Mikro-KWK, gekoppelte Wärme- und Stromerzeugung mit Kleinstanlagen unter Nutzung fester biogener Brennstoffe

(Micro-CHP, combined heat and power production in small scale plants with solid biogenic fuels)

Energieworkshop: „Der rasant wachsende Energiebedarf in Sub-Sahara Afrika“
Technologie Zentrum Dresden, 27. November 2012

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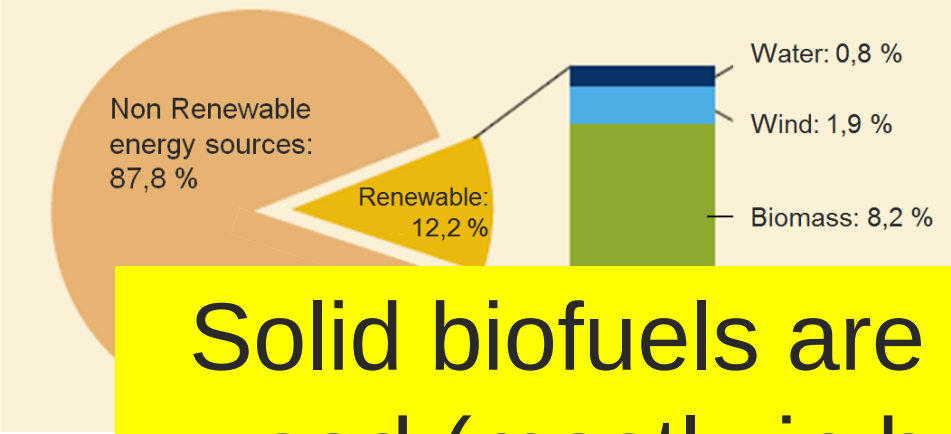
Biomass in the energy system

Energy consumption in Germany in 2011[1] (preliminary)



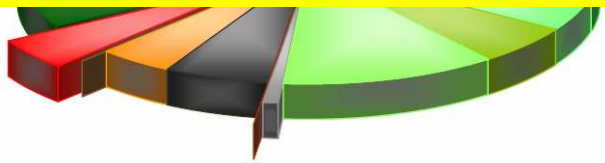
Solid, liquid and gaseous biomass (67 %)

Solid biofuels are predominantly used (mostly in households) for heat production from renewable energy

Total h

Solid
(hous

Solar- & Geothermal energy 8,6 %



Liquid, gaseous, other mostly biogenic fuels 29,1 %

[1] Erneuerbare Energien 2011, BMU Vorläufige Angaben der AG Stat, 03. 2012

[2] F. Musiol, T. Nieder, T. Rüther, M. Memmler, S. Rother, S. Schneider, Erneuerbare Energien 2011, Vorläufige Angaben, Stand 08. März 2012, (Ed.) Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) Referat KI III 1

Small biomass combustion in Germany

In Number

Total number of small furnaces for solid fuels: app. 14 million[3]

Small central heater 5 - 7 %[4]

Single fireplaces 93 - 95 %[4]

In Energy

Total

Small

Single

Domestic biomass based heating is rather diverse

Variety

More than 20 different technologies[4]

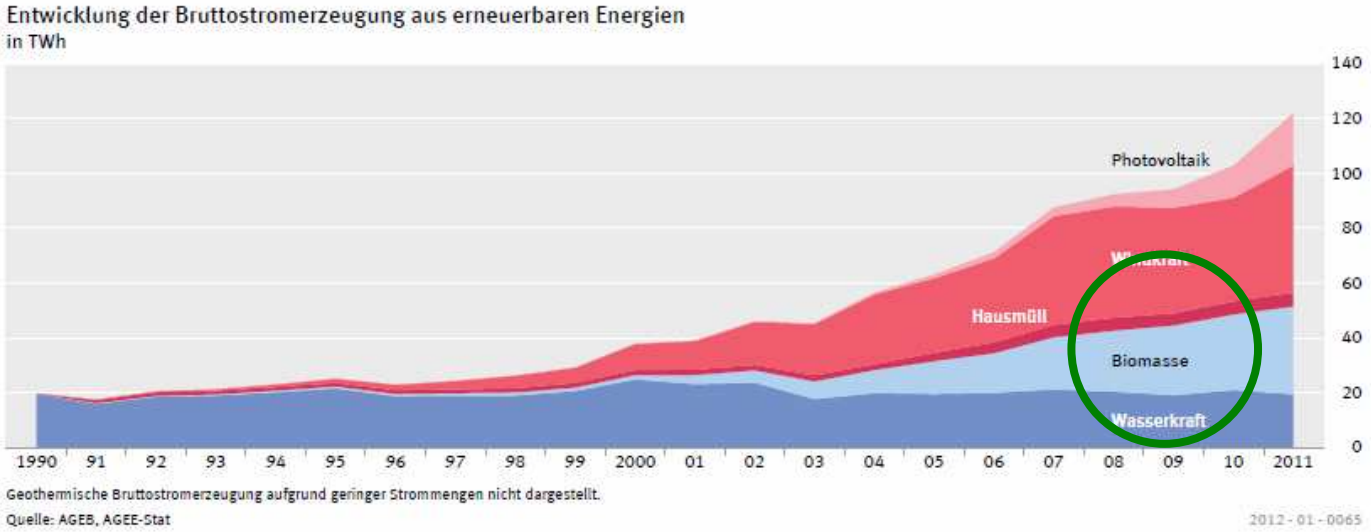
More than 30 different kinds of solid biogenic fuels[5]

[3] Struschka M., Kilgus D., Springmann M., Baumbach G., Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung, Forschungsbericht 205 42 322, Umweltbundesamt UBA-FB 001217 Texte 44/08, ISSN 1862-4804, 11. 2008

[4] Schröder T., Viehmann C., Bienert K., Wazula H. (2012) Domestic biomass based heating in Germany, determination of the number of single fireplaces for wood fuels by an all-German data collection, 20th European Biomass Conference and Exhibition

[5] Bundesrepublik Deutschland (2010): Erste Verordnung zur Durchführung des Bundes- Immisionsschutzgesetztes (Verordnung über kleine und mittlere Feuerungsanlagen - 1. BImSchV). Deutscher Bundestag, Drucksache 17/74, vom 25.11.2009, Inkrafttreten: 22.03.2010

Electricity with Biomass



Micro CHP, general explanation

CHP

CHP – Combined Heat and Power:

The simultaneous conversion of input energy into useful heat and electricity in a stationary plant [6] .

Micro - CHP

...CHP with electrical output of less than 15 kW_{el} [7]

Household and small industry are typical assignment site.

Heat

Used for room heating and hot water supply.

Electricity

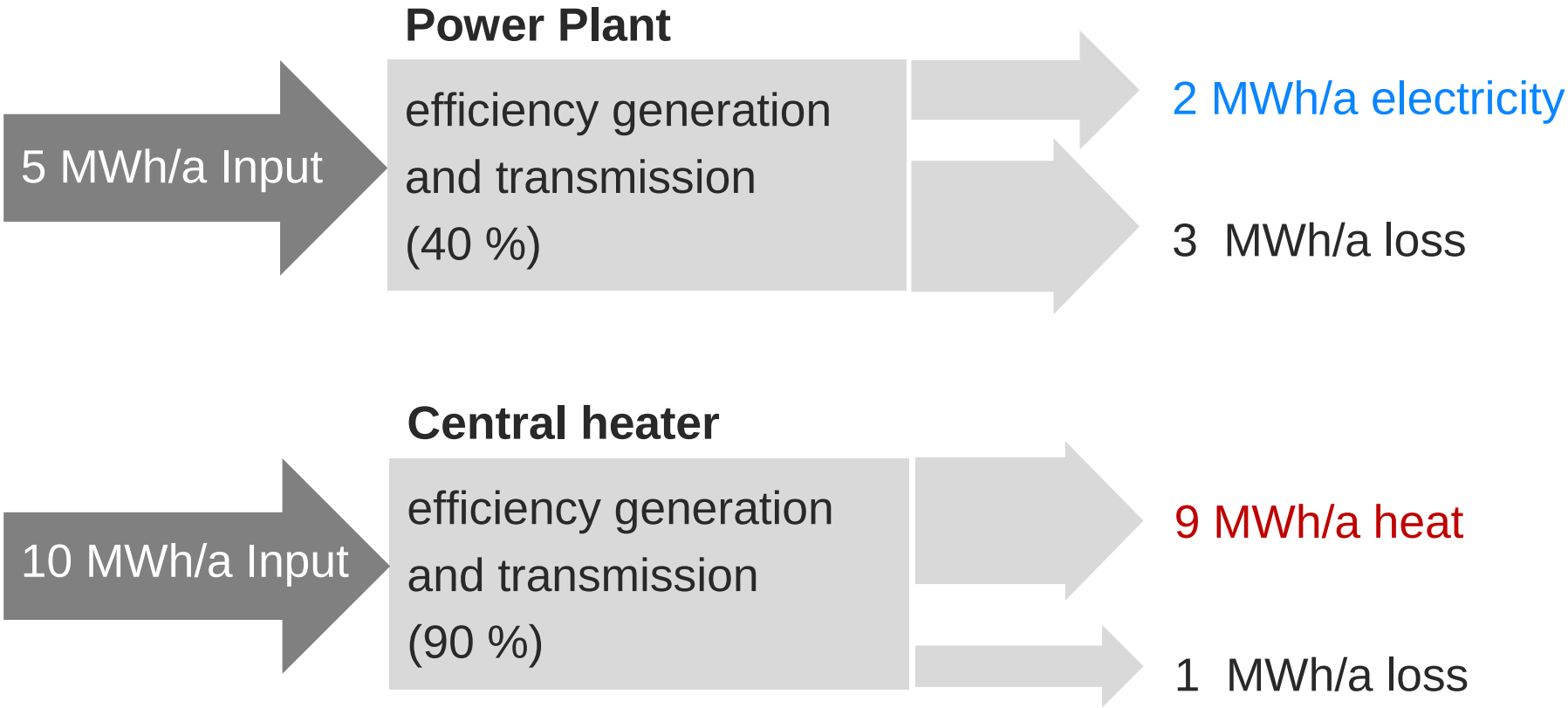
Used for own needs or decentralized injection into public grids.

[6] Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (Kraft- Wärme-Kopplungsgesetz) KWKG 2002

[7] Martin Pehnt, Environmental impacts of distributed energy systems—The case of micro cogeneration 2007

Micro-CHP vs. conventional energy production

Example household annual consumption: 2 MWh/a electricity / 9 MWh/a heat



11 MWh/a : 15 MWh/a = 73 % efficiency

Micro-CHP vs. conventional energy production

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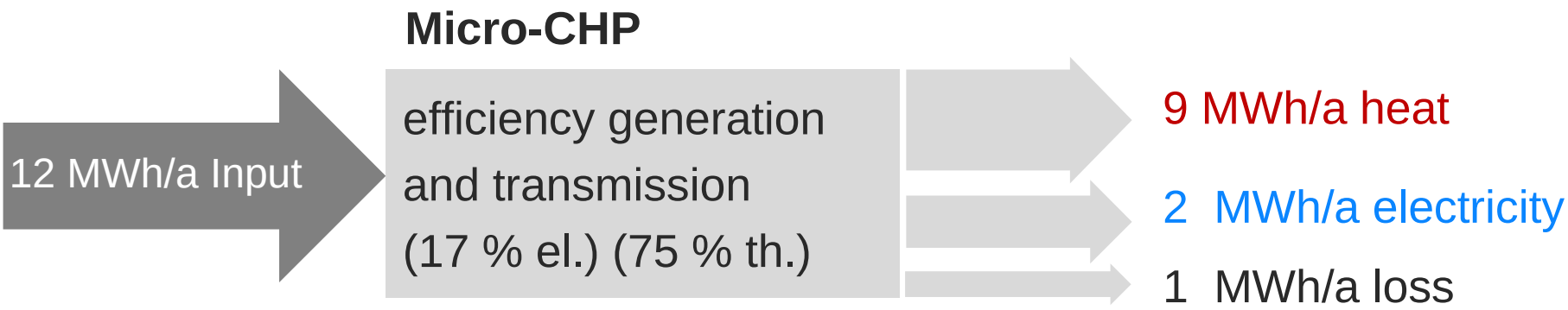


Primary energy use

CHP: 12 MWh/a – Conventional: 15 MWh/a

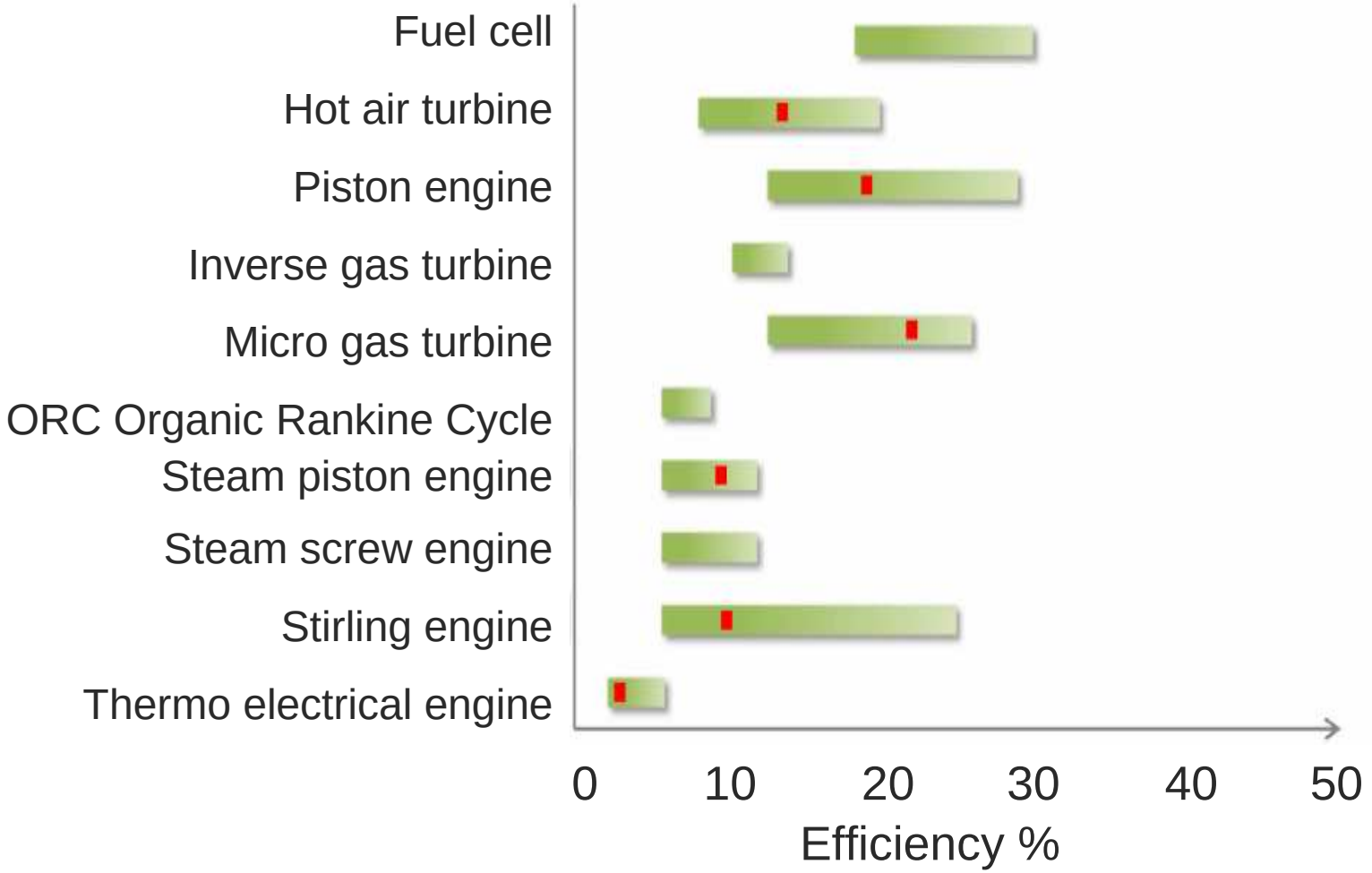
Conserved primary energy: 3 MWh/a (20 %)

Micro-CHP with solid biogenic fuels

Reasons for Micro-CHP with solid bio-fuels

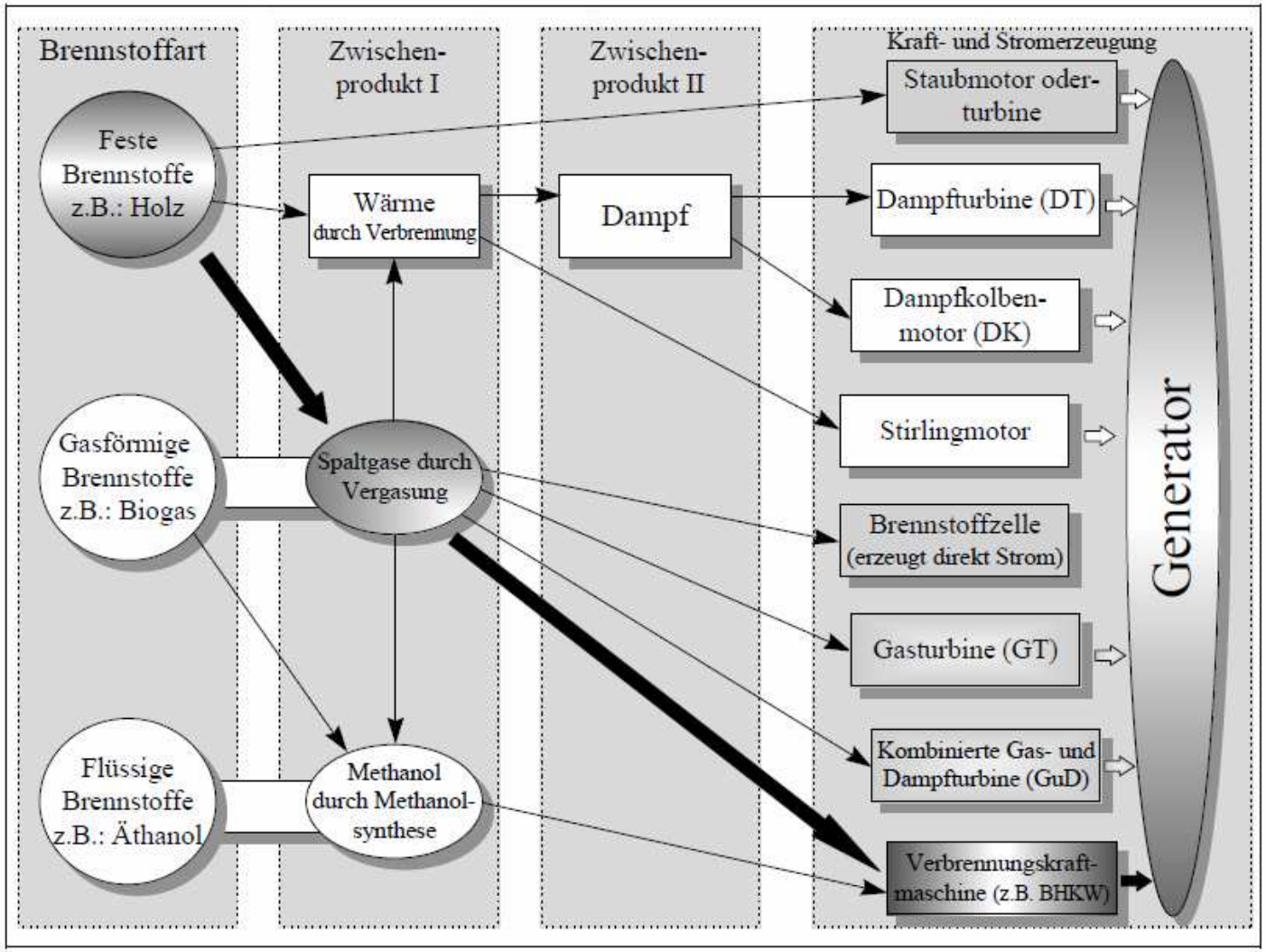
- The use of biomass reduces greenhouse gas emissions.
- Solid bio-fuels are frequently used in households.
- Specific demands for heat and electricity in households will be reduced due to better insulation and efficient electrical consumers within the next years.
- Small scale heating systems are needed.
- Growing prices for electricity offer opportunities for alternative (CHP) technologies.
- Independence of the power supply through decentralization.

Overview[8]



[8] Buechner Daniel, Mikro-KWK mit Festbrennstoffen -Stand der Entwicklung- (Leipzig 2011)

Possible Classification[9]

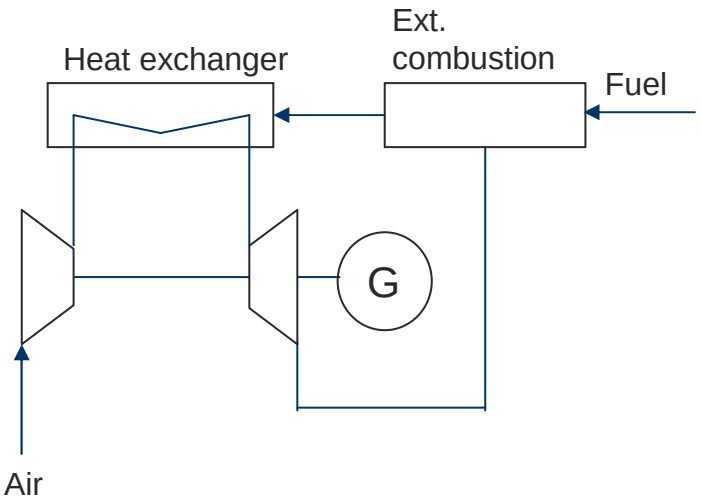


[9] Nils Steinbrecher, Joachim Walter: Marktübersicht dezentrale Holzvergasung, Institut für angewandte Ökologie e.V. (2001)

Example: Hot air turbine

Working principle:[10]

- External combustion
- Air-heat exchanger
- Expansion unit
- generater



Talbott BG 100 (Talbott's Biomass Generators UK) [11]

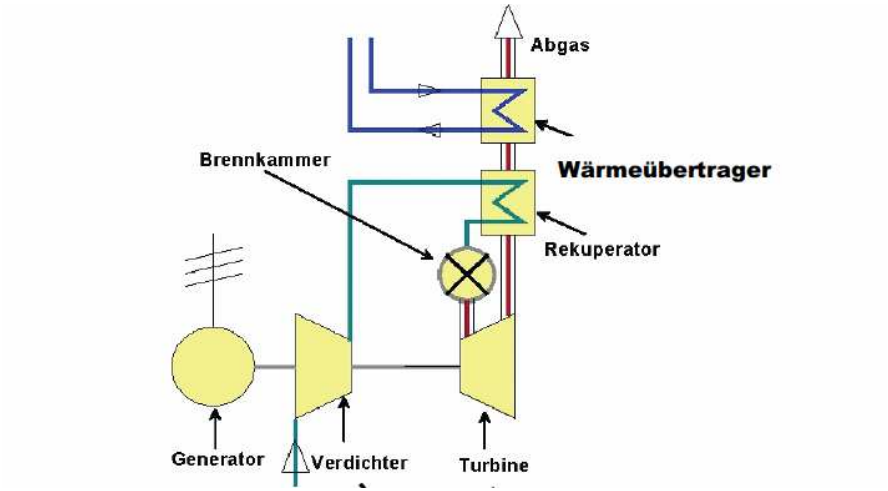
[10] Georg Gallmetzer, Bernhard Dobmaier (2006): Konzepte zur Realisierung indirekt mit Biomasse befeuerter Heißluftturbinen

[11] Martin Schmidt: Holzbefeuertes Blockheizkraftwerk mit Heissluftturbine: Pilotanlage in Rümlang mit 450 kWth und 100 kWel

Example: Micro gas turbine

Features and working principle:[12]

- Isolated operation possible
- Low caloric gas possible
- High el. efficiency
- Compact unit



Capstone Micro gas turbine[13]

[12] Matthias Betsch: Umbau einer µ-Turbine zu einer extern befeuerten Maschine mit Ankopplung an eine Stationäre-Wirbelschichtfeuerung 2009

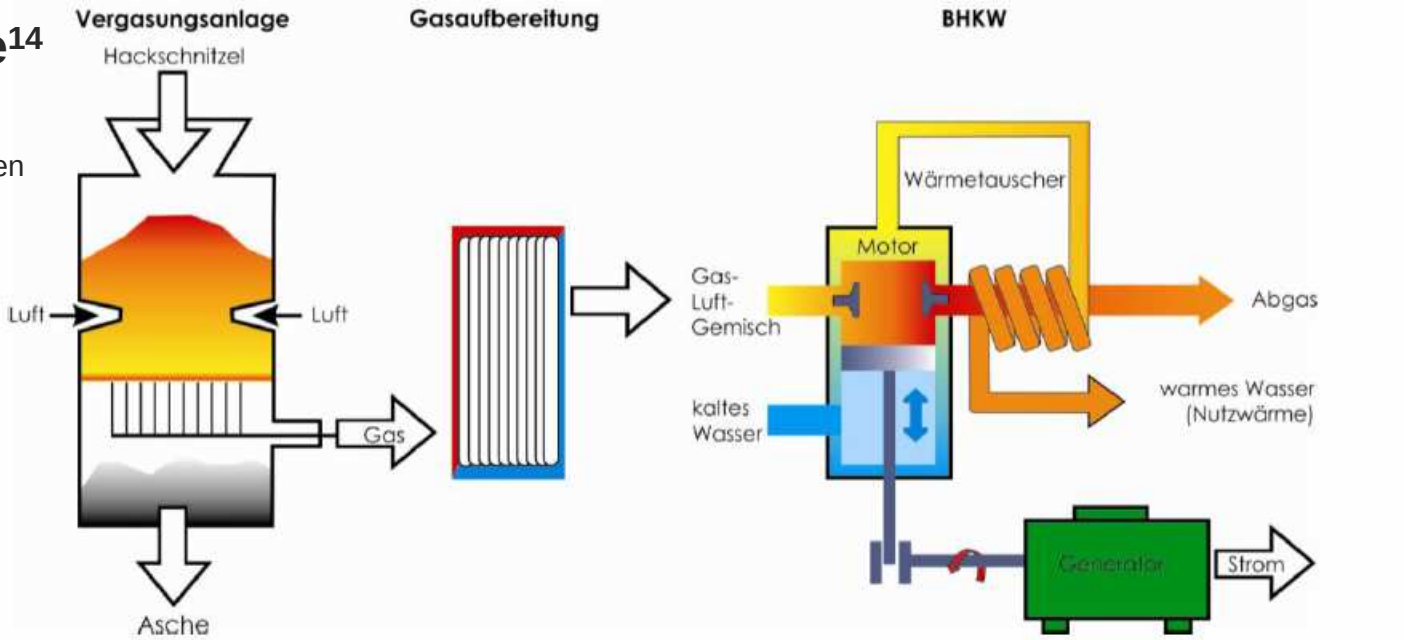
[13] Marcus Mehlkopf: Capstone MicroTurbine E-Quad Power Systems GmbH, Herzogenrath 2011

Piston engine

Functional principle[14]

[14] Sebastian Kilburg, C.A.R.M.E.N. e.V.: Kleine Holzvergasungsanlagen Handlungsempfehlungen für Kapitalgeber (2012)

[15] Entwicklung eines Verfahrens zum störungsfreien Dauerbetrieb eines Verbrennungsmotors mit Holzgas zur Erzeugung von Strom und Wärme (BHKW) Abschlussbericht

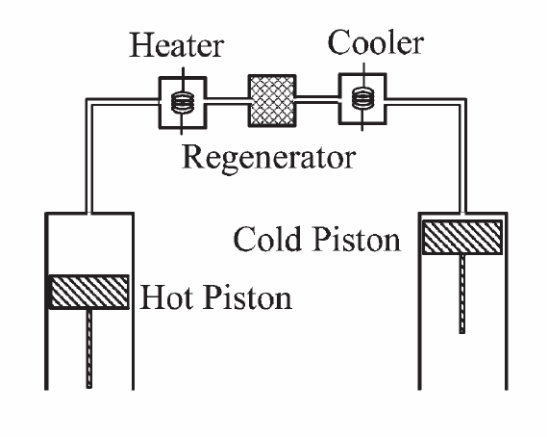


Explanatory notes:[14, 15]

- Long-chained hydrocarbons (Tar) and dust are problematic → precipitation and disposal necessary
- Wood preferred, because of low content of chlorine, nitrogen and ash forming comp. (potassium etc.)
- Gasification tech.: downdraft and updraft gasifier
- Several boundary conditions to be considered within the planning phase

Example: Stirling Engine

Functional principle (α-configuration)[18]



© Hoval[17]

© Stirling DK[16]

Explanatory notes:[19]

- Different working principles
- Completely encapsulated mechanism → high durability
- Different external heat sources possible
- High temperature resistant materials necessary

[16] Gerald Manitsch, Developement of a pre-combustor for small scale biomass Stirling engine CHP plants, 20th EU BC&E Milano 2012

[17] Daniel Hegele, Einbindung von Stirling-Motoren in Stückholz- und Pelletskessel

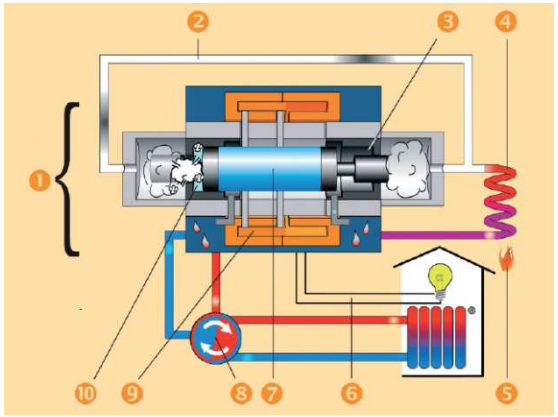
[18] Bancha Kongtragool, Somchai Wongwises, A review of solar-powered Stirling engines and low temperature differential Stirling engines

[19] Bernd Thomas, Stirling-BHKW‘s Einsatz von Biomasse

Example: Steam piston engine

Functional principle

- Closed C.-Rankine Cycle
- Steam piston
- Linear generator
- External heat source (wood pellets)
- 4-15 kWth / 2 kWel



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bison®-Powerblock

- Commercial available
- Households and small industry
- Electrical supply necessary

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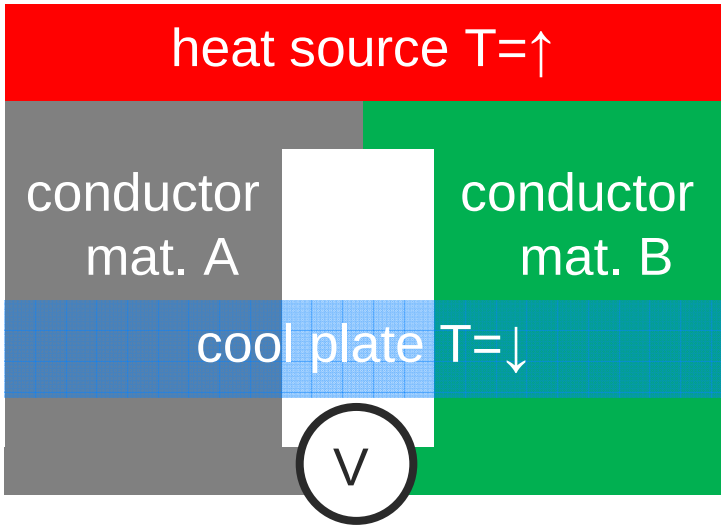
Thermo electrical engine

Principle

- Seebeck-effect
- 2 different electrical conductor (metal or Semiconductor)
- Temperature difference (hot source and cool plate)



➡ electrical potential and /or current

Latest developments

- 2 wood pellet furnaces tested by “Bioenergy 2020+” (AUT)
- no moving parts, no noise
- el. efficiency up to 8 %

boiler 10 kW_{th}, 200 W_{el}

Source: BIOENERGY 2020+ GmbH
Inffeldgasse 21b, 8010 Graz, Austria

Conclusion & Outlook

- Micro-CHP is an important element of a modern sustainable energy supply.
- Micro-CHP with solid biogenic fuels has tech. and economically challenges to overcome.
- Large variety of technological solutions available.
- Technological development and financial support are necessary for market penetration.

Thank you!

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