

Workshop of IEA Bioenergy Task 32: Biomass Combustion

Latest Innovations in Residential Boiler Technology

Fachgespräch Arbeitskreis Holzfeuerungen
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= Bundesministerium
Arbeit und Wirtschaft

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Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie



Für die
Stadt Wien



Overview



State-of-the-art

- Technology milestones
- Technology overview
- Overview dimensioning

Recent Innovations

- Combustion technology
- System integration
- Co-production

Innovation Impacts

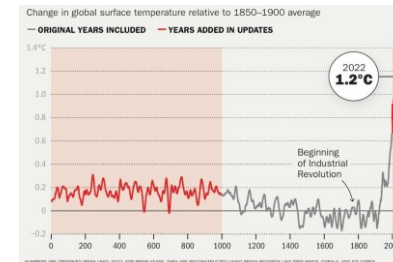
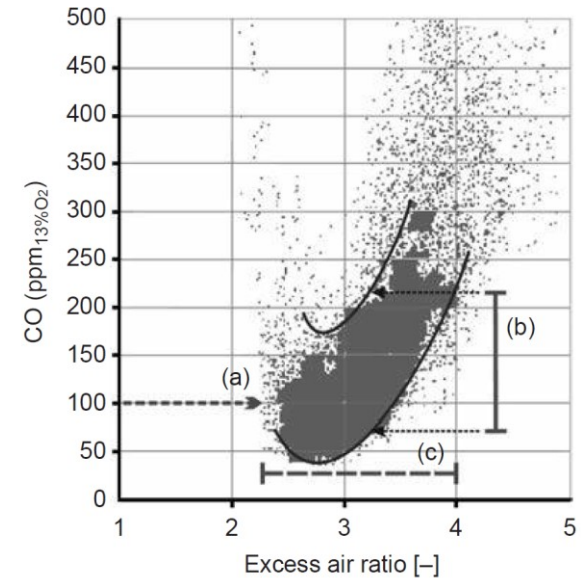
Conclusions





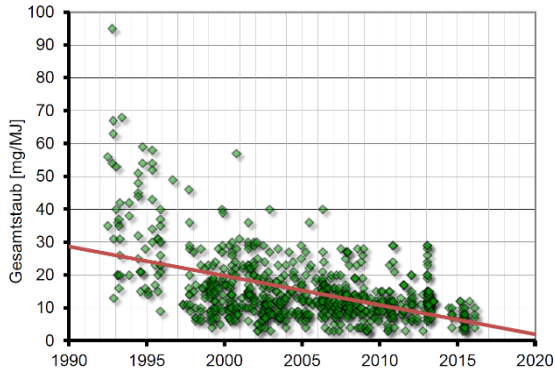
Introduction

- All information presented (and more) is included in an upcoming IEA Bioenergy Task 32 report
- Residential biomass boiler technology is looking back to more than 40 years of development
- For a long time the main innovation focus was on reducing emissions and increasing efficiency
 - Standardisation, both of technology and testing procedures was crucial
- **Technologies shown in the presentation are just examples, there are many more available!**



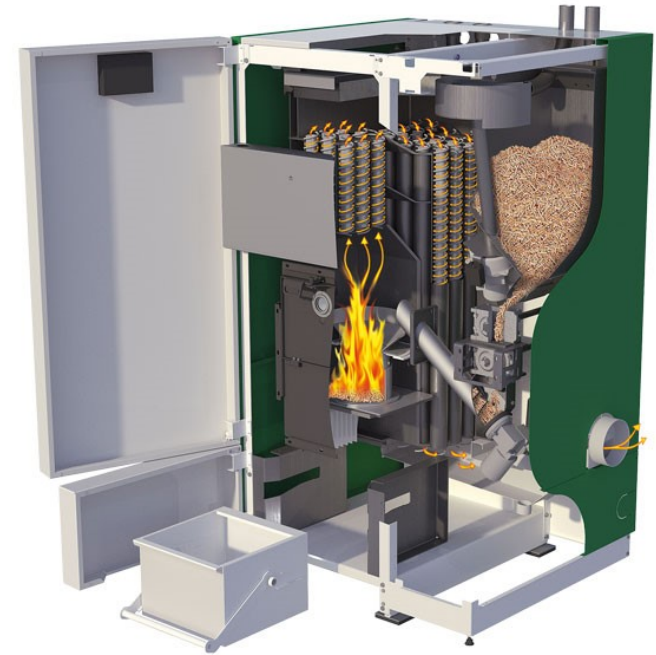
another
„hockey-
stick curve“

State-of-the-art – Technology milestones



Particulate matter emission
assessment during type testing
Source: type testing data of FJ BLT Wieselburg

- Primary and secondary air distribution
- Combustion control
- Flue gas recirculation
- Load control
- Condensing heat-exchanger
- Multi-fuel systems



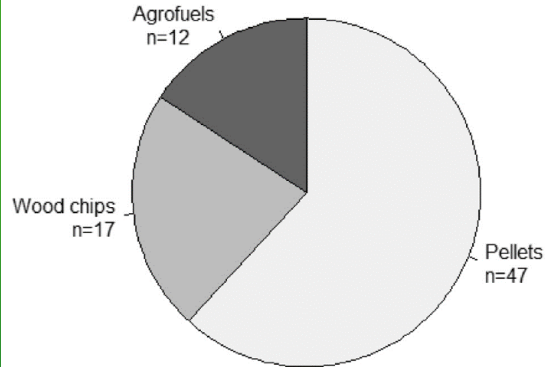
pelletstar CONDENSATION by HERZ

Source: <https://www.herz-energie.at/produkte/pelletkessel/pelletstar-cond/>

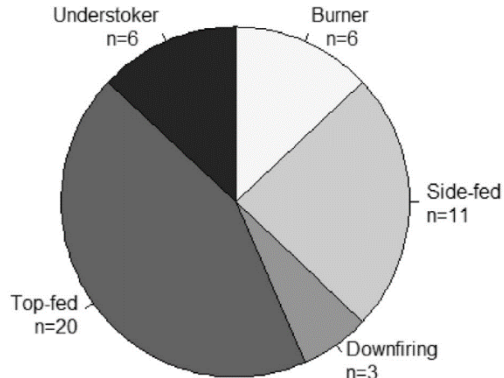


State-of-the-art – Technology overview

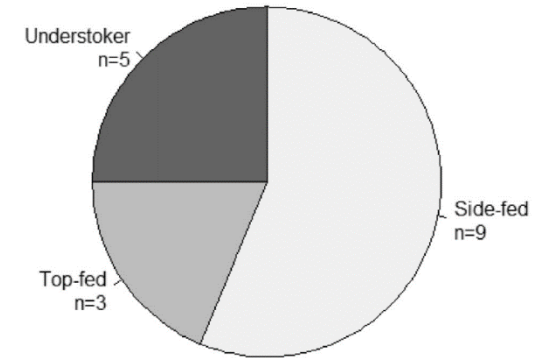
Technologies by approved fuel



Pellet boilers by feeding system



Woodchips boilers by feeding system



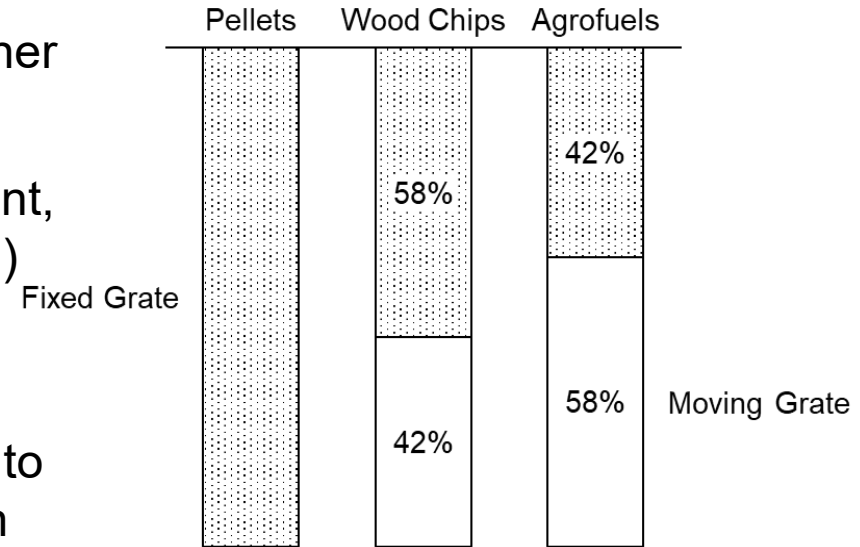
Survey of 76 commercially available residential biomass combustion appliances

Source: Sabine Feldmeier, Markus Schwarz, Elisabeth Wopienka, Christoph Pfeifer, **Categorization of small-scale biomass combustion appliances by characteristic numbers**, Renewable Energy, Volume 163, 2021, Pages 2128-2136, ISSN 0960-1481, <https://doi.org/10.1016/j.renene.2020.10.111>.



State-of-the-art – Grate type

- Selection of grate-type defines the further system dimensioning process
- Challenging (cheaper) fuels (ash content, slagging properties, size distribution,...) place higher demands on grate technology
- Even high-tech grate solutions (similar to large scale combustion plants) found in residential boiler today



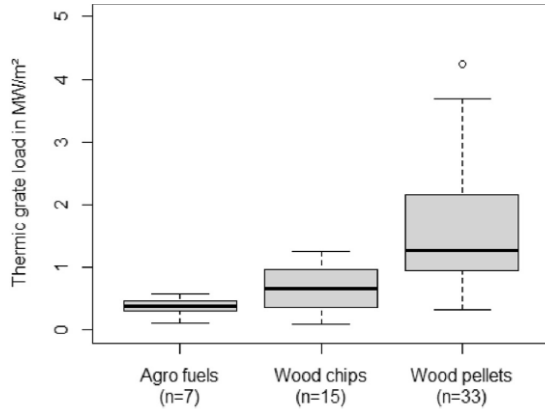
Grate types for different fuel combustion technologies

State-of-the-art – Dimensioning



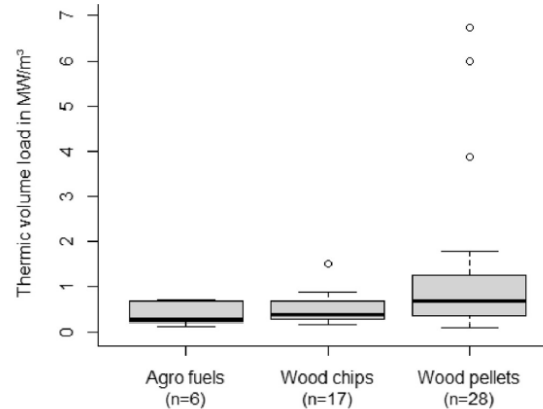
Grate Load

- Energy release density on the grate



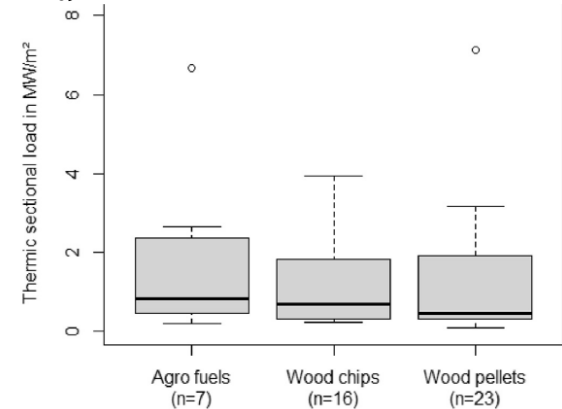
Volume load

- Thermal load in the combustion chamber



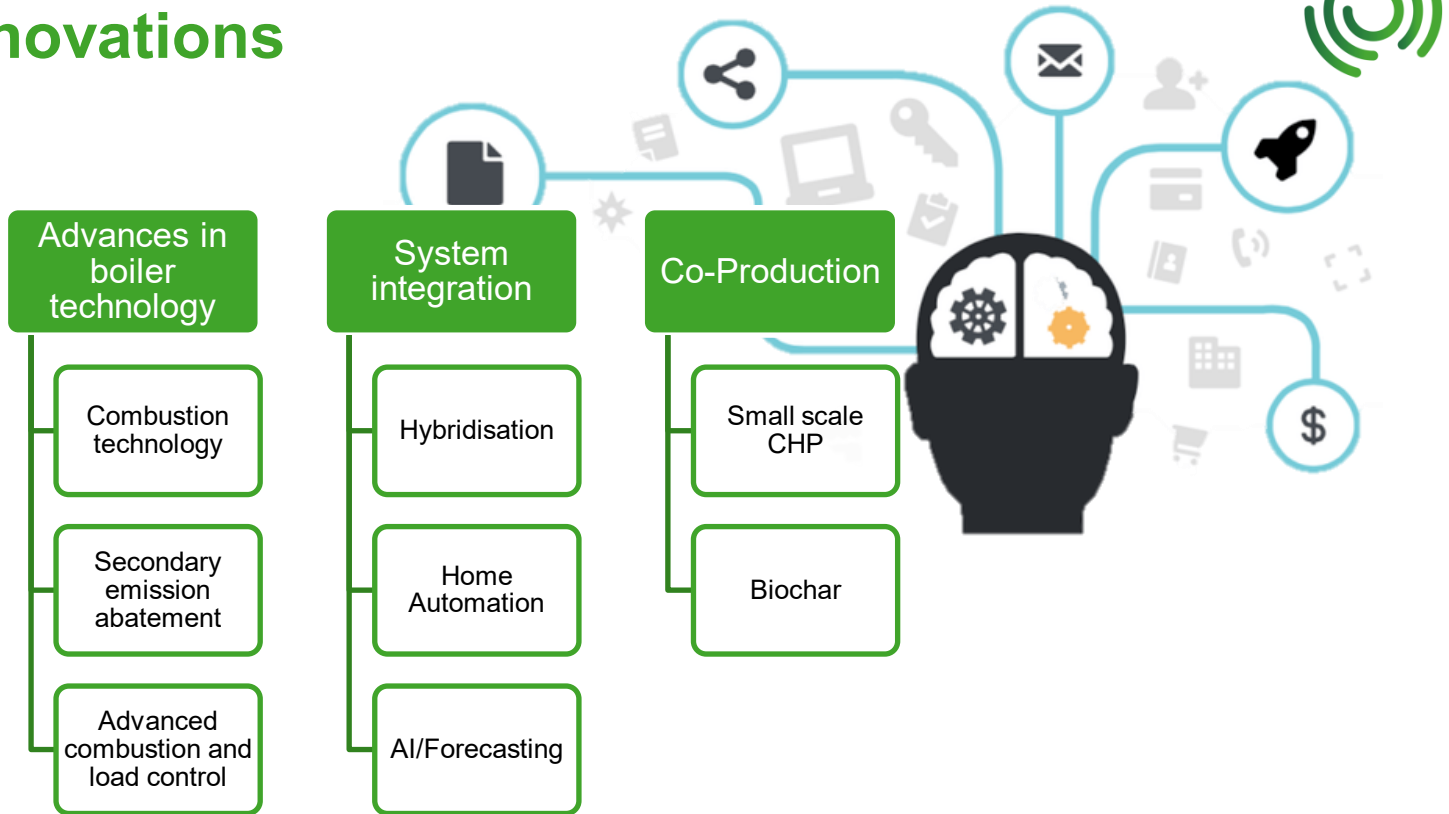
Sectional load

- Turbulence and mixing in combustion chamber



Source: Sabine Feldmeier, Markus Schwarz, Elisabeth Wopienka, Christoph Pfeifer, **Categorization of small-scale biomass combustion appliances by characteristic numbers**, Renewable Energy, Volume 163, 2021, Pages 2128-2136, ISSN 0960-1481, <https://doi.org/10.1016/j.renene.2020.10.111>.

Recent innovations





Latest innovations – Boiler technology

Combustion technologies

- Further development of air staging concept
- Pyrolysis/gasification separated from gas combustion
- Temperature/lambda control in the fuel bed → reduced volatilisation of inorganic species
- Well mixed gas combustion zone

Gasifier Technology

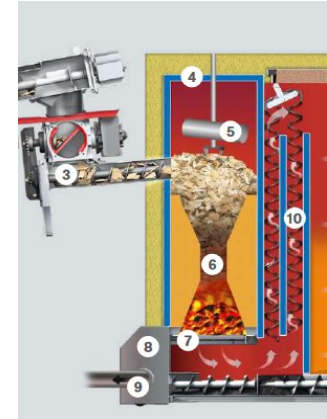
updraft



PuroWIN by company
Windhager

Source: <https://www.windhager.com/de-at/produkte/hackschnitzelheizung/puowin/>

downdraft



CHP-gasifier unit by company
Hargassner

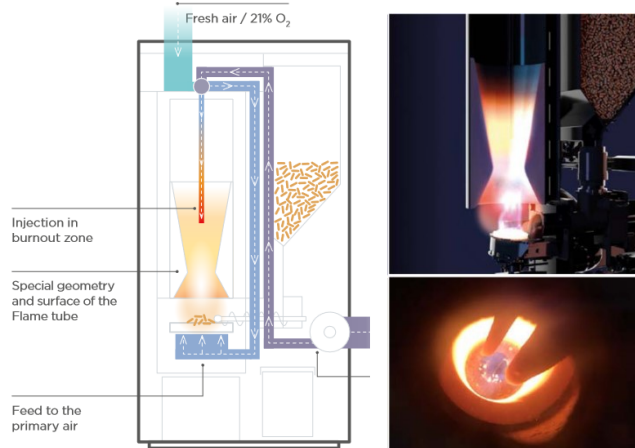
Source: <https://www.hargassner.com/wp-content/uploads/2022/08/kwk-prospekt-de.pdf>



Latest innovations – Boiler technology

Combustion technologies

Flameless combustion



Pellematic Compact by Ökofen,
zero flame technology

Source: <https://www.oekofen.com/de-at/pellematic-compact/>

- Similar concept as gasifier technology: pyrolysis and volatilisation → gas phase combustion
- Flue gas recirculation to control temperature of the fuel bed
- Injection of preheated secondary air in the gas combustion zone (almost no flames visible)

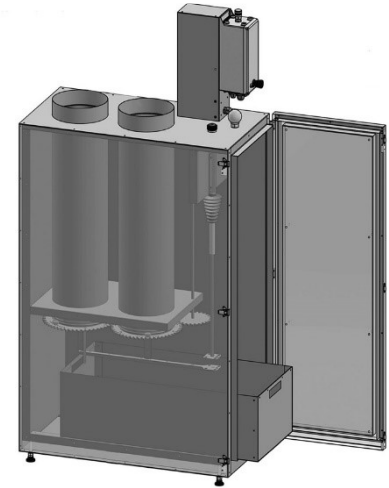


Latest innovations – Boiler technology

Emission abatement

- Secondary abatement as alternative or add-on to advanced combustion concepts
- Several emission abatement technologies have been tested for resident applications
- Electrostatic precipitators (ESP) “won” the race:
 - Good separation efficiency for all particle sizes
 - Low pressure drop (= operation costs)
- Market implementation either as standalone device (also for retrofitting)

Retrofit and modular electrostatic precipitation



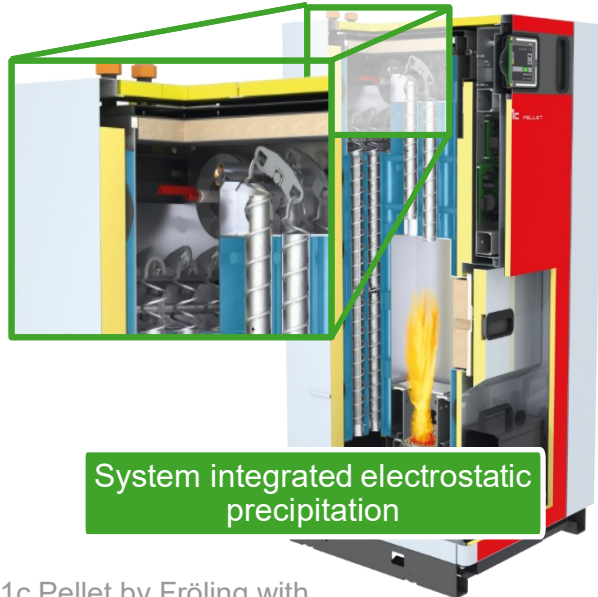
HERZ Elektrofilter

Source: <https://www.herz-energie.at/produkte/elektrofilter/>



Latest innovations – Boiler technology

Emission abatement



- or integrated into the boiler system
- Advantages:
 - Easy „communication“ between boiler and EPS (on control unit)
 - Boiler heat exchanger can be used for particle separation
- Challenges / Cons:
 - No retrofitting possible
 - Finding the right place for installation of electrode (temperature / moisture restrictions)

PE1c Pellet by Fröling with integrated electrostatic precipitator

Source: <https://www.froeling.com/de-de/produkte/pellets/neu-pe1c-pellet/>



Latest innovations – Boiler technology

Advanced combustion- and load-control

- Modern combustion technology is almost at the optimum (limits) of primary combustion conditions (temperatures, excess air ratio, mixing,...)
- Advanced control solutions required:
 - Adaptive control (e.g. with fuel quality online measurement)
 - Model-based control (using mathematical models predicting the reaction of the boiler)
 - Weather-forecasting for load control



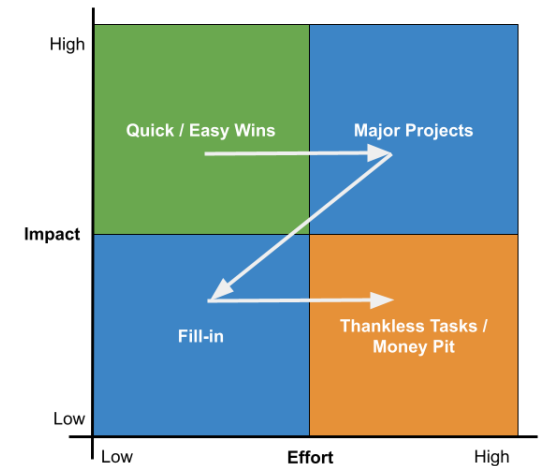
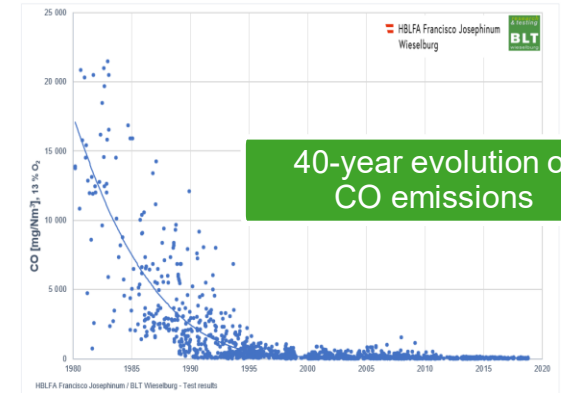
Fuel adaptive control

Personal Touch Revolution Adaptive from company Schmid Energy Solutions AG

Source: Reinhold Spörl, Dietrich Vogel: **Neue Konzepte für 15 % Teillastbetrieb und adaptive Feuerungsregelung an automatischen Holzfeuerungen.**
17. Holzenergie-Symposium Innovationen zur Rolle von Energieholz im Energiesystem. 16. September 2022, ETH Zürich
Verenum Schweizerische Eidgenossenschaft

Wrap-up: Combustion Technology

- Modern biomass combustion technologies are approaching their zero-emission goals, while
- Measurement methods are approaching their limits of determination (e.g. dust)
- Further improvement is possible BUT with very small impact at a high price („thankless tasks“)
- Extremely low emissions and maximum efficiency are becoming “state-of-the-art”
 - Fields of innovations have broadened





Lastest innovations – System integration

Hybridisation

Biomass combustion & Solar thermal

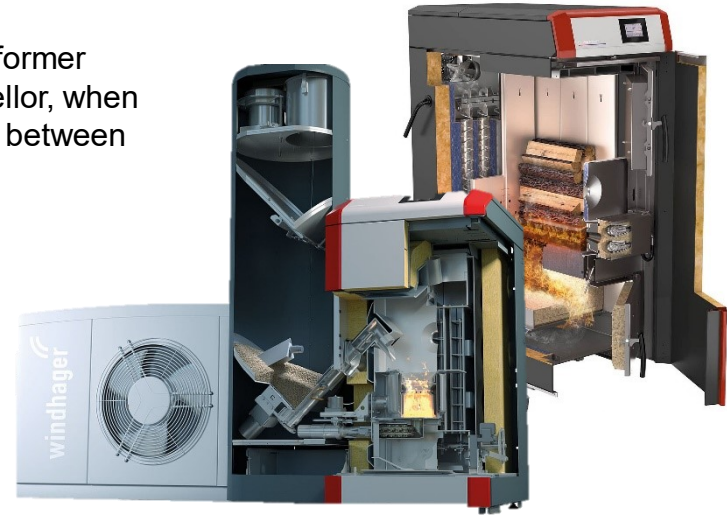


Solarfocus ecotop^{zero} with CPC - solar collector
Source: https://www.solarfocus.com/en/products/solar-system/cpc-panels?_ptp=12

“Combining the best of two worlds”

(quote: Sebastian Kurz, former Austrian Federal Chancellor, when announcing the coalition between ÖVP and Green Party)

- Mostly useful on an energy perspective
- Economics are sometimes a bit tricky
- **Sector coupling is an opportunity**



Biomass combustion & Heat pump

Windhager BioWin2 or LogWIN with AeroWin heat pump
Source: <https://www.windhager.com/de-at/produkte/hybridheizung/biowin2-hybrid/>



Lastest innovations – System integration

Home Automation / AI & Forecasting

smart control



KWB Comfort Online Control

Source: <https://www.kwb.net/de-at/produkte/regelung-und-bedieneung/kwb-comfort-online/>



LOXONE KNX Interface

Home automation

ETA connection to LOXONE interface

Source: <https://www.eta.co.at/index.php?id=151&download=7ab70b6fe14423b290d63a975c97d7a0>

Automatic adaption and learning on user behaviour



Sommerauer LOOP+ AI for ECOS

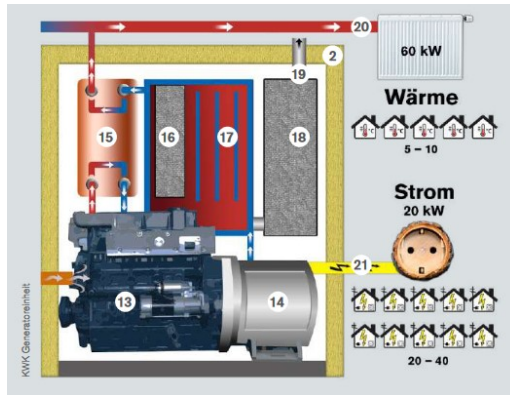
Source: <https://sommerauer-energie.com/wp-content/uploads/2022/01/Kuenstliche-Intelligenz-LOOP.pdf>



Lastest innovations – Co-Production

CHP / Biochar

Combined Heat and Power



HARGASSNER CHP internal combustion engine with power generator

Source: <https://www.hargassner.com/wp-content/uploads/2022/08/kwk-prospekt-de.pdf>

Biochar Co-production



Guntamatic POWERCHIP Biochar

Source: <https://www.guntamatic.com/heizungen/pflanzenkohleheizung/>

Innovation impacts



Innovation Impact on	Boiler technology			System integration			Co-production	
	Combustion technology	Advanced controls	Emission abatement	Hybrid-system	Home Automation	KI / Forecasting	CHP	Biochar
Energy efficiency	+	+	+	o	o	o		
Emission reduction	+	+	+	+				
Cost effectiveness	o	o		+	+	+	+	+
Sector coupling				+	+	+	+	+
User friendliness					+	+		
Carbon sequestration								+
Circular economy								o



Conclusions

- Residential biomass boiler technology is **highly developed** (“mature” technology)
- Emission and efficiency requirements for **incentives** are still drivers for development, BUT the impacts addressed in the innovations have become more versatile
- System integration includes people: Boilers are becoming more “**user-centric**”
- New co-production concepts open potentials for residential applications in **circular economy and carbon sequestration**
- **µCHP systems** have been developed, but market is still hesitant (economics)

Residential Biomass Boiler Systems

State-of-the-art and recent Innovations



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Available soon:
<https://task32.ieabioenergy.com/>



Thank you for your kind attention!

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IEA Bioenergy Task 32