KARELIA-AMMATTIKORKEAKOULU | KARELIA UNIVERSITY OF APPLIED SCIENCES

Energy solutions for private houses and municipalities

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Aims of this presentation

- To discuss about heating energy consumption of buildings and compare Romanian and Finnish climate
- Basics of biomass and solid fuel combustion
- To introduce to you some different biomass combustion systems for single houses and municipalities that most commonly used

Heating energy consumption

- Heating energy is consumed in buildings to provide comfortable interior climate and to provide hot dwelling water
  - 60-85 % of heating energy for space heating (SH)
  - 15-40 % of heating energy for hot water production (HDW)
- Ratio between space heating and hot dwelling water energy demand varies a lot in different types of buildings and in relation to energy efficiency (insulation)
- In warmer climates energy demand for HDW production equals or is even higher that SH energy demand (smaller SH energy demand)

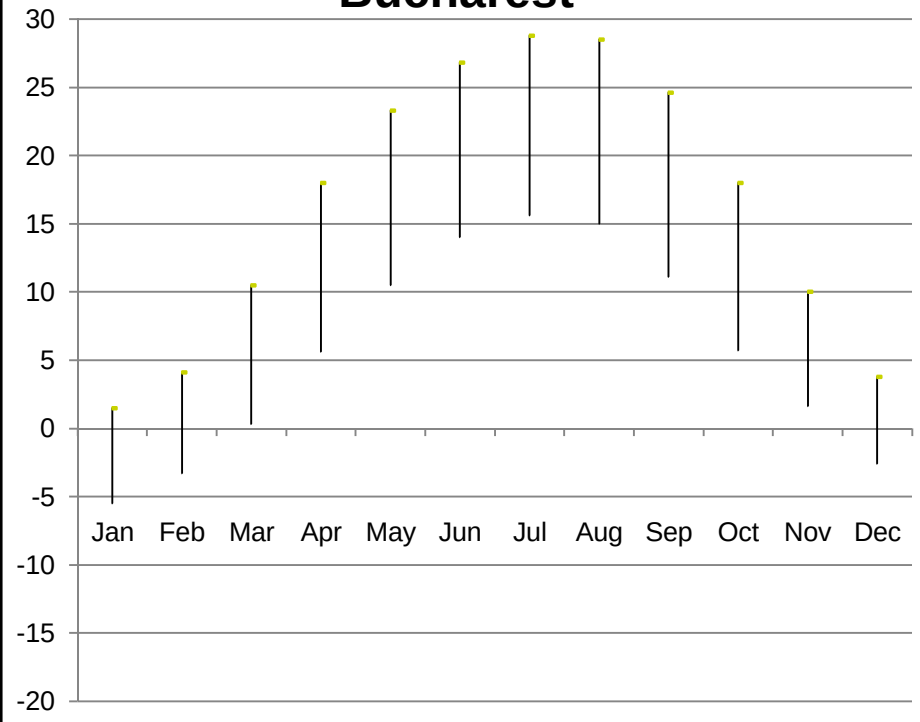
Heating energy consumption in Finnish buildings

- Average Finnish houses and buildings:
  - Average single house uses ≈ 80 % of heating energy for SH and ≈ 20 % for HDW production. ≈ 16 000 kWh/a for SH and 4000 kWh/a for HDW production
  - Average apartment building uses ≈ 60 % of heating energy for SH and ≈ 40 % for HDW. Energy amounts in relation to size of the building
- Whole EU is moving to more energy efficient direction which leads to decrease in SH energy demand
- Passive houses in Finnish climate consumes ≈ 50 % of heating energy for SH and ≈ 50 % of heating energy for HDW production → Single House: ≈ 4000 kWh/a for SH and ≈ 4000 kWh/a for HDW production
  - Massive energy saving in SH but it is hard to decrease HDW production energy demand

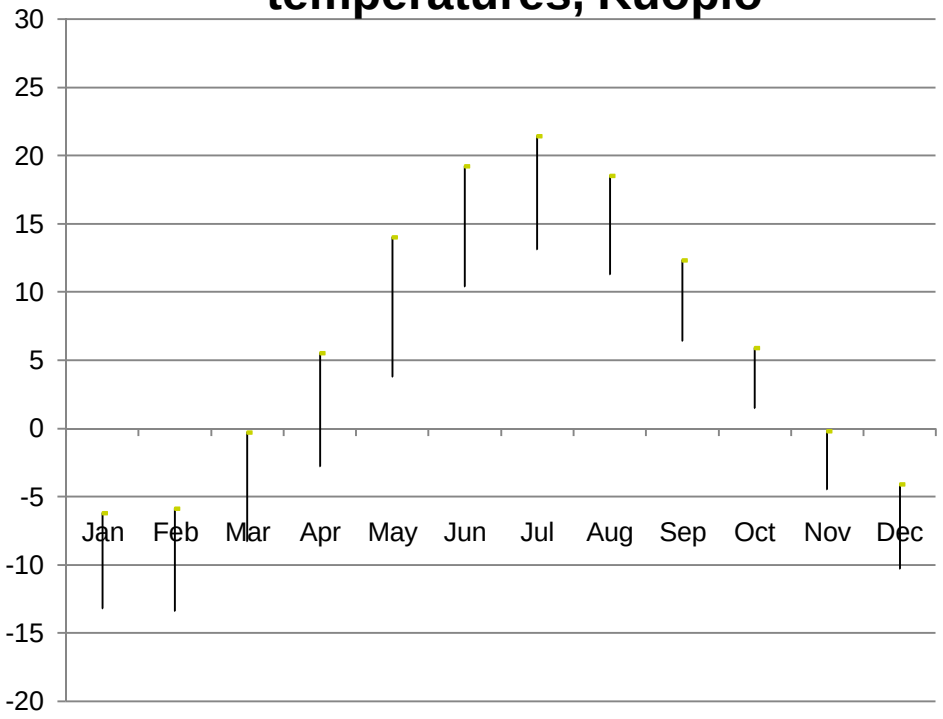
Heating energy consumption in warmer climates

Finland is a cold place to live in comparison to Romania ☹☺

Romanian mean temperatures, Bucharest



Finnish mean temperatures, Kuopio



Heating degree days as a comparison tool between different climate zones

- Heating degree days of a one year period represents the cumulative sum of temperature differences for each day between indoor and outdoor temperatures
  - Generally 17 °C is used as a nominal indoor temperature, extra heat load comes from electrical appliances increasing the temperature above 20 °C
- For example 4000 heating degree days consumes twice the heating energy for SH compared 2000 heating degree days
  - Energy demand for space heating is in straight relation to temperature difference between indoor and outdoor temperature
- In short: Heating degree days are a good indicator for comparing SH energy consumption in different climates

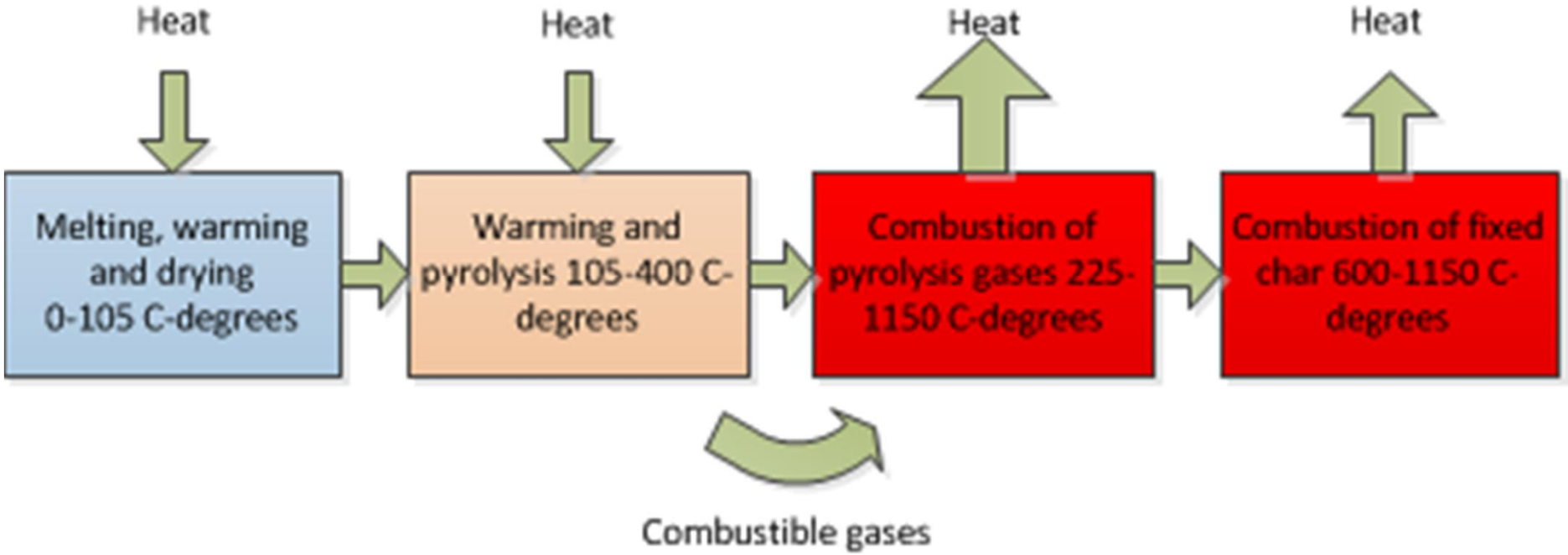
Romania vs. Finland

- Heating degree days:
  - Romania 2500-3500 ^{o}Cd (heating degree days)
  - Finland 4500-6500 ^{o}Cd
- Two identical houses, one in Romania and one in Finland → Same house in Finnish climate would consume almost twice the heating energy for space heating!
- Regardless of the climate, we all need environmentally friendly bioenergy to keep us warm ☺

Basics of biomass combustion

- While there are several different types of biomass burners and boilers, their very principle of operation is always the same → biomass combustion
- Combustion happens always the same way regardless of the technique used
- 3T's for good combustion: Time, Temperature, Turbulence

Combustion of solid fuel



Basics of Biomass utilization systems

- Following components are needed
  - Fuel storage to store selected fuel (pellets, wood chips, wood logs)
  - Fuel feeding system to feed the burner (carrying by hand or automated conveyor/auger/pneumatic)
  - Biomass burner for fuel combustion
  - Biomass boiler for heat recovery from combustion and flue gases
  - Chimney for exhaustion of flue gases
  - Ash collector to discard uncombustible components of the fuel used

Biomass utilization – boiler classification

- There are several different ways to classify biomass combustion systems:
  - By fuel used
  - By combustion technique
  - By heat output power
  - By automation level
  - By feeding system etc.
- Let's have a look at the most commonly used burners and boilers for single houses and for municipalities

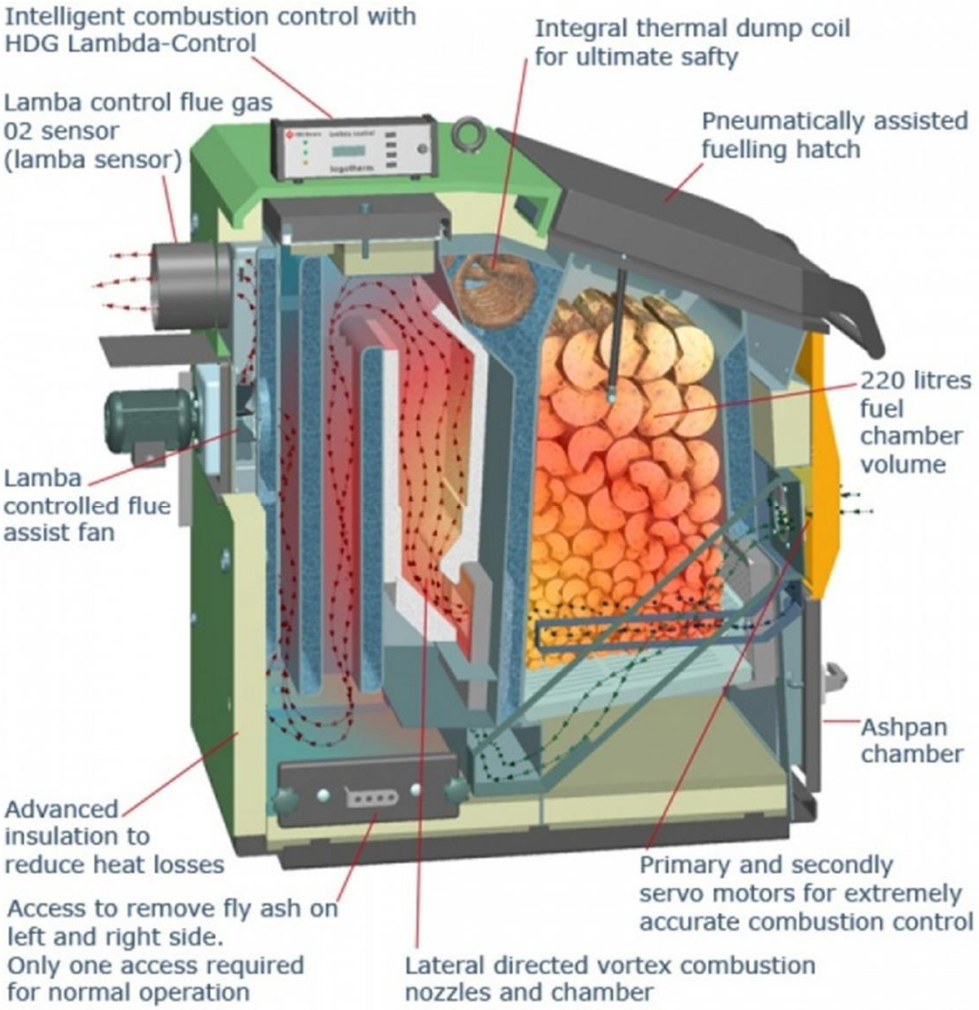
Single house solutions

- Wood log boilers (batch fed biomass boiler)
  - Down draft (current technology)
  - Up draft (traditional technology)
- Pellet systems (continuously fed biomass boiler)
  - Modulating burners
  - On/Off burners
- Always requires water circulated heating if biomass is used for both HDW production and SH
  - Stoves can also be used but only for SH

Wood log boilers

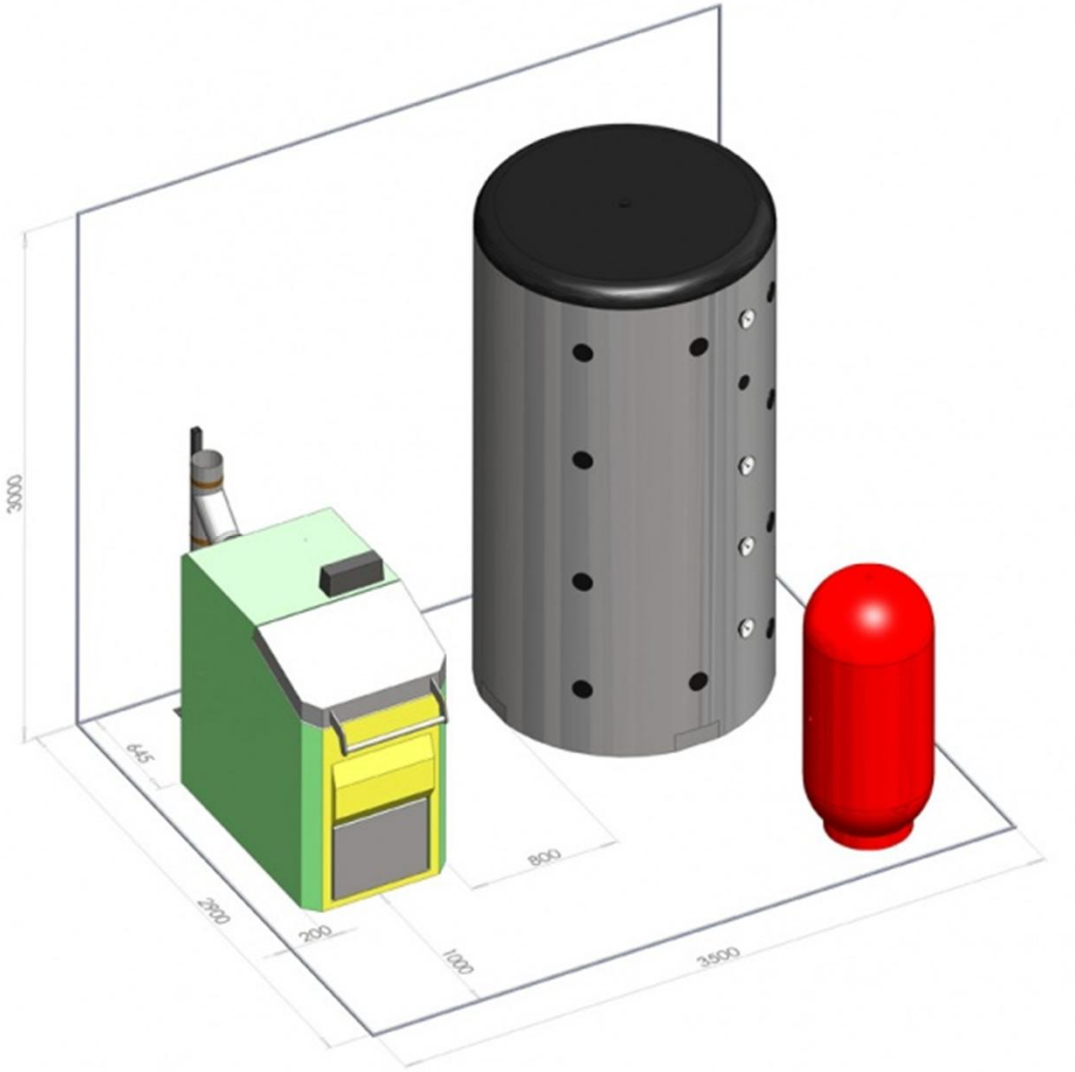
- Pro's
  - High efficiency with modern gasification technology (down draft) $\eta > 85\ \%$
  - Low refining rate of the fuel (low price)
- Con's
  - Batch fed → Loading by hand takes time
  - Without heat accumulator loading has to be done 1-3 per days
  - Fuel quality may vary depending on the source → affects efficiency
  - Fuel storage requires space
- Generally wood log stoves are paired with heat accumulator
  - Volume of the accumulator depends on the size of the house. Usually varies between 1500 - 5000 l

Wood log boiler (down draft)



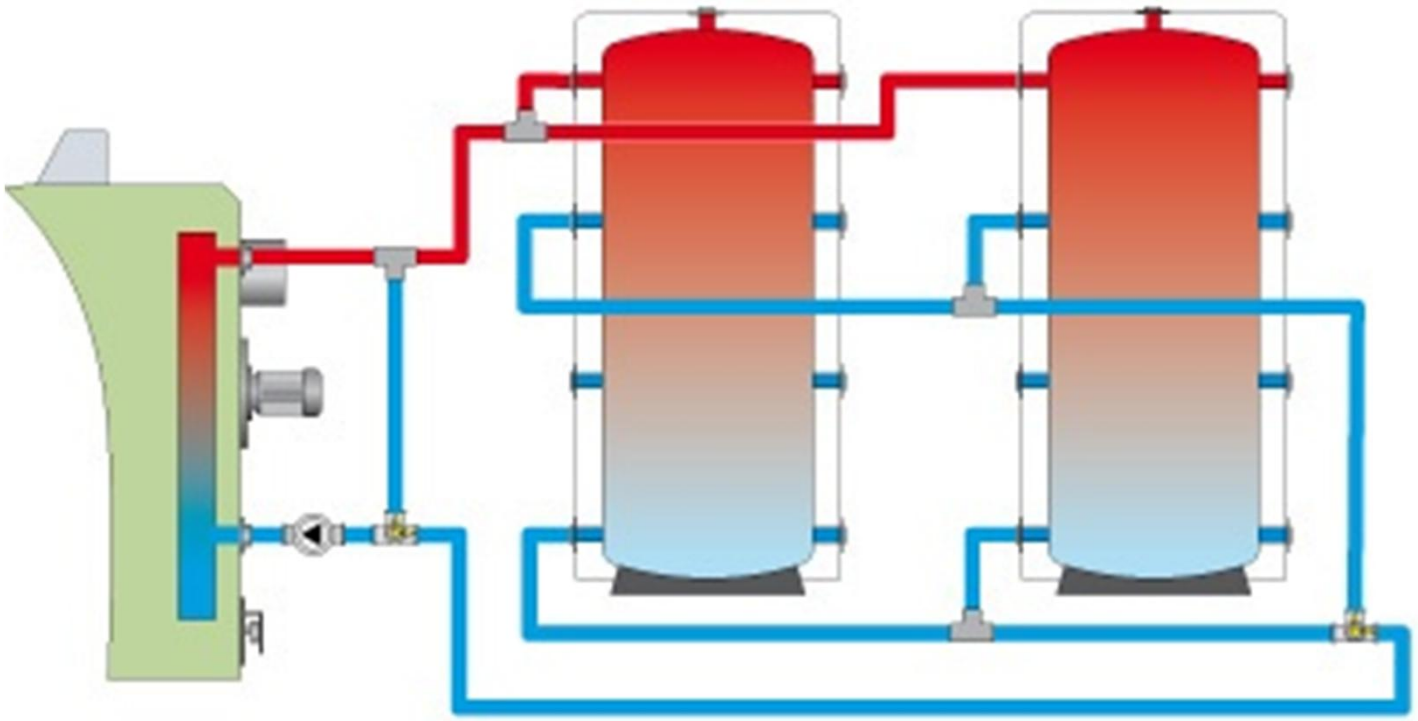
Source: HDG Bavaria / Euroheat Distributors (HBS) Limited

Wood log boiler with accumulator



Source: HDG Bavaria / Euroheat Distributors (HBS) Limited

Wood log boiler's connection to accumulator

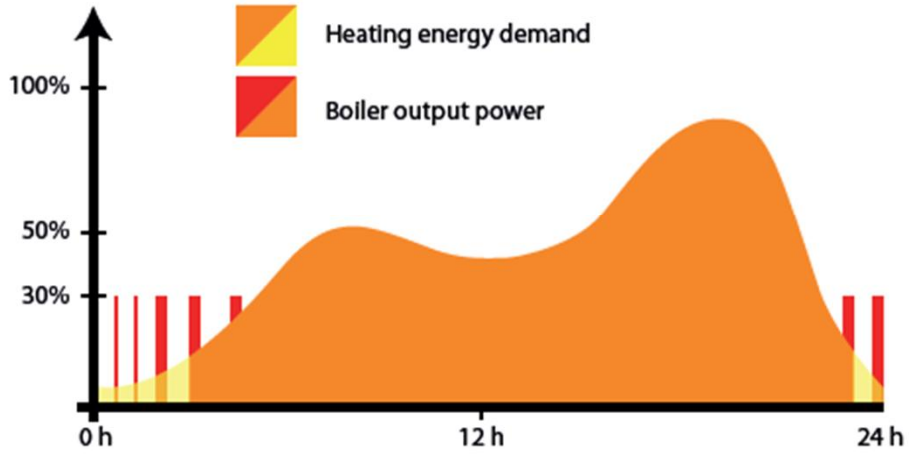


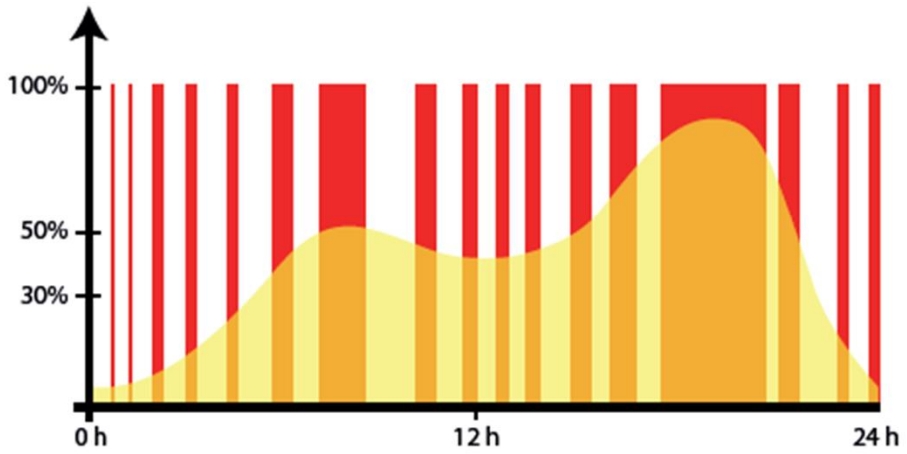
Source: HDG Bavaria / Euroheat Distributors (HBS) Limited

Pellet systems

- Pro's
  - High efficiency η > 90 %, low emissions (modulating)
  - Fully automated → no hand feeding etc.
  - Consistent fuel quality → cleaner combustion
  - No need for heat accumulator → smaller space requirements and smaller investment
- Con's
  - Fuel storage space requirements, although much less than with wood logs, not to mention wood chips
  - Refined wood fuel is a bit pricier than inrefined (wood logs, wood chips) but not much
- Two types operating principles:
  - Modulating burners (adaptible to given heat load) ≈ 20 – 100% of nominal heat power
  - On/Off burners (ignition → full power → shut down)

Modulating burner vs. On/Off-type burner

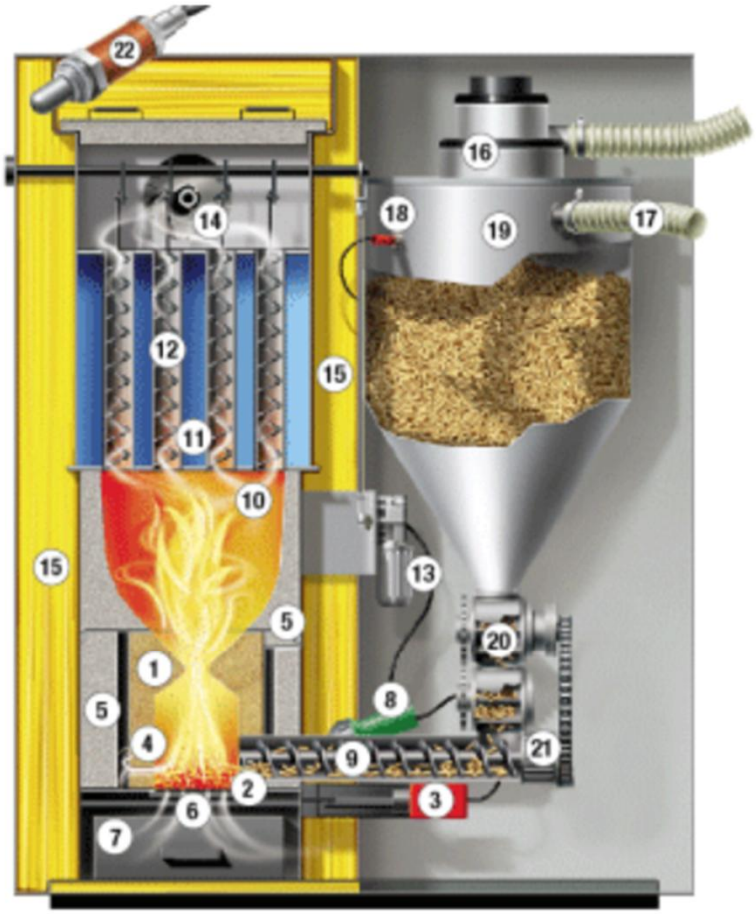




Modulating vs. On/Off -burners

- Modulating burners have considerably less ignition/combustion –cycles → considerably smaller particle and gaseous emissions
- On/Off –burners operate rarely on optimal level (only during high heat power demand → long ignition/combustion cycle)

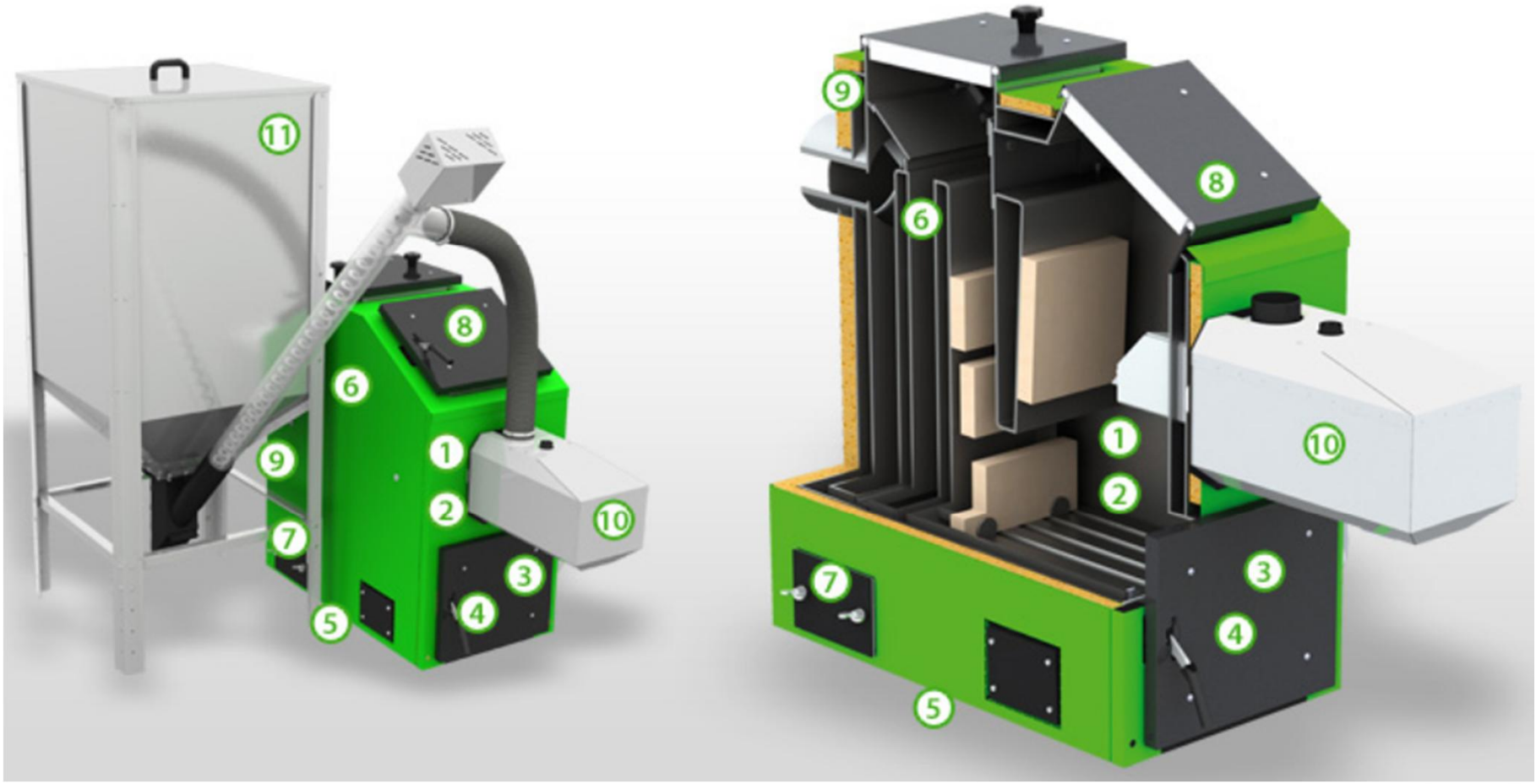
Modulating integrated pellet burner and boiler



1. Fully refractory-lined combustion chamber
2. Sliding grate
3. Drive motor for sliding grate
4. Secondary air flow
5. High temperature resistant insulation plates
6. Primary air
7. Ash box
8. Automatic ignition
9. Stoker auger
10. Circulation zone
11. Boiler heat exchanger
12. Turbulators
13. Automatic boiler cleaning system
14. Induced draught fan
15. Cover insulation
16. Pellets vacuum turbine
17. Closed vacuum system, maintenance-free, no filter
18. Level detector
19. Cyclone hopper
20. NEW: Double rotary valve
21. Motor drive unit
22. Lambda sensor

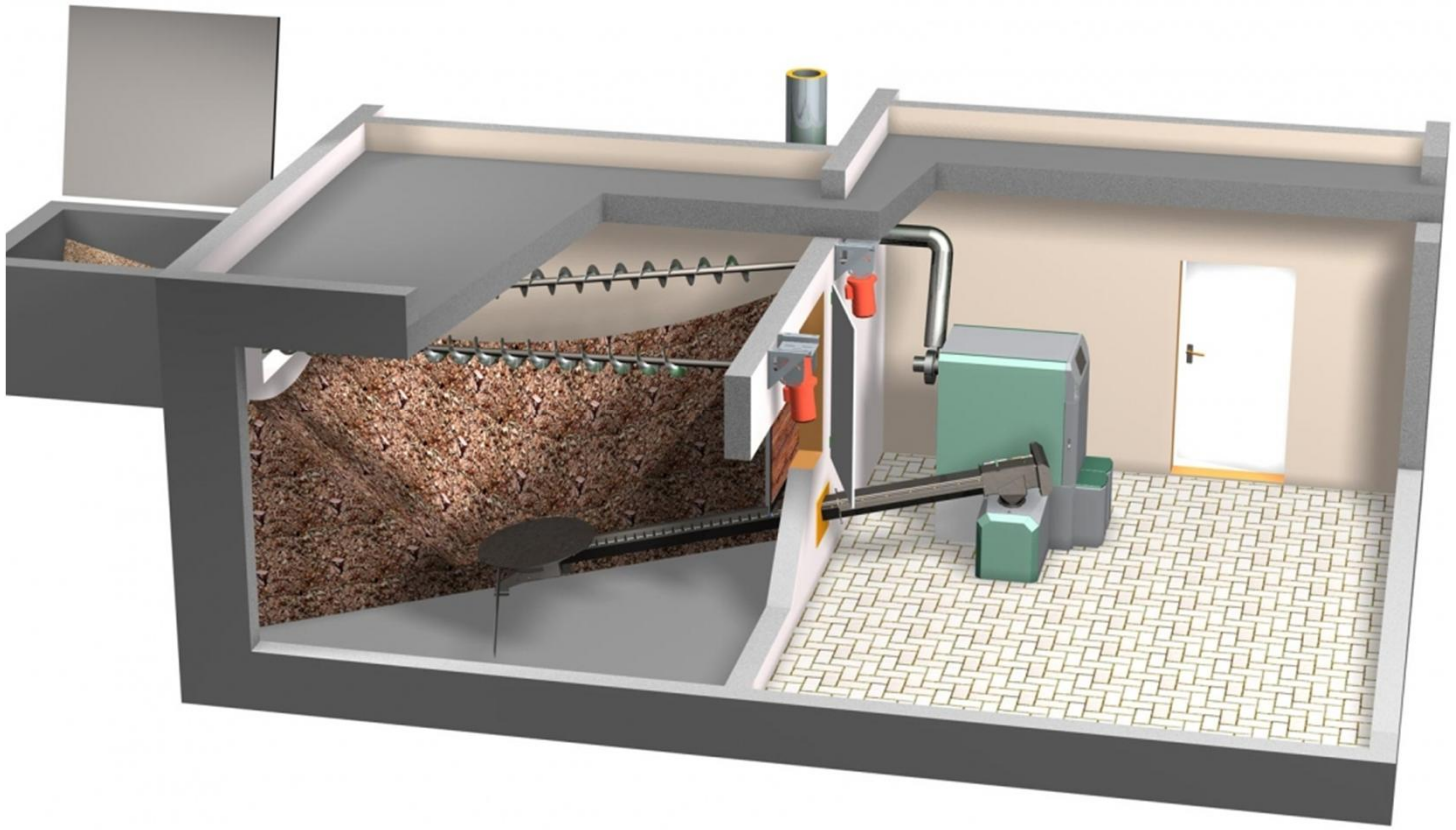
Source: Hargassner GesmbH

On/Off-type traditional separate pellet burner and boiler



Source: Kostrzewa ®

Pellet heating system



Source: Herz Energietechnik GmbH

Solutions for municipalities

- Generally heat production in municipalities is most beneficial to arrange with central heating plant in which all the needed heating energy is produced by biomass combustion (Excl. emergency and peak hours)
- Heating energy is then transferred via water-based district/local heating network to clients
- Heat production capasity is generally between 300-3000 kW
- Eno energy co-operative for example

Centralized heat production for municipalities

- General Pro's
  - Centralized heat production enables efficient use of local biomass resources
  - Almost all types of biomass can be utilized for heat production
  - Economics of scale
    - Higher Combustion efficiencies (good partial load performance 25-100%)
    - Local pollution control → One source is easier and cheaper to control vs. single house boilers → health benefits and cleaner neighbourhood
  - Extremely easy for the clients, requires very little space

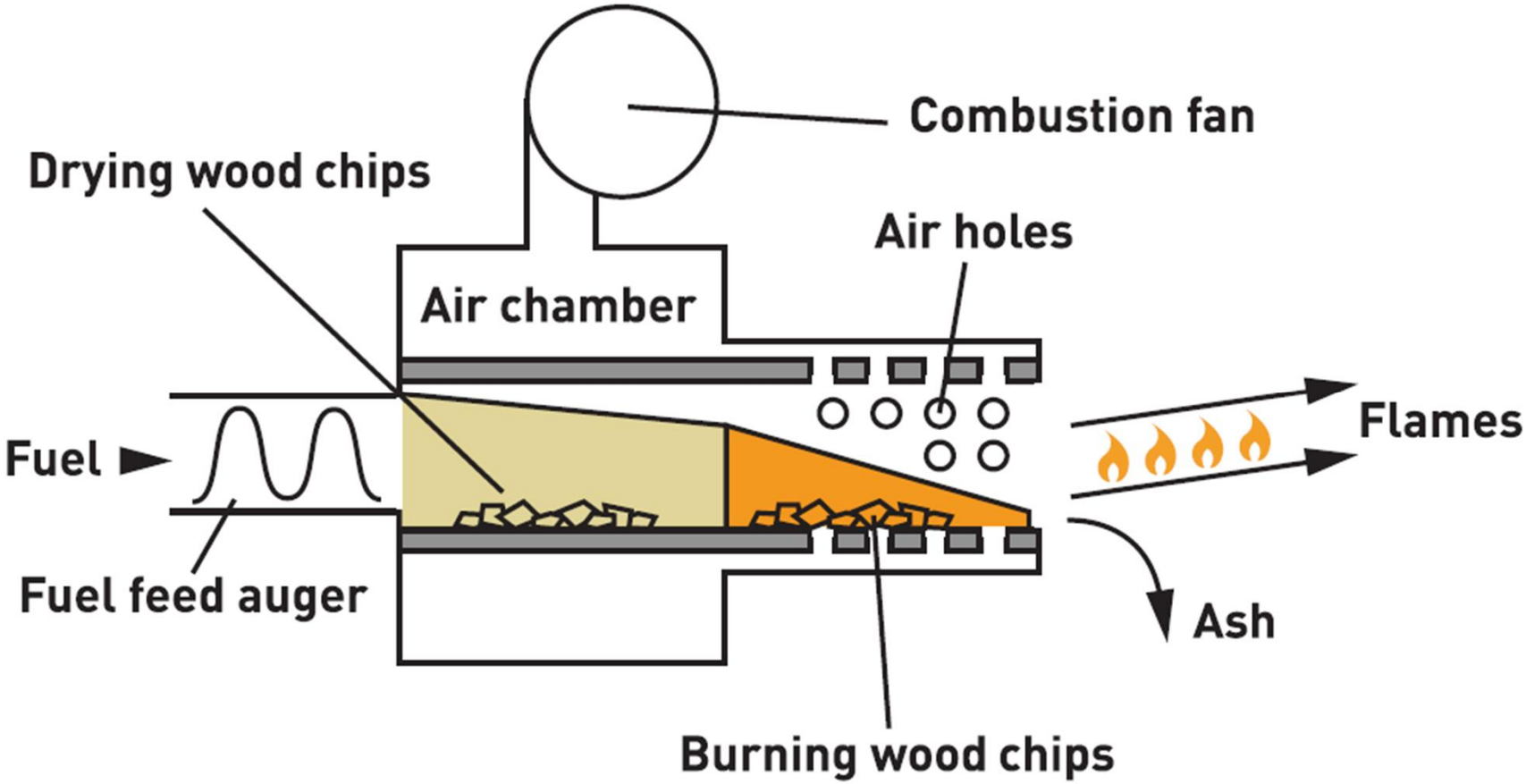
Centralized heat production for municipalities

- General Con's
  - Requires heating network
    - Increases investment costs (typically 30-50% of total investment)
    - Clients needs to invest on building specific heat exchangers
    - Heating network induces heat losses (generally 10-20 % of distributed heating energy)
  - Some people consider centralized heating to have gained monopoly position
  - Clients have basically no ways of effecting the price of heating energy

Commonly used combustion and boiler solutions for municipal level

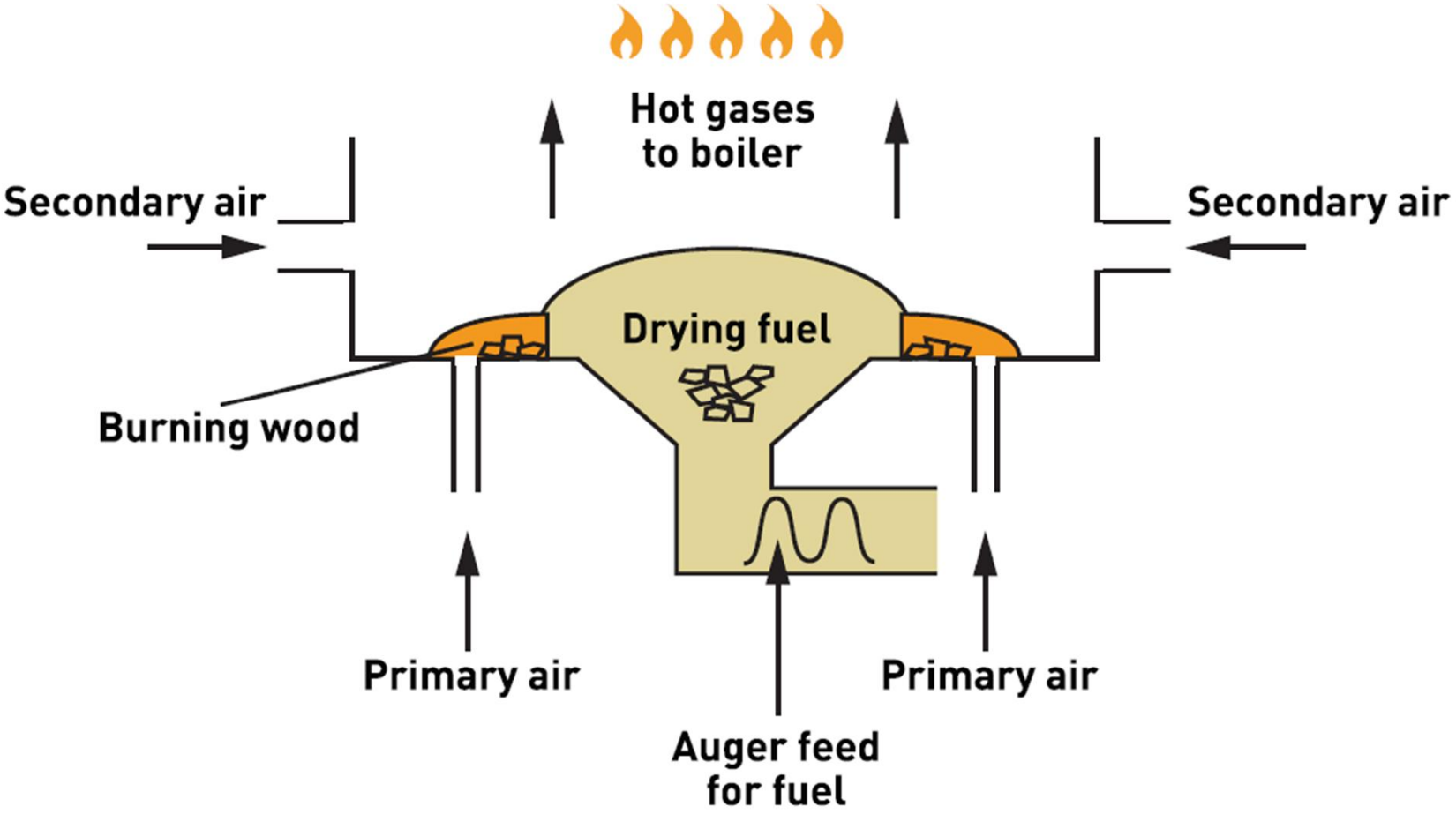
- Stoker burner boilers
  - Simplest way to provide heat from wood chips in 50-300 kW scale
  - Poor performance, high emissions, risk of backfire
- Underfed stoker burner boilers
  - Commonly used for pellet combustion
  - Enhanced version of traditional stoker
- Grate burner boilers
  - Most commonly used solution for wood chip and agrofuel combustion
  - Tried and tested technology
  - Many different grate options for different solutions

Stoker burner boilers



Source: Palmer D. et al. 2011. Biomass heating: a guide to medium scale wood chip and wood pellet systems

Underfed stoker boilers



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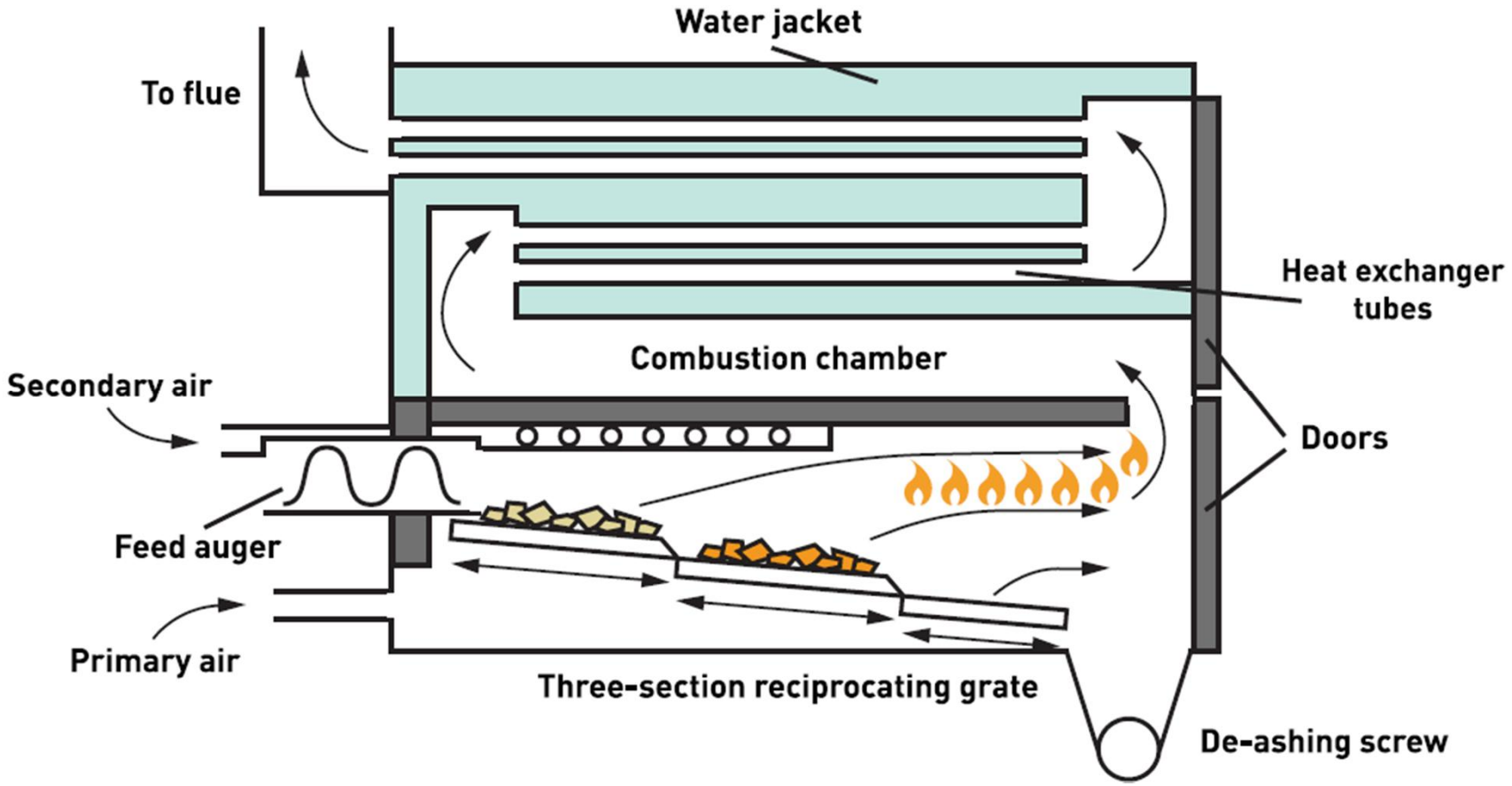
Moving grate boiler



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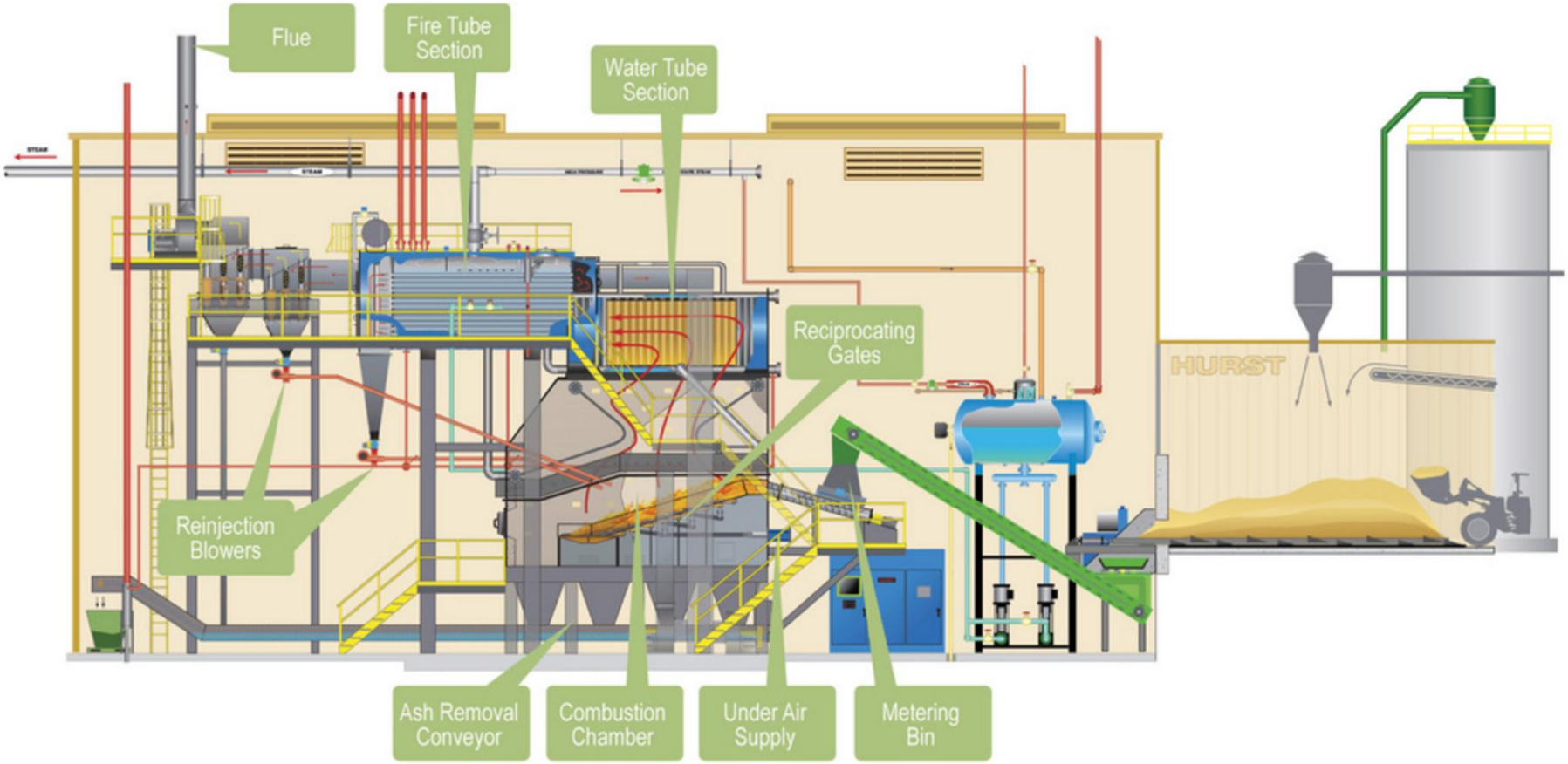
Heat and steam production utilizing moving grate design



Source: Biomass Magazine

Conclusions

- We all need heating energy!
- Lot's of different technical solutions for biomass utilization but still they all have the same operating principle
- There isn't a universally right solution for every site, right choice depends on so many different factors that needs to be addressed propely

Thank you for your attention

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