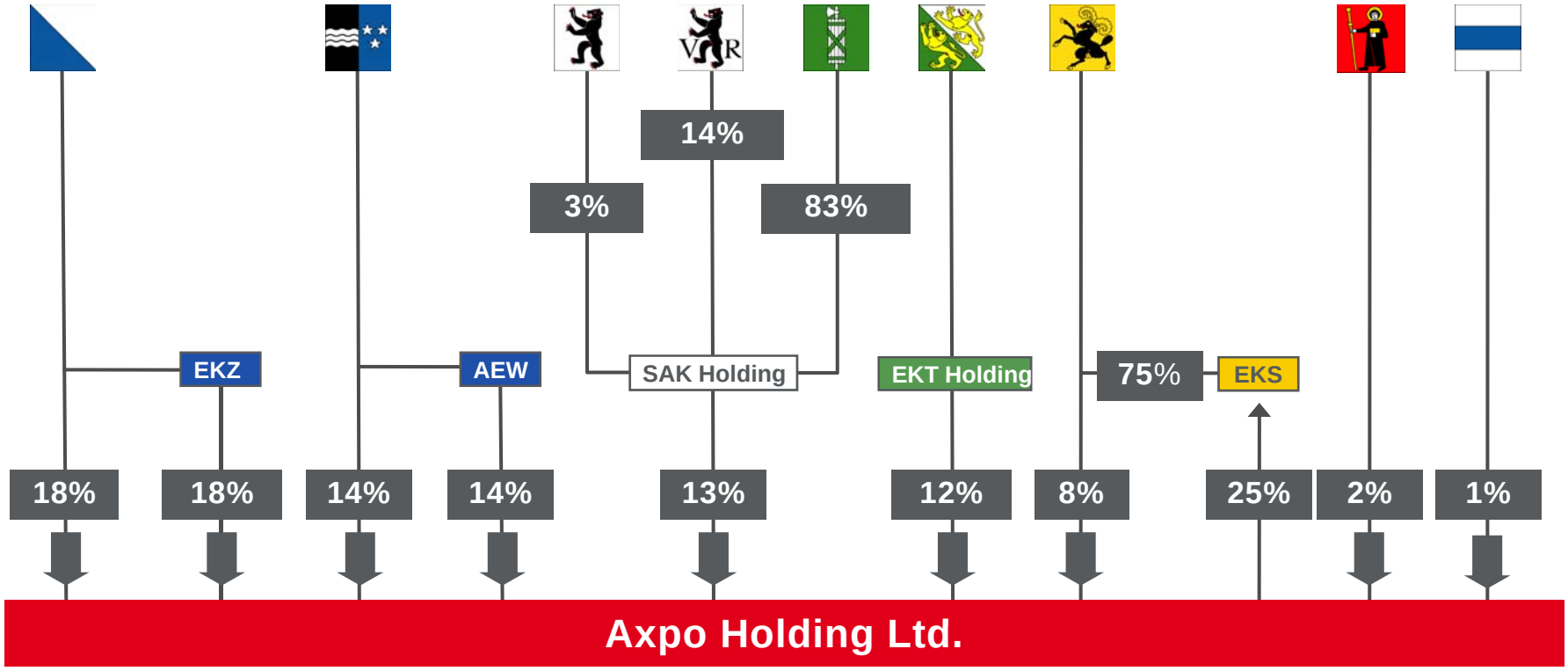
Experience of operating nuclear district heating in Switzerland

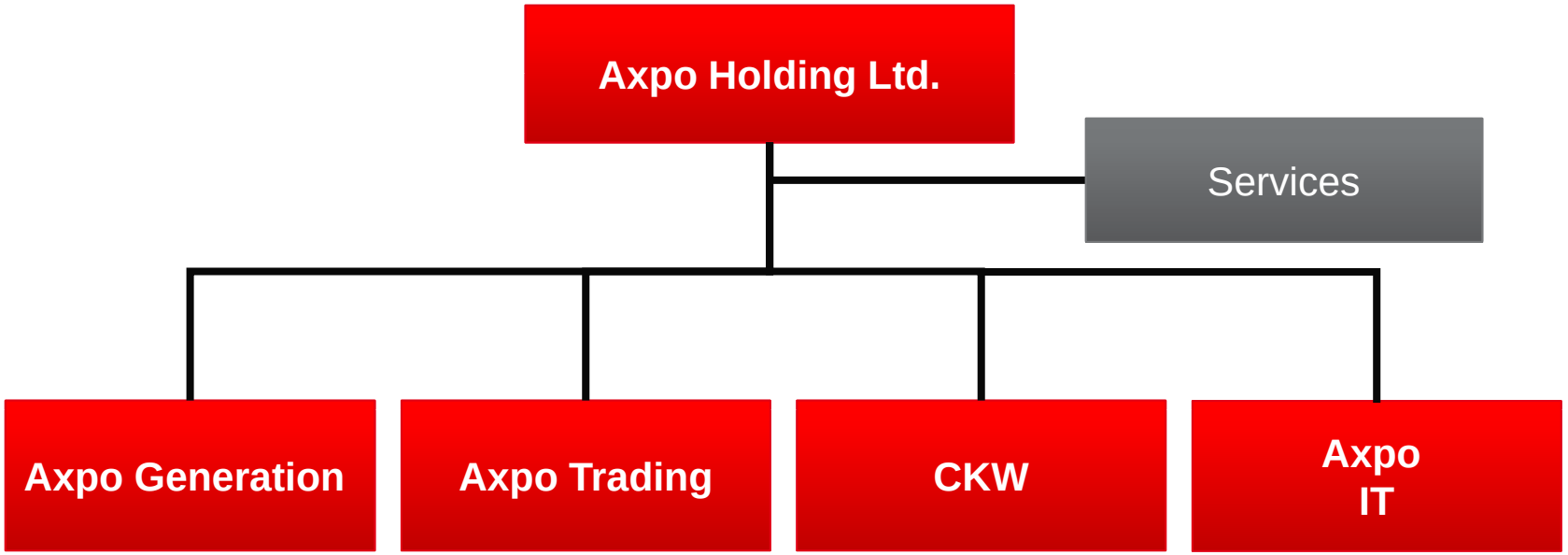
Technical & Economic Assessment of Non-Electric Applications Of Nuclear Power, 4 – 5 April 2013

Roland Schmidiger, Head of Asset Management Nuclear Power Division

Axpo Group – 100% in Public Ownership



Group structure



Speaker

- **Roland Schmidiger, Axpo Power AG**
  Head of Asset Management Nuclear Power Division,
  Member of the Executive Management Team
- **MSc EE ETHZ / MBA (BWI) ETHZ**
- **married, 2 children**
- **Hobbies: family, skiing**

Content

- NPP in Switzerland
- Suitability of NPPs as District Heating Suppliers
- Nuclear Safety in Heat Supply
- Economical Aspects
- NPP District Heating vs. CO_2 Emission Reduction Targets

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NPPs in Switzerland

NPP Beznau
2 x 365 MWe
1969 & 1971

PWR
Westinghouse
„2-loop“

NPP Gösgen
970 MWe
1979

PWR
KWU „Vor-Konvoi“

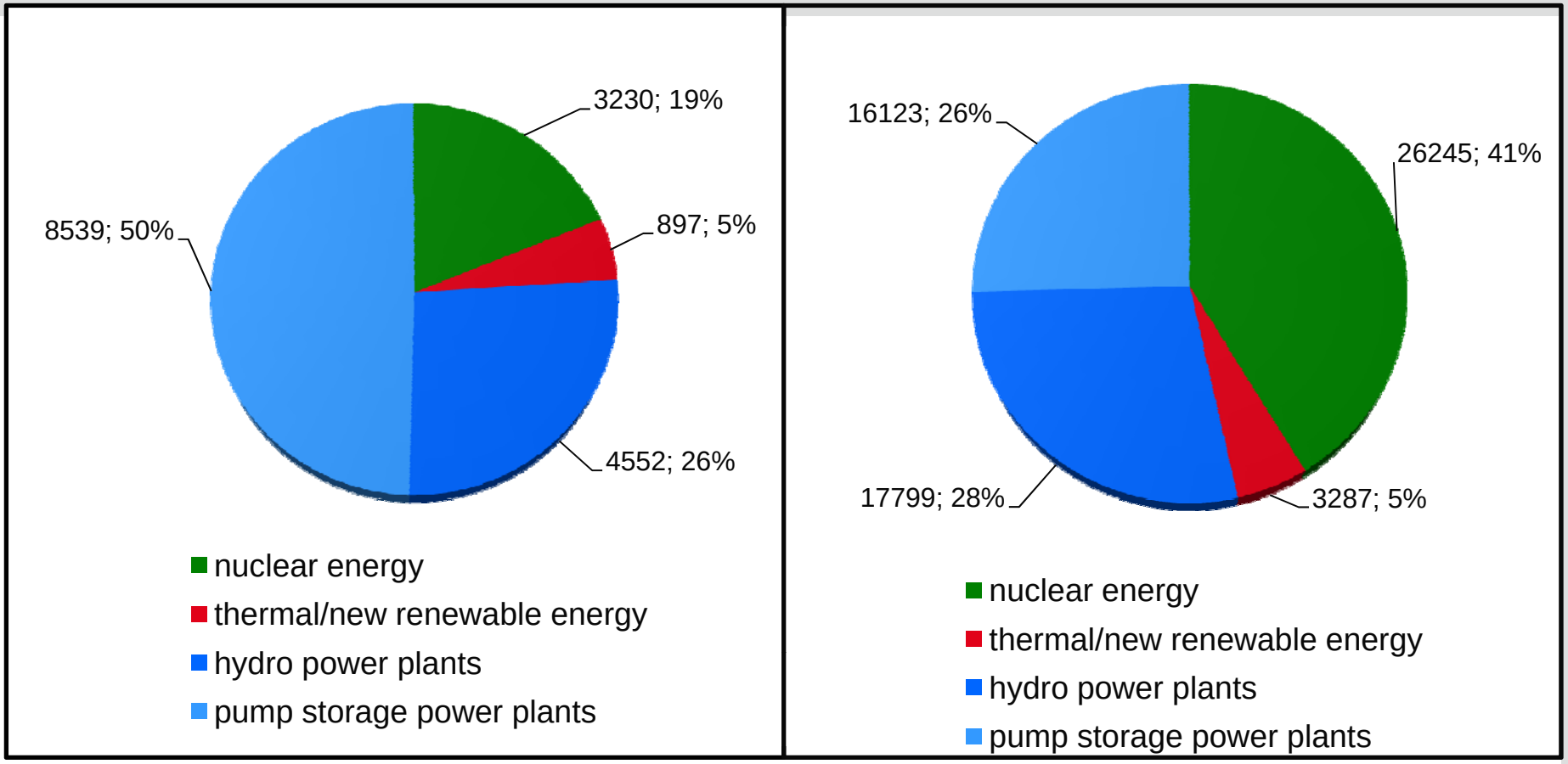
NPP Leibstadt
1190 MWe
1984

BWR
GE BWR 6

NPP Mühleberg
373 MWe
1972

BWR
GE BWR 4

Background: Swiss Generation Portfolio



Quelle: Axpo Analysis 2007/8, Schweizerische Elektrizitätsstatistik BfE

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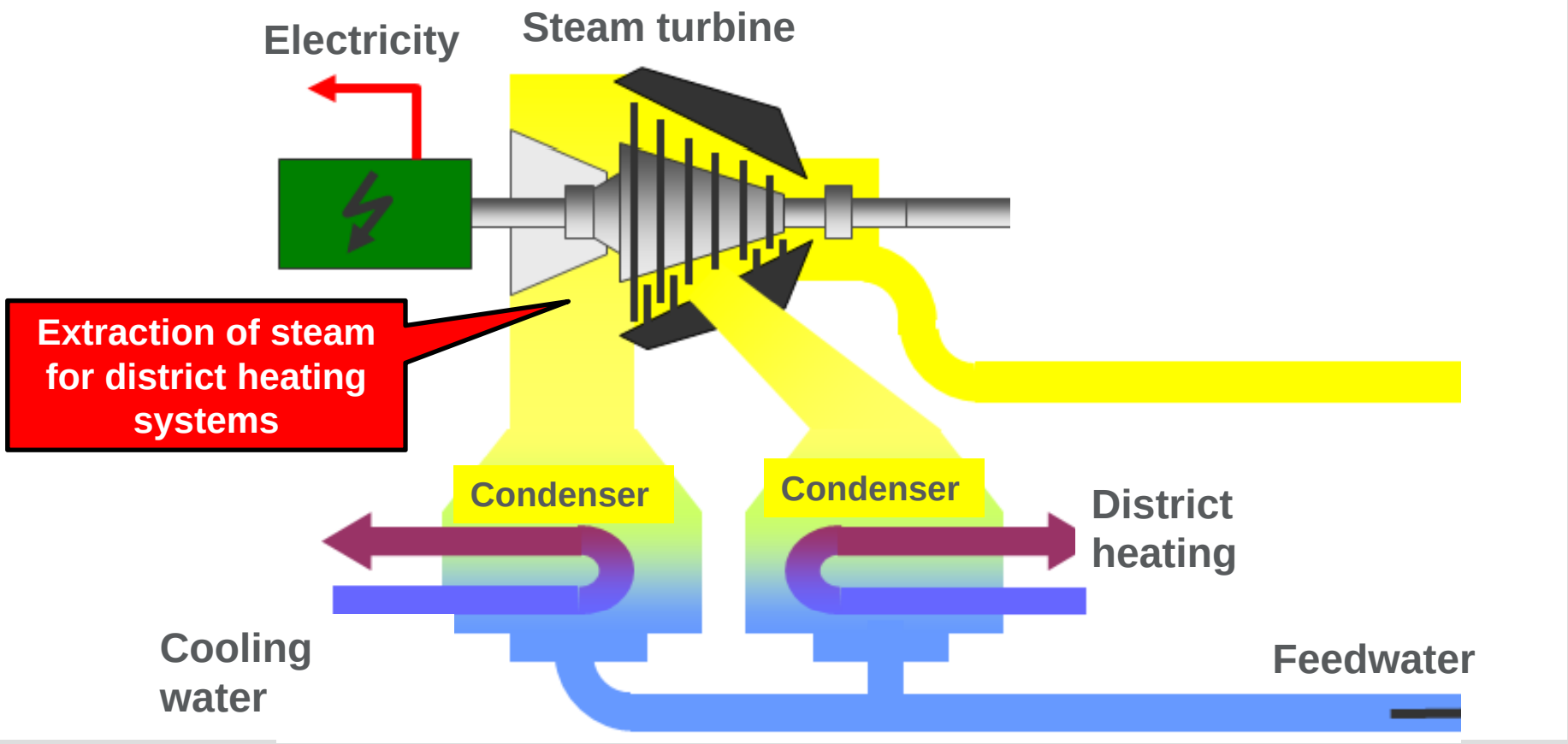
Nuclear power plants are thermal power plants

- Nuclear power plants are – as all thermal power plants which are used to produce electricity – generally suitable for heat extraction.
- Positive effect: the utilization of the fuel is improved, which is more important for fossil-fueled thermal plants than for nuclear power plants.
- Necessary investments for a heat extraction in a nuclear power plant are low compared to the total investment (if built during construction of the NPP).
- Worldwide, NPPs are not often used as heat suppliers.

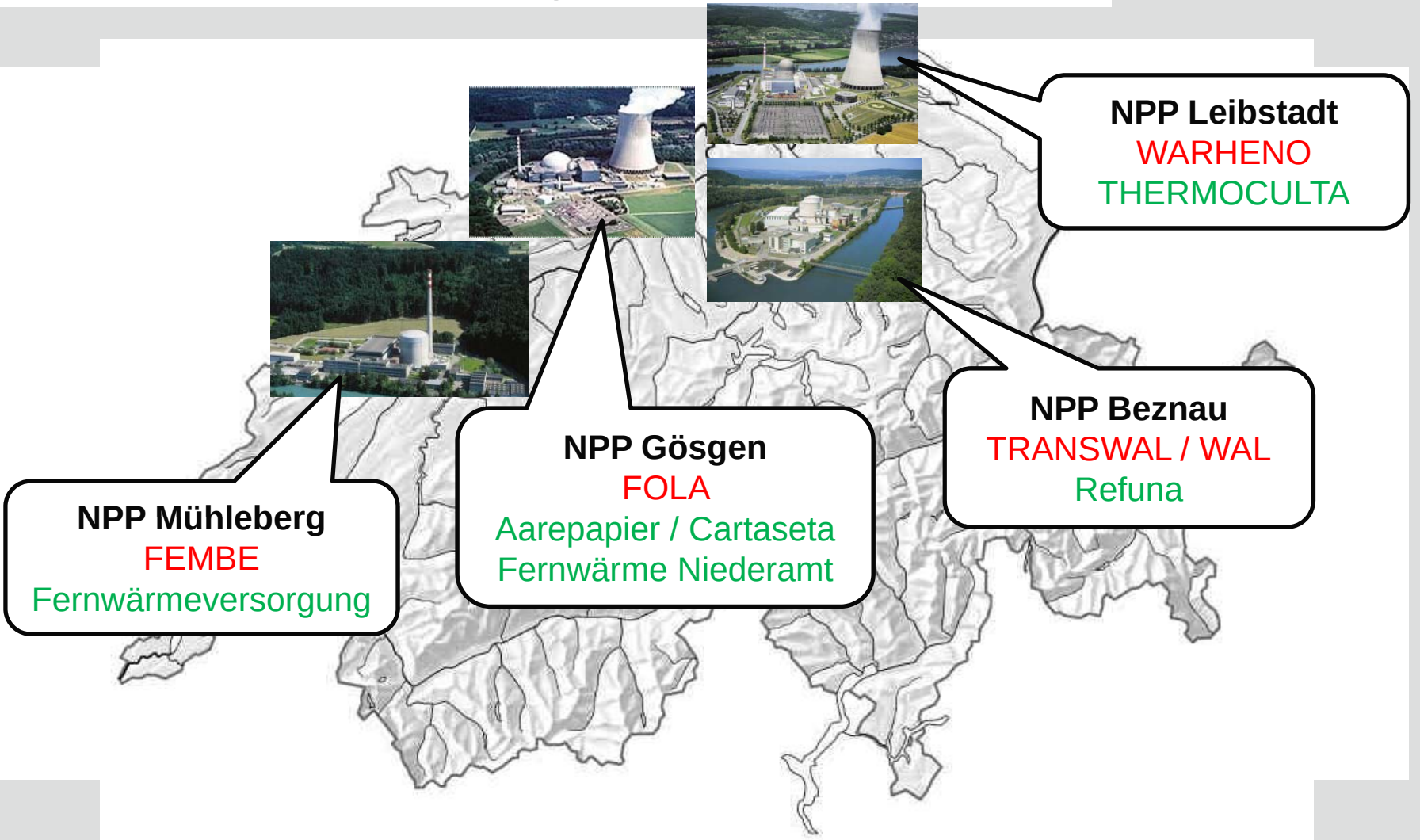
Nuclear power plants are thermal power plants



NPPs and district heating – Projects in Switzerland

NPP	Project	Remark	Status
Mühleberg	FEMBE		not realized
	District heating system	comfort heat	realized
Beznau 1 + 2	Transwaal		not realized
	Refuna	comfort heat	realized
Leibstadt	WARHENO		not realized
	THERMOCULTA	residual heat	realized
Gösgen	FOLA		not realized
	Aarepapier / Cartaseta	process steam	realized
	Fernwärme Niederamt	comfort heat	realized

NPPs and district heating – Projects in Switzerland



NPPs and district heating – Projects in Switzerland

TRANSWAL

not realized

- approx. 60 km of main lines
- Connected load 485 MW (up to 750 MW)
- Whereof 270 MW base load from Beznau NPP
- projected prices (1986) 6.5-8.4 Rp./kWh
- follow-up project WAL

Source: PSI presentation

NPPs and district heating – Projects in Switzerland

FOLA

not realized

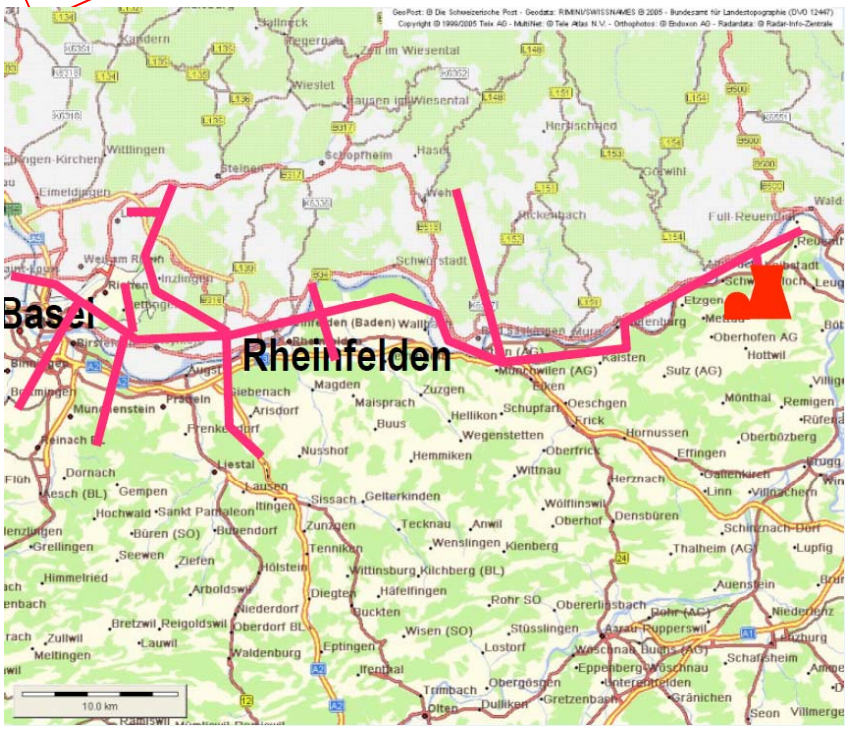
Source: PSI presentation

- 20 km main lines
- Connected load 175 MW
- Whereof 150 MW base load from Gösgen NPP
- projected prices (1986) 6.5-8.2 Rp./kWh

NPPs and district heating – Projects in Switzerland

WARHENO

not realized



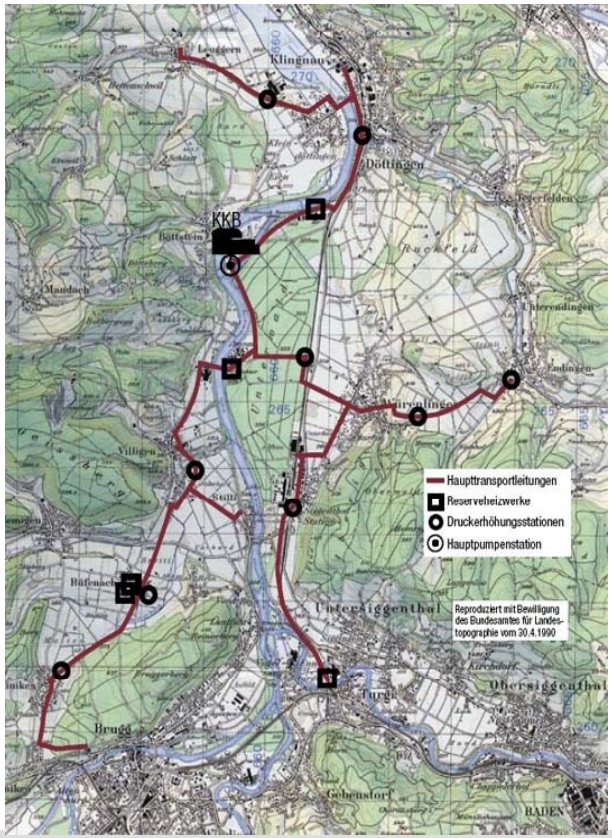
Source: PSI presentation

- approx. 100 km main lines
- Connected load 792 MW
- Whereof 396 MW base load from Leibstadt NPP
- projected prices (1986) 7.5-10.5 Rp./kWh

NPPs and district heating – Projects in Switzerland

REFUNA – District Headting System out of Beznau NPP

realized



heat supply (MWh)	2006/07	2005/06
Independent local networks	75‘136	89‘172
Customer distribution	33‘578	37‘634
Special contract customers	12‘928	15‘013
Total	**121‘642**	**141‘819**

Customer	2006/07
Home connections in operation	2‘425
Industrial customers	7
Total	**2‘432**

REFUNA district heating – facts and figures

- Heating without CO_2 emissions since 25 years.
- More than 2 million megawatt hours heat replaces approximately 200 million liter fuel oil. Nearly 8500 fuel trucks would have been necessary to transport these quantities, while producing 600‘000 tons of additional CO_2.
- 31 km backbone (high pressure system); 101 km distribution system.
- Connected load 76 MW_{th} (max.).
- 142 GWh of heat sold per year -> avoids approx. 46‘000 t CO_2.
- Initial financial difficulties have been overcome by a recapitalization in 2001.
- Competitive compared to gas and oil, even without CO_2-taxes.

NPPs and district heating – Projects in Switzerland

Utilization of residual heat from Leibstadt NPP

realized

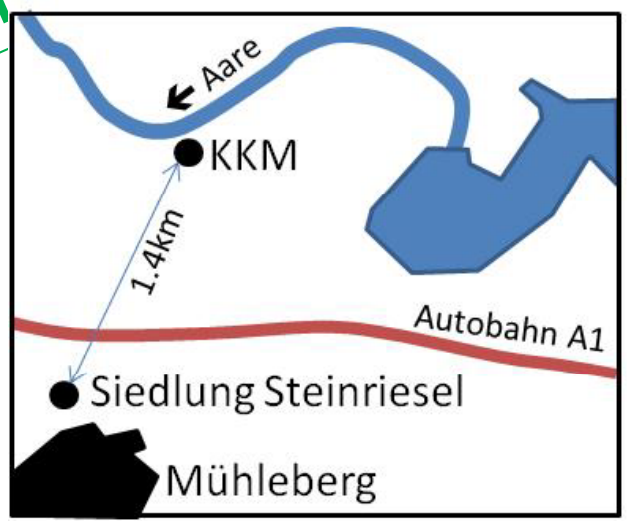
Garden center Leuenberger‘s THERMOCULTA using warm water from the cooling tower

Gardening Leuenberger Leibstadt

NPPs and district heating – Projects in Switzerland

district heat extraction from Mühleberg NPP

realized



Technical data

• Consumption 2008	1‘700 MWh_{th}
• Temp. central heating	125/65 °C
• Temp. district heating	125/75 °C
• Flow rate	4.4 l/s
• Length of the line KKM → Steinriesel	2 km

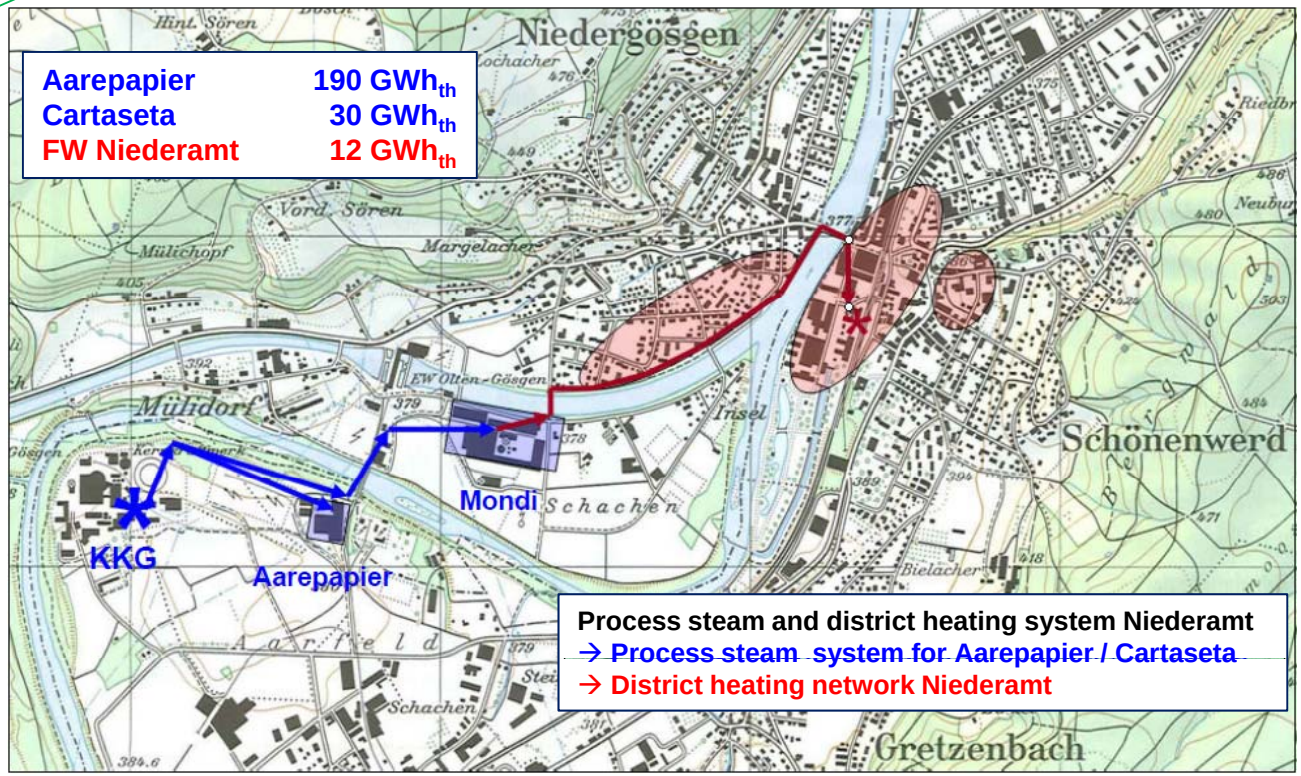
Description

- District heat extraction to heat KKM office building as well as BKW‘s Steinriesel residential area
- Heat extraction takes place between the high and low pressure turbine
- In case of failure an auxiliary boiler is used to supply heat to the system

NPPs and district heating – Projects in Switzerland

Process heat from Gösgen NPP

realized



District and process steam from Gösgen NPP

	COD	technology	power	energy
Process steam system Aarepapier	1979	12 bar	50 MW_{th}	190 GWh/a
Process steam system Cartaseta	2009	15 bar	7 MW_{th}	30 GWh/a
District heating network Niederamt	1996	120/70°C	12 MW_{th}	12 GWh/a

Quelle: Alpiq

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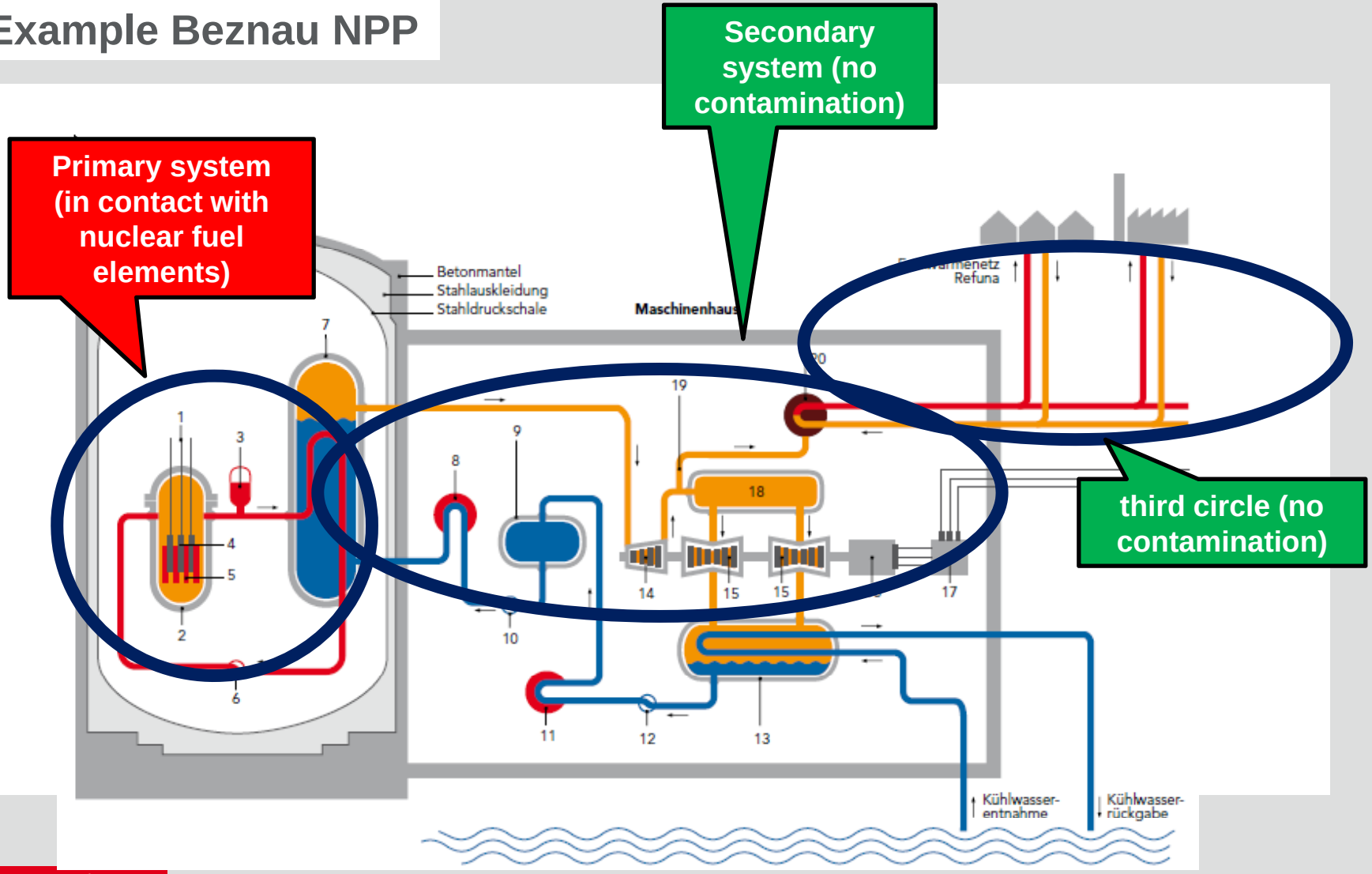
Nuclear safety in heat supply

Example Beznau NPP



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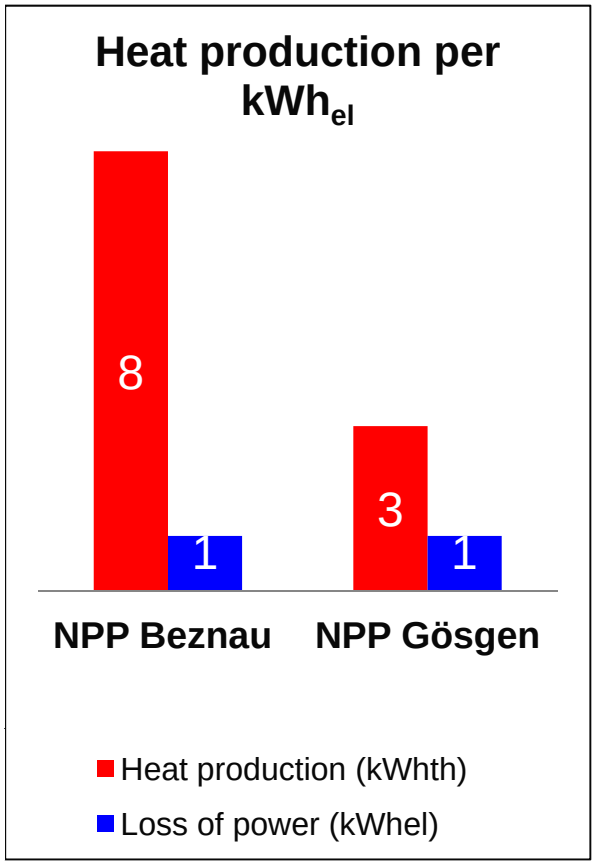
Lost electricity due to heat extraction

Loss of electricity production due to heat/steam extraction depends on pressure and temperature.

Approaches to assess value of heat:

- Opportunity costs of power plant operators
- Opportunity costs of district heating network operators



Lost electricity due to heat extraction

Illustrative example

Calculation from the perspective of the power plant operator:

Market price electricity	**8 Rp./kWh$_{el}$**
Lost electricity production (corresponds to the situation of KKB)	**1 kWh$_{el}$/8 kWh$_{th}$**
Opportunity costs for heat (without taking into account capital costs as well as operation and maintenance cost for the heat exchanger)	**1 Rp./kWh$_{th}$**

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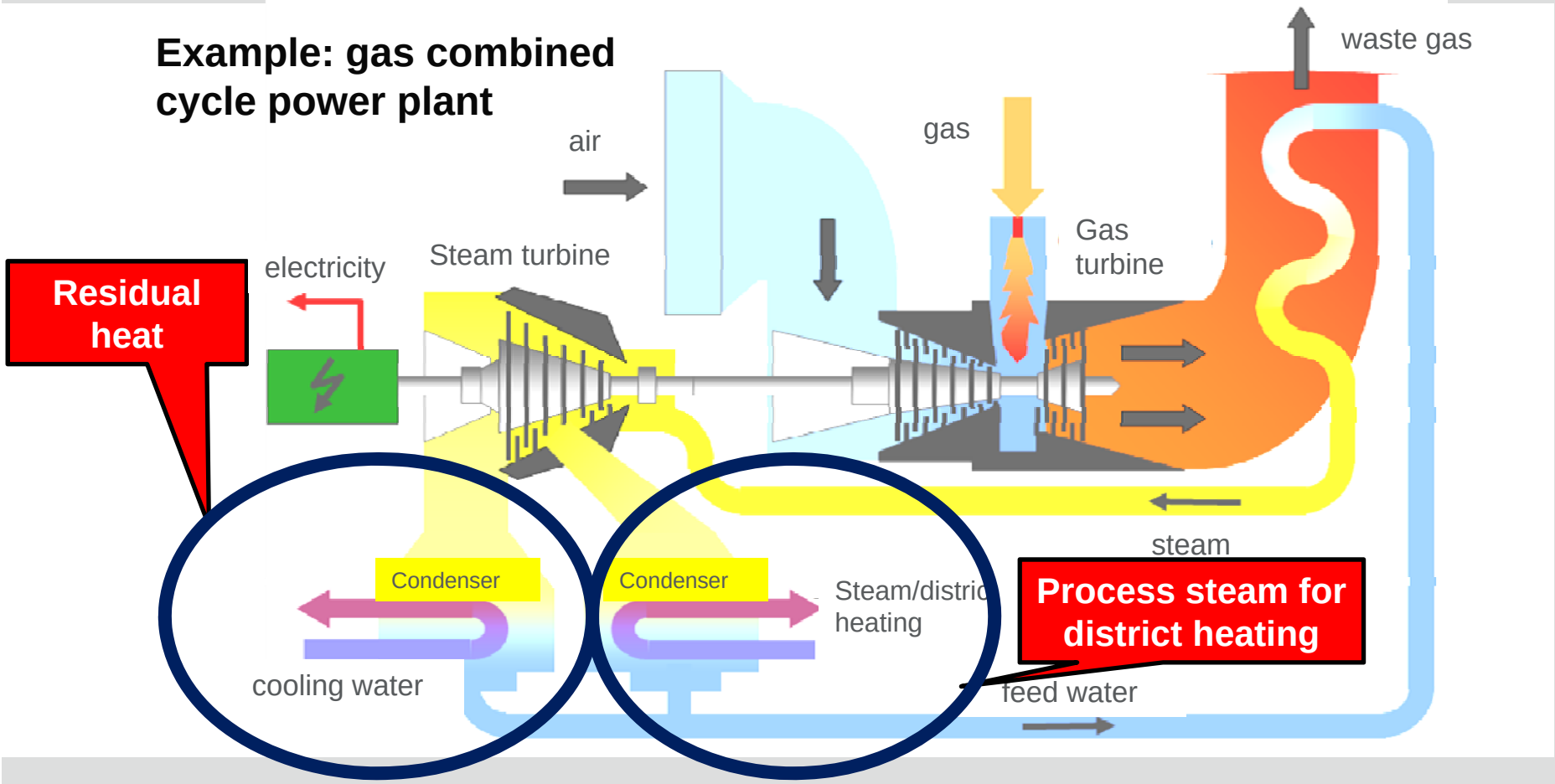
Political claim: utilization of residual heat



Distinction between use of residual heat …

Low temperature: warm water of 25-30 ° C – potential customers:

- Greenhouses (required space approx. 1 ha; 2 MW_{th})
- Production of exotic fruits (required space approx. 1 ha; 2 MW_{th})
- Sport and leisure centers (for each facility 0.2 MW_{th})
- tropical greenhouses (for each facility 2.5 MW_{th})
- fish farms (for each facility of 400m^3 0.2 MW_{th})
- drying of scrap wood (100'000 m^3 timber / year; approx. 10 MW_{th})

Illustration: fish nursery Wolhusen

Illustration: drying of scrap wood

Illustration: Masoala hall at Zürich zoo

… and decoupling of process steam

Decoupling of process steam for:

- District heating system
- Paper factories
- Food production
- chemistry

Illustration: chemistry

Illustration: paper factory

Illustration: district heating network Refuna

Heat from NPPs – a contribution to the solution of the CO_2 problem?

Example REFUNA (70 MW_{th}/140GWh_{th}):

- 10 Mio. liter heating oil per year
- savings of more than 26‘500 t CO_2
- equivalent to the CO_2 emissions of about 12’000 cars every year

Thank you for your attention.

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