energy consumption (site specific) (e.g. Iron foundry)

Weighted average SEC

SEC at sub-sector level (e.g. Iron processing)

Physical production and general energy profile

SEC for individual production step (e.g. Melting, casting)

Comparison with thermodynamic minimum values

Theoretical potential

EnAW database

Diffusion estimates

Methodology- Energy efficiency cost curves

Specific cost (CHF/GJ) vs Cumulative energy savings potential (GJ/yr OR GJ/t)

$$Specific\ cost = \frac{I*ANF+OM-B}{ES}$$

OR

$$\text{CO2 abatement } cost = \frac{I*ANF+OM-B}{CA}$$

Where, I = Initial investment

ANF = Annuity factor

OM = Annual operation and maintenance cost

B = Annual benefits

ES= Energy savings

CA=Total annual CO_2 abatement (t CO_2/yr)

*Source (Blok, 2007)

$$ANF = \frac{(1+r)^L * r}{(1+r)^L - 1}$$

r= discount rate

L= lifetime of the measure

$$B = ELS_y * P_e + FS_y * P_f + C_{sy} * P_{CO2}$$

ELS_y and Fs_y = electricity and fuel savings by measure y per year

P_e ,P_f and P_{CO2}= energy and CO_2 prices

$$ES_y = (ELS_y + FS_y) * Pr_i * dr_y$$

Pr_i= production of sub sector i

dr_y= remaining diffusion of measure y

$$dr = (EC_x - ED_{yEnAW}) * Pt_x$$

EC_x= Energy consumption of process x

ED_{yEnAW} = Energy demand to which measure y is implemented in EnAW database

Pt_x = theoretical potential for the process x = $(SEC_{CHx} - SEC_{wx}) * Pr_i$

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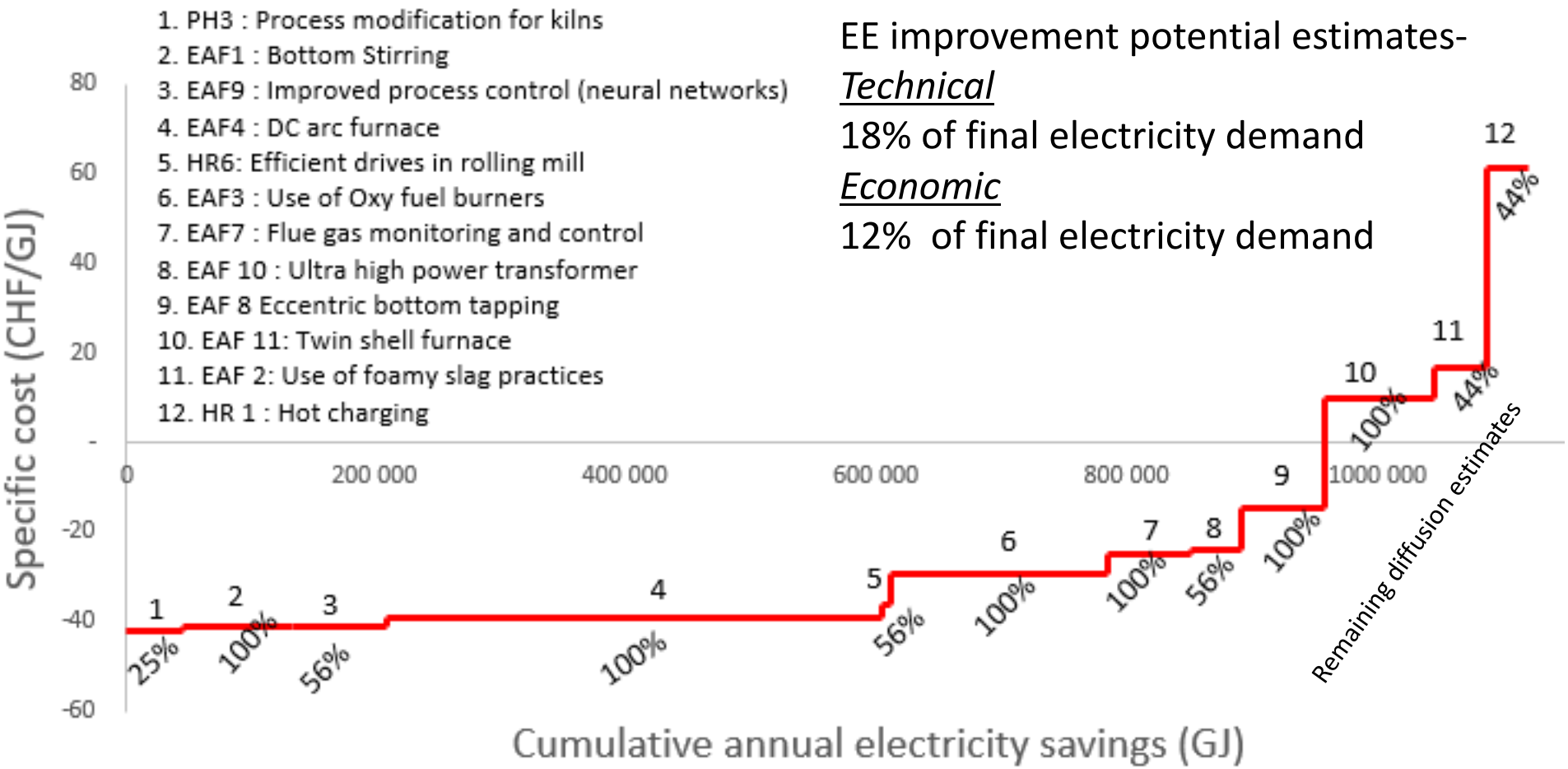
Theoretical energy efficiency improvement potential estimates

Sub-sector	Production of sub sector (kt)	Production step	SEC in Switzerland (GJ/t)	SEC thermodynamic minimum (GJ/t)	Theoretical EE improvement potential	Share in total final energy demand
Secondary steel production and processing	1236	EAF	2.18	1.6	26%	35%
		Continuous casting	0.08	0.1	0	1%
		Rolling	1.64	0.9	45%	26%
Iron processing	58.2	Melting, Holding	4.52	1.2	73%	3%
		Molding	0.85	-	-	1%
Non-Ferrous processing	16.19	Melting, holding	2.61	2	23%	8%
		Molding	1.73	-	-	
Metal fabrication (production of tools, tanks containers)	-	Machining and surface treatment	-	-	-	10%

Theoretical potential for complete sector – 25%

Sources : Physical production – Modern casting, 2017; FOEN,2018
Thermodynamic minimum SEC - Fruenhan et.al., 2000; Schifo et.al., 2004
Energy share estimates (2016) – Based on analysis of EnAW database

Energy efficiency cost curves - Electricity



EE improvement potential estimates-

Technical

18% of final electricity demand

Economic

12% of final electricity demand

Based on specific energy saving potential of all measures -
Economic potential: 16% of final electricity demand

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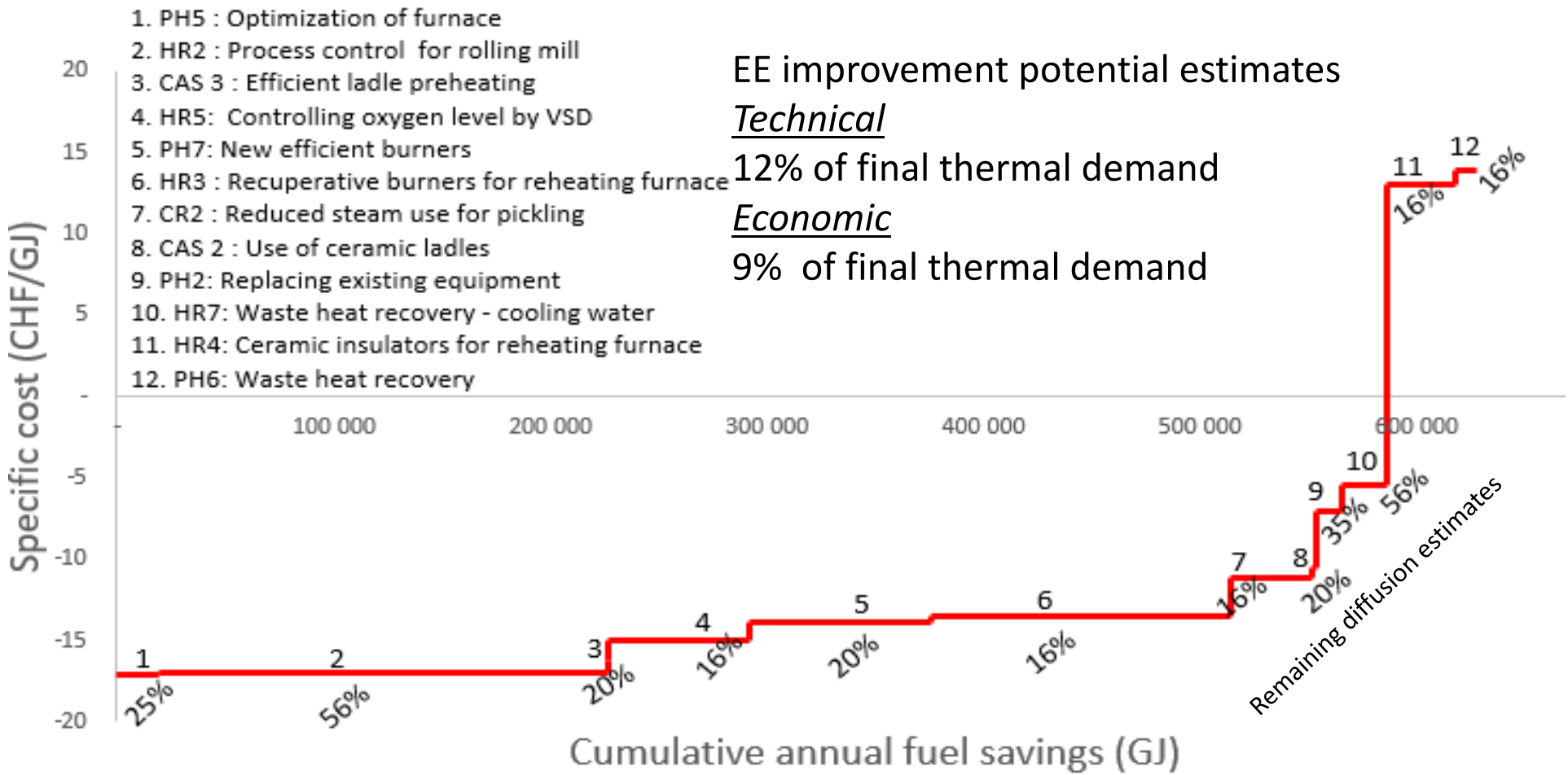
Energy efficiency cost curves - Fuel



EE improvement potential estimates

Technical

12% of final thermal demand

Economic

9% of final thermal demand

Based on specific energy saving potential of all measures -
Economic potential: 11% of final thermal demand

Results- Sensitivity analysis

	Base case	High Prices (50%)	Low price (50%)	Discount rate (6%)	Discount rate (15%)
Cost effective electricity potential	6%	8%	6%	7%	6%
Cost effective fuel potential	5%	5%	3%	5%	4%
Total economic energy saving potential	11%	13%	9%	12%	10%

15% technical potential

	Base case	Full CO_2 levy*	CO_2 levy (2035)*
Economic CO2 potential	6%	6%	8%

**CO_2 levy 2018: 96 CHF/t-CO_2 ; CO_2 levy 2035: 540 CHF/t – CO_2 (as projected by ECOPLAN)*

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Conclusions

- Overall economic EE potential: –11%
  - Relatively low but consistent with the 2035 projections of Swiss Energy Strategy
  - Already wide implementation of EEMs and inherently efficient ways of production

- Corresponding CO_2 emissions reduction potential: – 6%

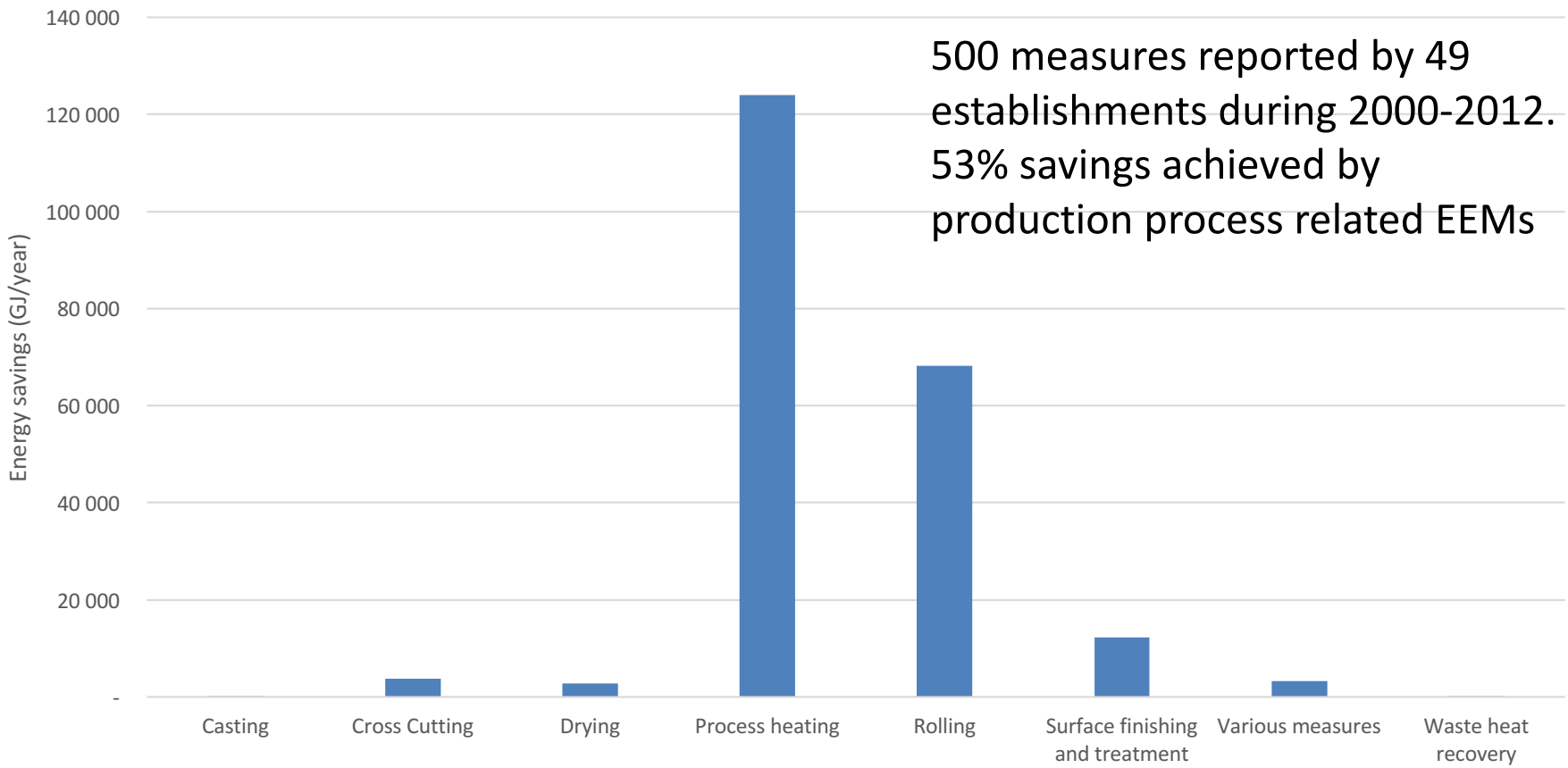
- Most widely implemented EEMs:
  related to furnaces (responsible for approx. 60% of total final energy demand)

- Relatively high energy prices: large number of EEMs are cost effective (19 out of 24) for Swiss metal processing and cost effective potential is not very sensitive to energy price changes

- Further opportunities for sustainable development:
  Through the adoption of emerging technologies and analysis of multiple benefits of these technologies

Additional slides

EnAW database anaysis



500 measures reported by 49 establishments during 2000-2012. 53% savings achieved by production process related EEMs

Annual energy savings for companies in EnAW dabase (first phase of implementation 2000-2012)

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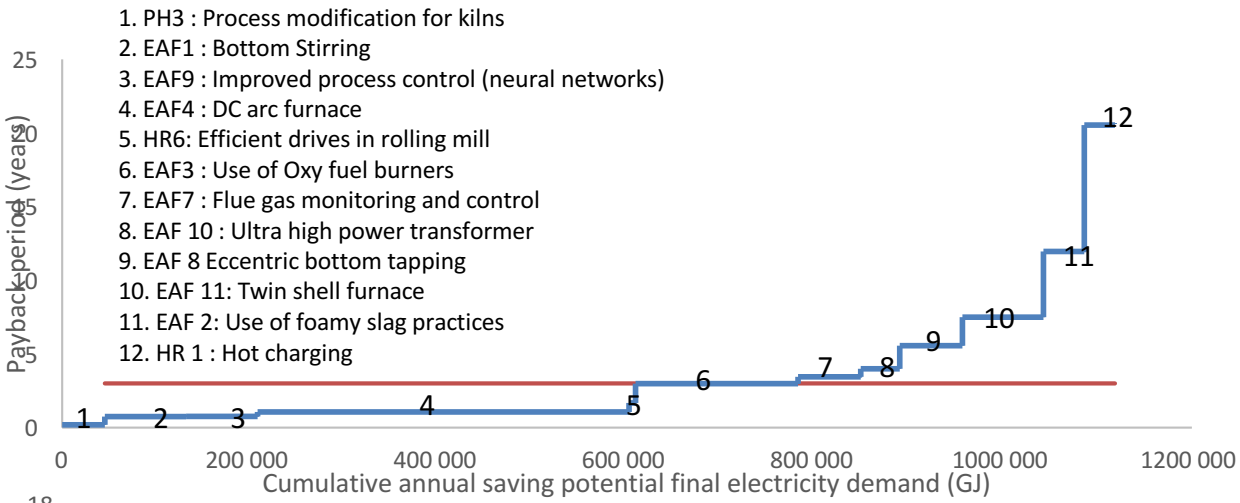
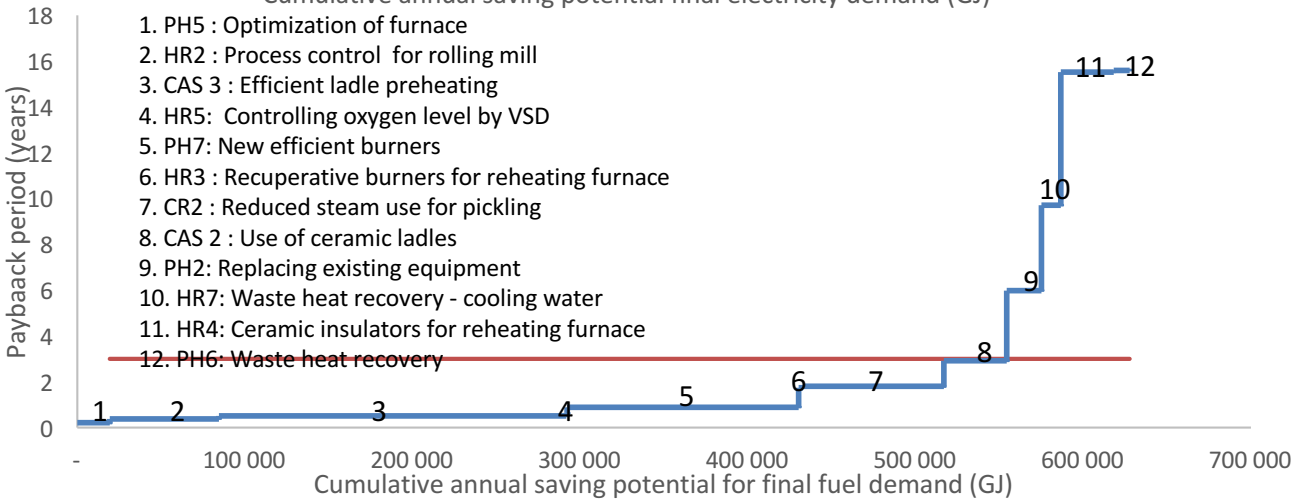
Energy efficiency cost curve (based on simple payback period)





Based on payback period criterial of 3 years
Economic potential : 8%

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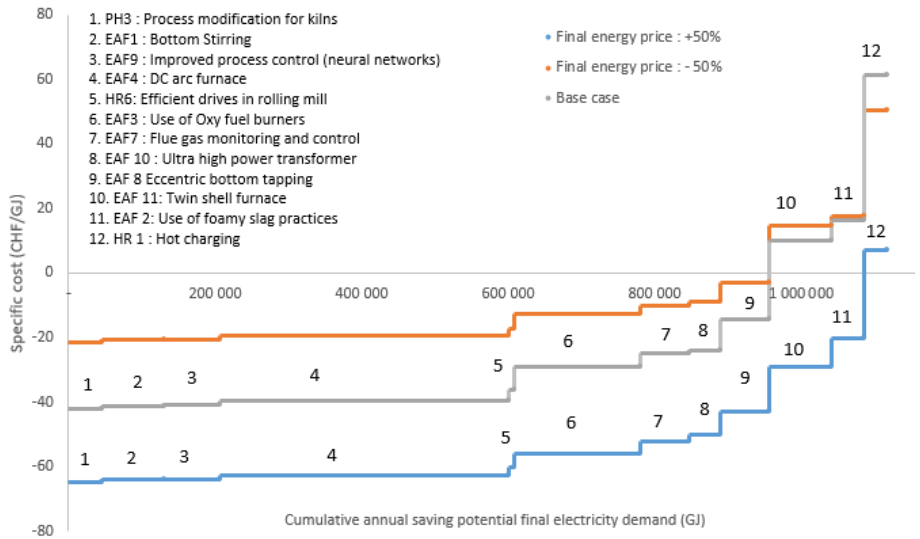
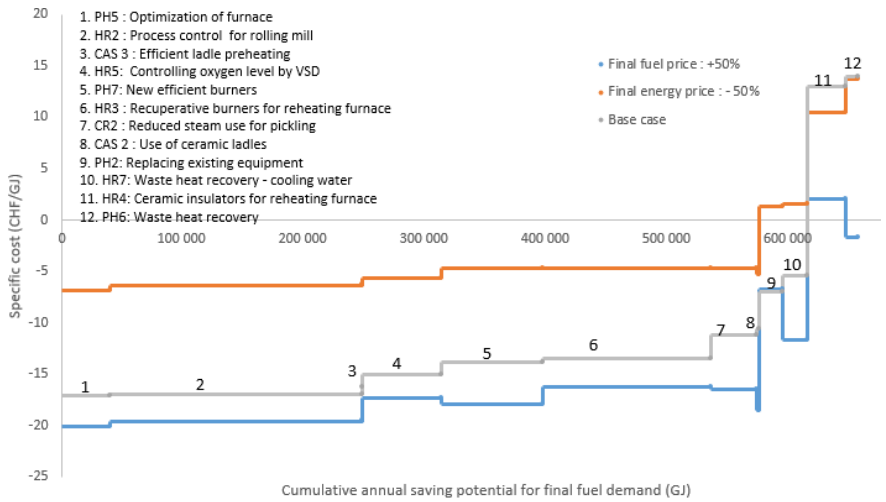
Sensitivity analysis of economic EE potential for electricity



Sensitivity analysis of economic EE potential for fuels



Sensitivity analysis

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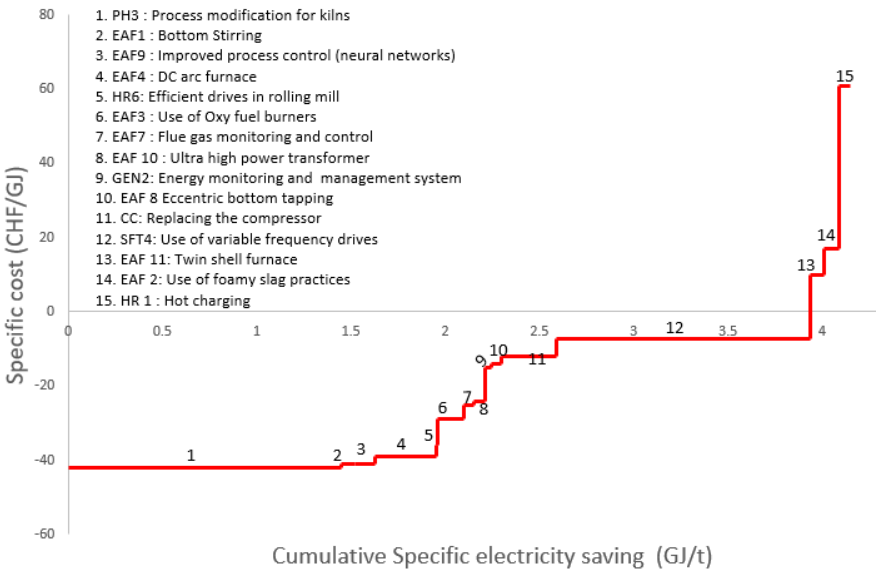
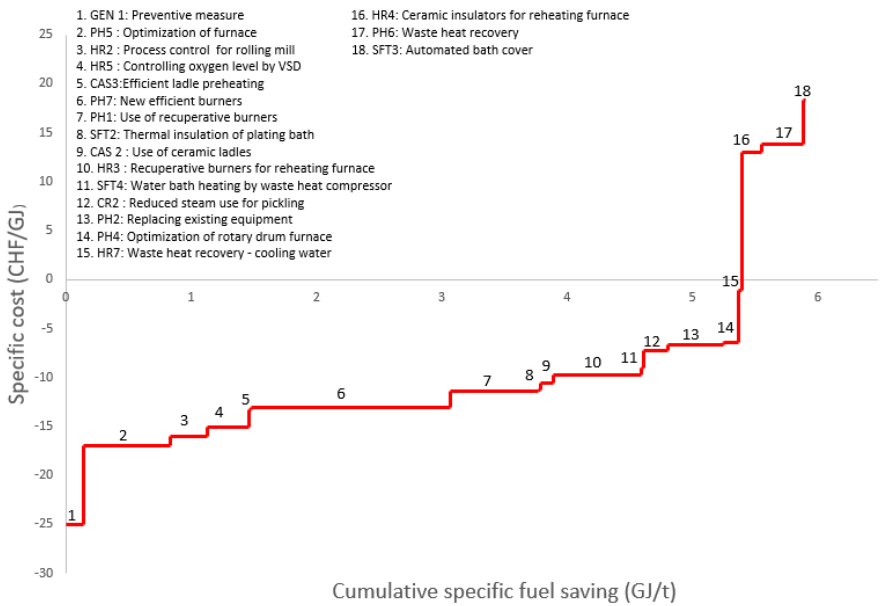
Specific economic EE potential for electricity



Specific economic EE potential for fuel



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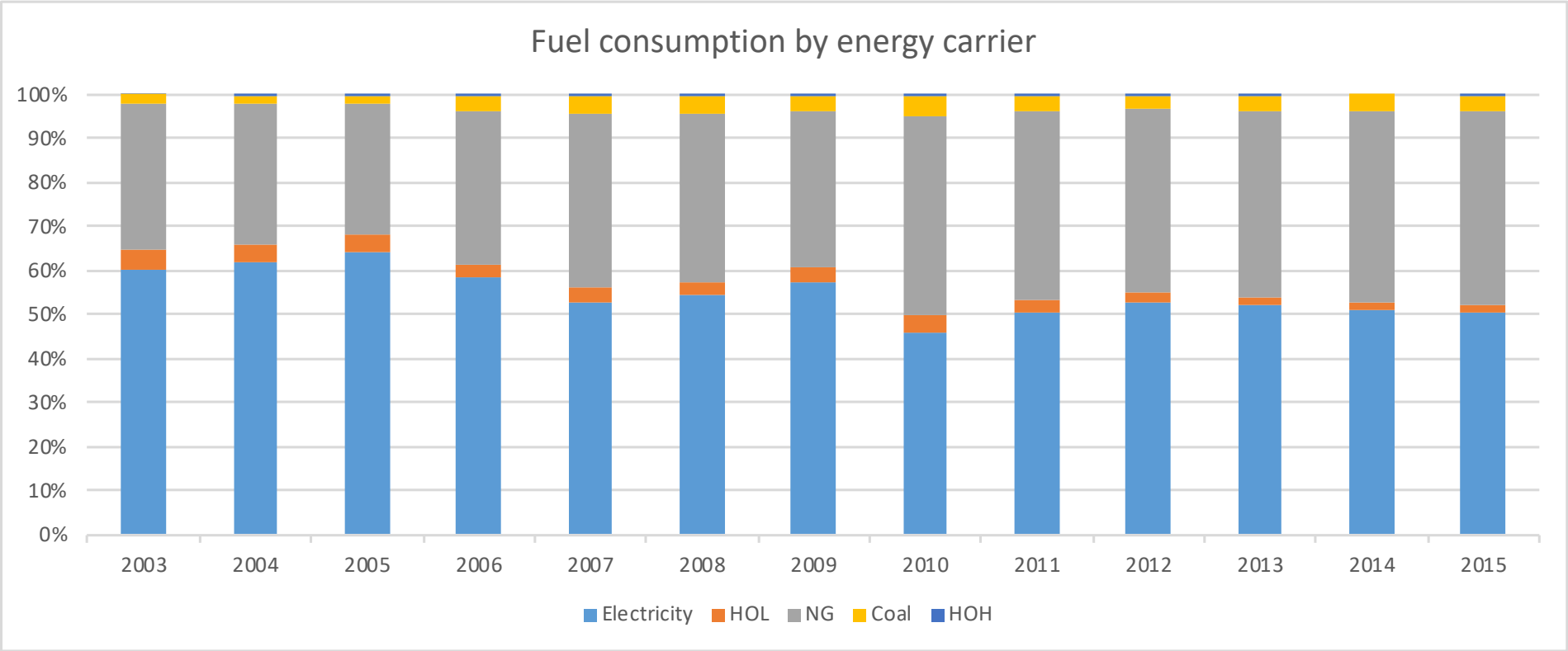
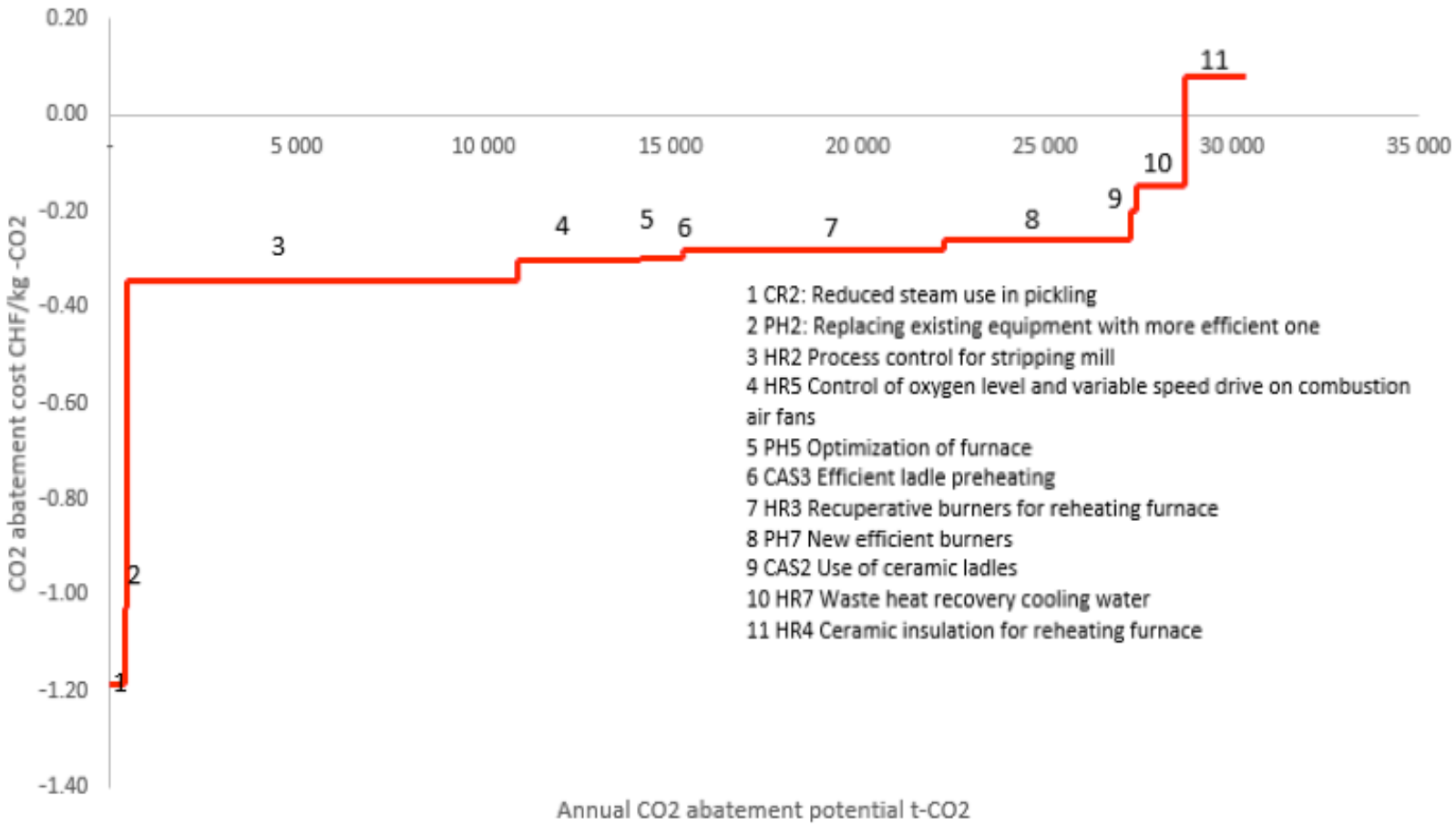
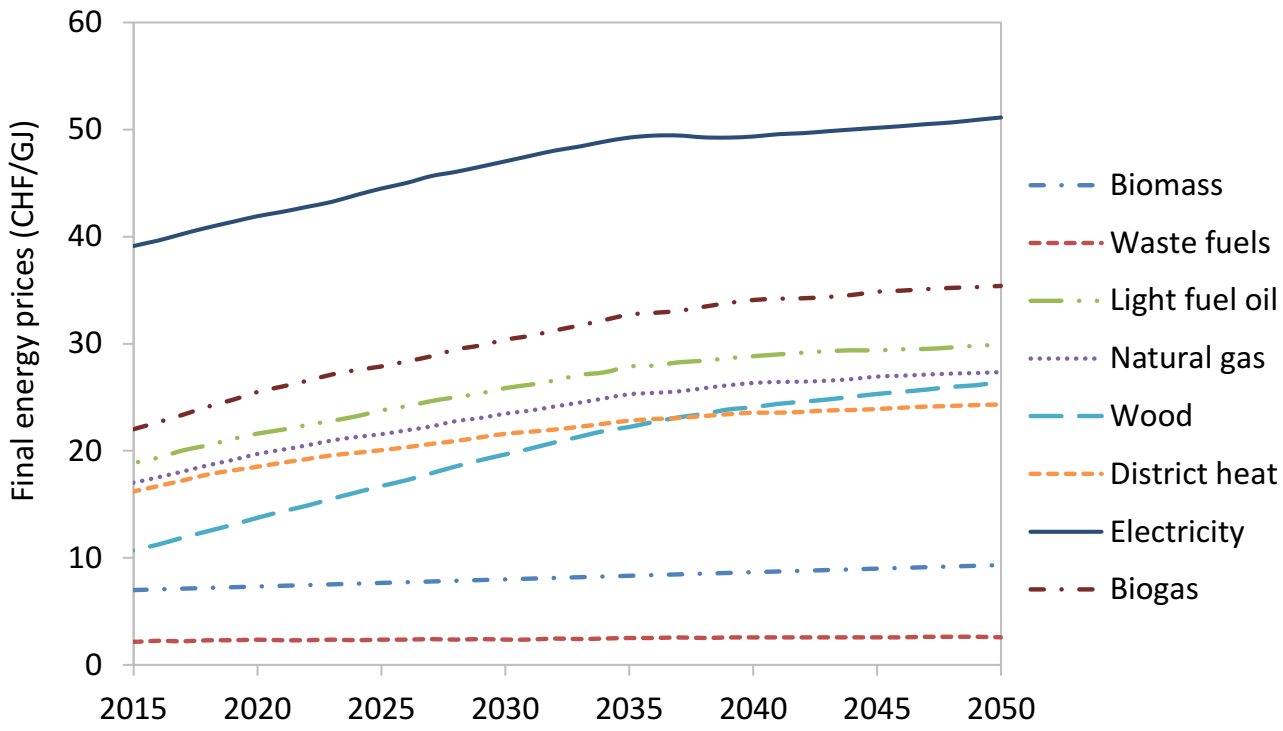
Fuel Mix


Fuel consumption by energy carrier
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Electricity
HOL
NG
Coal
HOH

CO2 mitigation cost curve



Energy prices



Source: Zuberi, 2017