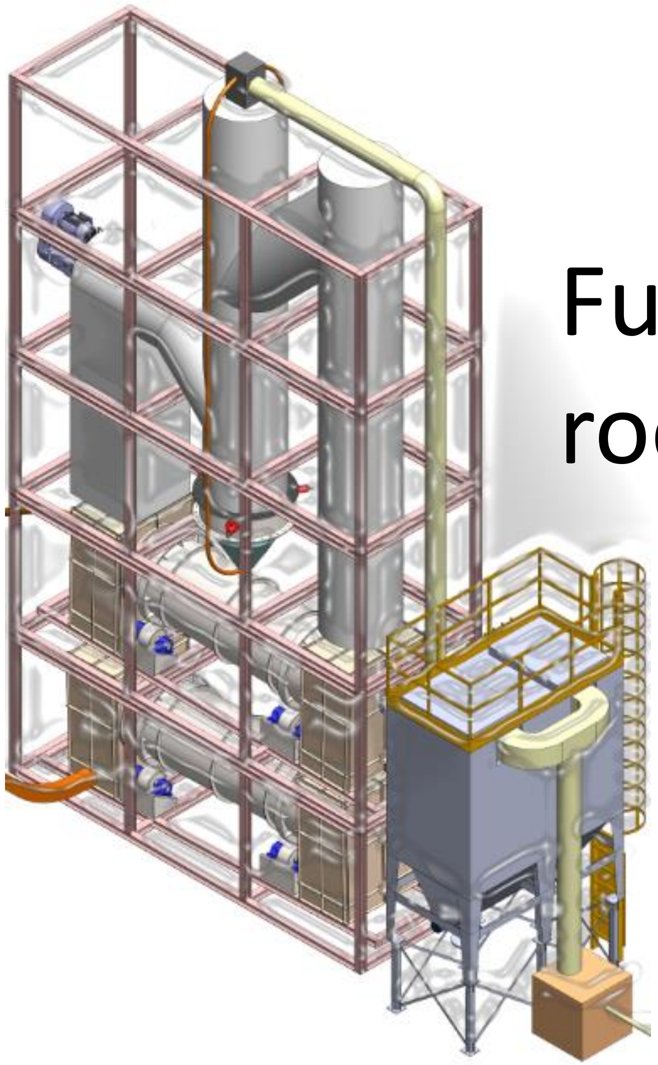


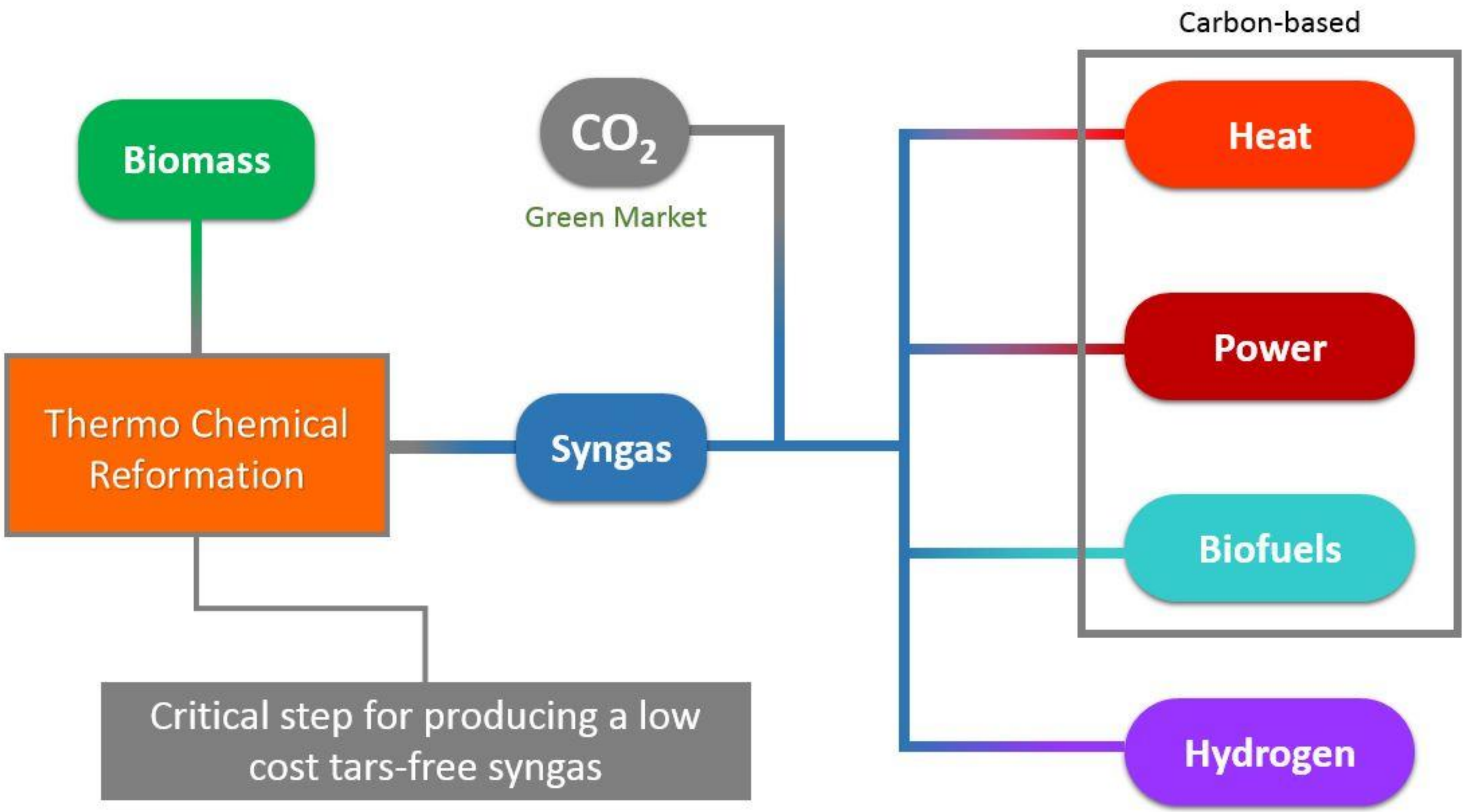
Fuel flexible gasification – low carbon root for energy and transport fuels

Valdis Bisters
Environmental Science Programme
University of Latvia

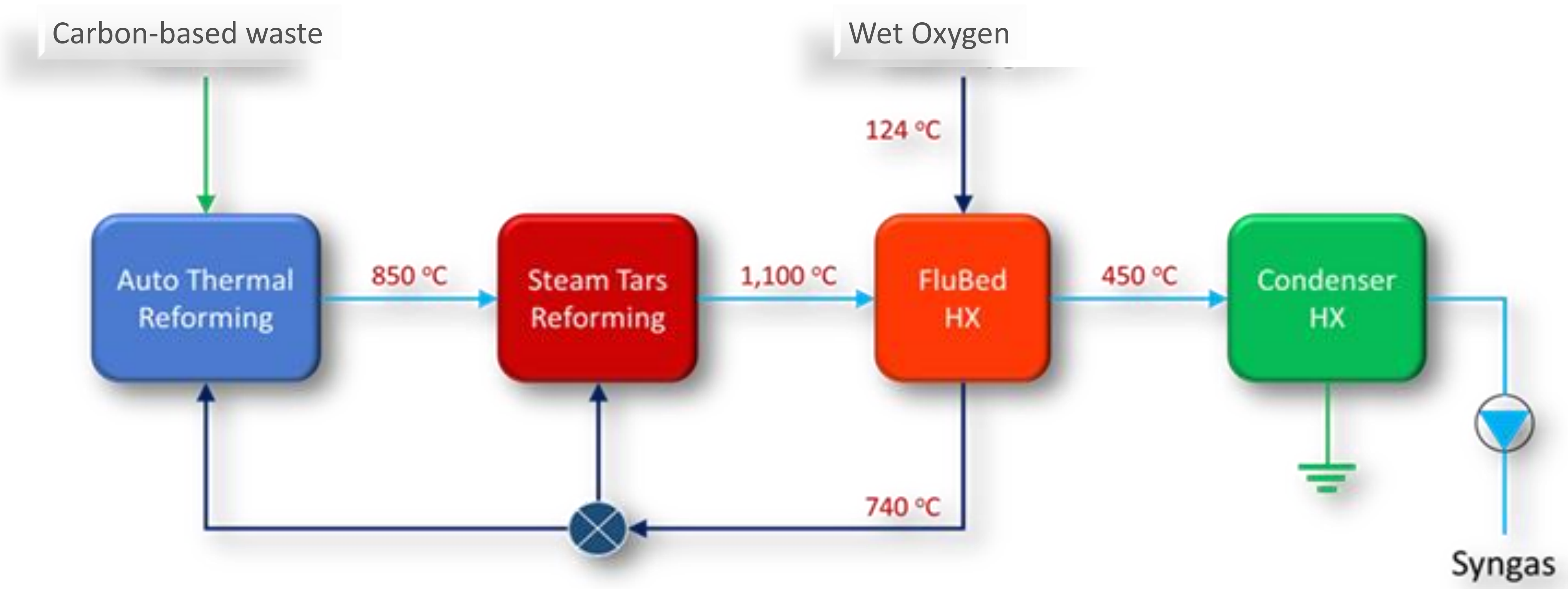
Presentation content

1. Team and focus – research and comercialization
2. Biomass/waste gasification – current status
3. Industrial research University of Latvia
4. Pilot project Milan – cold, clean syngas
5. Case study – RDF (Latvia), policy context
6. Case study – bioSNG (Netherlands), policy context
7. Case study – green hydrogen (Liguria, Italy)
8. Green hydrogen for transport
9. Some take aways and next research

Biomass/RDF Conversion Options



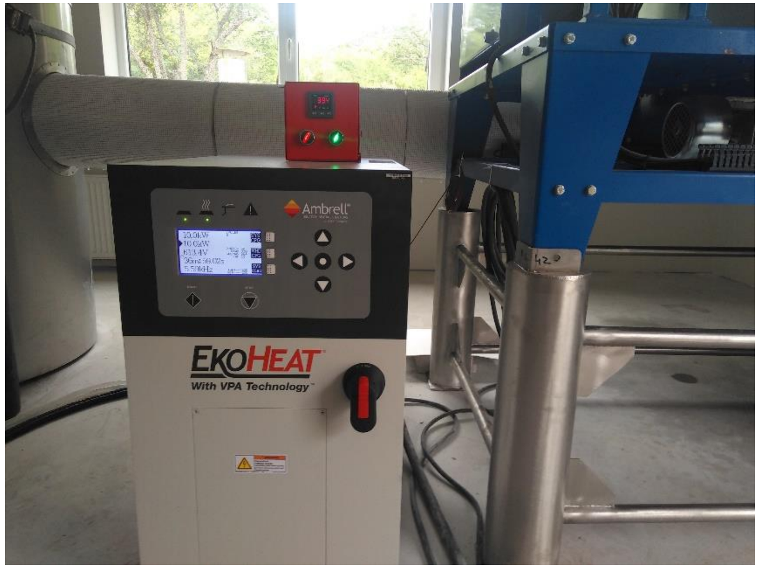
Illustrative gasification path



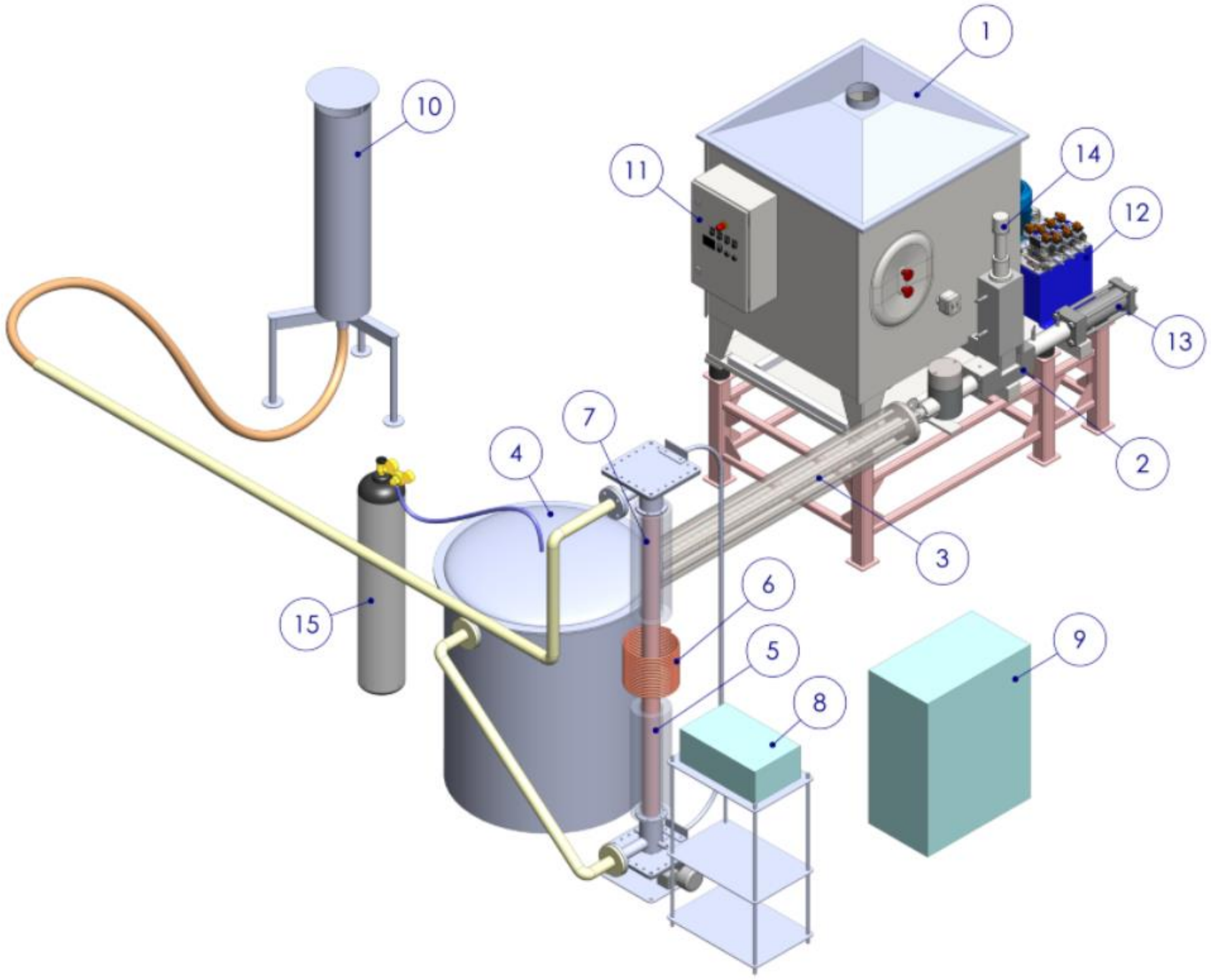
Note: Tempertures are for illustration

University of Latvia gasification research lab



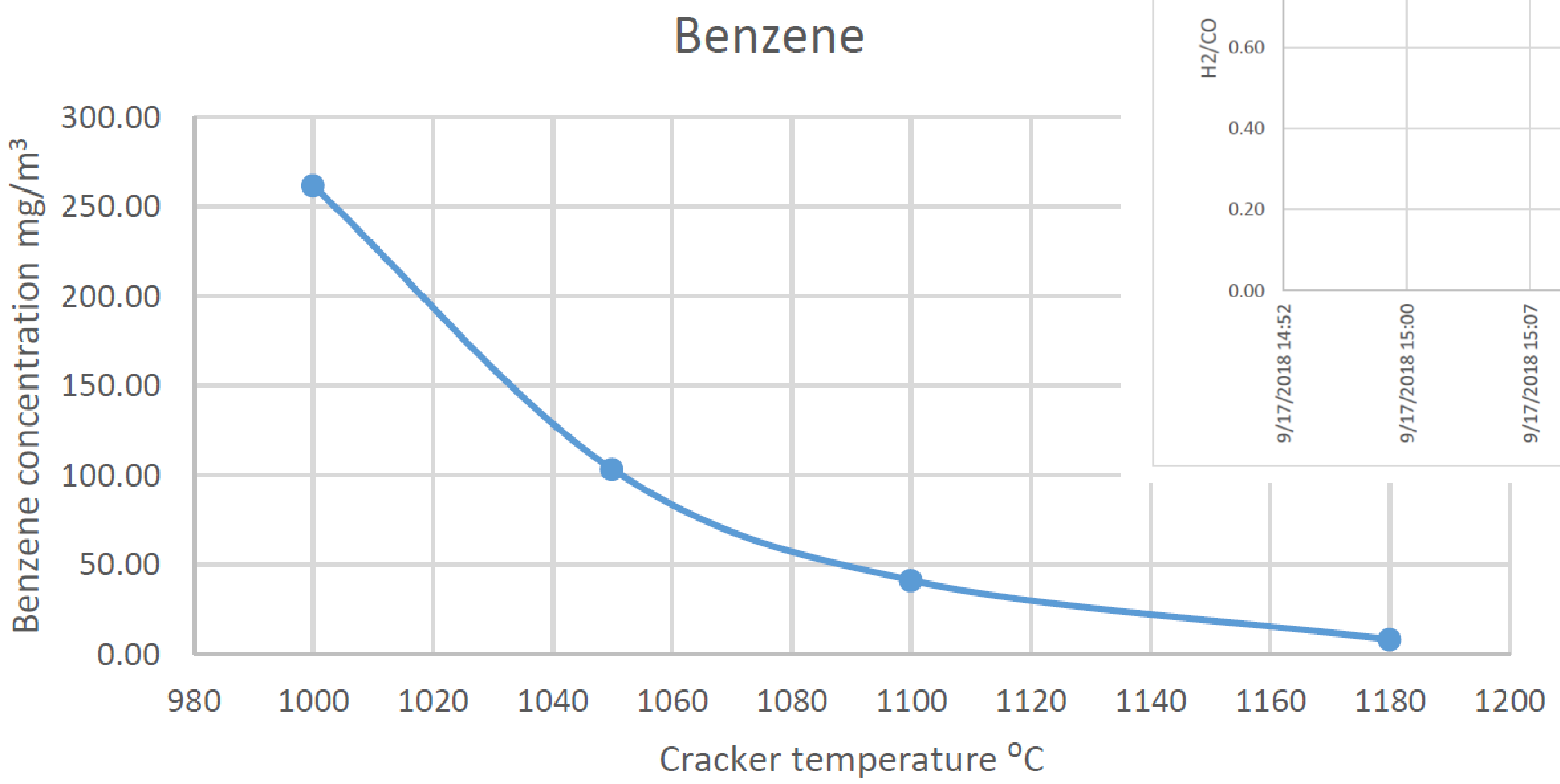
University of Latvia research project SRFgas

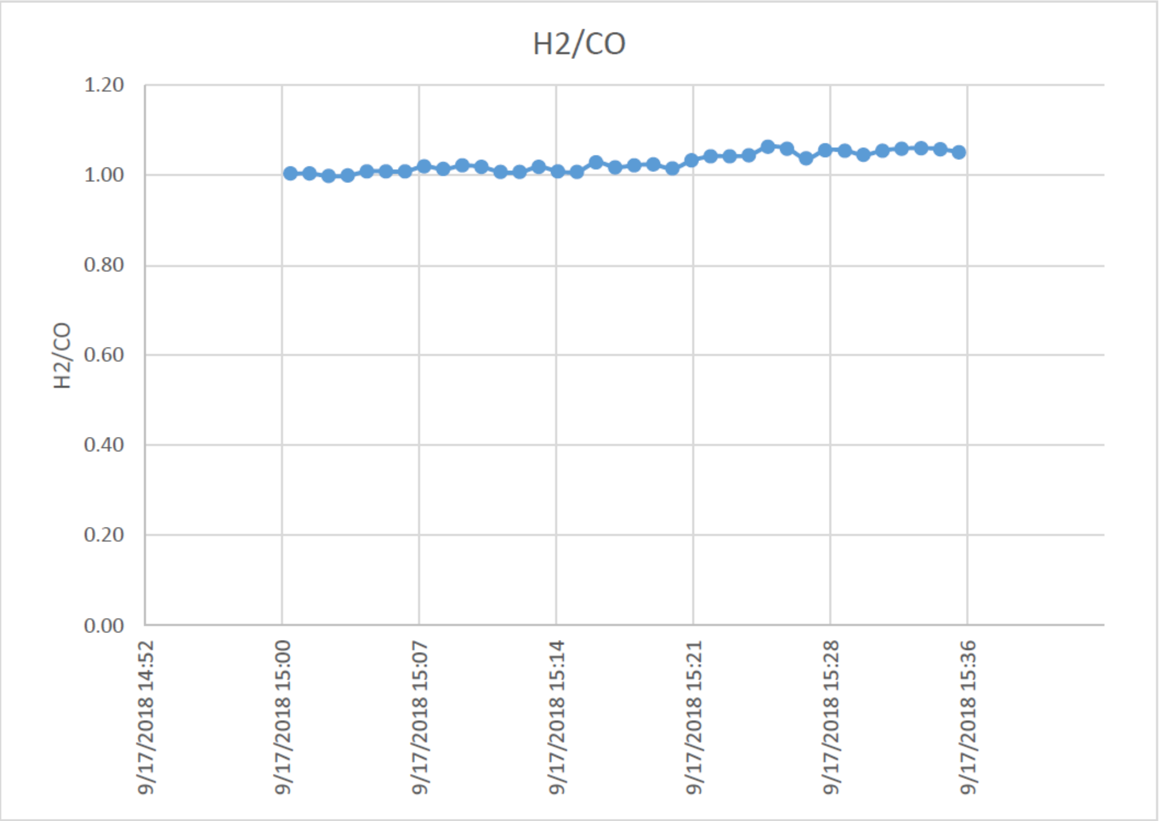


1. Feedstock bunker
2. Hydrolic press feeder
3. Heated extruder
4. Gas and char accumulation tank
5. Secondary gas cracking
6. External inductive heater
7. Gas cooler
8. Inductive heater resonator
9. Inductive heater power box
10. Flare
11. Control cabinet
12. Hydrostation
13. Hydrocilinder
14. Prior hydropresser box
15. Nitrogen baloon.

Visuals (Milan pilot plant)

Some experimental data, pilot installation

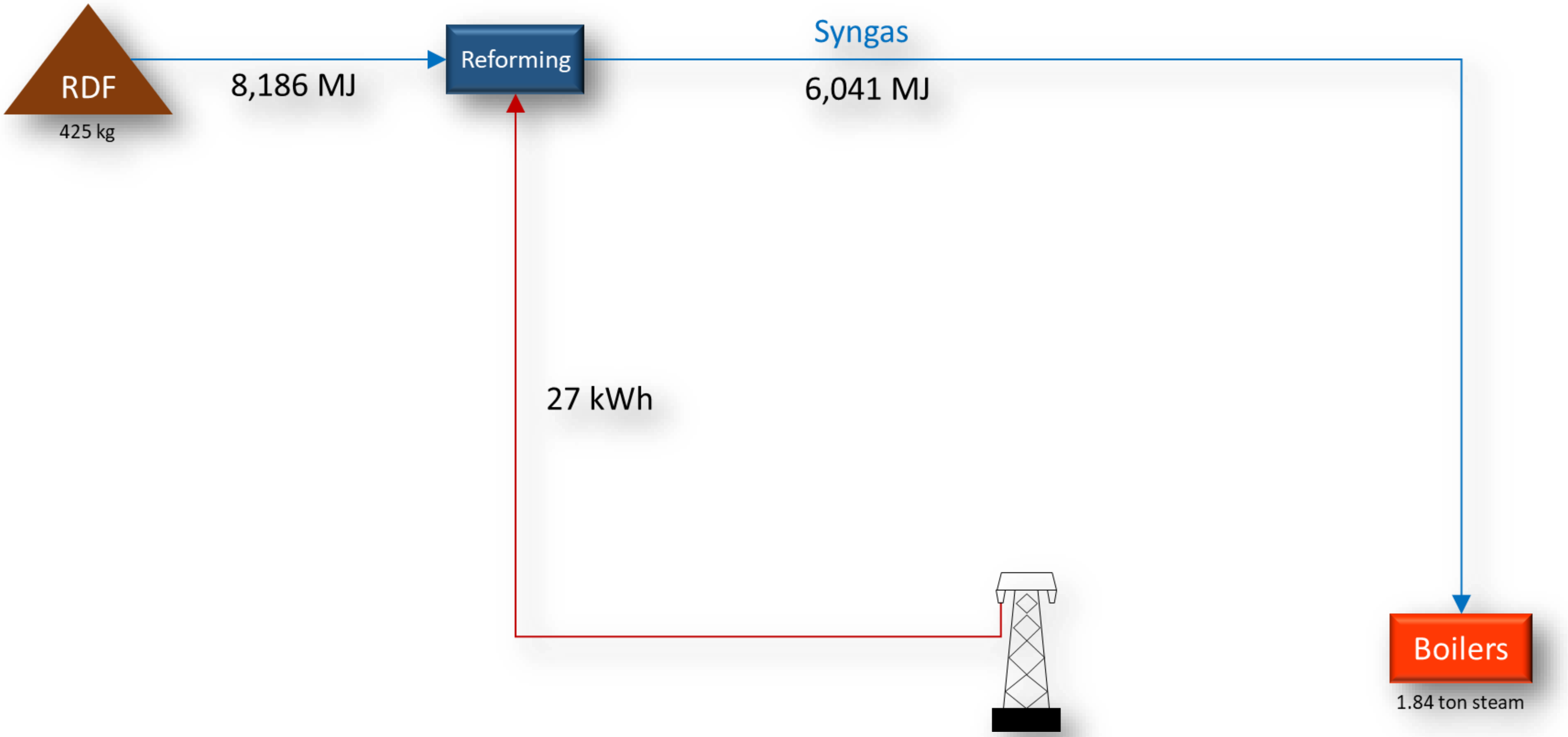




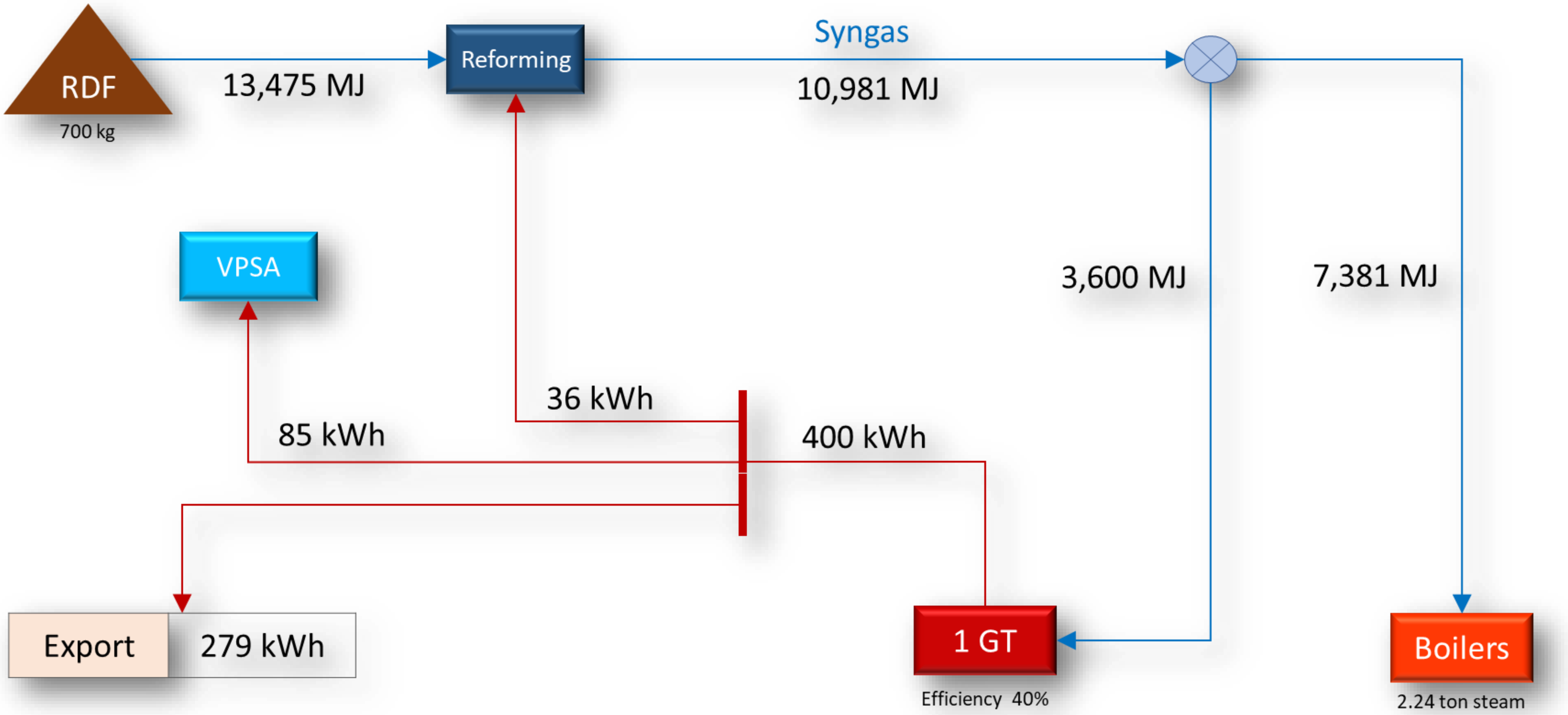
Calorific value of feedstock MSW processing group

	RDF Fraction							
	6.25%		75.00%		18.75%		100.00%	
	PB		**EKK**		**NP**		MIX	
Ultimate	Dry	as received	Dry	as received	Dry	as received	Dry	as received
C	73.68%	59.90%	47.18%	35.20%	72.30%	71.50%	54.73%	43.55%
H	10.41%	8.46%	6.21%	4.63%	11.70%	11.57%	7.75%	6.17%
O	12.92%	10.50%	26.54%	19.80%	4.65%	4.60%	20.57%	16.37%
N	0.11%	0.09%	0.55%	0.41%	0.30%	0.30%	0.46%	0.37%
S	0.02%	0.02%	0.15%	0.11%	0.01%	0.01%	0.11%	0.09%
Cl	0.07%	0.06%	0.44%	0.33%	0.09%	0.09%	0.34%	0.27%
Ash	2.80%	2.28%	18.93%	14.12%	10.95%	10.83%	16.04%	12.76%
Water		18.70%		25.40%		1.10%		20.43%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
HHV MJ/KG	34.47	28.03	19.39	14.46	35.93	35.53	24.20	19.26

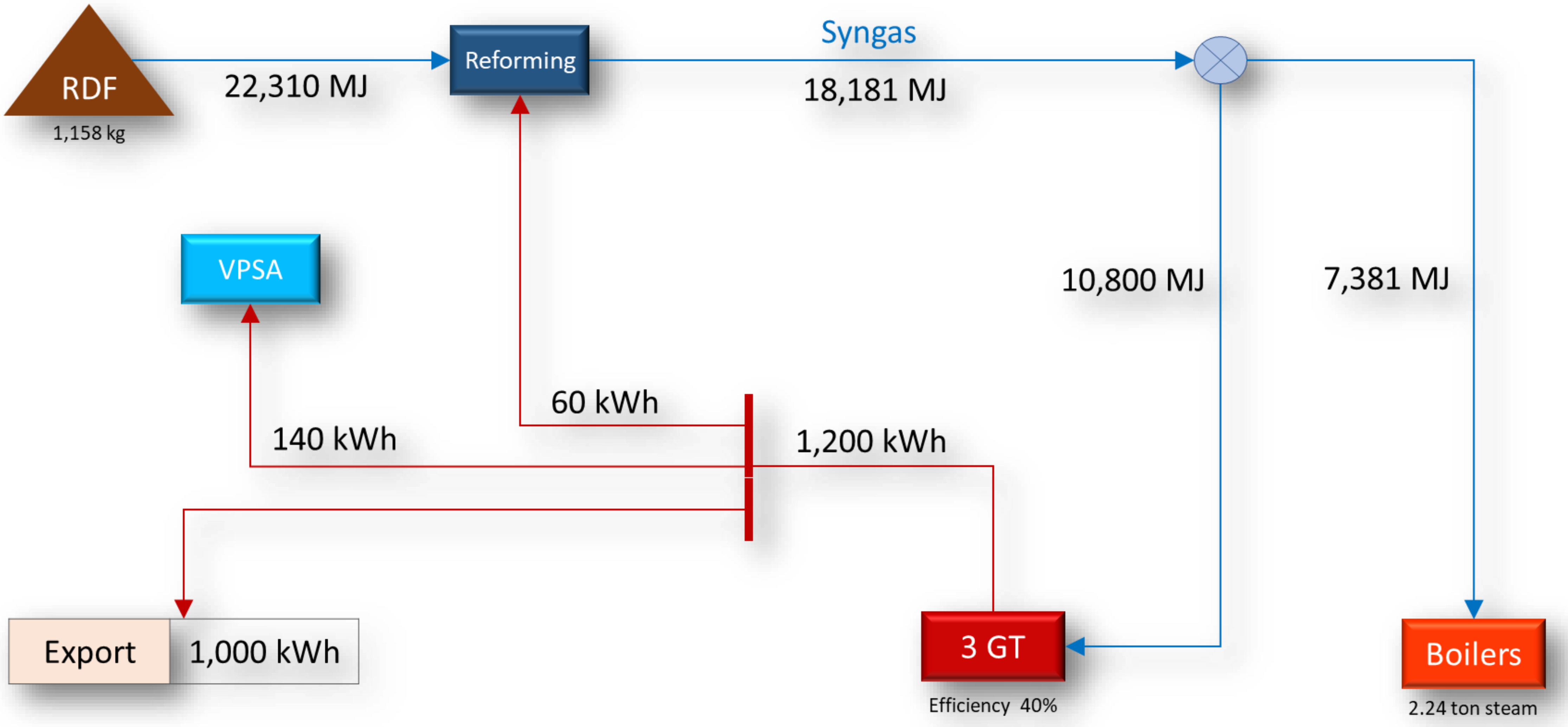
Overall Power Balance no GT – STAGE I



Overall Power Balance 1 GT - STAGE II



Overall Power Balance 3 GT - STAGE III



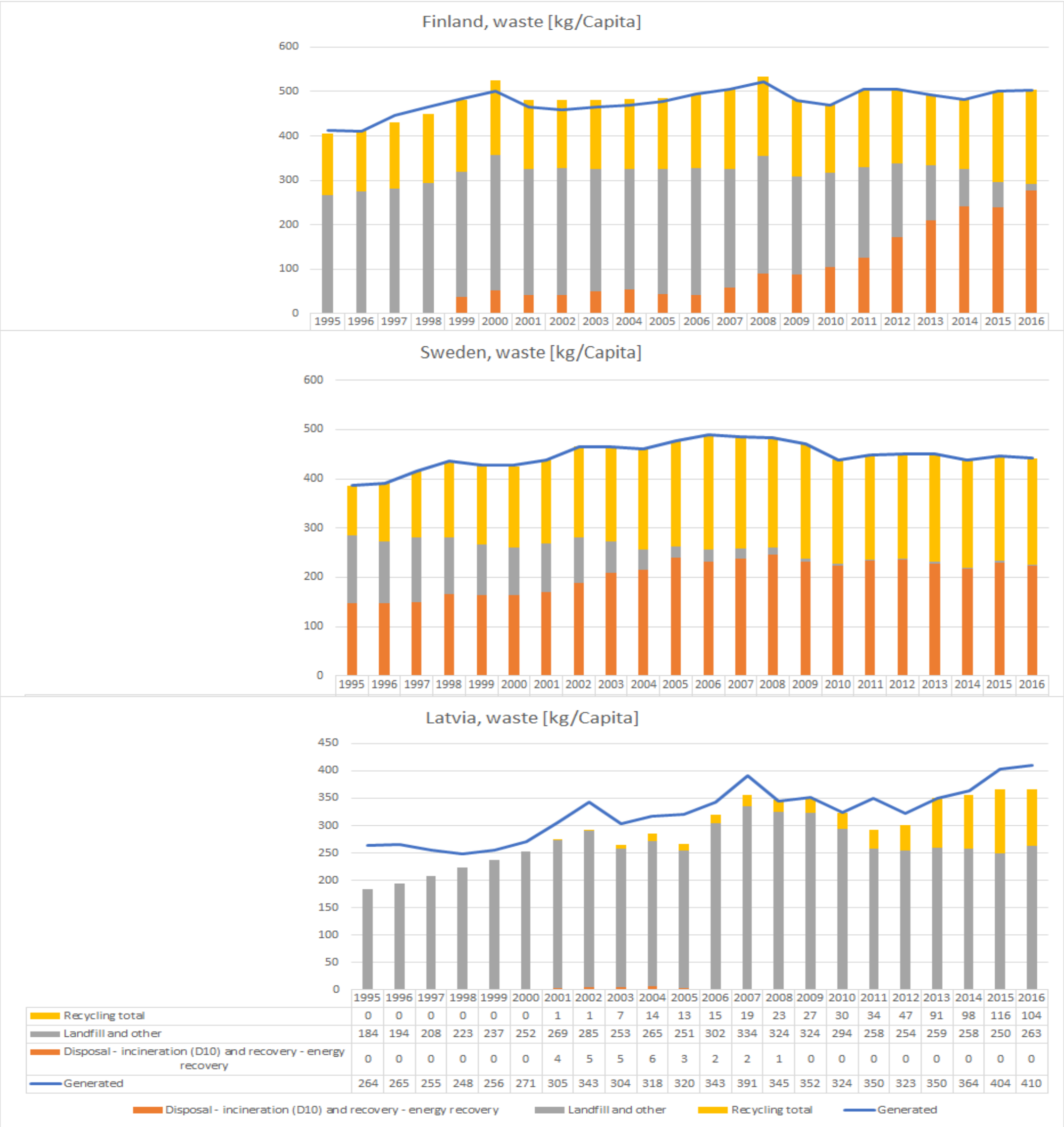
Policy context and opportunities for Latvian waste sector

<u>EU new waste policy</u>

- Recycling 65% of municipal waste by 2030
- Recycling 75% of packaging waste by 2030
- Landfill target to reduce landfill to a maximum of 10% of municipal waste by 2030
- A ban on landfilling of separately collected waste
- Promotion of economic instruments to discourage landfilling
- Simplified and improved definitions and harmonized calculation methods for recycling rates throughout the EU
- Concrete measures to promote re-use and stimulate industrial symbiosis
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes

<u>Challenges and opportunities for Latvia</u>

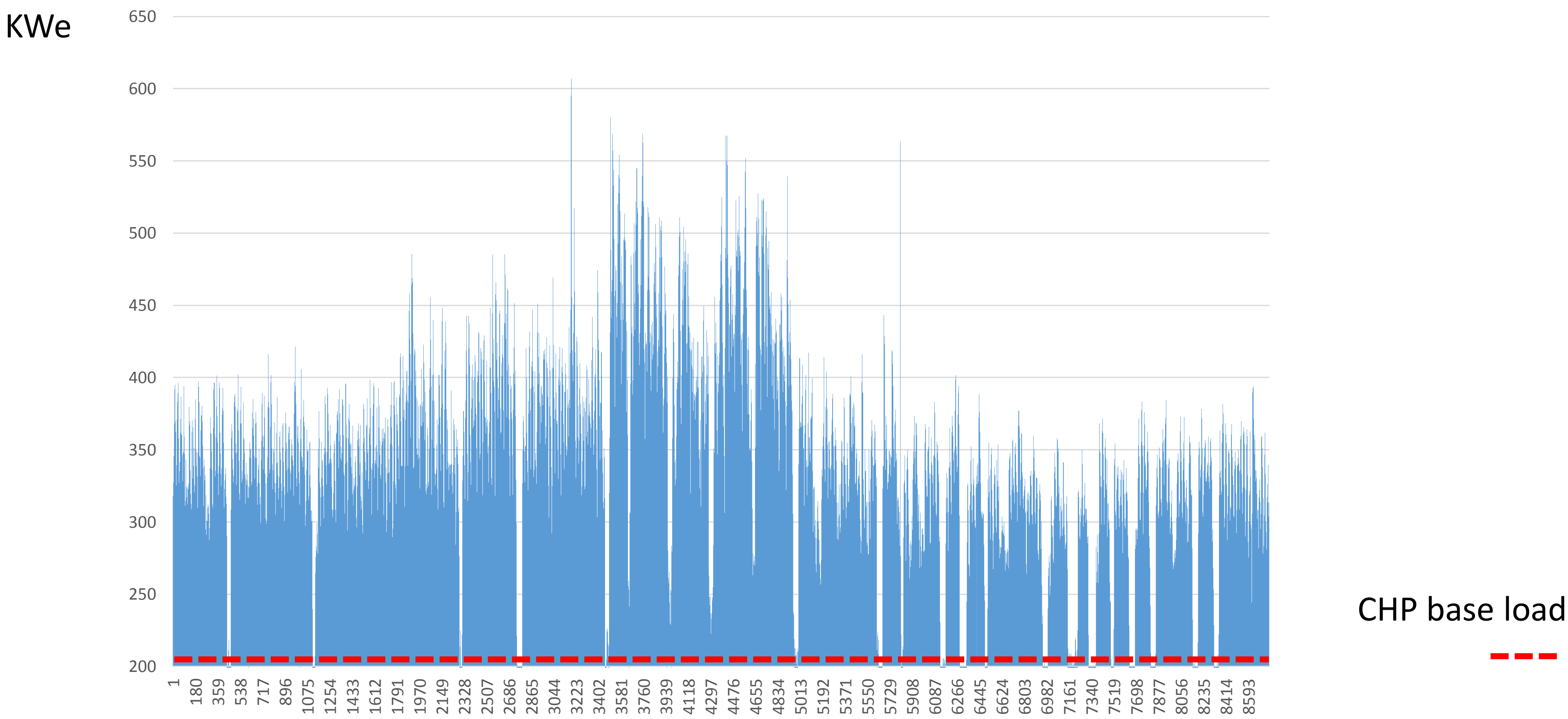
- To increase recycling rate
- To avoid large incineration set up but reduce landfilling
- To deviate from landfill non recyclable plastics and other refuse derived fuels
- Implement flexible regionally based waste to energy or waste to fuels solutions



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Recycling total	0	0	0	0	0	0	1	1	7	14	13	15	19	23	27	30	34	47	91	98	116	104
Landfill and other	184	194	208	223	237	252	269	285	253	265	251	302	334	324	324	294	258	254	259	258	250	263
Disposal - incineration (D10) and recovery - energy recovery	0	0	0	0	0	0	4	5	5	6	3	2	2	1	0	0	0	0	0	0	0	0
Generated	264	265	255	248	256	271	305	343	304	318	320	343	391	345	352	324	350	323	350	364	404	410

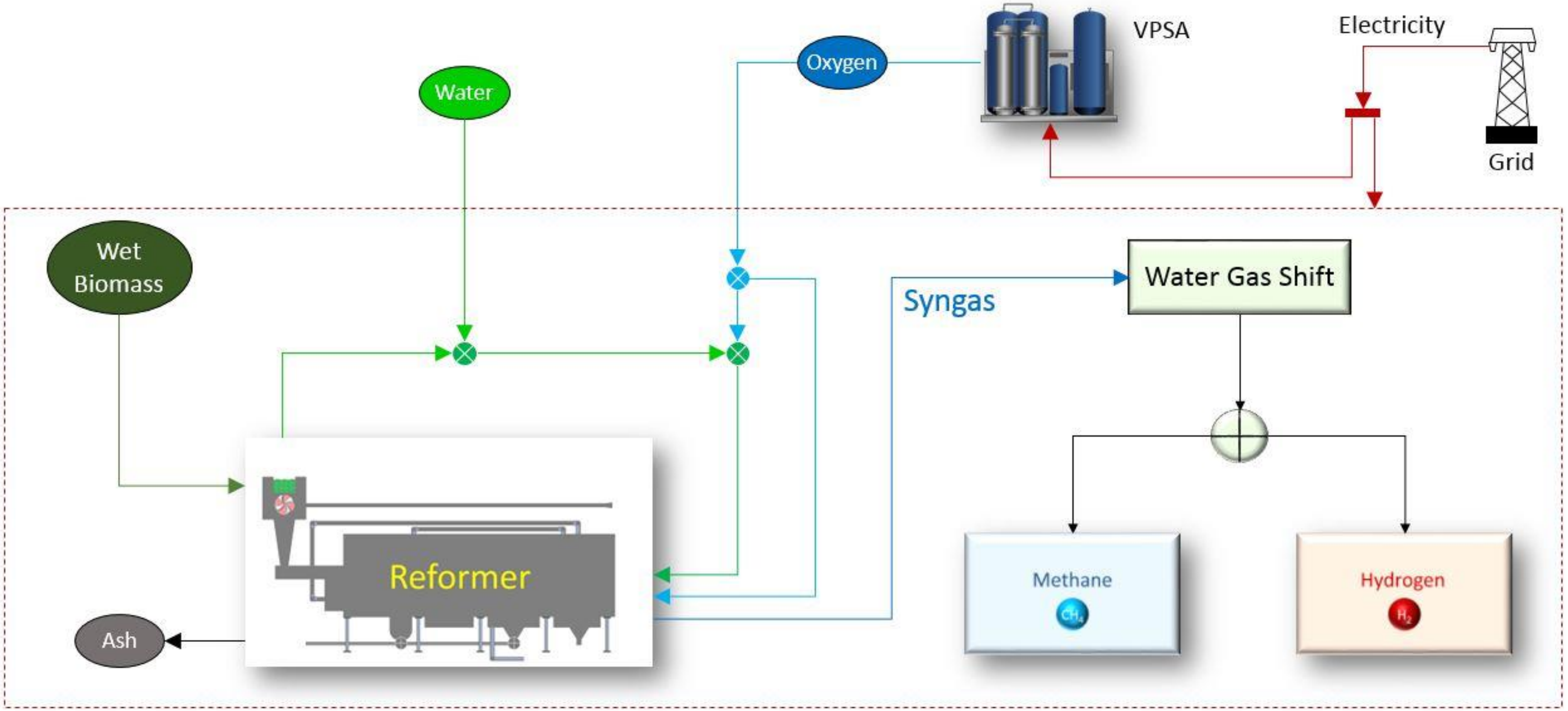
Source: national statistics

Small processing industry (example 1)



Energy Island Leeuwarden – bioSNG to grid project

Integration of H2 and SNG production (Dutch project)



Note: an "+" sign in the circle after Water Gas Shift means production of Methane or Hydrogen. In both cases, CO2 is a byproduct.

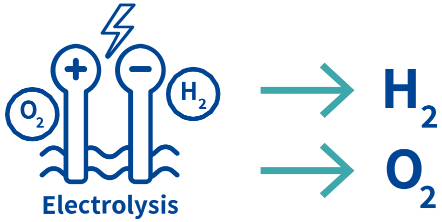
Projected Bio-Fuel Yield & Efficiency (Dutch project case 1t/h)

Bio-Fuel	Gases	kg	Nm^3	Purity	Imported kWh
Methane	CH_4	280	352	≥ 89.0%	108
	$CO_{2\ (gas)}$	1,000	520	≥ 99.0%	
Hydrogen	H_2	80	885	≥ 99.8%	125
	$CO_{2\ (gas)}$	1,425	747	≥ 99.0%	

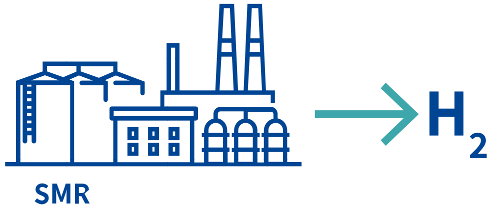
- Calculations per ton of wood chips, 10% moisture (18 MJ/kg db)
- Heat used to dry wet feedstock (excess to be exported as hot water ~ 80^{o}C)

Hydrogen production technologies

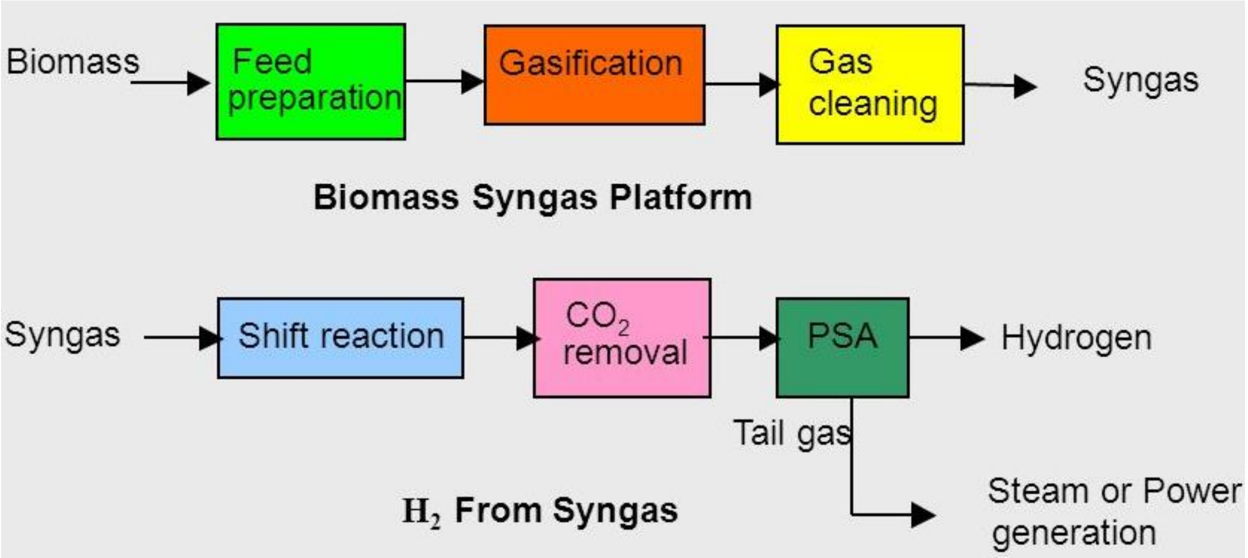
Electrolysis



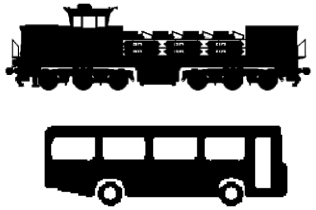
Steam methane reforming (SMR)



Forestry biomass to hydrogen



Hydrogen supply chain cost estimate

Production	Tranporation	Filling	Use
4,10 – 3,21 EUR/kg Depend on production technology and Resources	1,0 – 0,6 EUR/kg (with volume for 10 train locomotives or 50 – 200 bus depo) Tranportation distance within 150 km	0,64 – 0,54 EUR/kg Depending on filling capacity requirements	5,3 - 5,9 EUR/kg Cost at fossil parity

Production + filling = **4,74 – 3,75*** EUR/kg

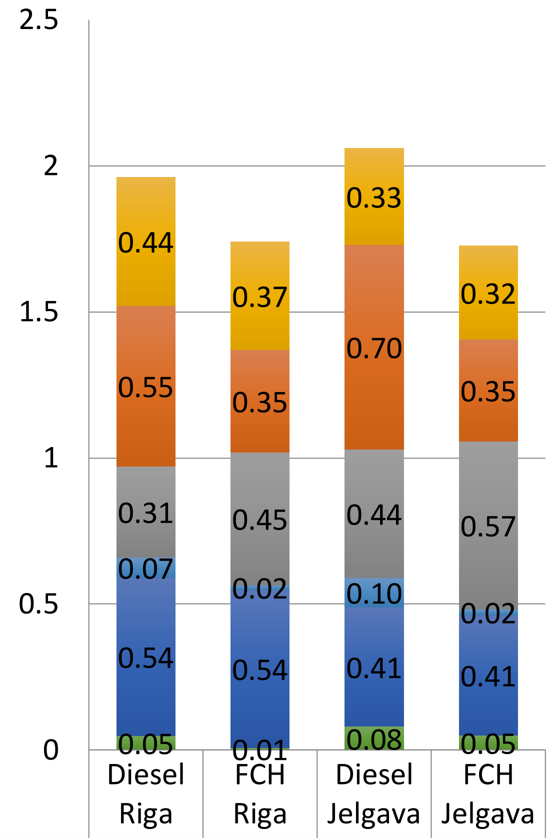
Production + Tranportation + filling = **5,74 - 4,35*** EUR/kg

* - Total cost depend from production technology and logistics

Source: Latvian Hydrogen association (H2LV)

TCO of hydrogen city buses (case study)

Total cost of ownership EUR/km



	Diesel Riga	FCH Riga	Diesel Jelgava	FCH Jelgava
Degviela	0.44	0.37	0.33	0.32
Serviss	0.55	0.35	0.70	0.35
Nolietojums	0.31	0.45	0.44	0.57
Finansēšana	0.07	0.02	0.10	0.02
Alga šoferiem	0.54	0.54	0.41	0.41
Administrācija	0.05	0.01	0.08	0.05
Kopā	**1,96**	**1,74**	**2,06**	**1,72**

Case study done for two cities Riga (population 704 000) and Jelgava (population 56 000).

Comparison of TCO diesiel buses vs FCH (200 bus units).

Assumptions:
Fuel price – 1.1 eur/l diesel, 5.5 EUR/kg hydrogen (SMR)
Depreciation 12 years
Full service package (bus leasing, maintanance, fuel)
EIB financing at 50% 0.6% loan, 50% 3.6 commercial loan for FCH.
Diesel bus fleet – out going, FCH new procurement at cost of 400K/unit.

English legend

Fuel
Serviss
Amortization
Financing costs
Drivers salaries
Administration

Contacts - consortium

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Industrial partners:

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RENTEHO

CO2apps

Hydrogen Europe