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Energy from Biomass – a multilateral, sustainable and reliable Alternative to Oil, Gas and Coal

Basic Informations, Profitability and Best Practise Examples in the Sector of Bioenergy

C. Letalik, Engineer of Agriculture, C.A.R.M.E.N. e. V.

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Who is C.A.R.M.E.N. e. V.?

*C*entral *A*gricultural *R*aw materials *M*arketing and *E*nergy *N*etwork , registered *non profit* association

- Coordination office for renewable resources in Bavaria
- Founded in 1992, 70 members, 40 employees
- Consulting, public relations and project management with regard to energetically use of biomass, bank reports
- Project assessment and project evaluation for the Bavarian Ministry of Economy, Media, Energy and Technology
- Further information: www.carmen-ev.de
- Christian Letalik, cl@carmen-ev.de

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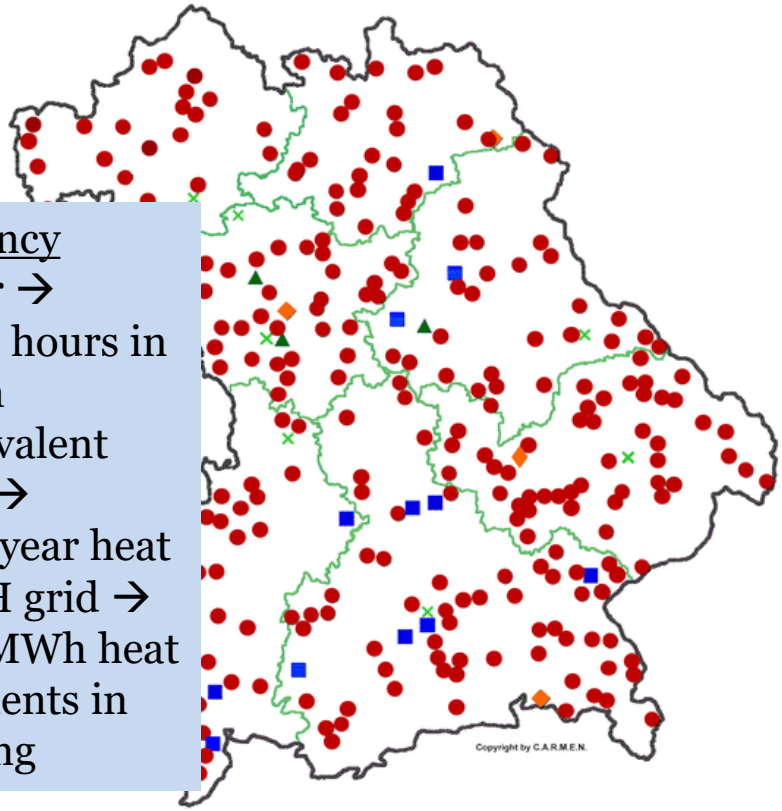
Evaluated Biomass Heat Plants in Bavaria

● Heat

Criteria of efficiency
- ➢ Biomass boiler →
- ➢ 2,500 full load hours in a bivalent system
- ➢ 2,000 h monovalent
- ➢ Heat pipeline →
- ➢1,500 kWh/m, year heat density in the DH grid →
- ➢1 km → 1,500 MWh heat demand by all clients in the district heating



More than ● 400 biomass heat plants (0,1 $MW_{th.}$ – 5 $MW_{th.}$) (with heat grid) in Bavaria. Supported with investment subsidies by the Bavarian Government and evaluated over 7 to 12 years → sources for *long term* technical and economical data.
15 CHP woodgasifiers



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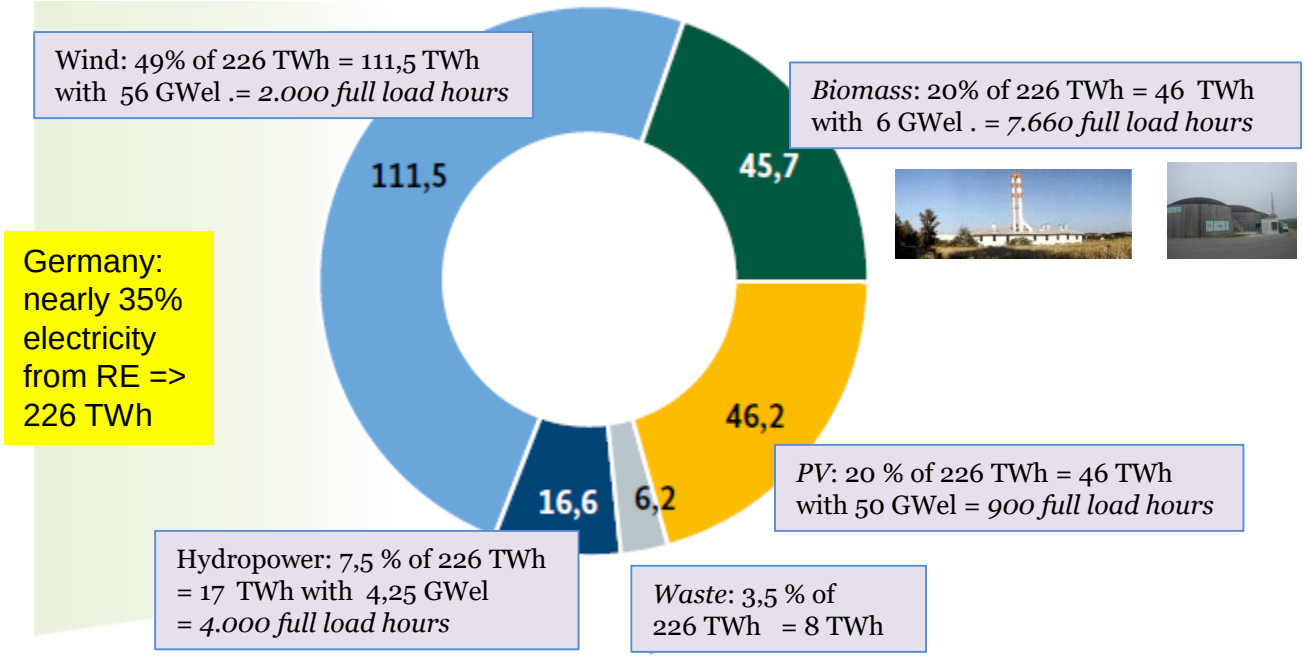
Electricity from renewables => 35% – a good mixture in Germany



- 20% of renewables - based electricity supply from biomass, dominated by biogas plants (2/3), 1/3 from solid fuels.
- Barely 50% from wind energy onshore and wind energy offshore (quickly rising)
- 20% from PV and 7,5 % from hydropower
- 3,5% from waste

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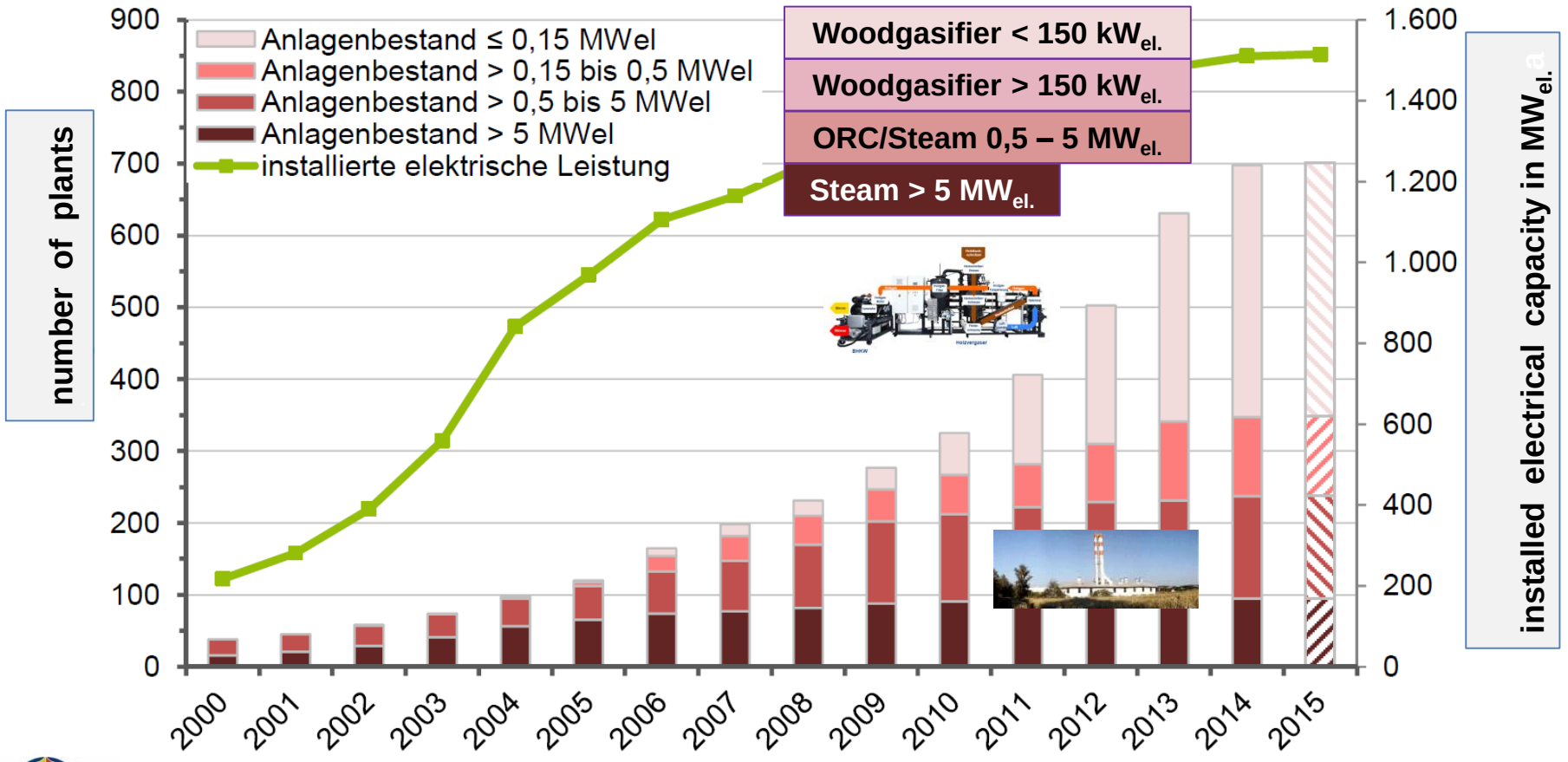
Number of CHP Biomass Plants incl. Wood Gasification Systems



Source: DBFZ, EEG Monitoring Zwischenbericht Mai 2015

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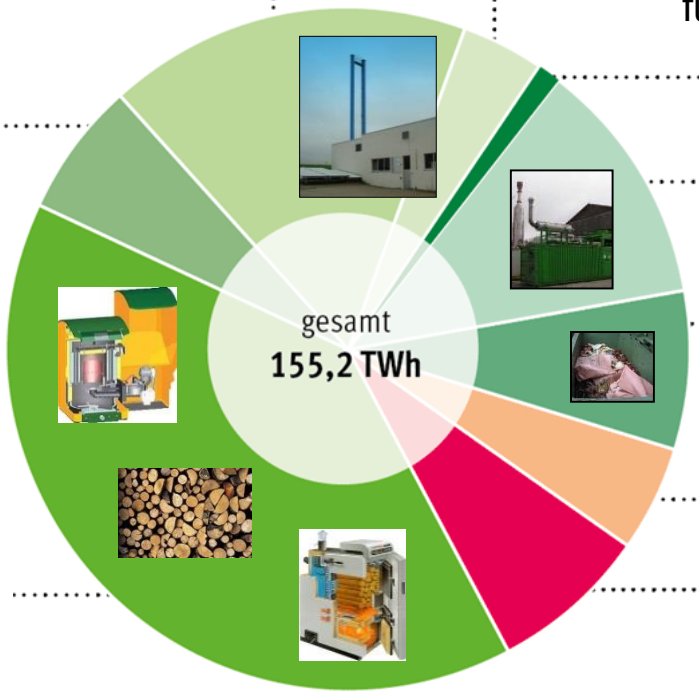
Renewable Energy Heat Supply in Germany 2015

17,1% biogenic solid fuels for industry

6,4 % solid fuels in services sector

88 % bioenergy share on renewable heat supply
means **12 %** of total heat demand in 2015

39,8 % biogenic solid fuels for households



3,9 % biogenic solid fuels heat plants/CHP

1,3 % biogenic liquid fuels

11,6 % biogas

7,5 % biogenic share in residual waste

5,0% solar heat

7,4 % geothermal heating

Source: BMWi, AGEE-Stat, FNR 2016

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Biomass Heat Plant–System → efficient and profitable heat sinks

very good conditions	**++ swimming pools, hospitals, dormitories,** **++ wood processing plants with drying station, laundries, dairies, breweries, slaughterhouses, food industry in general (fish, fruit, meat…), greenhouses,** **++ hotels, spa areas, residential areas and apartment buildings; FOSSIL *DISTRICT HEATING SYSTEMS***
good conditions	**+ new developement areas, densely populated** **+ municipal and office buildings, schools** **+ commercial areas and industrial areas** **+ farming such as chicken / pig breeding** ***maybe combination of solar heat and biomass***
bad conditions	**- low energy houses** **- residential areas with few houses** **- small individual objects with low heat demand such as storage halls**

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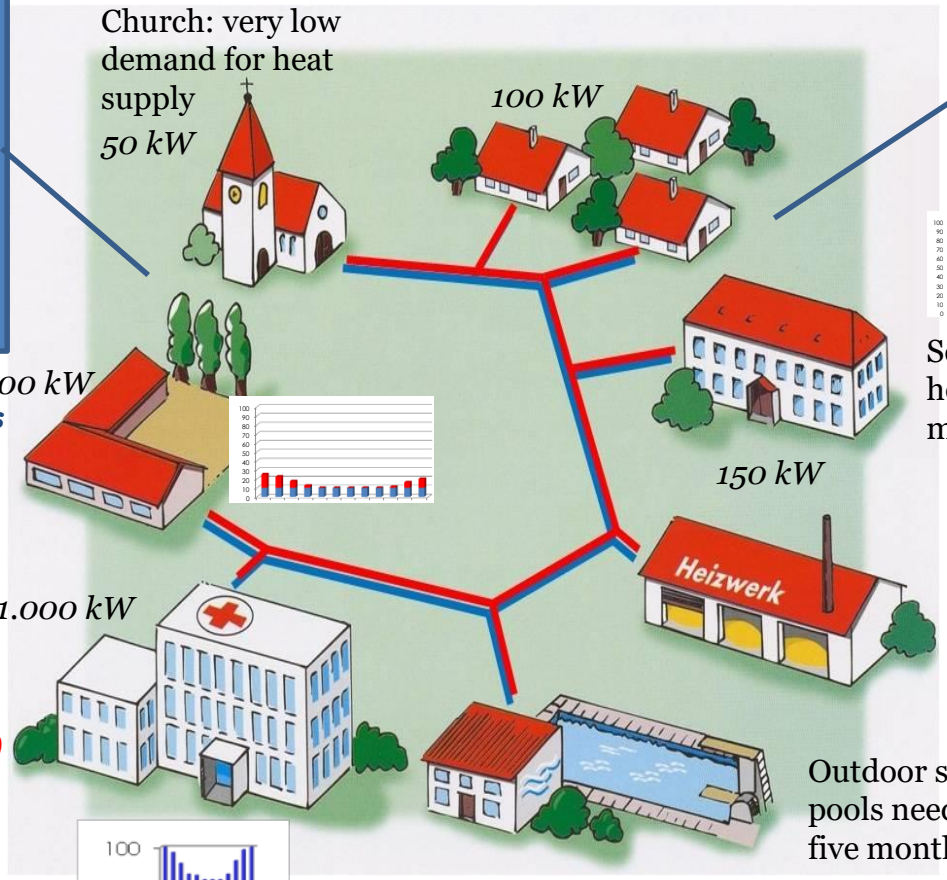
Biomass Heat Plant System – *Technical Design*

heat load of all clients = 2.000 kW → „diversity factor“ 80% → heat load in the DH system: 1.600 kW



Different heat sinks with different annual curve and peak load

Hospitals do need heat (cooling) and hot water all year round → *same conditions in tourism (hotels, spa…) and e.g. food industry (processing heat)*

Schools need the heat up to eight months a year

Biomass plant with wood chip bunker

Outdoor swimming pools need the heat five months a year

Heat demand and heat load of all clients must be well evaluated → Ask for former energy consumption (heat oil, natural gas, wood logs, electricity…) Regard the efficiency of old boilers and the „diversity factor“ 70-90%

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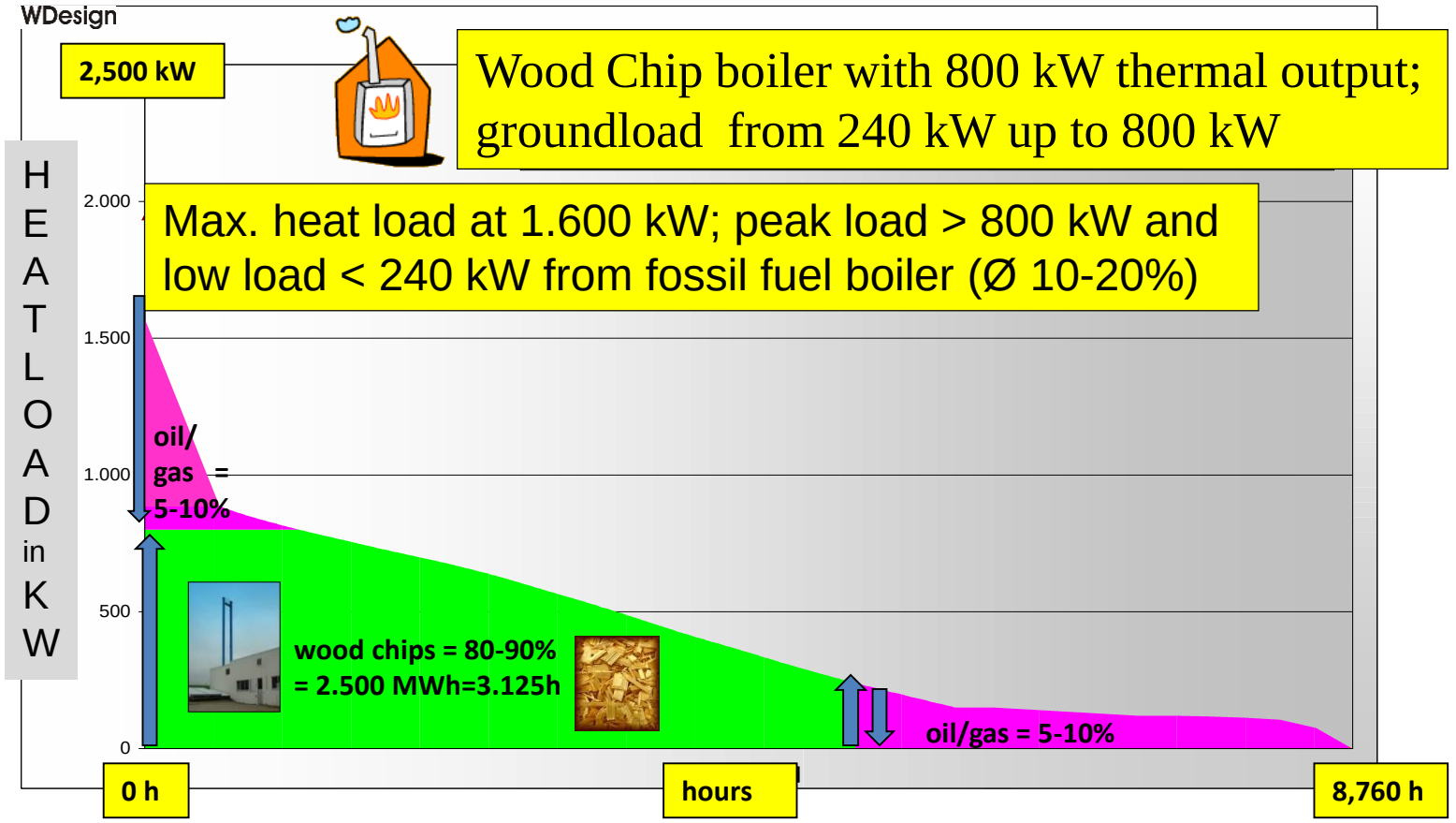
Dimensioning of a Biomass Heat plant – Wood Chip Boiler



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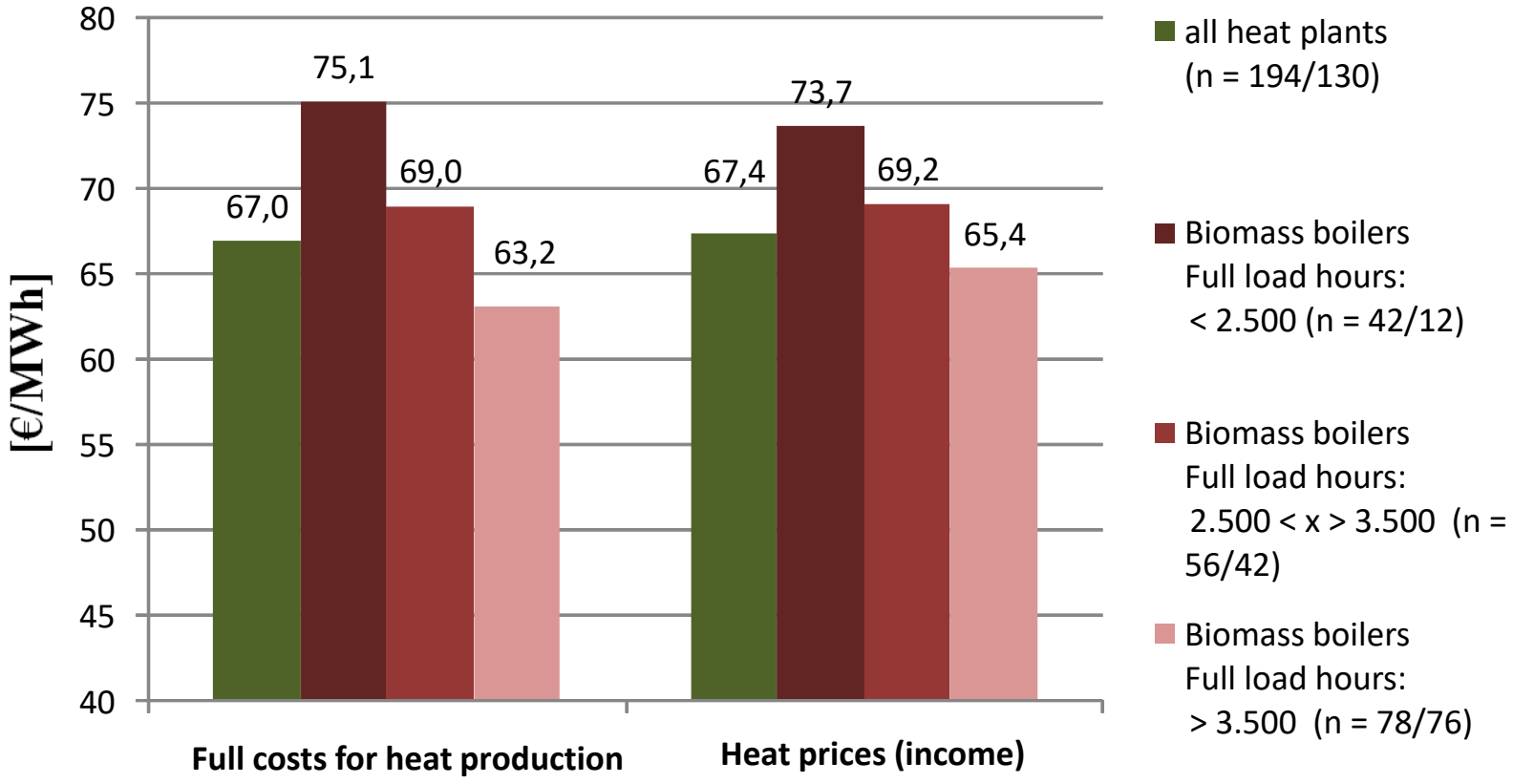
Dimensioning of Wood Chip Boilers – Ø *Full Load Hours*



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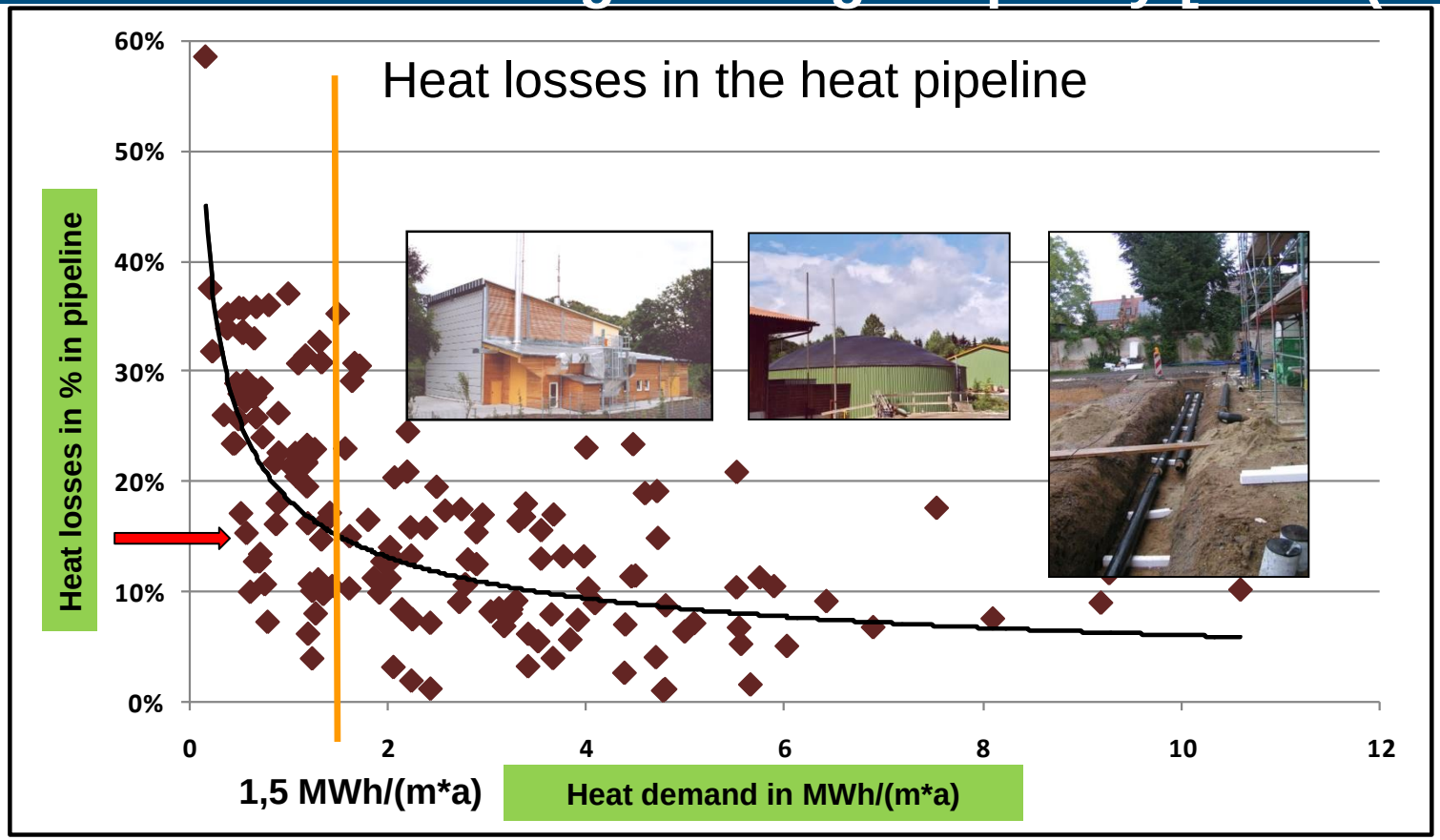
Efficiency of a Biomass Heat plant Project – heat losses - heating coverage capacity [MWh/(m*a)]



- Minimal proportion of heat demand should be 1,5 MWh/m, year.
- example: 1 km of heat pipe should transport at least 1.500 MWh of heat to the clients (replacing 150.000 litres of heat oil); heat losses not included
- heat losses in district heating network should be kept as low as possible in terms of efficiency and profitability.
- Target value: 15%

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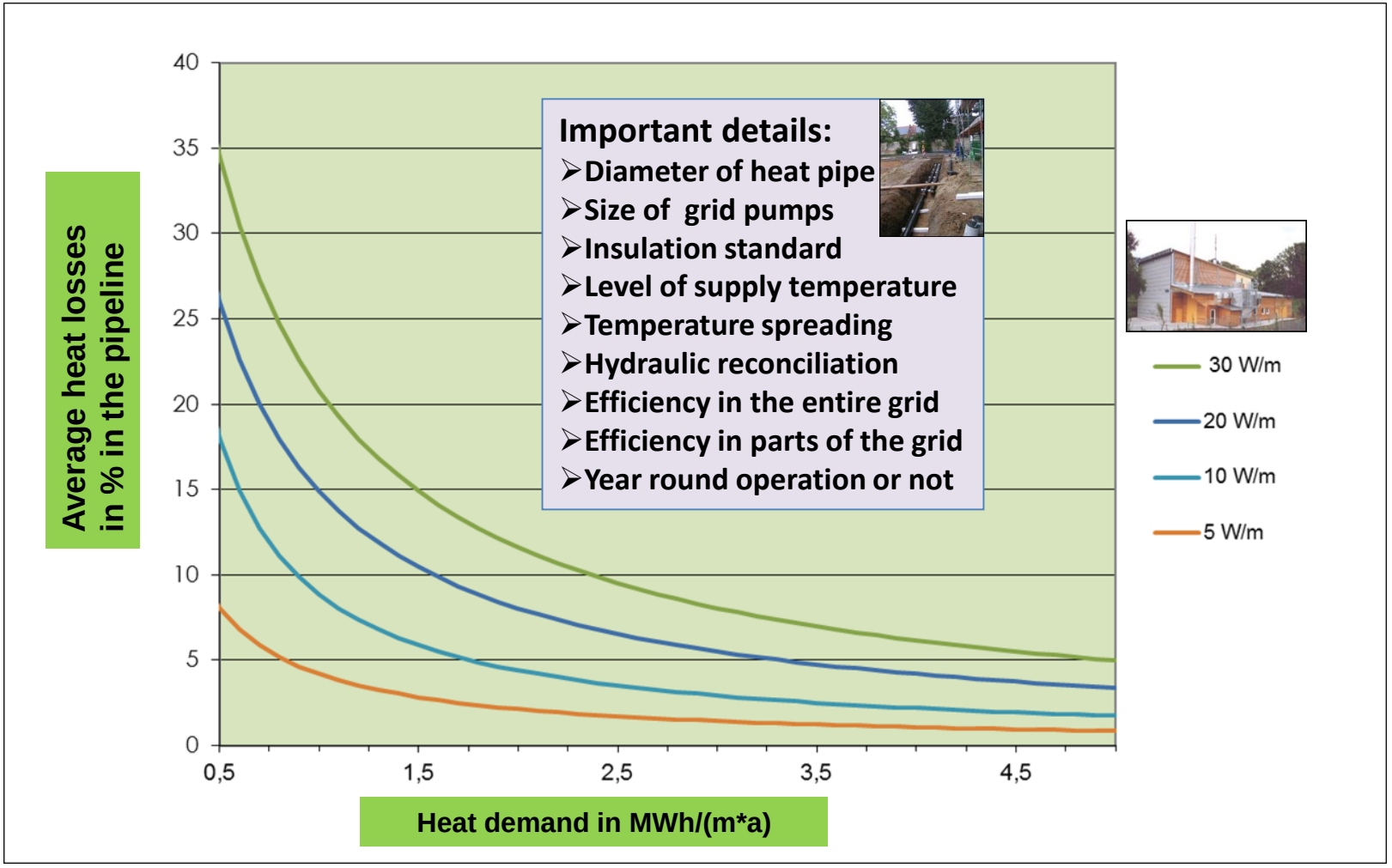
PARAMETERS TO REDUCE HEAT LOSSES



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Structure of costs of a Biomass Heat plant Project

- **Capital Investment (amount of annuity) – Overhead costs**
- Investment for building (heating house, bunker, chimney) and heat pipe
- wood chip fired boiler; fossil boiler for peak demand
- hydraulic systems, control technology
- pumps, compressor and other components
- installation and commissioning
- technical planning and design, building permission


- **Consumption bound costs – variable costs**
- wood chips, heating gas oil, natural gas;
- electricity, waste (ash) management



- **Operating and other costs**
- manpower costs for maintenance and repair, cleaning
- management, insurances, measurement of fume etc.

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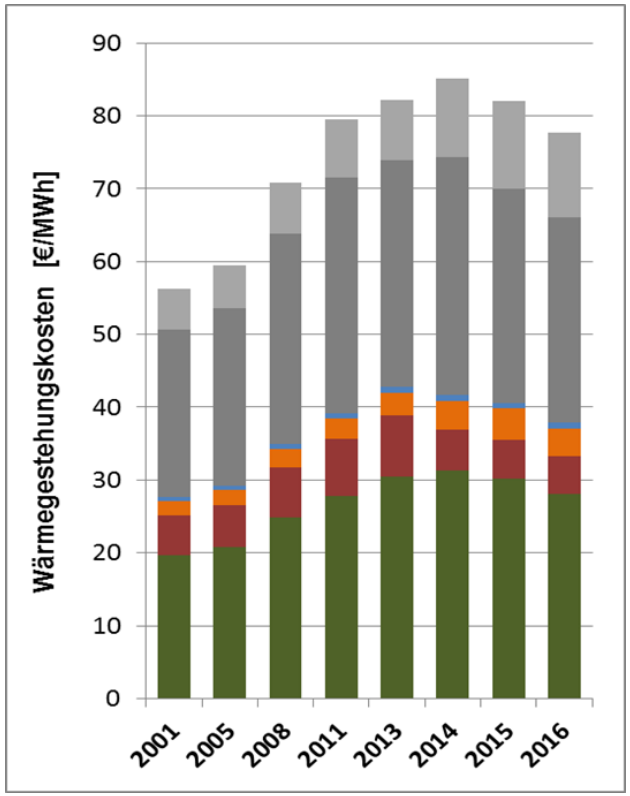
Structure of costs of a Biomass Heat plant (wood chips)



Structure of costs in %, *on the left in €/MWh*

- Fuel costs for biomass: ~ 30 - 40 %
- Fuel costs for gas or fuel oil: ~ 5 - 10 %
- Costs for electricity: ~ 3 - 5 %
- Capital costs: ~ 30 - 40 %
- Operating costs: ~ 15 - 20%
- Costs for waste disposal (wood ashes): 1-3 %

- Fuel costs for (natural) biomass with about 35 -45 % of total costs – larger share than capital costs (principal and interest costs)
- → No waste wood or landscape material as biomass fuel calculated! Price for wood chips in Germany = 2,5 ct/kWh = 85 €/to

2019: same structure; average full costs 8-9ct/kWh

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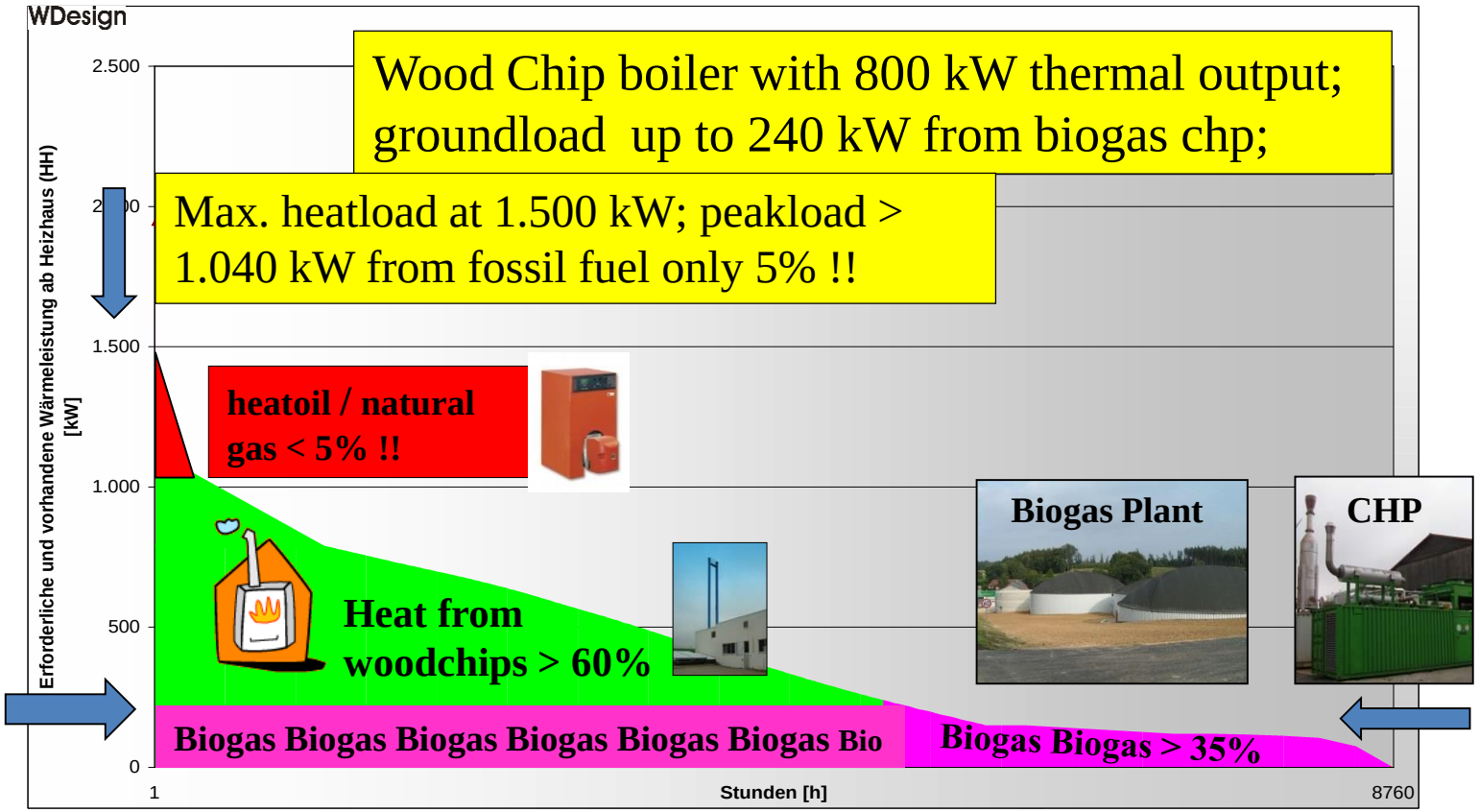
Combination of Biomass Heat Plant and Heat from Biogas CHP



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Best Practice: Agricultural Academy Triesdorf



Bioenergy project „LLA Triesdorf" about 50 km in the west of Nuremberg, Bavaria
→ a combination of

- Biomass heat plant with 2 wood chip boilers 1,4 MW and 0,7 MW
- Biogas plant with 250 kW electrical output and 200 kW thermal output from cogeneration unit
- 40 buildings (diary, university, offices, restaurant, stables, operating rooms etc.) are 100 % supplied by heat from biomass all over the year. No fossil fuels.
- Groundload up to 200 kW $_{th.}$ from Biogas cogeneration unit (CHP) for 8,000 hours per year.
- Middle load supplied by one of the wood chip boilers depending on season (spring / autumn)
- In the high winter season both wood chip boilers are running.
- Biogas Plant is fed by maize and grass silage and slurry from the own agricultural holding.

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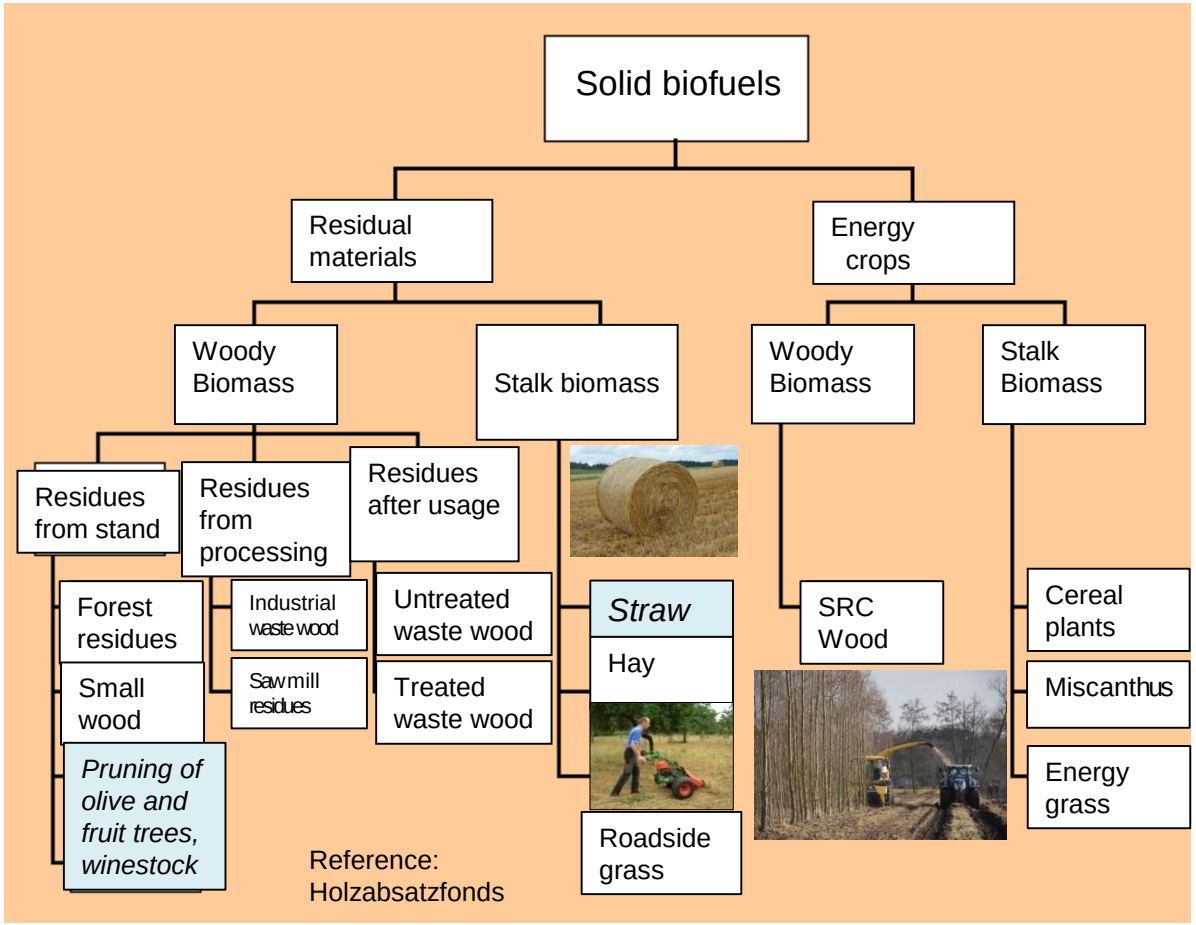
OVERVIEW ON SOLID BIOFUELS



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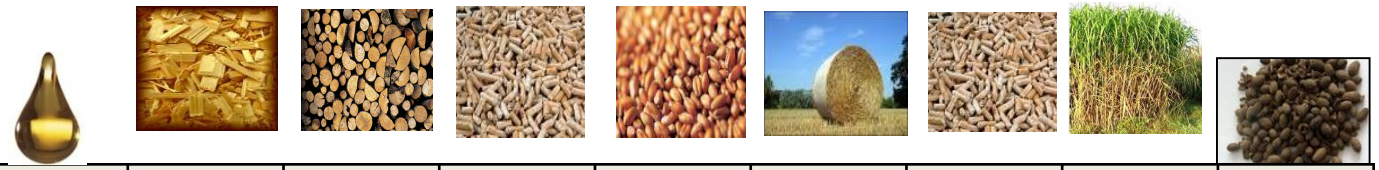
Prices of Solid and Fossil Fuels in €-Cent per kWh netto

Prices for wood chips, wood pellets, split logs and other solid biomass fuels in Germany



	Fuel oil	Wood chips (35% H_2O)	Split logs 33 cm	Wood-pellets	corn	Straw	Straw - pellets	Miscan -thus	Olive residues (nuclei) in Spain
Cur-rent price	0,60 €/l	85 €/t	60 €/m³	220 €/t	200 €/t	80 €/t	150 €/t	80 €/t	150 €/t
Costs per kWh in €-cent	6,0	2,5	4,5	5,0	4,0	2,0	3,5	2,0	3,5

Price for natural gas: 3 €-Cent up to 8 €-Cent per kWh !!

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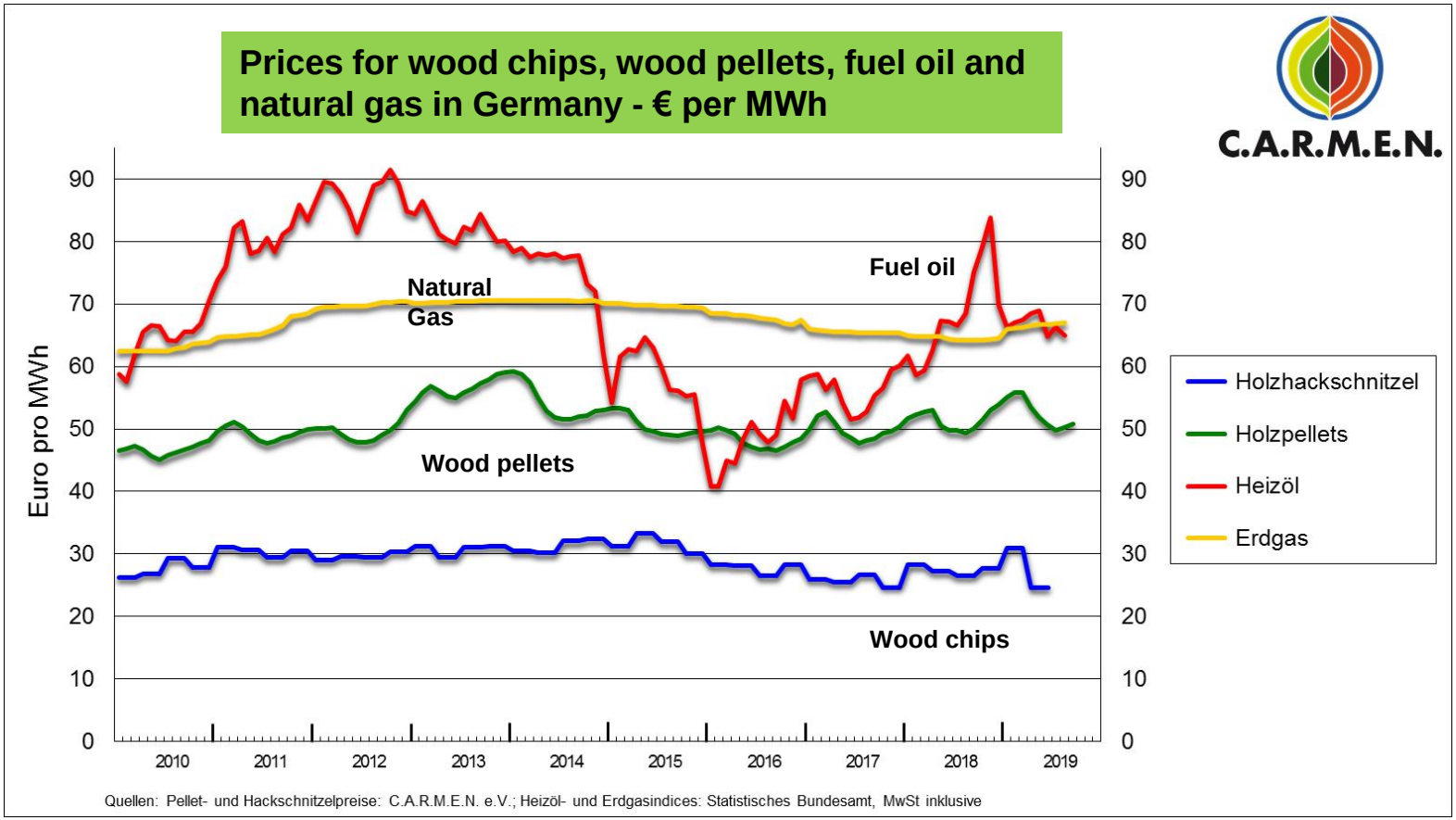
C.A.R.M.E.N. Index for Prices of Solid and Fossil Fuels



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Residues from Oil and other food production - *solid fuels?*

TEST: Firing pellets from Olive residues – no slag

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Source: ÖKO THERM®

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STRAW AS A SOLID FUEL FOR HEATING

+ Straw is available in rural areas (mind humus!)

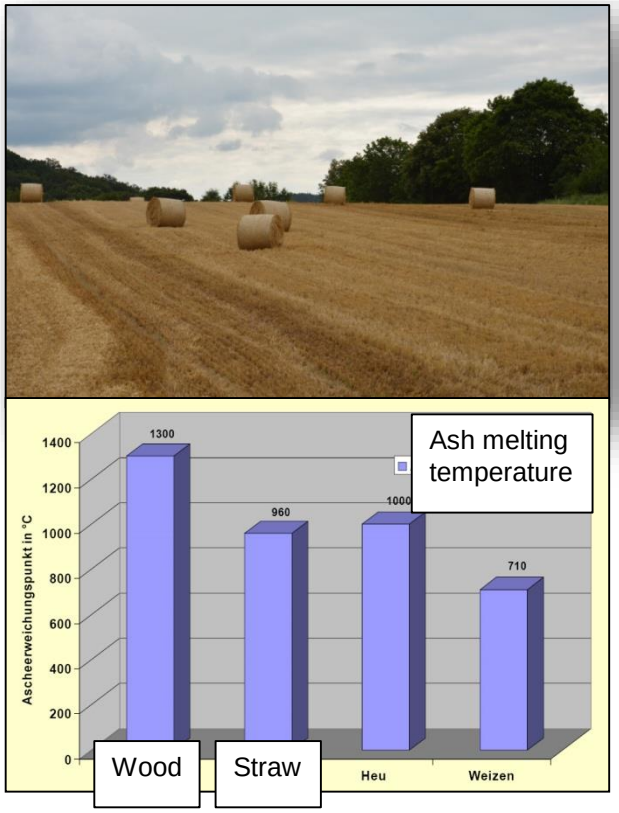
+ Technology for burning, harvesting and storage is state of the art (special German, Austrian and Danish boiler technology is available)

– Although ash melting point is significantly lower

– Storage = harvest campaign during few weeks

– Higher ash content, higher Cl and S content could lead to corrosion problems → Higher requirements to the combustion technology and flue gas cleaning (bag filter, electric filter)

– Removal of humus feedstock and C by straw utilization



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Solid Fuels from Tree Cuttings in one efficient Working Step

Transport

Storage

Drying

Chipping
and sieving

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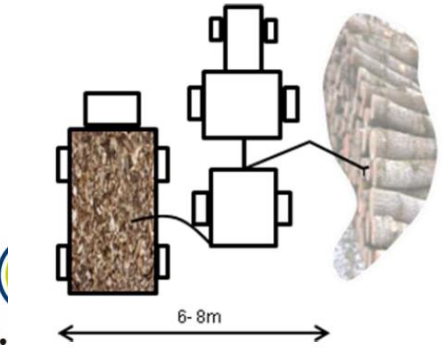
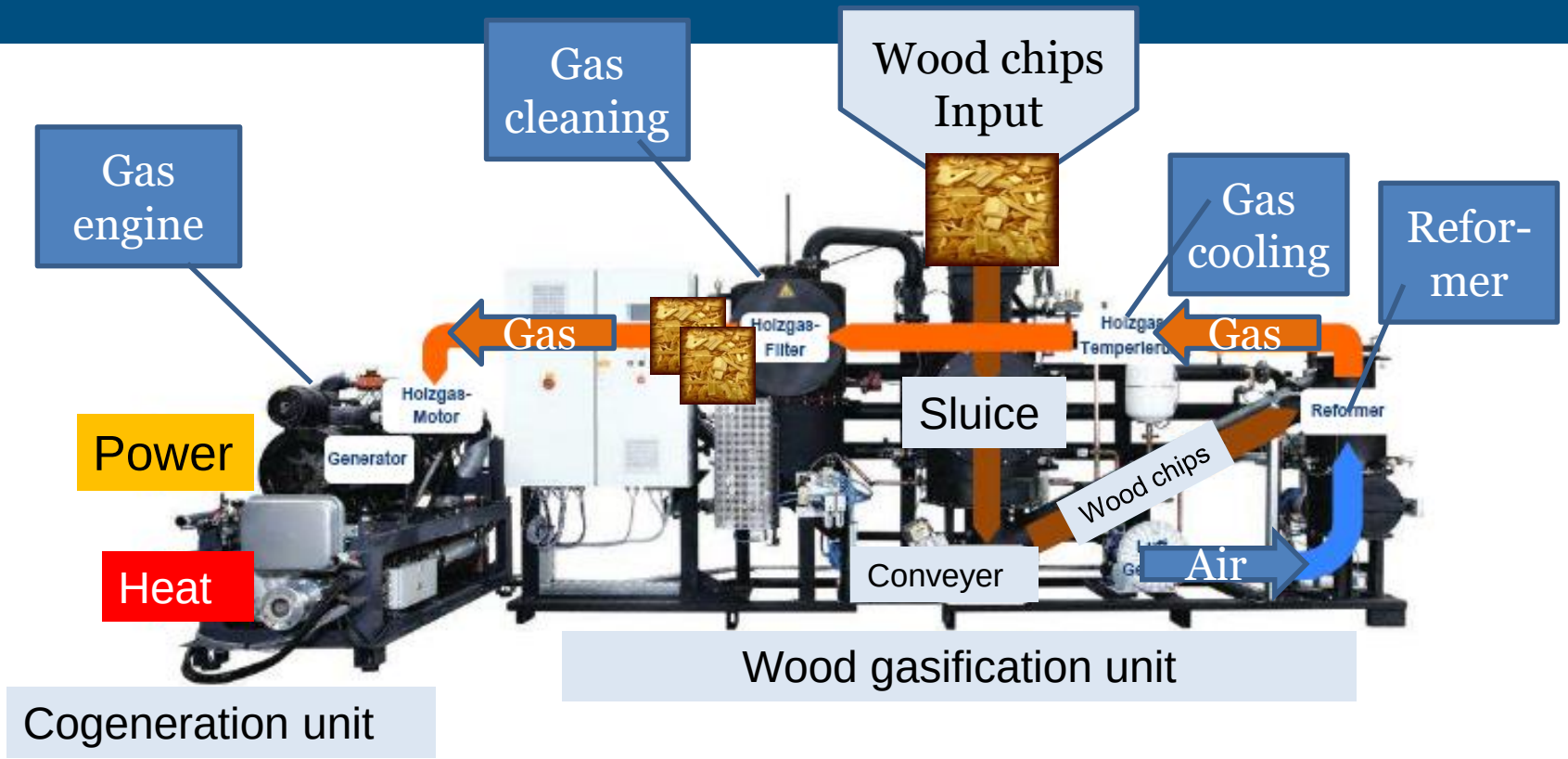
Efficient Wood Chipping along the Forest Road



- Allocation as decoupled process step with large mobile wood chipper
- On-site chipping can be approved if the truck can approach properly (driveway should be 8-10 m wide, flat and not steep)
- Raw material should be stored consitently with the thicker end horizontally right angled to the forest road
- Feeding of chippers often is organized on the right!
- Highest productivity for round timber is Ø 100 m³/h, for forest residues (crown and branches) Ø 75 m³/h
- The stronger the chipper‘s gear the higher the output
- Output/h for softwood > hardwood
- Knife sharpness is very important!
- Overall efficiency is dependent on adjusting the logistics to the chipper‘s efficiency – to avoid waiting time!
- Avoid input of soil, stones etc.

Wood gasification system – example for a funktional schematic



→ required space at least 6 m x 5 m and 2,5 - 3,5 m of hight. CHP 45 kW $_{el.}$ 120 kW $_{th.}$

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Wood Gasification CHP (wood chips), 45 $kW_{el.}$ // 110 $kW_{th.}$

Spanner Re² HKA 45

Farmer family, milk production **San Cassiano**

- Dairy farm 1,600 m over NN, Dolomite Alps, Italy
- Heat use in the house and in stables for the cows
- Drying system for hay and woodchips

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Wood Gasification CHP (wood chips), 30 $kW_{el.}$ // 70 $kW_{th.}$

Spanner Re² HKA 30
„Haus Blatthofer“ im Lesachtal, 2015

- Small hotel with rooms for 10 guests
- Drying system for wood chips and split logs
- District heating in the neighbourhood

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WHY (DISTRICT) HEATING WITH BIOMASS?

Benefits for the clients (private and industrial)

- Home comfort, no more work and responsibility for heating, no boiler room
- Competitive costs for heating, long term contracts

Benefits for the area

- Utilization of domestic resources
- Valorization of lower-quality energy wood
- Increasing added value for the local economy

For the environment

- Climate-neutral heating
- Combined Heat and Power (CHP) possible?

Thank you for listening.
Do you have any questions?

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Energy from Biomass – a multilateral, sustainable and reliable Alternative to Oil, Gas and Coal

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Hotel Facility – Real Case Best Practise Example with Biomass

- 180 rooms and apartments
- Outdoor pool, indoor pool
- Wellness, beauty, sauna, whirlpool, steam bath, fitness center etc.
- Different restaurants, bars
- Full summer/winter season
- Heat demand 1,700 MWh/a
- For heating and hot water
- Full Service Heat Contracting

Max. heat load 800 kW; heat demand 1,700 MWh/a; 2,125 full load hours

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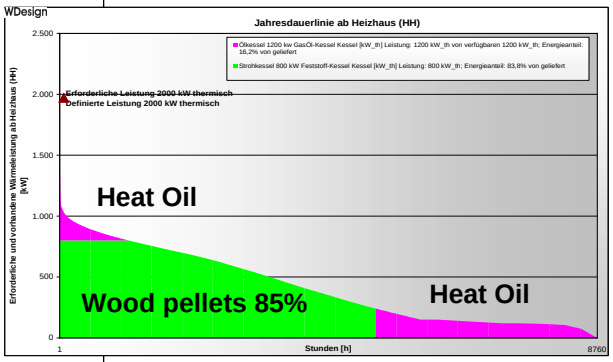
Biomass Heatplant Calculation – Real Case *HOTEL*

Calculation of Biomass Heatplant - Hotel Complex 800 kW heat load

Heat Demand		**1.700 MWh/a**	210,000 liters of heat oil
Heat losses in pipeline		**2,5 %**	
Heat Production		**1.745 MWh/a**	
	Pellet boiler		**Heat oil boiler**
Share of heat production	**85 %**		**15 %**
Heat production	**1.483 MWh/a**		**262 MWh/a**
Thermal output	**0,54 MW**		**0,80 MW**
Fuel	***Wood pellets***		***Heat oil***
Caloric value of fuel	**4,9 kWh/kg**		**10 kWh / liter**
Thermal efficiency full load	**90 %**		**90 %**
Thermal efficiency 365 days	**85 %**		**85 %**
Full load hours	**3.231 h/a**		**385 h/a**
Fuel demand	**360 t/a pellets**		**30.788 liters / a**
Electricity consumption	**1,5 % of heat demand**		**0 %**
Electricity consumption in MWh	**26 MWh/a**		**0 MWh/a**
Price for electricity	**180 €/MWh**		**180 €/MWh**



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Investment Plan for a Biomass Heatplant - Hotel Complex 800 kW

Biomass Heat Plant - supplying a hotel complex with 180 units		*Invest in T€ netto*	
Name of component	**specification**	**SUM in €**	**% of invest**
Biomass components (boiler, buffer tank, conveyer …)	*540 kW Pellets*	*145*	*31*
Peakload components (2 boilers, existing)	800 kW heatoil	20	4
Hydraulic systems		*20*	*4*
Building (heating house, bunker etc)	separate building	160	34
Heat pipeline	*170 meters*	*105*	*22*
House connection/heat exchanger (incl. in pipeline)		0	0
Planning costs		*25*	*5*
Other costs		0	0
Total investment		475	100
Subsidies		100	21
Total investment minus subsidies		375	79

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Investment Plan for a Biomass Heatplant - Hotel Complex 800 kW

Herkunft	Verfügbare Bioenergie	Energiepotenzial (PJ)
Biogas aus Nutztierhaltung (m³)	20.100.000	0,506
Äste von Obstbäumen (t)	211.257	0,739
Getreidereste (t)	634.000	8,876
Reste von Hülsen- und Ölfrüchten (t)	3.858	0,038
Reste der Verarbeitung von Holzstämmen (m³)	1.141.398	7,524
Brennholz (m³)	1.464.706	13,181
Geäst (m³)	599.251	2,621
Gesamt		**33,485**

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Biomass Heatplant Calculation – Real Case *HOTEL*

	Capital costs							
	Invest netto €	Operating life a	Rate of interest %	Annuity %	Capital costs €/a	Reserves for repairs %	Reserves for repairs €/a	Investment costs €/a
Biom	145.000	15	2,5	8,07	11.704	2	2.900	14.604
Peak	20.000	15	2,5	8,08	1.615	2	400	2.015
Hydr.	20.000	15	2,5	8,08	1.615	2	400	2.015
Build	160.000	40	2,5	3,98	6.374	1	1.600	7.974
Grid	105.000	40	2,5	3,98	4.183	1	1.008	5.191
Grid	0	40	2,5	3,98	0	1	0	0
Plan	25.000	30	2,5	4,81	1.202	0	0	1.202
other	0	30	2,5	4,81	0	0	0	0
∑	475.000				26.693		6.308	33.001
Subs	*100.000*							
∑	*375.000*				*21.087*		*6.308*	*27.395*

5,600 € less capital costs because of 21% subsidies → means 3,30 € less per MWh = 0,33 ct / kWh less → for total heat demand = 1.700 MWh per year

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Biomass Heatplant Calculation – Real Case *HOTEL*

Calculation of Biomass Heatplant - Hotel Complex 800 kW heat load

Price for pellets / heat oil	220 €/t		0,7 €/liter
Fuel costs pellets / heat oil	79.188 €/a		21.550 €/a
Costs for electricity	4.590 €/a		
Sum of fuel costs	79.190 €/a		21.550 €/a
Sum of costs for fuel and electricity		105.330 €/a	
Manpower requirement	357 h/a		0 h/a
Wages per hour	14 €/h		14 €/a
Manpower costs/year	5.000 €/a		0 €/a

Insurance	0,3% of total invest
~ Operating life	30 a
Rate of interest	2,50 %
Length of pipeline	170 m
Heat losses per year	45 MWh
Heat losses / m pipeline	30 W/m
Heat losses in pipeline	2,5 %
Max. heat load $kW_{th.}$	800 simultaneity factor 0,9 (890 kW*0,9)
Installed heat capacity	1.340 kW

Wood pellets: 220 €/ton = 4,5ct/kWh caloric value

Wood chips: 85 €/ton = 2,5ct/kWh caloric value

Olive residues ?

C.A.R.M.E.N.

Total costs calculation - Hotel Complex 800 kW – Pellet boiler

Total Costs Calculation

	Pellet boiler (ground load)	*Peak load (oil/gas)*
Fuel costs	79.190 €/a	21.550 €/a
Electricity	4.590 €/a	0 €/a
Disposal of ash	1.270 €/a	0 €/a
Sum	85.050 €/a	21.550 €/a

Sum of consumption costs	*106.600 €/a*	*68%*
Management costs	5.000 €/a	Administration
Preventive maintenance	5.000 €/a	Service
Maintenance costs	5.000 €/a	Cleaning
Insurance/regulations	2.500 €/a	Metering
Sum of operating costs	*17.500 €/a*	*11%*
Sum of investment costs	*33.001 €/a*	*21%*
Total costs per year	*157.101 €/a*	
Total costs per MWh	*92,41 €/a*	*1,7 GWh/a*



Using wood chips (530 t/a) instead of woodpellets (360 t/a) → = 45,000 €/a instead of 79,000 €/a costs for solid fuels → 77,40 €/MWh → 1,5ct/kWh less


Total costs calculation - Hotel Complex 800 kW – wood chip boiler

Total Costs Calculation

wood chip boiler	*(ground load)*	*Peak load (oil/gas)*
Fuel costs	45.150 €/a	21.550 €/a
Electricity	4.590 €/a	0 €/a
Disposal of ash	3.000 €/a	0 €/a
Sum	52.740 €/a	21.550 €/a

Sum of consumption costs	*74.290 €/a*	*56%*

Management costs	5.000 €/a	Administration
Preventive maintenance	5.000 €/a	Service
Maintenance costs	9.800 €/a	Cleaning
Insurance/regulations	2.500 €/a	Metering

Sum of operating costs	*22.300 €/a*	*17%*
Sum of investment costs	*35.034 €/a*	*27%*
Total costs per year	*131.624 €/a*	
Total costs per MWh	*77,43 €/a*	*1,7 GWh/a*

Using wood chips (530 t/a) instead of woodpellets (360 t/a) → = 45,000 €/a instead of 79,000 €/a costs for solid fuels → 77,40 €/MWh → 1,5ct/kWh less

C.A.R.M.E.N.