CTU

CZECH TECHNICAL UNIVERSITY IN PRAGUE

POWER-TO-HEAT RETROFITS IN CHP PLANTS:

LOW-COST, HIGH-EFFICIENCY ENERGY STORAGE

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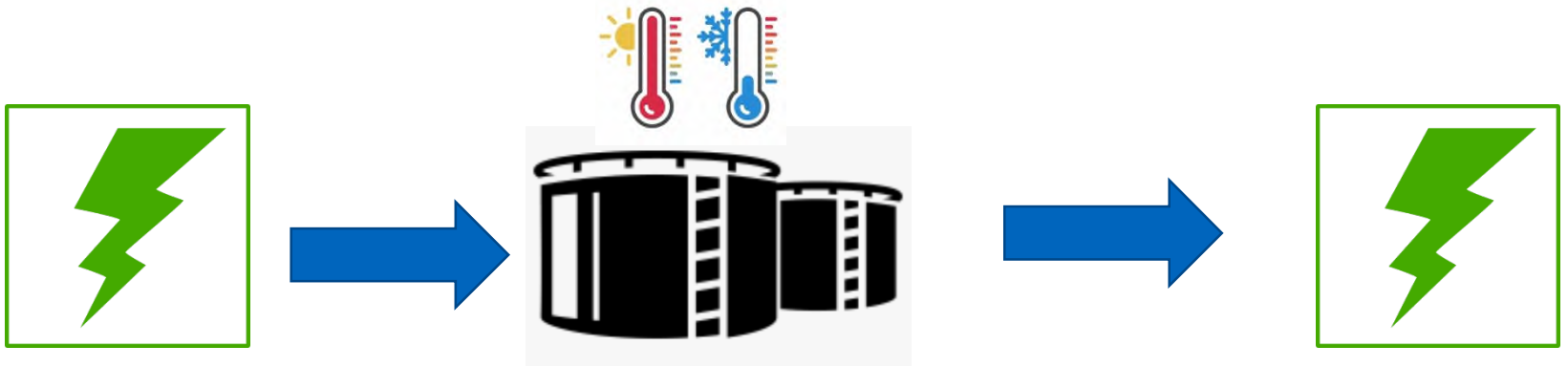
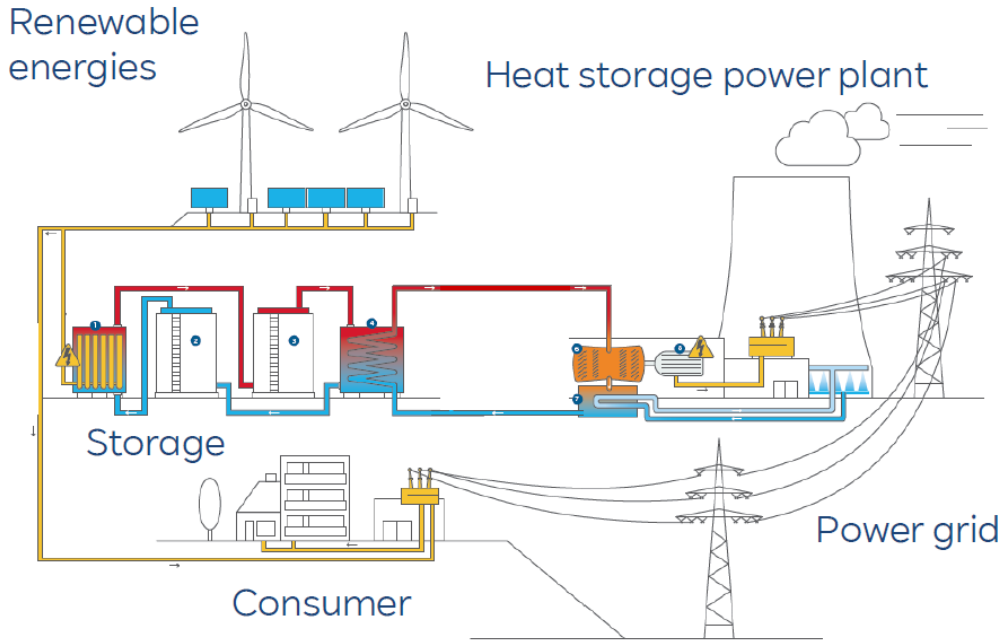
POWER 2 HEAT 2 POWER (P2H2P)



- Prospects of very low per energy costs ($/MWh)
- Issue of efficiency limitations

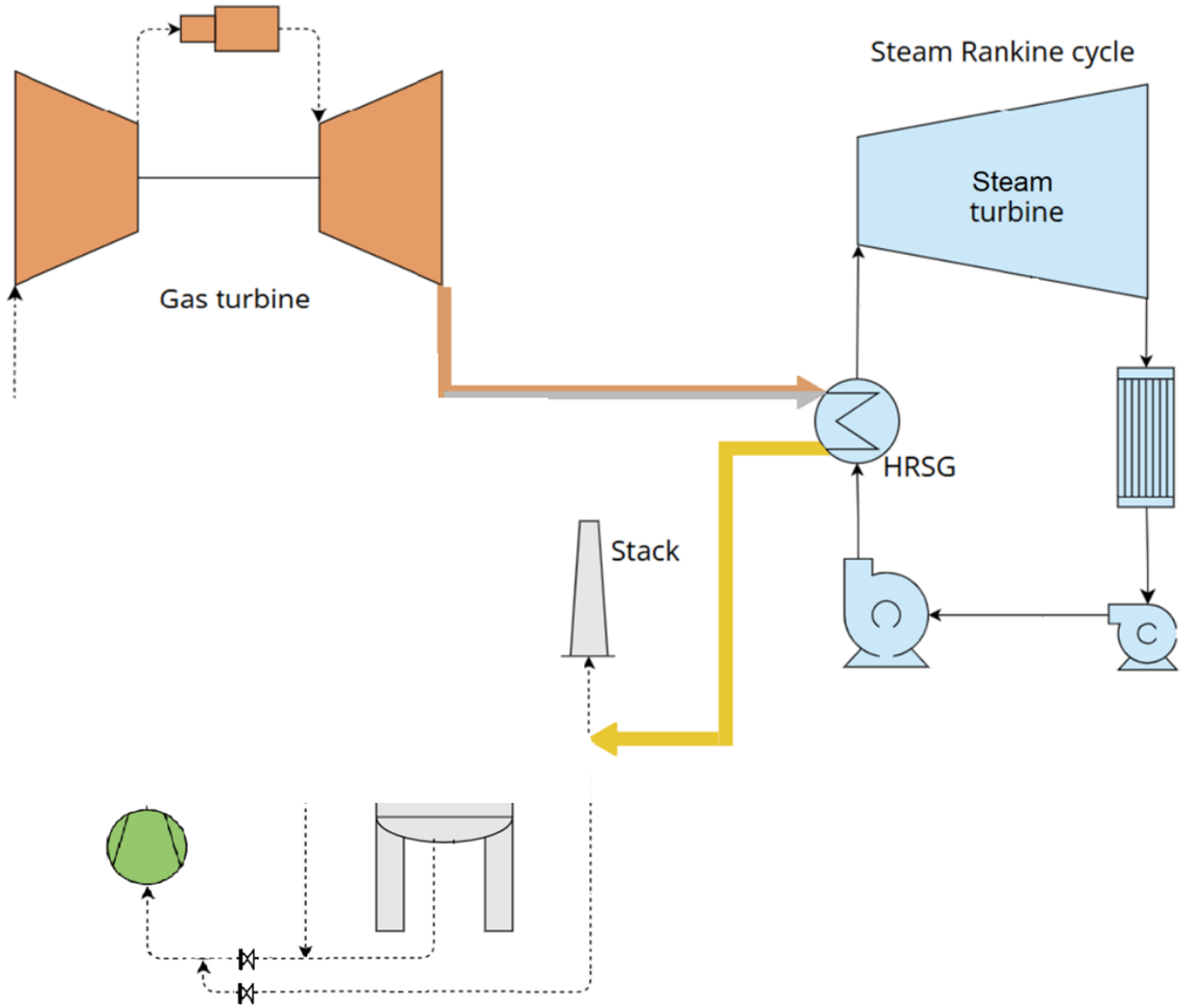
SECOND LIFE FOR COAL PLANTS



(Arnold W., StoreToPower - Pilot plant for the development of a heat storage power plant, 15.09.2020, RWE)

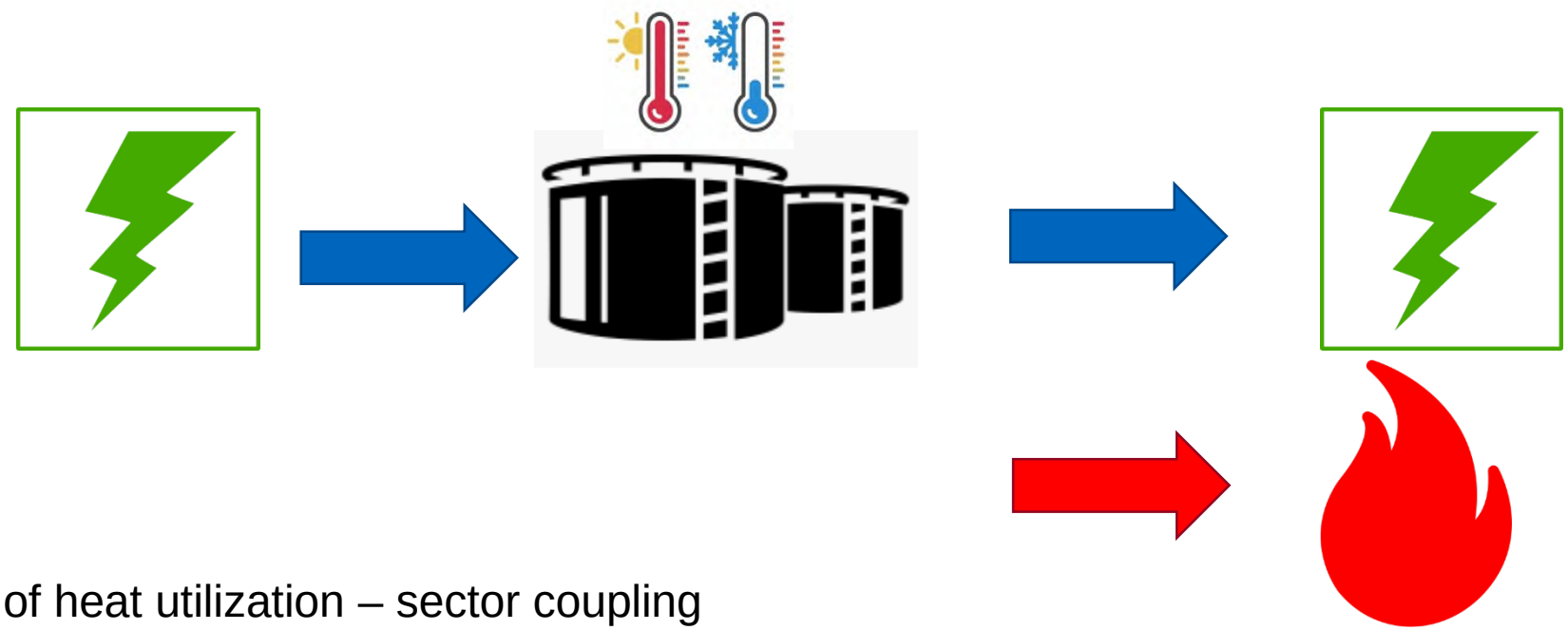
ADDITION OF P2H2P TO CCGT PLANTS

- Compared to coal plant, steam generator already present (HRSG)
  - Even lower integration cost
  - Works well only with packed bed TES



POWER 2 HEAT 2 POWER → P2H2(CHP)

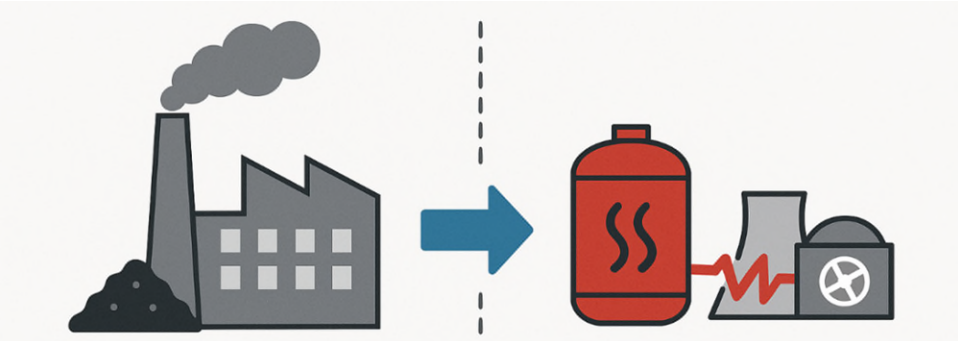
- Fossil power plant conversion – very low roundtrip efficiency



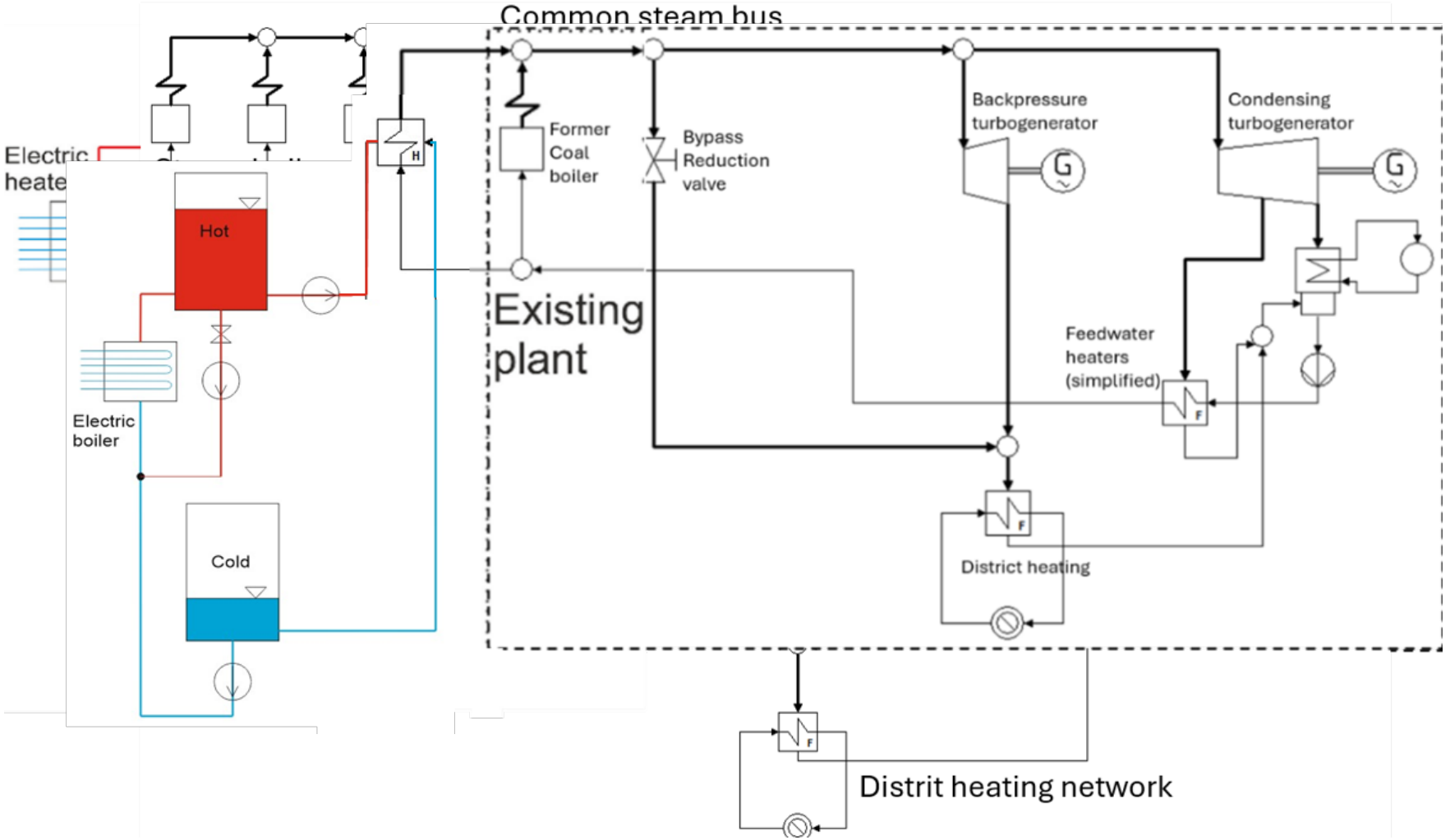
- Addition of heat utilization – sector coupling
  - Can improve economic viability
  - Improves overal efficiency, possibly towards >90% roundrip η

MORE ARGUMENTS FOR CHP PLANTS RETROFIT

- In CEE, major share of population uses district heating (CZ 44%, PL 50%, UA 50%)
- Heat & power station **suitable for early P2H2P retrofits**
  - Benefits of converting larger power plants
  - plus
  - **Demand for heat**
  - **Flexible steam system**
  - **Lower steam *p*, *T* - less costly materials** than for large coal power plants
  - Geographically distributed, smaller capacities (dozens MW)

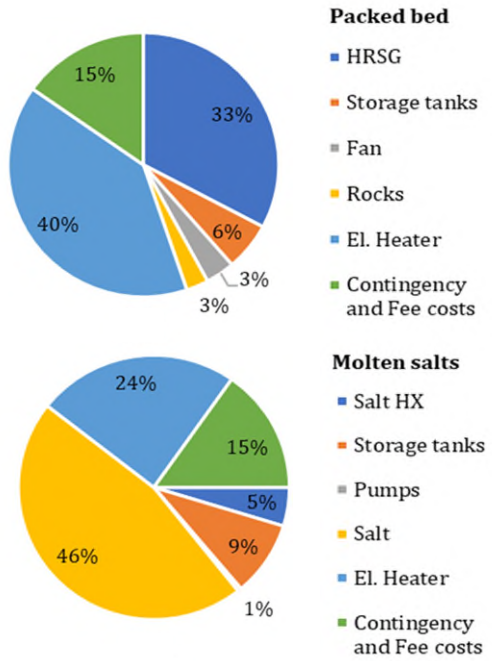


RETROFIT CONFIGURATON FOR COAL CHP PLANT



12 h charge / discharge

Molten Salt	Packed Bed	Unit cost
31	21	$/kWh(CHP)
103	69	$/kWh(el)

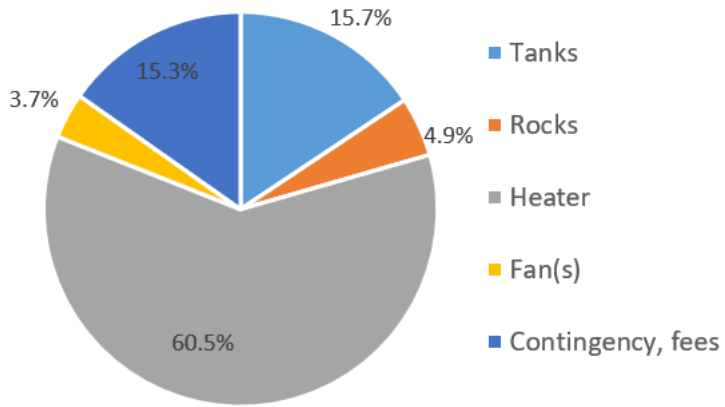


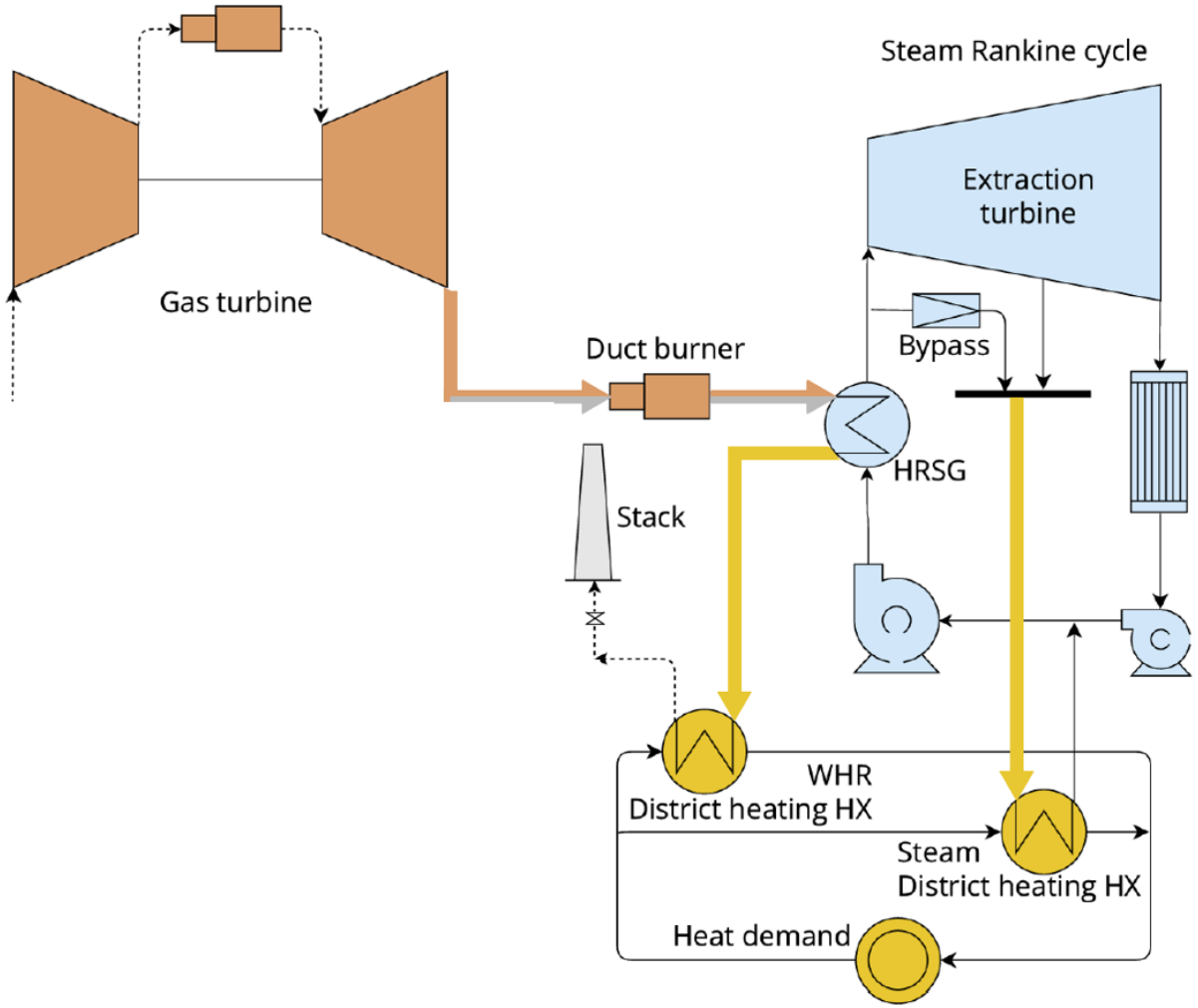
RETROFIT CONFIGURATION FOR CCGT CHP PLANT

- Conversion of CCGT CHP plant
  - TES decoupling GT and bottoming CHP RC
  - Only rock packed bed TES

12 h charge / discharge

Unit cost 41 $/kWh(e), 14 $/kWh(CHP)





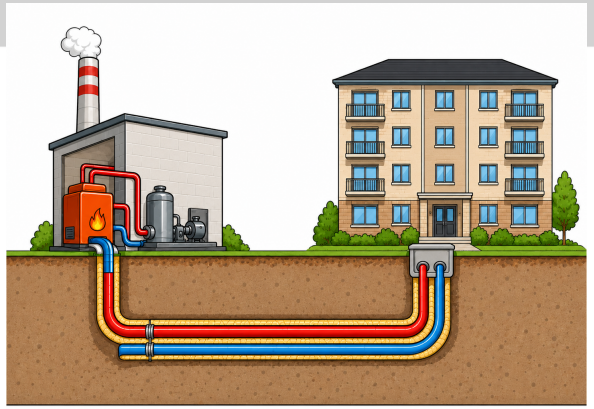
CCGT CHP INTEGRATION ENABLES LARGE NUMBER OF OPERATION MODES

	Mode	Mode description	TES	GT	D. Burn.	El. H	RC	DH
Original CHP CCGT plant	1	GT	OFF	ON	OFF	OFF	OFF	OFF
	2	GT+RC	OFF	ON	OFF	OFF	ON	OFF
	2.1	GT+RC+WHR DH	OFF	ON	OFF	OFF	ON	Low
	2.2	GT+RC(backpres. DH)+WHR DH	OFF	ON	OFF	OFF	ON	High
	2.3	GT+bypass RC(only DH)+WHR DH	OFF	ON	OFF	OFF	ON	High
	2D	Mode 2 + duct burner	OFF	ON	ON	OFF	ON	OFF
	2.1D	Mode 2.1 + duct burner	OFF	ON	ON	OFF	ON	Low
	2.2D	Mode 2.2 + duct burner	OFF	ON	ON	OFF	ON	High
	2.3D	Mode 2.3 + duct burner	OFF	ON	ON	OFF	ON	High
TES charging via GT	3	GT+FG to TES	CHAR	ON	OFF	OFF	OFF	OFF
	3.1	GT+FG to TES+bypass DH	CHAR	ON	OFF	OFF	BYPASS	ON
	3.2	GT+RC(backpres. DH)+WHR DH+FG to TES	CHAR	ON	OFF	OFF	ON	ON
	3.3	GT+RC(no DH)+WHR DH+ FG to TES	CHAR	ON	OFF	OFF	ON	Low
Electric heater	4	El. charge TES	CHAR	OFF	OFF	ON	OFF	OFF
	4.1	El. charge TES+DH	CHAR	OFF	OFF	ON	BYPASS	ON
	4.2	El. to heating	OFF	OFF	OFF	ON	BYPASS	ON
TES discharge to RC	5.1	Disch. TES+RC	DISCH	OFF	OFF	OFF	ON	OFF
	5.2	Disch. TES+RC+WHR DH	DISCH	OFF	OFF	OFF	ON	Low
	5.3	Disch. TES+RC(backpres. DH)+WHR DH	DISCH	OFF	OFF	OFF	ON	High
	5.4	Disch. TES+bypass RC(only DH)+WHR DH	DISCH	OFF	OFF	OFF	BYPASS	High
GT + TES discharge boost to RC	6.1	GT+discharge TES+RC(boost instead of DB)	DISCH	ON	OFF	OFF	ON	OFF
	6.2	GT+discharge TES+RC+WHR DH	DISCH	ON	OFF	OFF	ON	Low
	6.3	GT+discharge TES+RC(backpres. DH)+WHR DH	DISCH	ON	OFF	OFF	ON	High
	6.4	GT+discharge TES+bypass RC(only DH)+WHR DH	DISCH	ON	OFF	OFF	BYPASS	High

GT	Gas turbine
RC	Steam Rankine cycle
WHR	Waste heat recovery
DB	Duct burner
DH	District heating
TES	Thermal energy storage
El. H.	Electric Heater

PROSPECT FOR US MARKET?

- Indeed not many residental district heating networks



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- But many industrial CHP systems
  - GT – HRSG – process steam
  - Retrofit can
    - Brings more flexibility
    - Absorb electricity at low or negative cost
    - Reduce gas consumption, especially duct firing

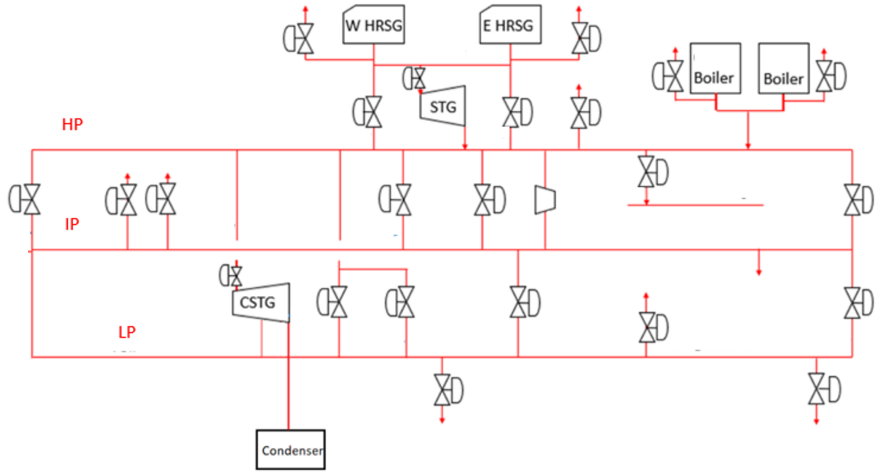

Figure from: Mikkelson, Daniel Mark, et al. *Nuclear Technology Selection and Preliminary Integration at St. Charles and Carrollton Chemical Plants*. No. INL/RPT--24-78505. Idaho National Laboratory (INL), Idaho Falls, ID (United States), 2024.

FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

UNIVERSITY CENTRE FOR ENERGY EFFICIENT BUILDINGS CTU IN PRAGUE

QUESTIONS?

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