

IEA – Workshop Copenhagen
Small scale biomass co-generation
with modern steam engines



Dipl.-Ing. Till Augustin

October, 7th 2010

Solid Biomass Cogeneration with Spilling Steam Engines

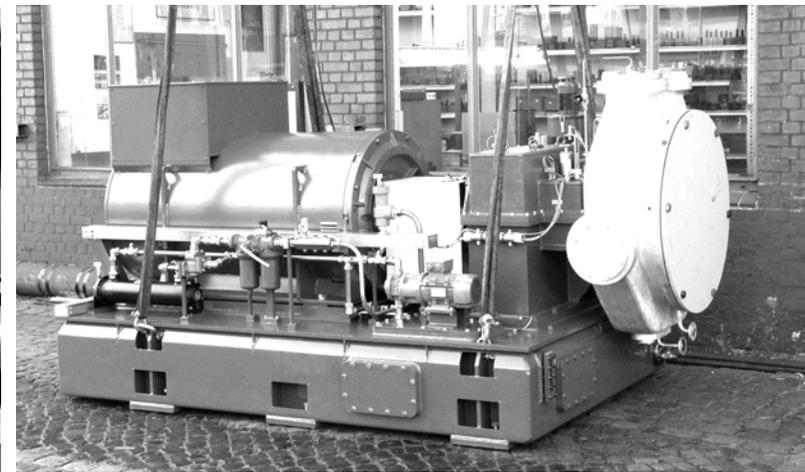
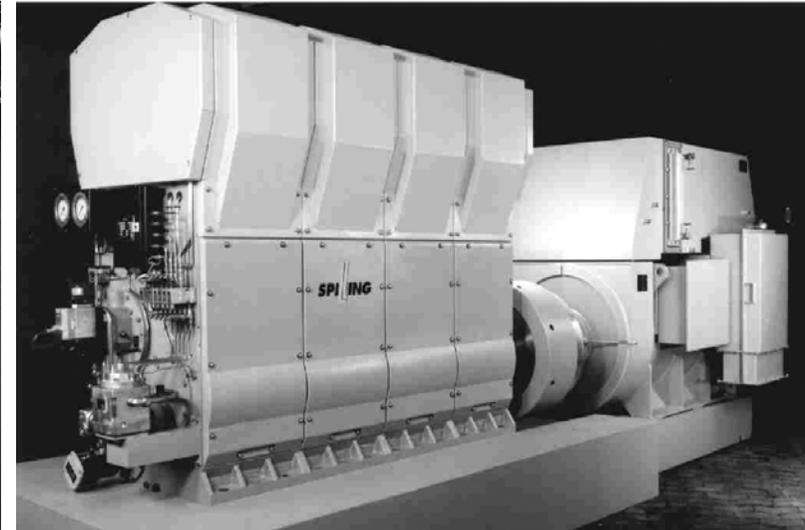
Contents:

- Who is Spilling
- Heat and Power from Biomass Steam Power Plants
- The Spilling Steam Engine
- Examples

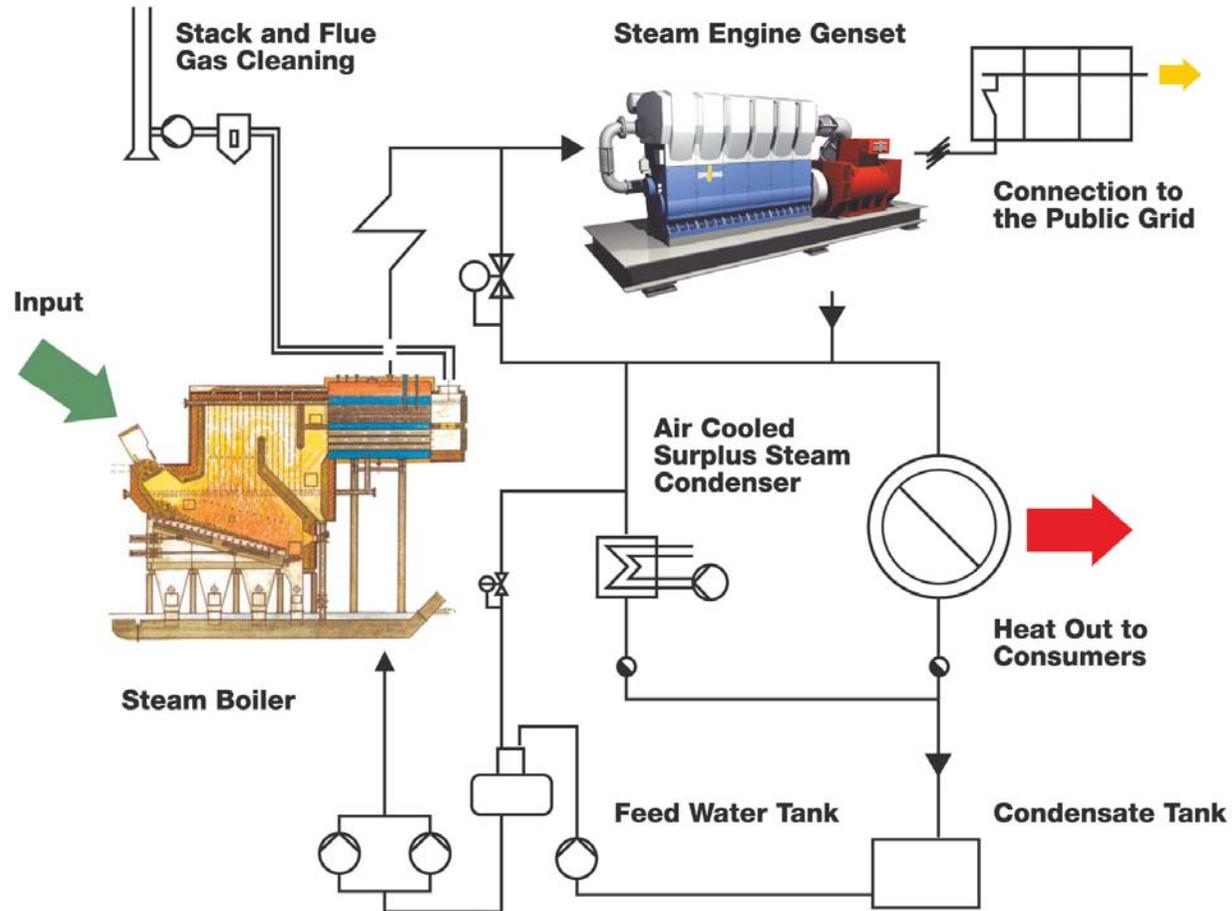
Spilling: Company Information

- Engine and Turbine Manufacturer
- Location: Hamburg
- Founded in 1889
- Product Lines:
 - Steam Engines
 - Steam Turbines
 - Gas Expanders

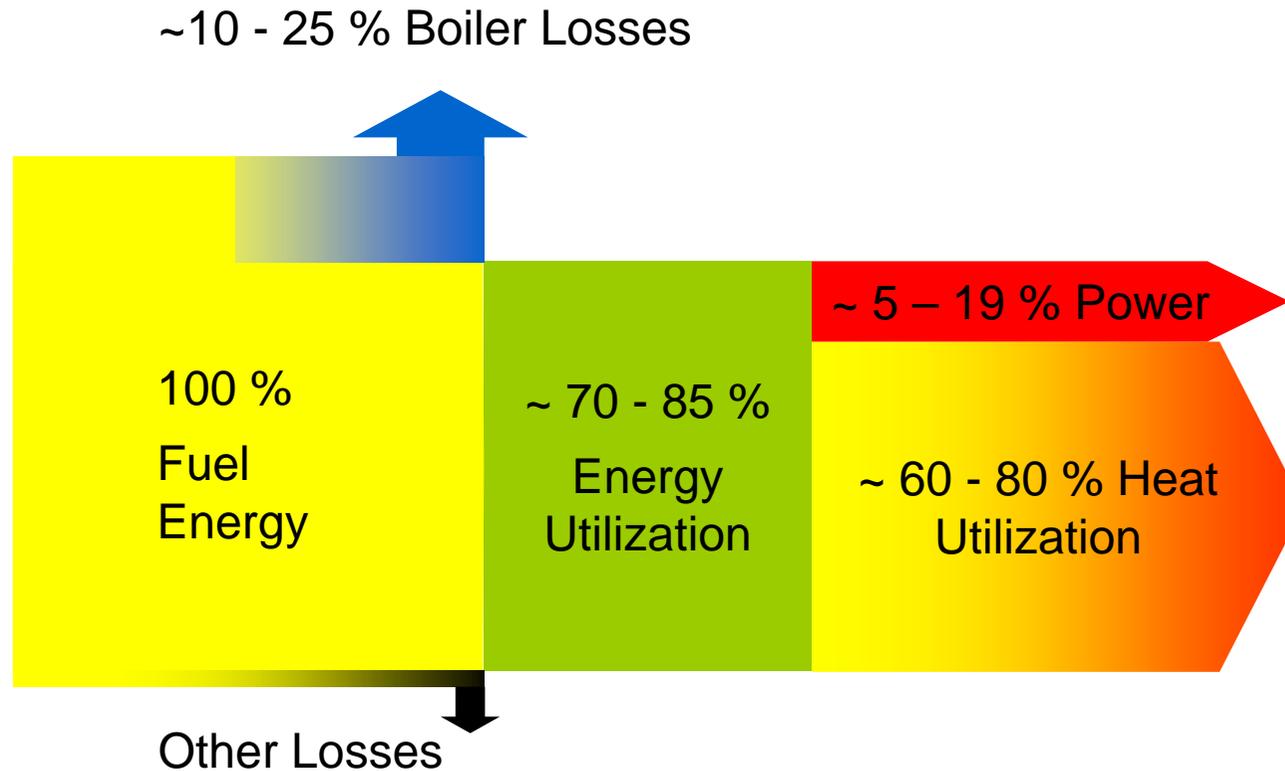
Spilling's Program: Decentralized Co-Gen Equipment



Biomass Steam Cogeneration



Optimal Use of Energy with CHP



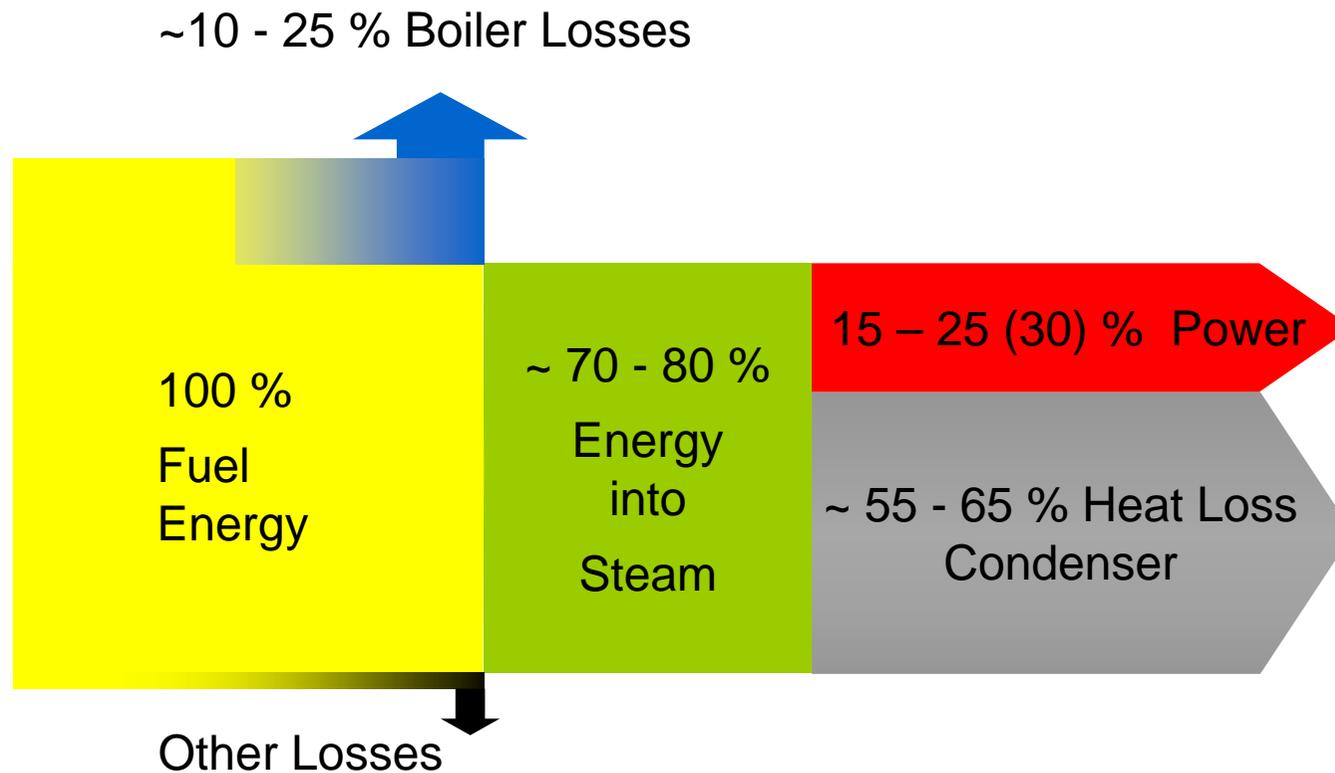
Sankey Diagram of Biomass Steam CHP-Plant

Optimal Use of Energy with CHP

| Examples for Energy Balances: Biomass Steam Cogeneration Plants | | Date / Name: | | 04.10.2010 / Au |
|---|------------|------------------|--------------|---------------------|
| Case | | 1 | 2 | 3 |
| Primemover | | Turbine | Engine | Engine |
| Design / Type | | Multi Stage | Single Stage | Double Stage |
| Steam Pressure Boiler Outlet | [bar abs.] | 42 | 62 | 26 |
| Steam Temperature Boiler Outlet | [°C] | 425 | dry sat. | 265 |
| Fuel | | Solid Biomass | | |
| Steam Procuton | [t/h] | 30,0 | 24,0 | 4,0 |
| Stecific Heat Demand for Steam Prorduction | [kWh/t] | 782 | 649 | 685 |
| Steam Heat Capacity Boiler | [kW] | 23.460 | 15.576 | 2.740 |
| Boiler Efficiency | | 0,88 | 0,88 | 0,84 |
| Firing Capacity Boiler | [kW] | 26.659 | 17.700 | 3.262 |
| Inlet Engine / Turbine | [bar abs.] | 40,0 | 60,0 | 25,0 |
| Inlet Engine / Turbine | [°C] | 420 | dry sat. | 260 |
| Outlet Engine / Turbine | [bar abs.] | 0,8 | 11,0 | 1,5 |
| Output at Generator Terminals | [kWe] | 4.830 | 1.000 | 333 |
| Exhaust Steam Heat | [kWth] | 18.000 | 13.500 | 2.330 |
| El. Efficiency (gross) related to fuel input | | 18,1% | 5,6% | 10,2% |
| Exhaust Steam Temperature | [°C] | 93 | 185 | 111 |
| Exhaust Steam Utilization | | District Heating | Process | Process and Heating |

Electricity as valuable by-product

Pure Electricity Production

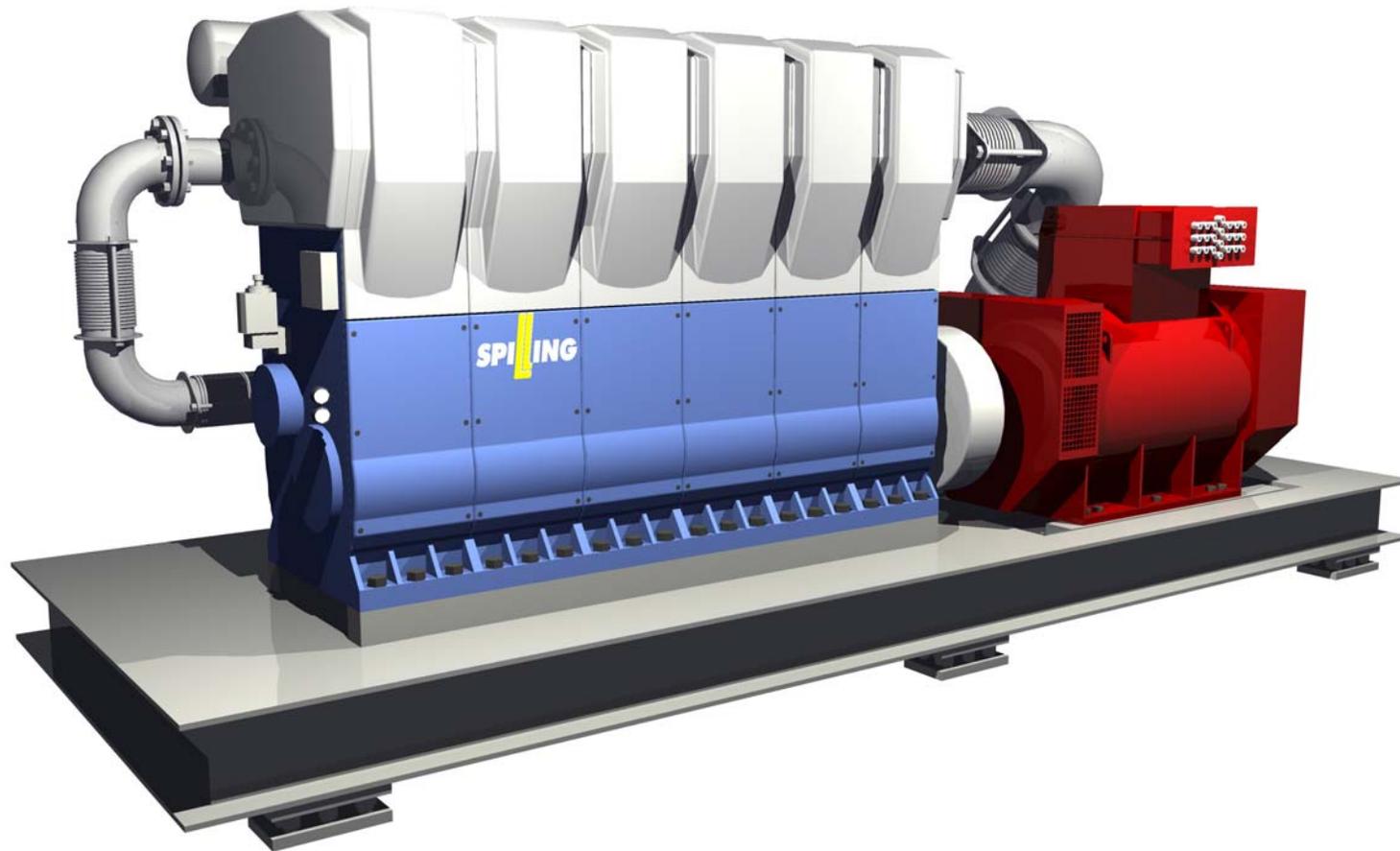


Sankey Diagram of Biomass Condensing Steam Power Plant

Example for Vacuum Condensing Power Generation

| Examples for Energy Balances: Biomass Steam Power Generation | | |
|--|---------------|--------------------|
| Case | | 1 |
| Primemover | | Turbine |
| Design / Type | | Multi Stage |
| Steam Pressure Boiler Outlet | [bar abs.] | 42 |
| Steam Temperature Boiler Outlet | [°C] | 425 |
| Fuel | | solid biomass |
| Steam Procuton | [t/h] | 30,0 |
| Stecific Heat Demand for Steam Prroduction | [kWh/t] | 782 |
| Steam Heat Capacity Boiler | [kW] | 23.460 |
| Boiler Efficiency | | 0,88 |
| Firing Capacity Boiler | [kW] | 26.659 |
| Inlet Engine / Turbine | [bar abs.] | 40,0 |
| Inlet Engine / Turbine | [°C] | 420 |
| Outlet Engine / Turbine | [bar abs.] | 0,1 |
| Output at Generator Terminals | [kWeI] | 6.700 |
| EI. Efficiency (gross) related to fuel input | | 25,1% |
| Exhaust Steam Temperature | [°C] | 46 |
| Exhaust Steam Utilization | | none |

The Spilling Steam Engine: Modular Design



The Spilling Steam Engine

Design Features:

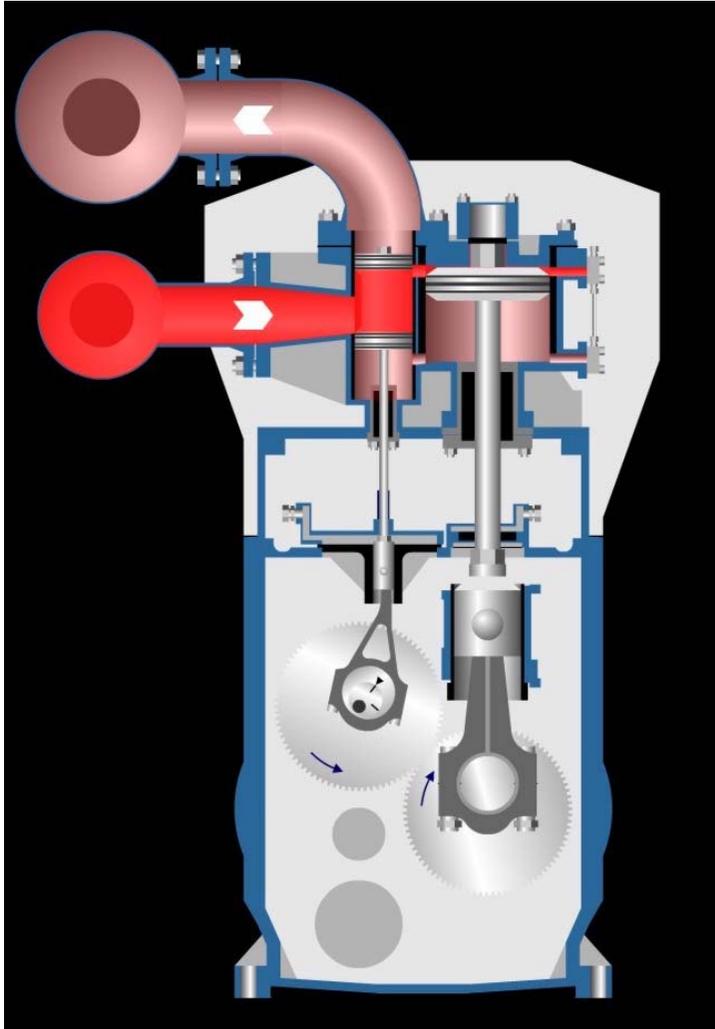
- modular design
(from 1 to 6 cylinders; 15 different piston diameters)
- volumetric flow control: filling regulation
- oil free steam
- skid mounted engine set for flexible installation

The Spilling Steam Engine

Key Figures and Facts

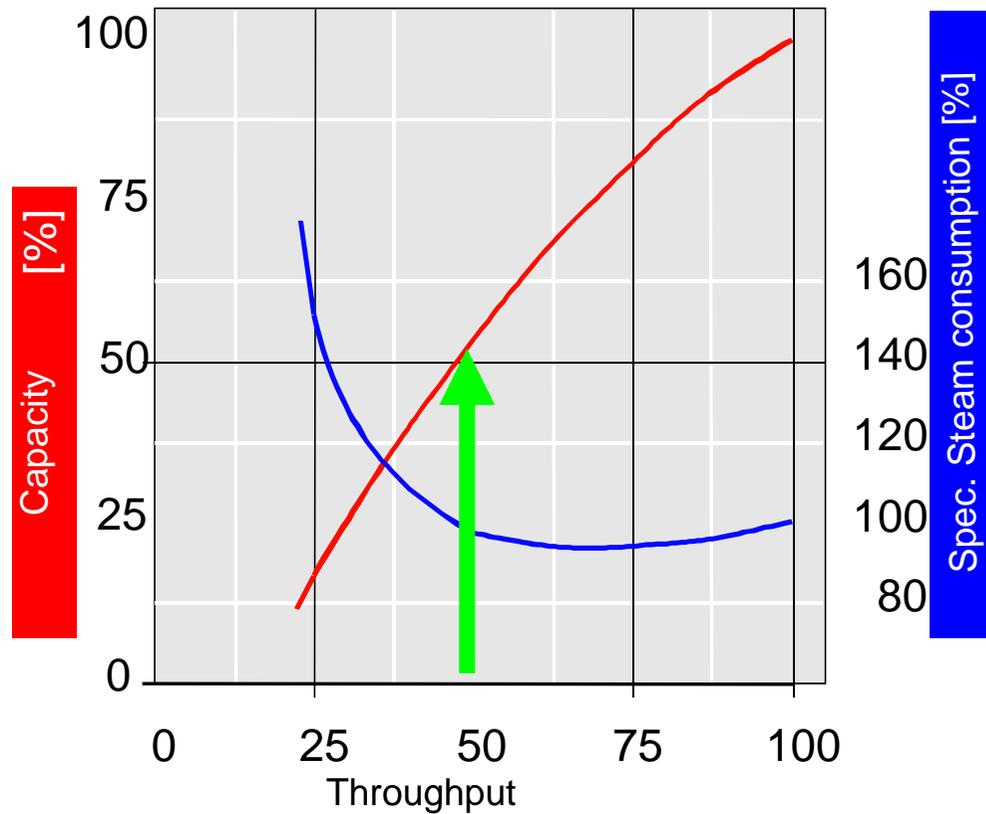
| | |
|------------------------|------------------|
| ■ Power Output | up to ~ 1.200 kW |
| ■ Steam Flow Rates | up to ~ 40 t/h |
| ■ Live Steam Pressures | ~ 6 to 60 bar |
| ■ Back Pressures | up to ~ 15 bar |

Spilling Steam Engine



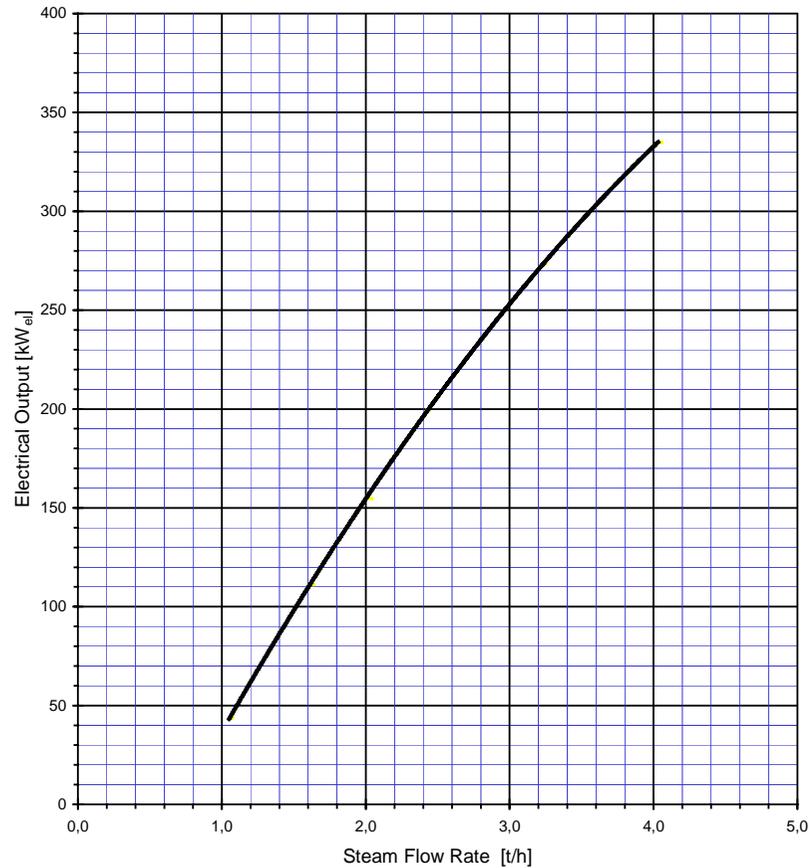
Animation Steam Engine

Spilling Steam Engines: High Part Load Performance



| | | |
|-----------------------------|---------------|-------------|
| Engine Type: | | 1/ 1-H12 TS |
| Number of Expansion Stages: | | 2 |
| Number of Cylinders: | | 2 |
| Speed: | [rpm] | 1000 |
| Generator Rating: | [kVA] | 420 |
| Voltage: | [V] | 400 |
| Frequency: | [Hz] | 50 |
| Boiler (Exit): | [barg] / [°C] | 25,0/ 265 |
| Inlet - Engine: | [barg] / [°C] | 24,0/ 260 |
| Outlet - Engine: | [barg] | 0,5 |

Spilling Steam Engines: Example 4 t/h



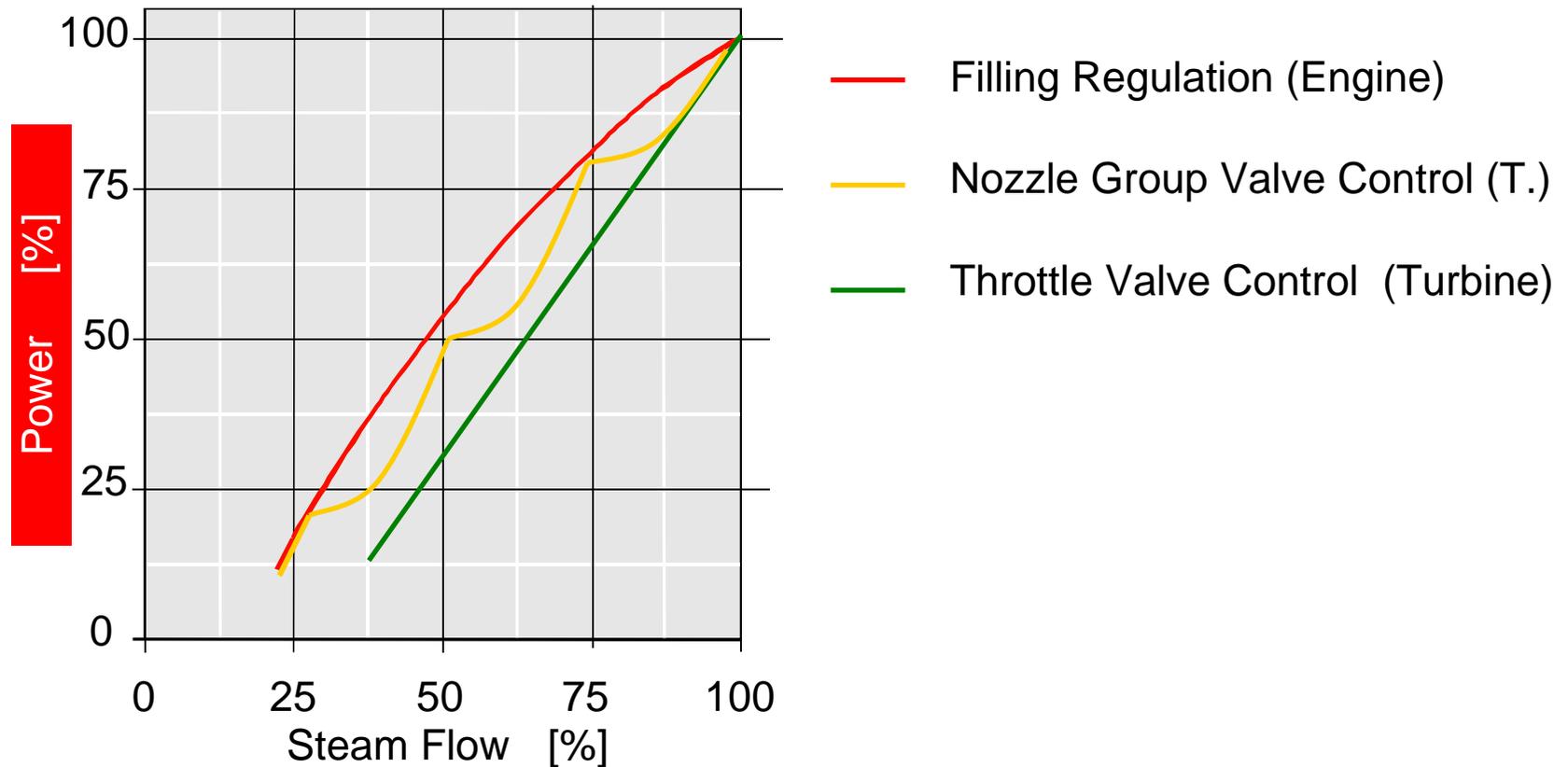
Project: Example IEA - Workshop
Steam Engine Set

Chart: DA 14056
Name: Au
Date: 4.10.10

Spilling Engine: Characteristics / Advantages:

- wide operation range
- high (partload) efficiencies
- good regulation behaviour at fluctuating live steam cond.
- good capability for saturated steam
- moderate requirements for boiler feed water treatment
- maintenance by local staff / technicians possible

Comparison of Output Regulation Principles



Example 1



**Bio Sludge Incineration
Plant
(Netherlands)**

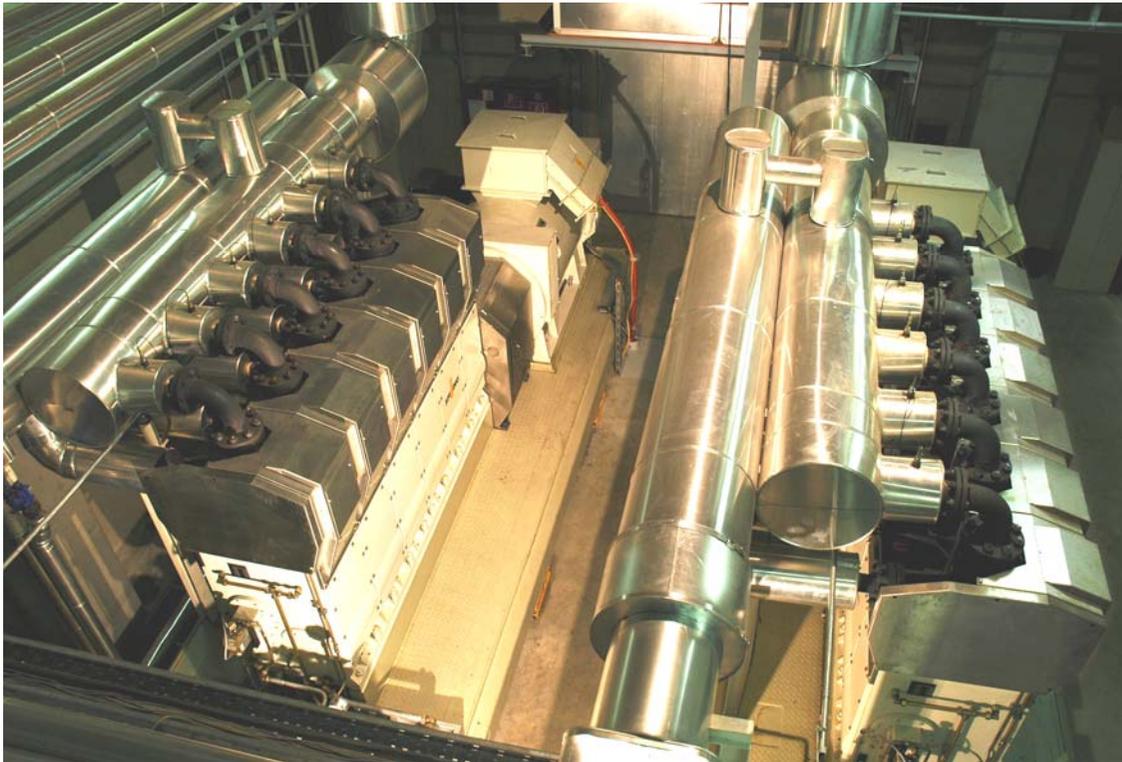
**Exhaust Steam
Utilization for Boiler
Feed Water Preheating
and Space Heating**

El. Output: 514 kWel

Live Steam Data: 11 t/h / 8 bar / Saturated

Steam Outlet Pressure: 0,5 barg

Example 2



**Wood Industry
Wood Residues Fired
Boiler Plant
(Austria)**

**Exhaust Steam
Utilization for Process
and Drying Kilns**

El. Output: 2 x 1.000 kWel
Live Steam Data: 2 x 24 t/h / 60 bar / Saturated
Steam Outlet Pressure: 11 barg

Example 3



**Remote Power
Generation for
Saw Mill
(Congo)**

**with Wood fired
Steam Boiler**

| | |
|-------------------------------|--------------------------------|
| El. Output: | 700 kWel |
| Live Steam Data: | 9 t/h / 25 bar / 250 °C |
| Steam Outlet Pressure: | 0,5 barg |

Example 4



**Power Generation
in a
Saw Mill
(Australia)**

**with Wood Fired
Steam Boiler**

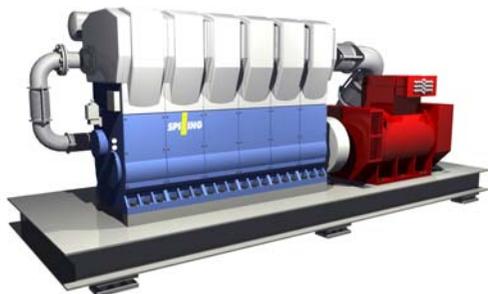
El. Output: 425 kWel

Live Steam Data: 5,5 t/h / 34 bar / dry sat.

Steam Outlet Pressure: 1,0 barg

Spilling Steam Engines suit perfect in small scale co-generation applications with ...

- typical output range from 100 to 1.000 kWel
- fluctuating live steam conditions
- variable steam flow rates
- moderate live steam parameters





Thank you very much for your attention!