Energieffektivisering i industrien

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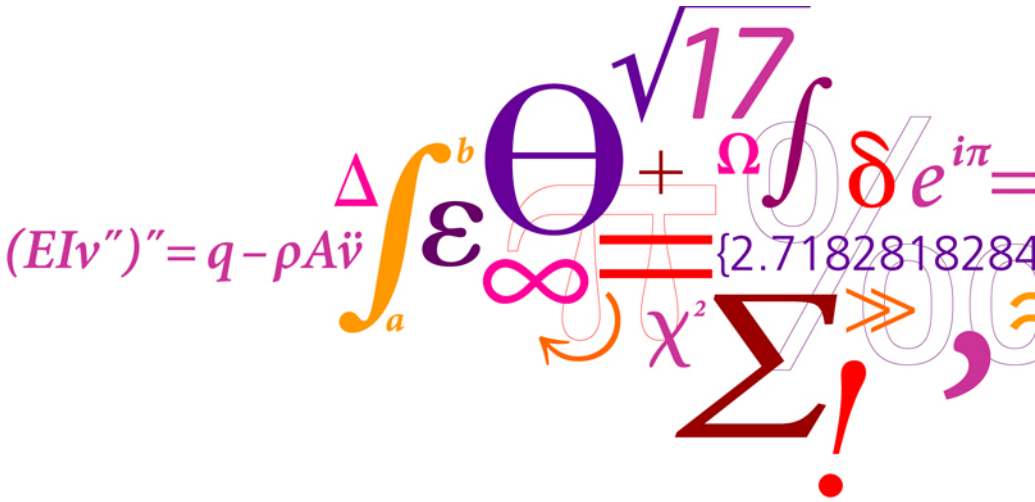
DTU Mekanik

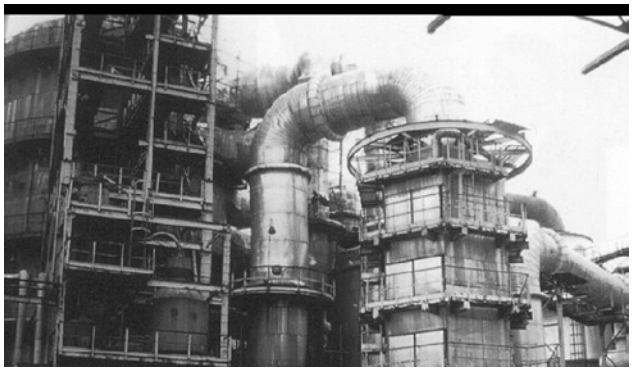
Teknologisk Institut
Århus
2. Marts 2015

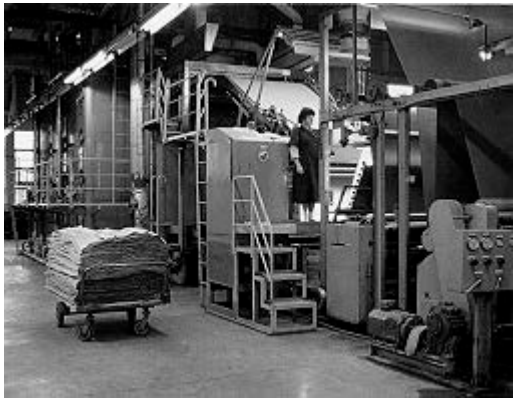


DTU Mekanik
Institut for Mekanisk Teknologi

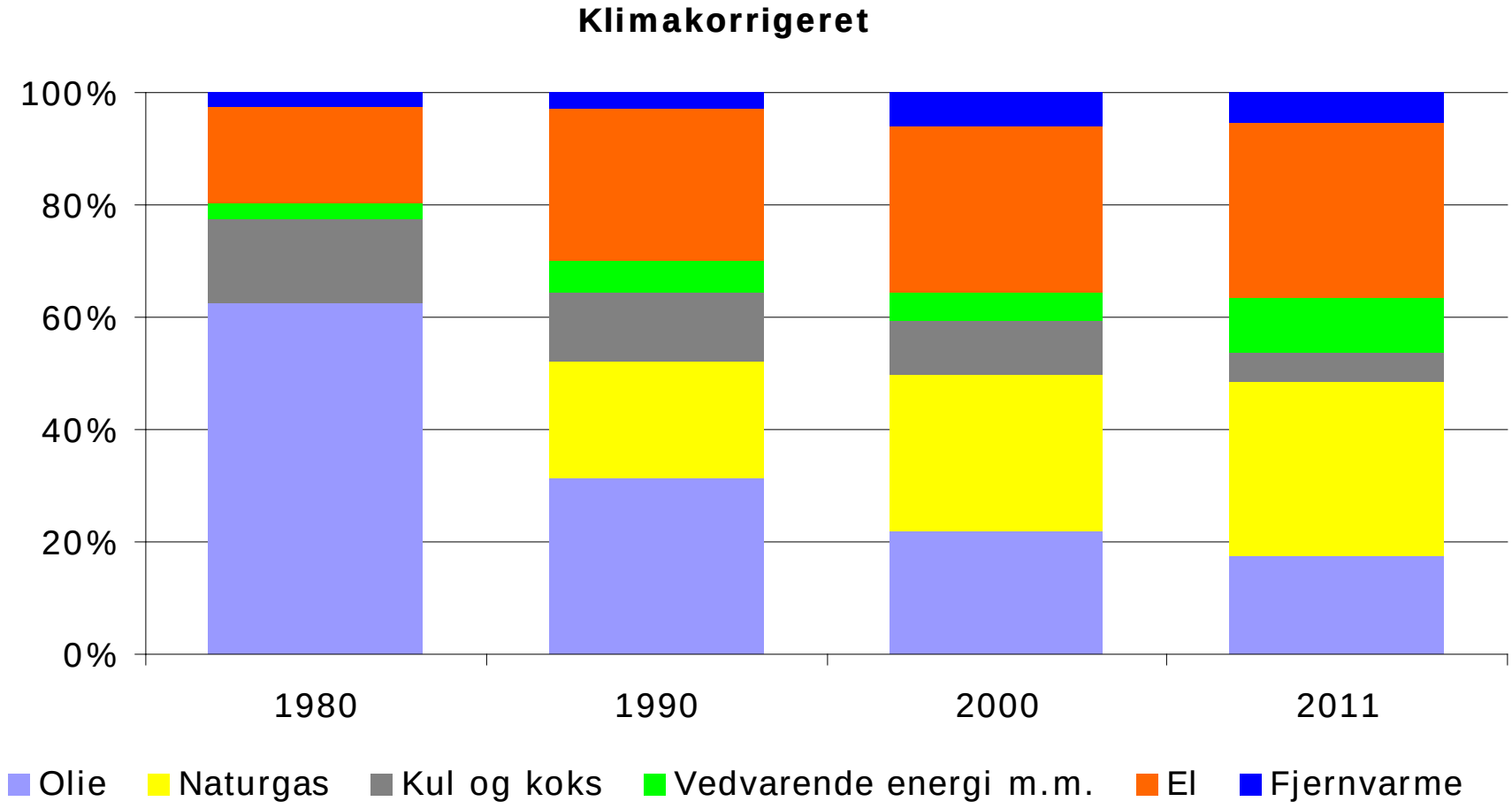
Indhold

- **Potentielle besparelser**
  - **Udnyttelse af overskudsvarme**
- Analyseværktøjer
  - Muligheder
  - Udfordringer
- Varmepumper





Energiforbrugets sammensætning i fremstillingsvirksomhed



Ref: Energistatistik, Energistyrelsen, 2012

THERMCYC Projektet

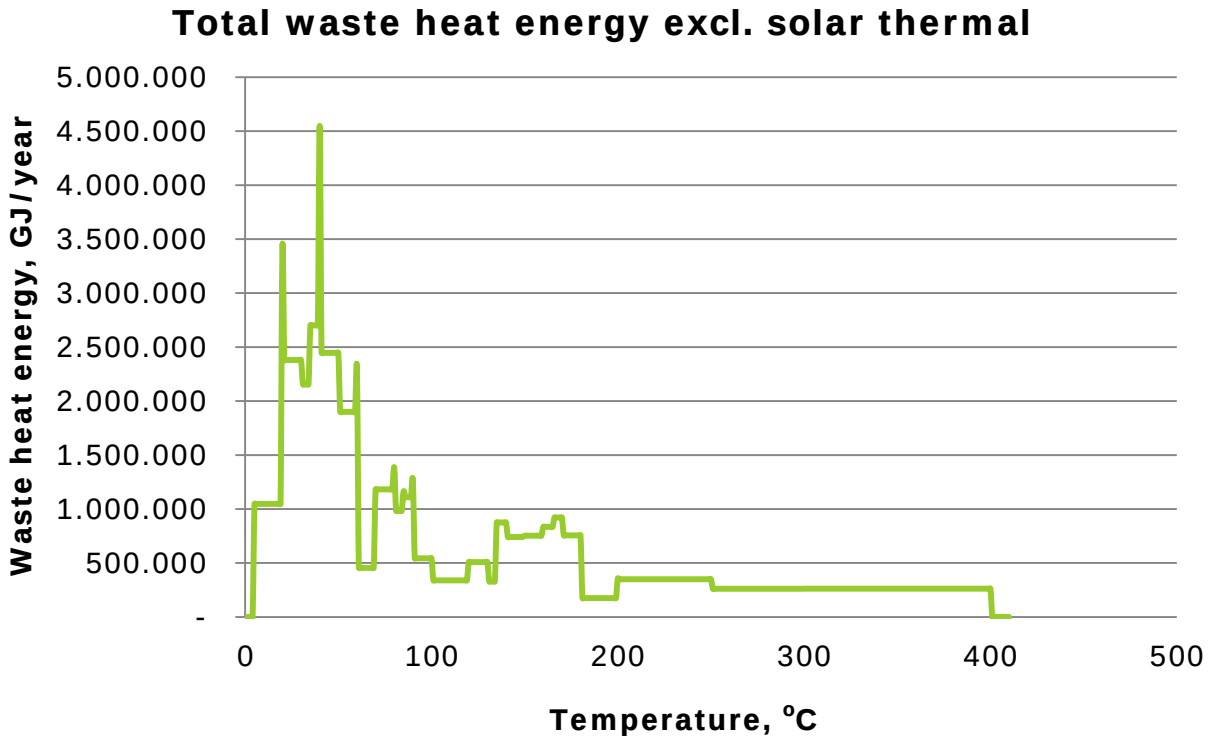
Marts 2014 – Februar 2019

Hypotese

Low-temperature heat sources are available in **many applications**, ranging from waste heat from marine diesel engines, industries and refrigeration plants to biomass, geothermal and solar heat sources.

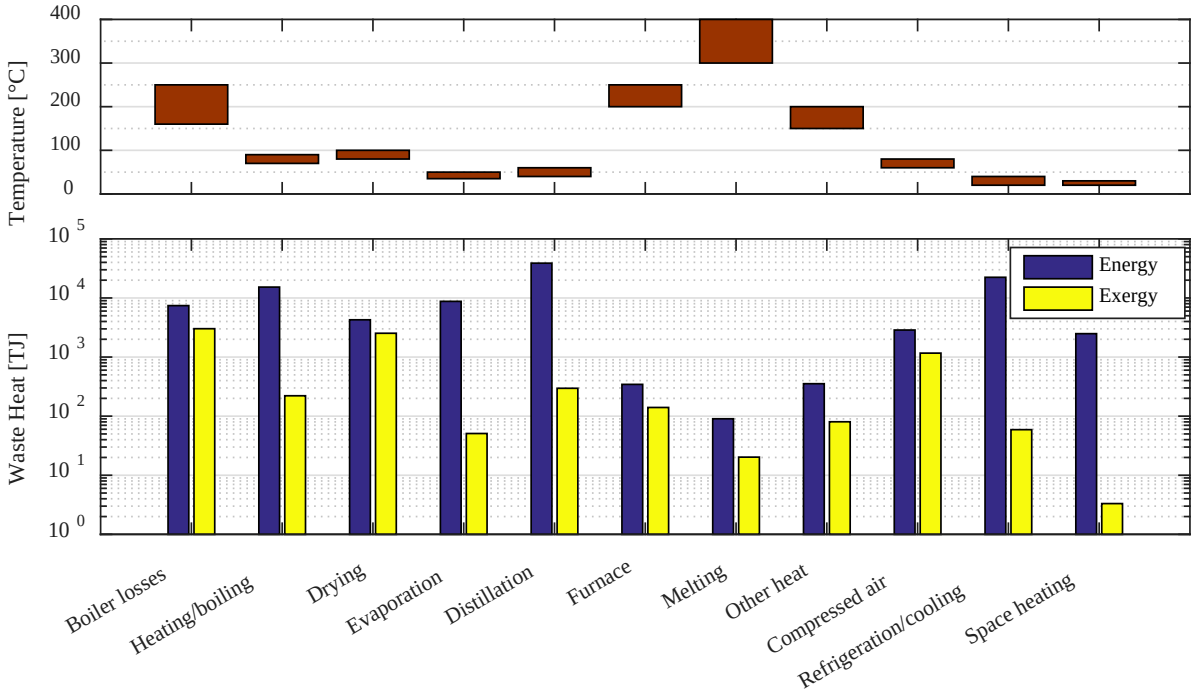
Great **potential for enhancing the utilization** of these heat sources by **novel cycle and component design** and use of **working fluid mixtures**."

Potentiel lavtemperatur varme 245 TJ/y



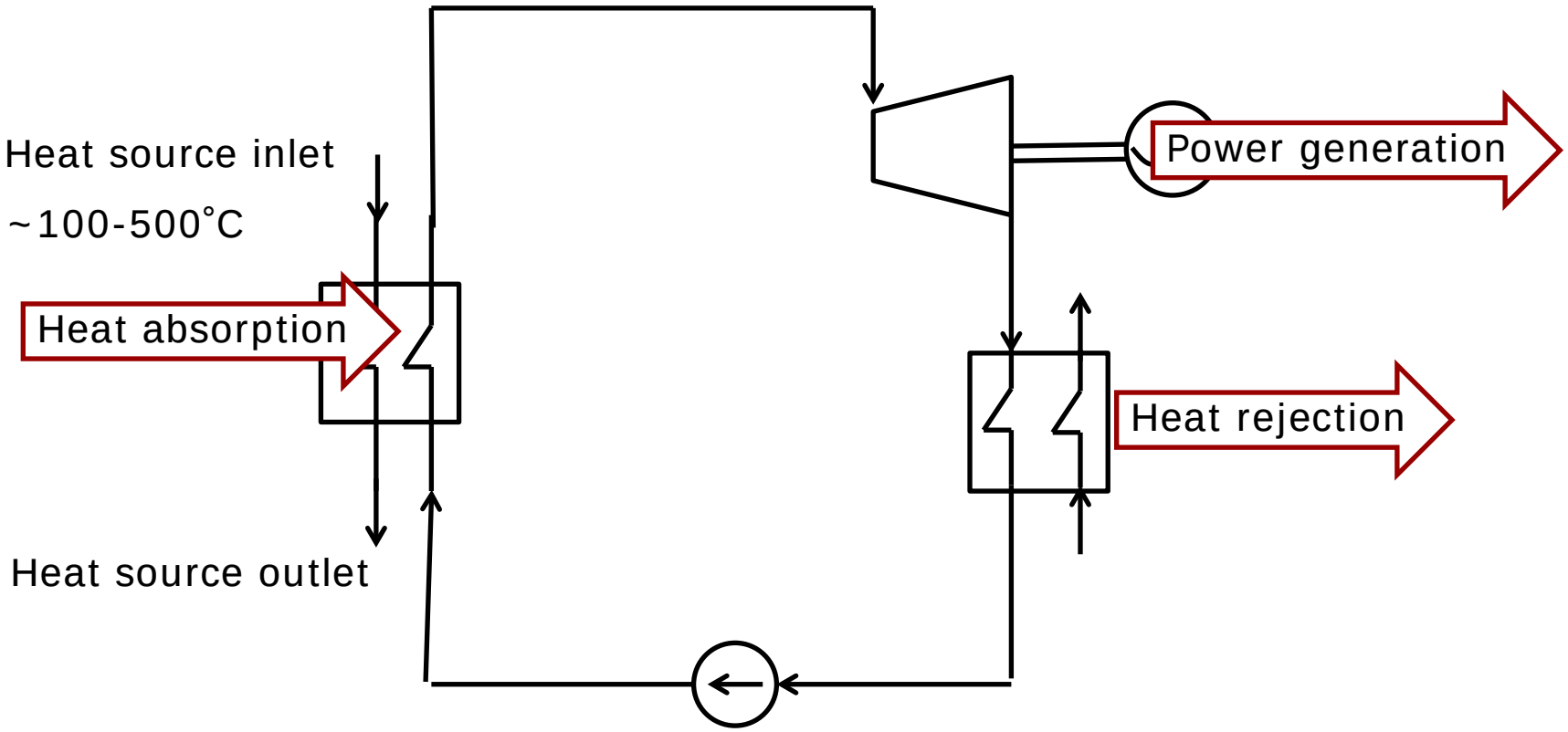
Ref: Huang et al "Industrial Energy Mapping – THERMCYC WP6", 2014

Potentiale for varmegenvinding

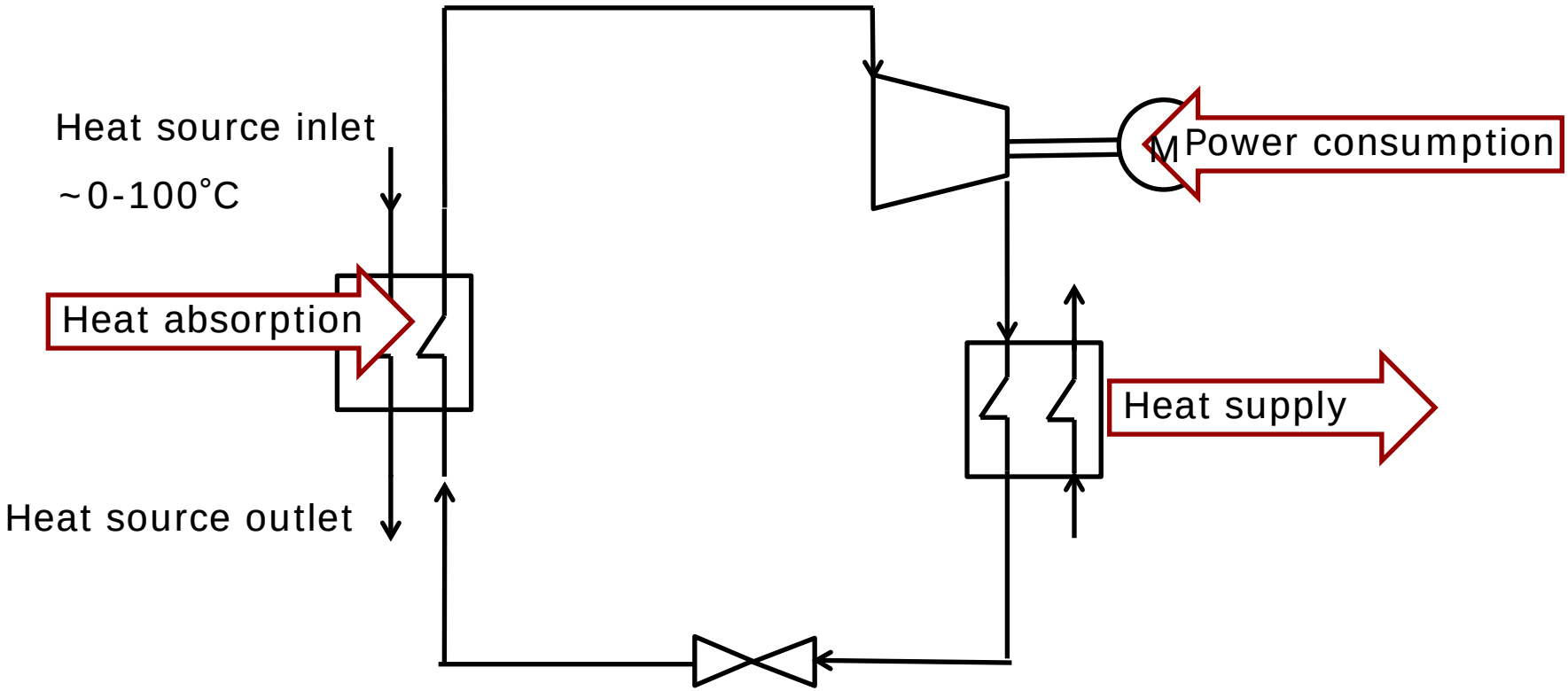


Ref: Bühler et al ”Mapping of low temperature heat sources in Denmark” indsendt til ECOS 2015

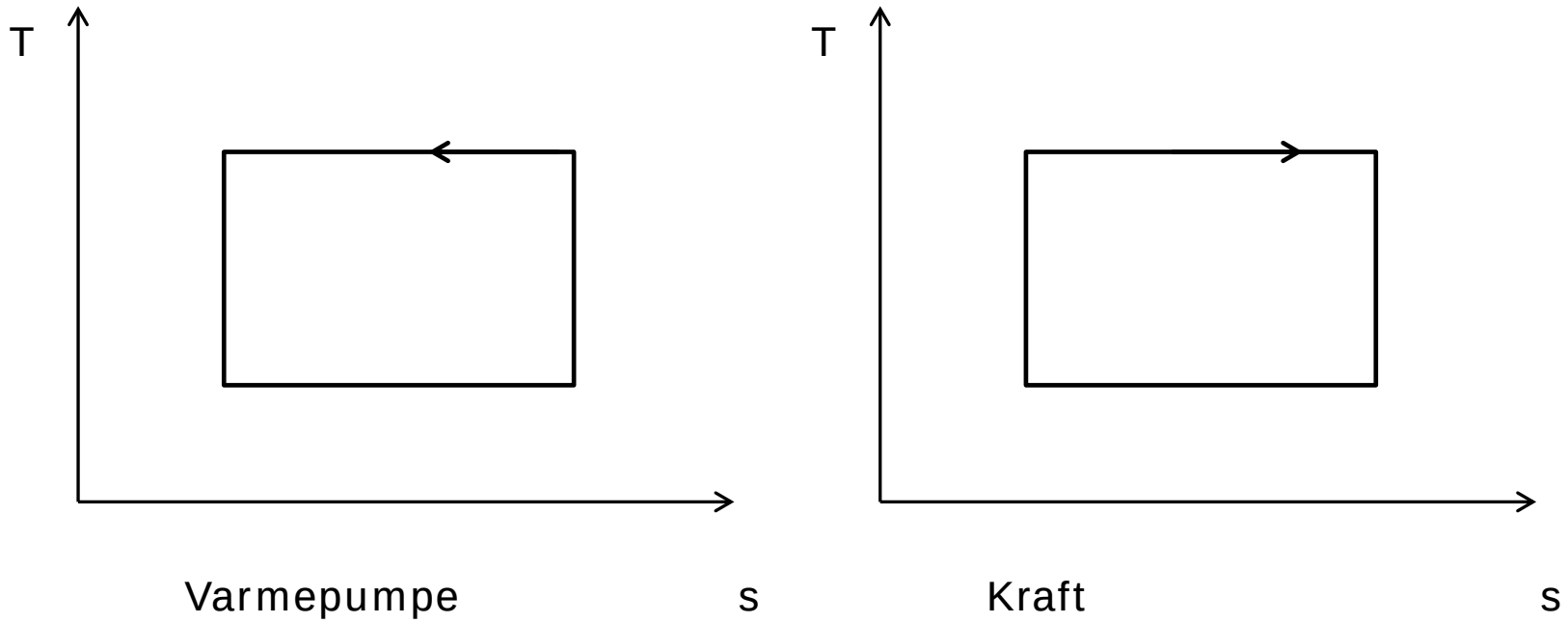
Kraftproces – Spildvarme til el



Varmepumpe – El og spildvarme til varme



Carnotprocessen

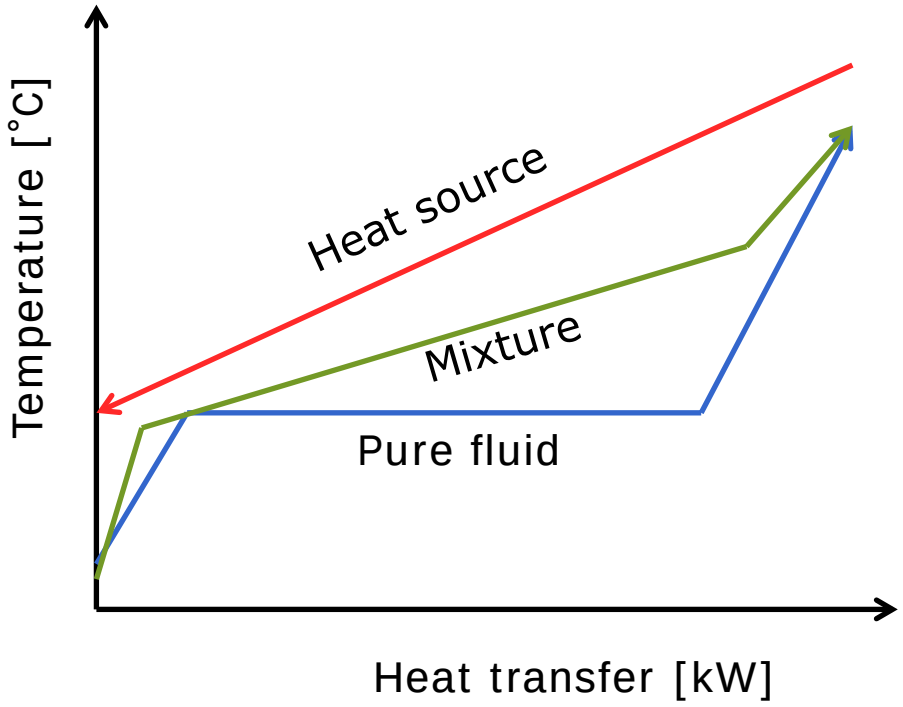


Varmepumpe

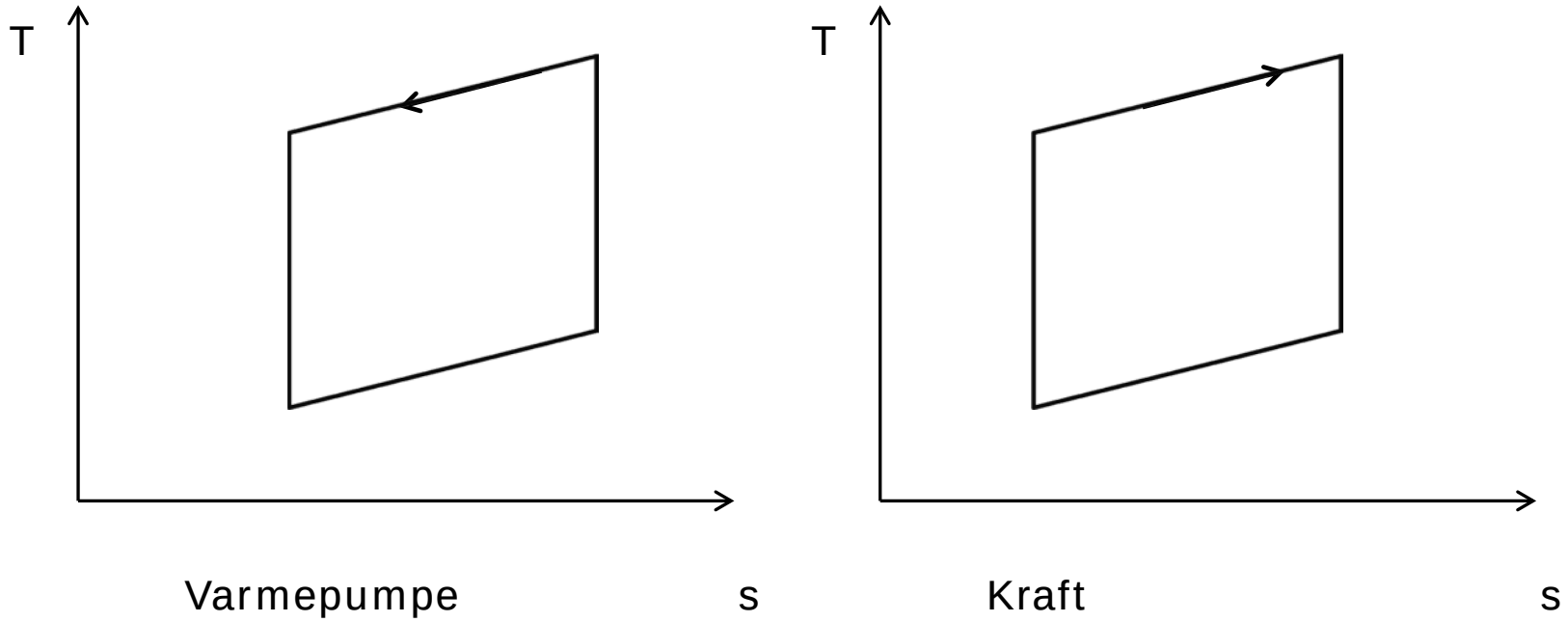
Kraft

Carnotprocessen sætter grænsen for udnyttelse ved konstant temperatur

Reel varmeveksling

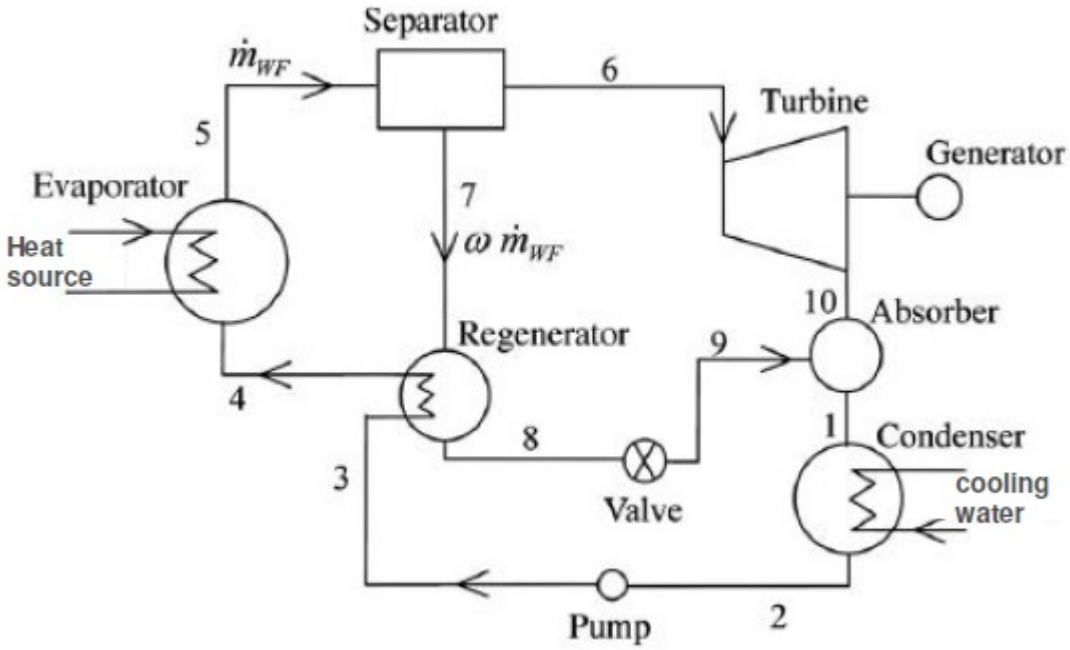


Lorenzprocessen

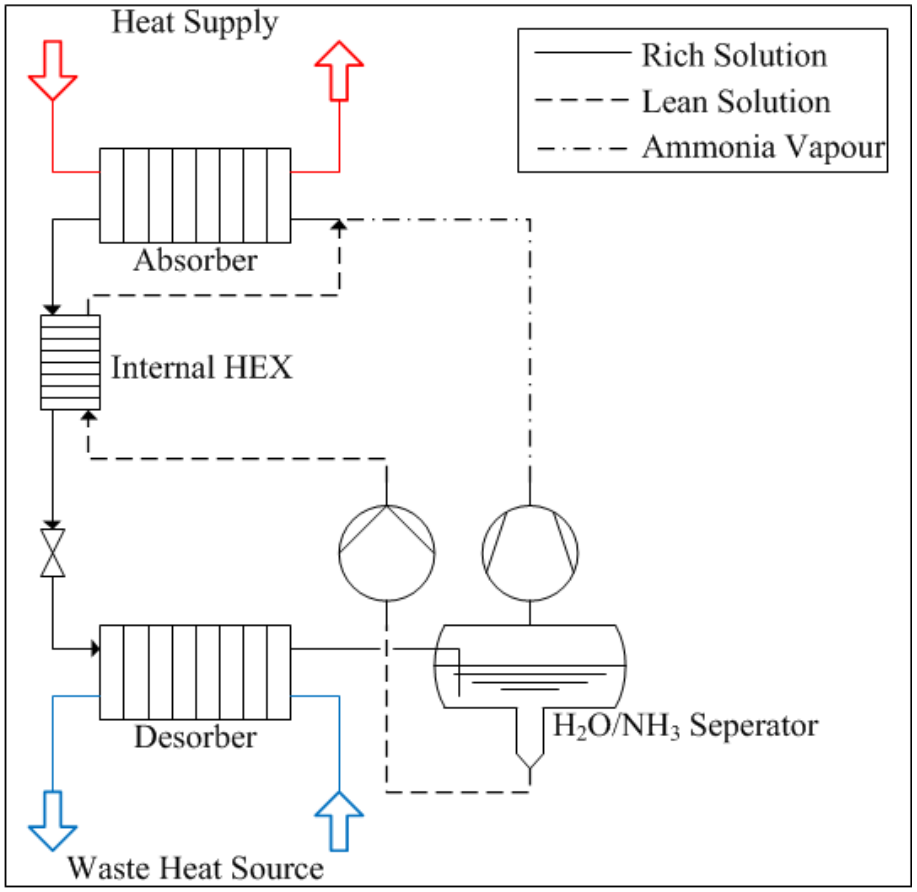


Lorenzprocessen sætter grænsen for udnyttelse ved temperaturglid

Kraftproces med blandet medie – Kalina



Varmepumpe med blandet medie – Osenbrück (Hybrid)



Komponent – Testfaciliteter

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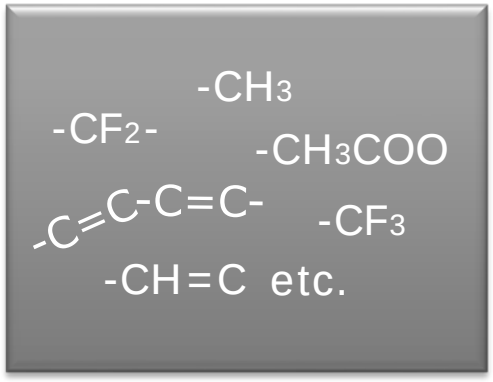
CAMD – Computer-aided Molecular Design



Building blocks:

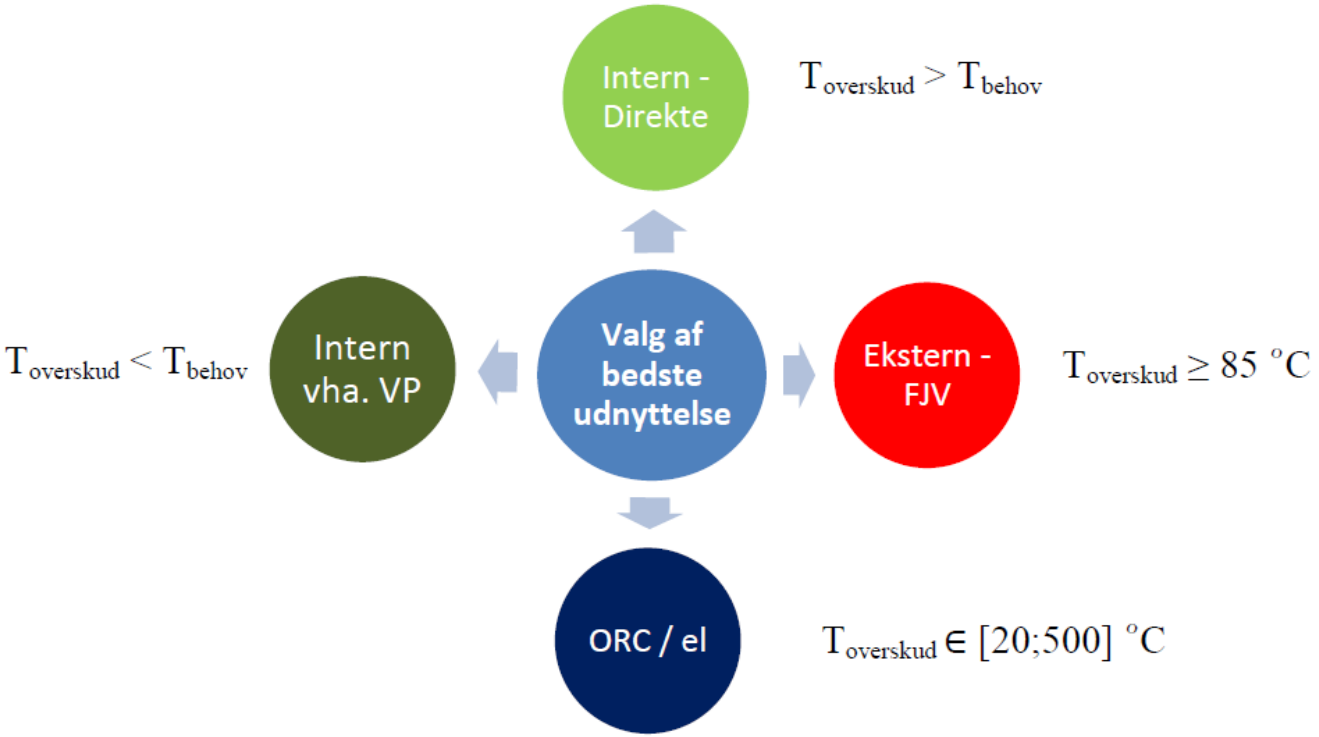
1) Molecular groups
2) Molecules

Optimization algorithm

Chemical product:

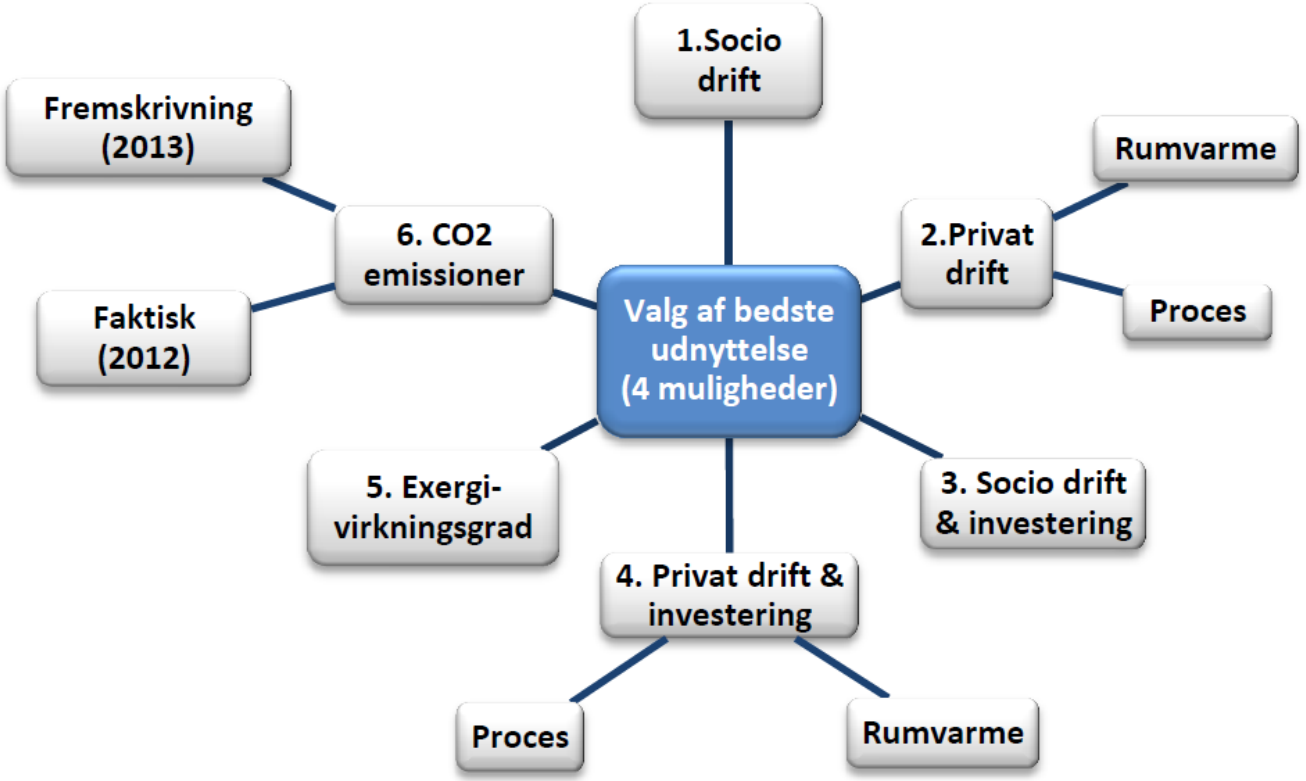
1) Pure components
2) Mixtures

Potentiale for udnyttelse

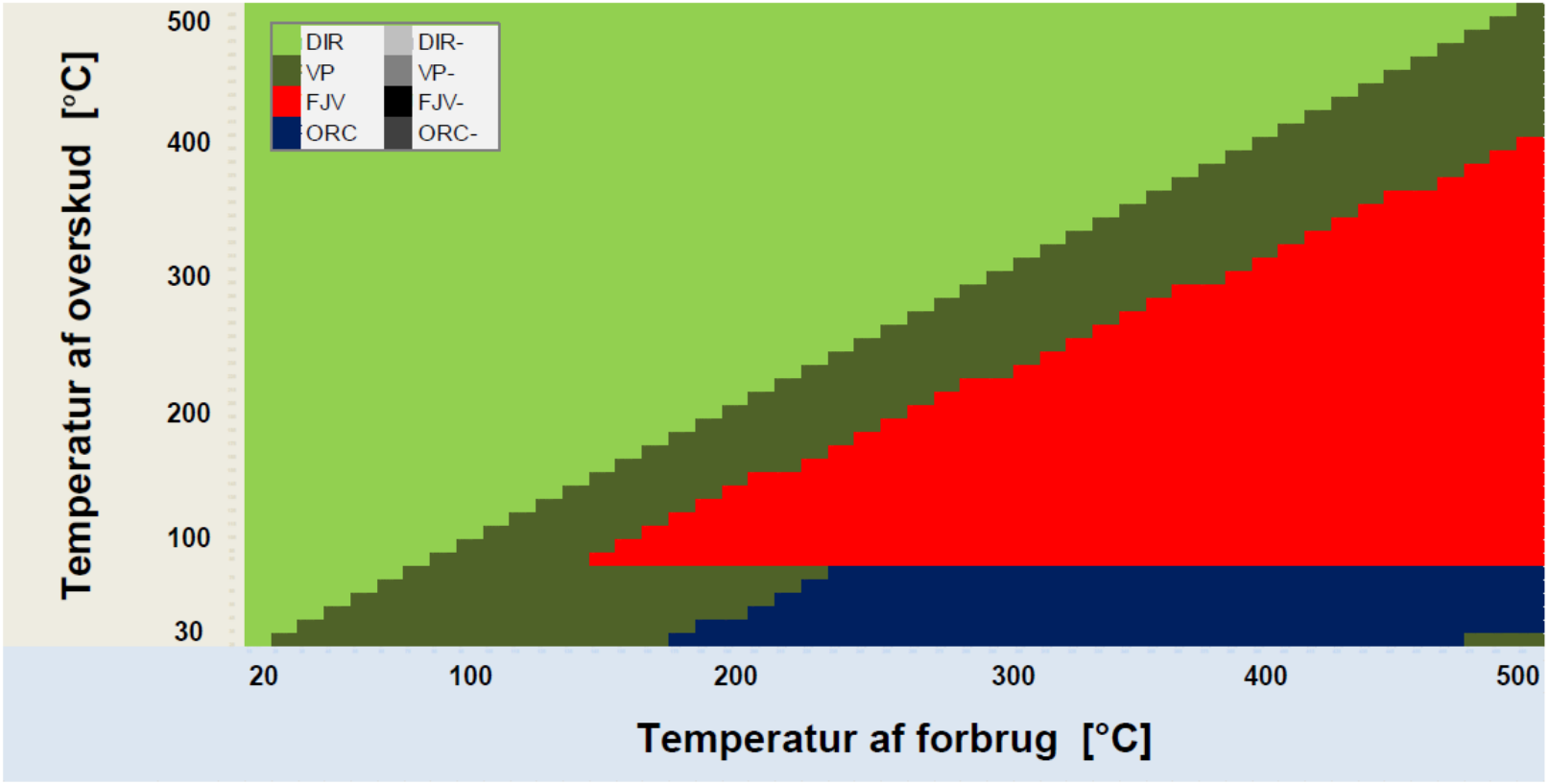


Ref: Sørensen ” Udnyttelse af industriel spildvarme”, Afgangsprojekt 2014

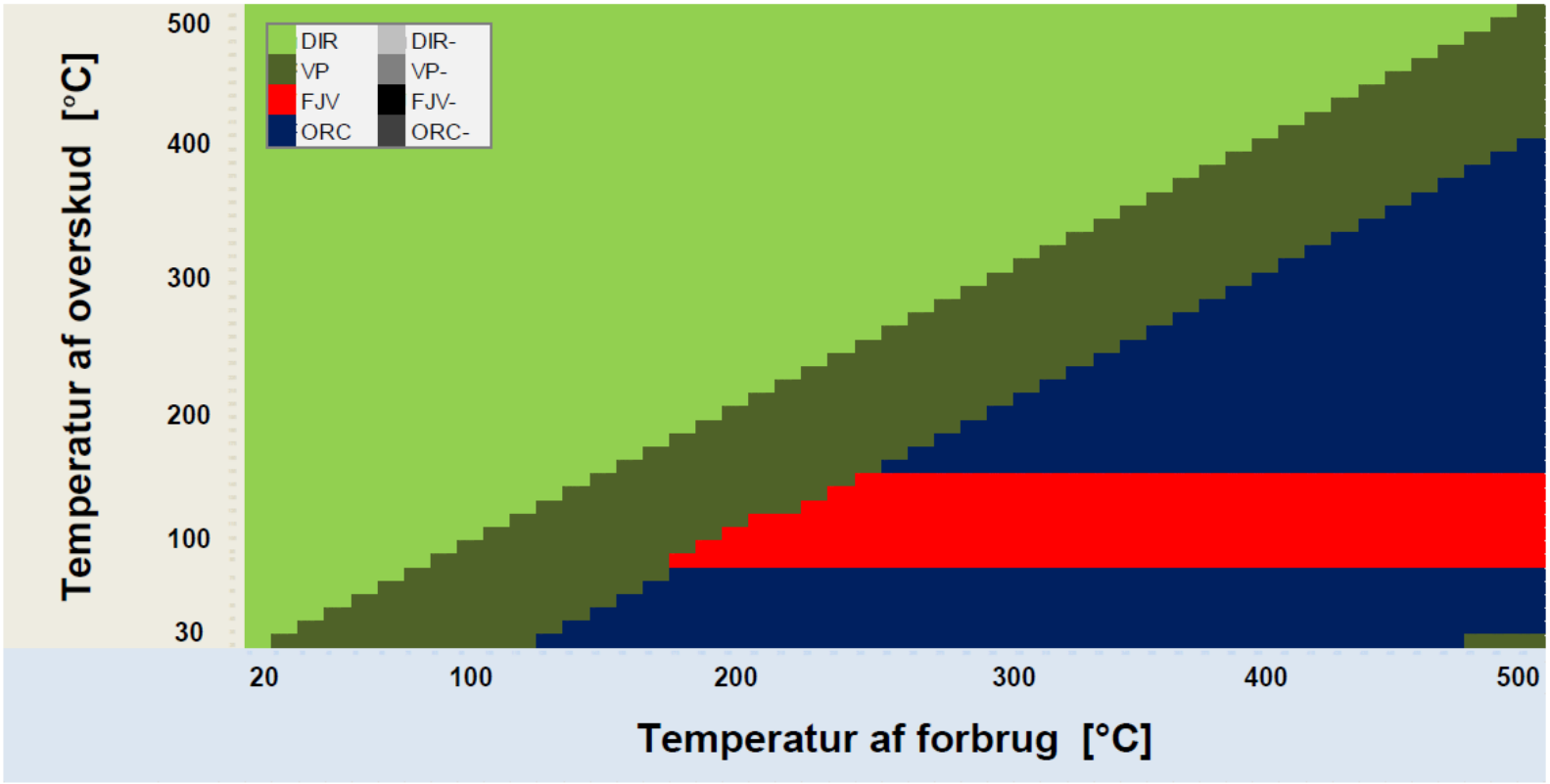
Kriterier for valg



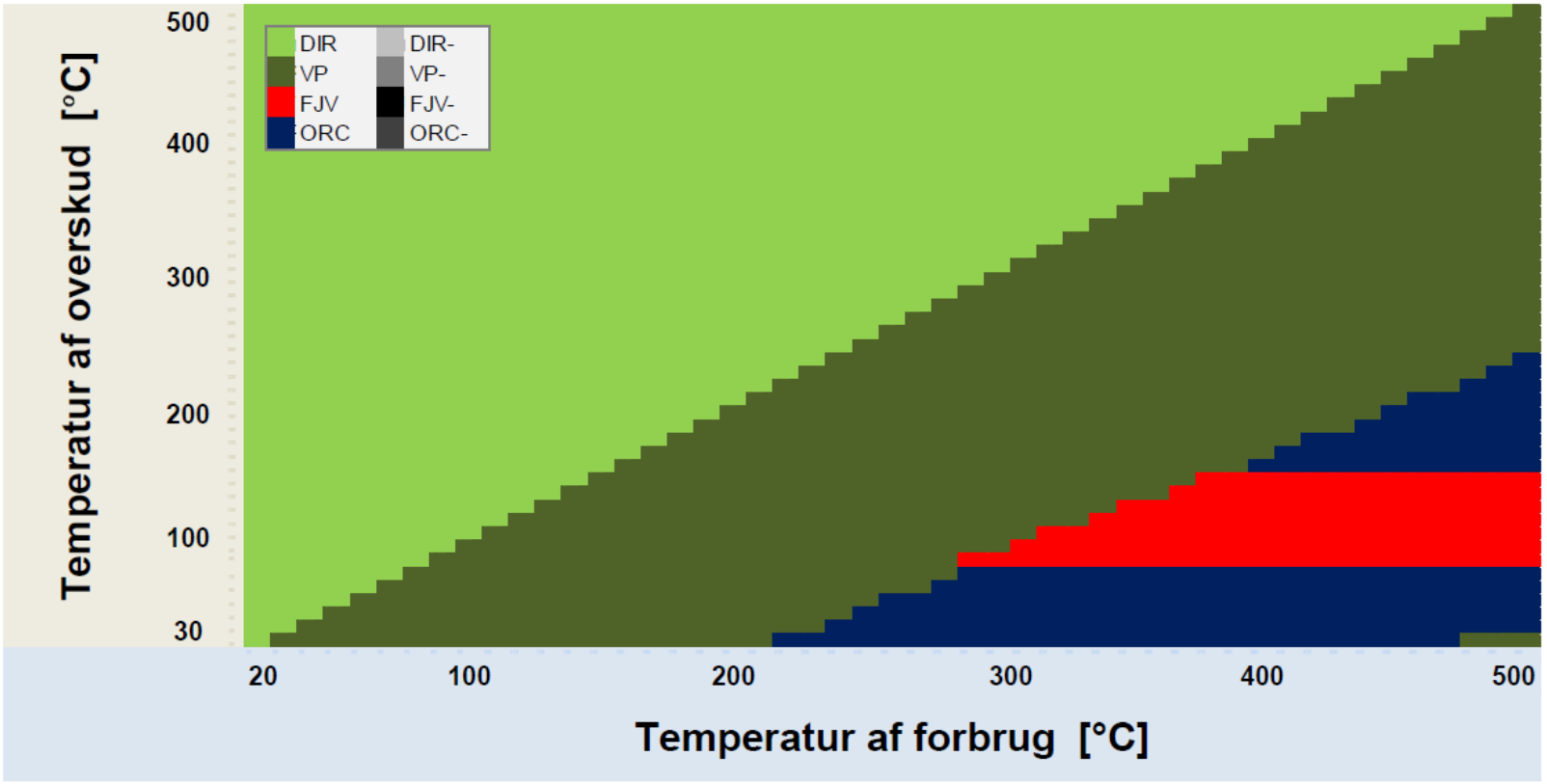
Bedste alternativ – Drift uden afgifter



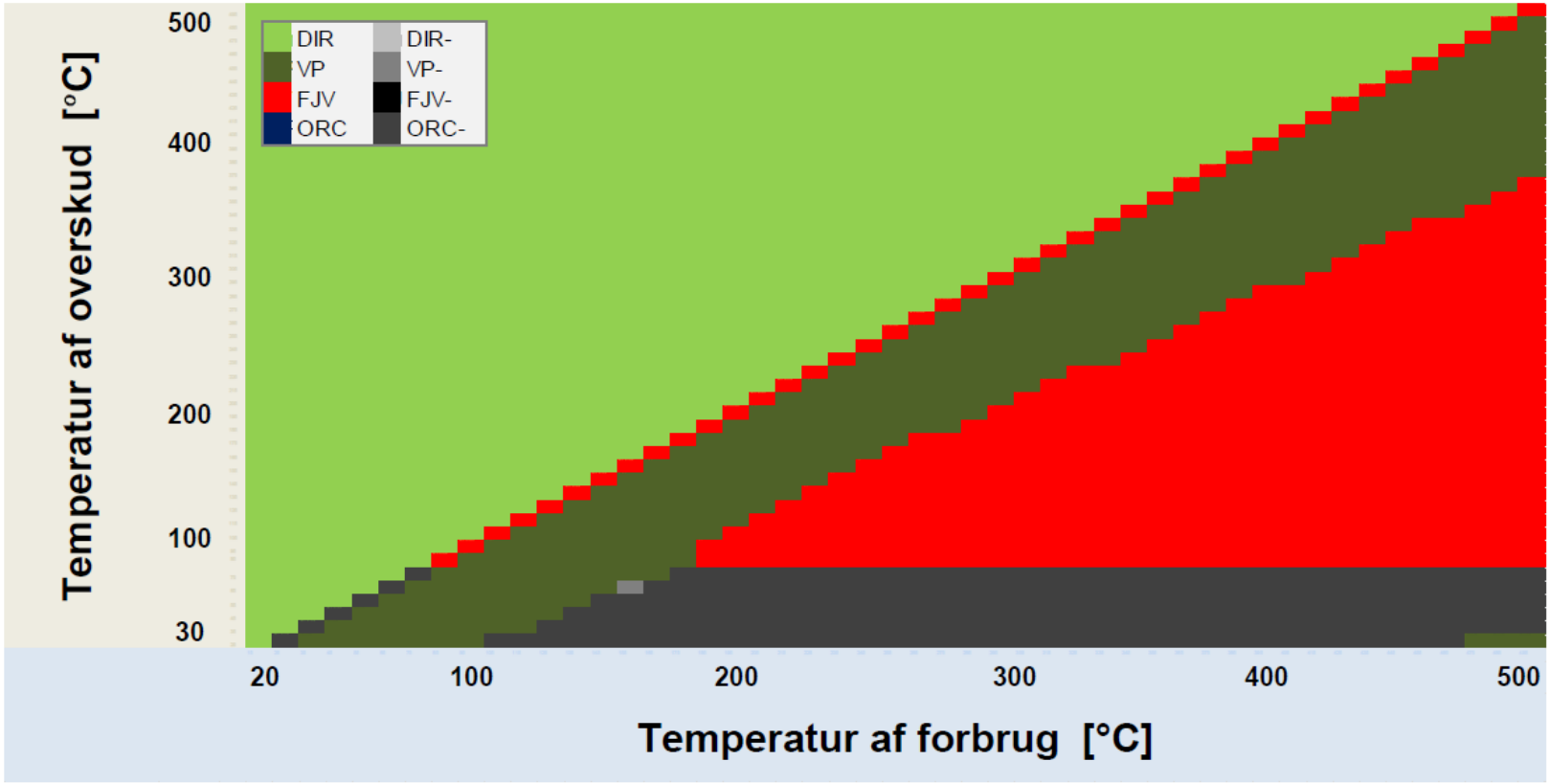
Bedste alternativ – Drift med afgifter proces



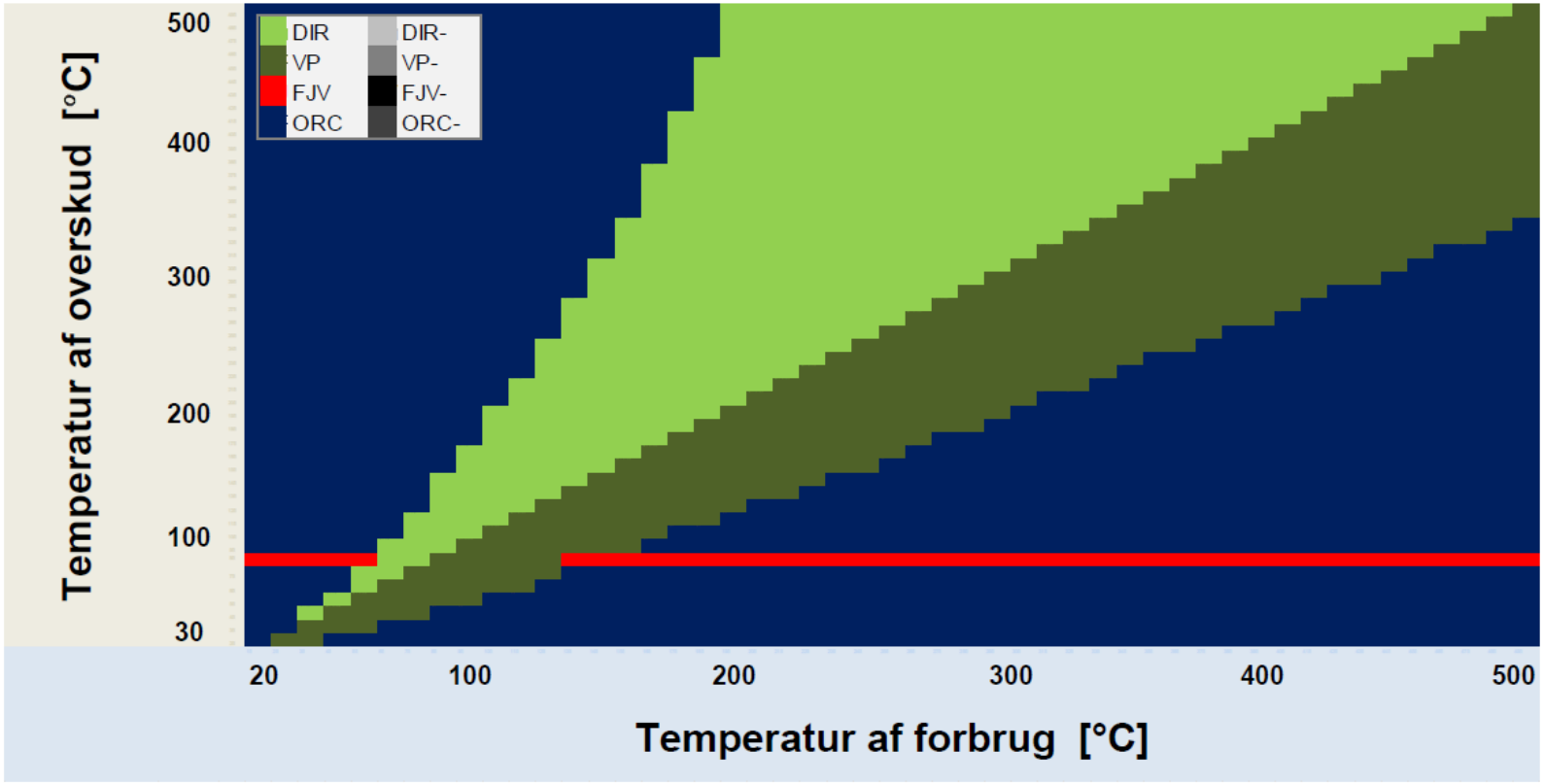
Bedste alternativ – Drift med afgifter rumvarme



Bedste alternativ – Drift + inv. med afgift proces

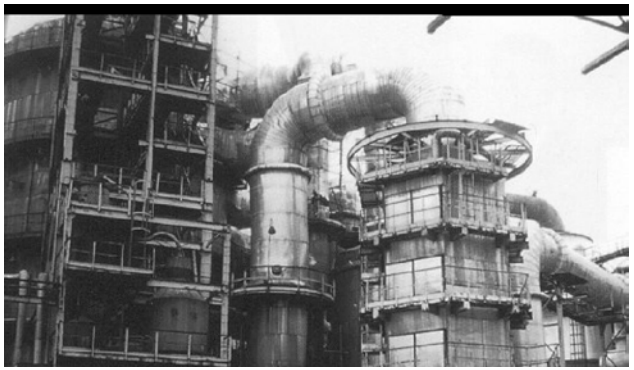


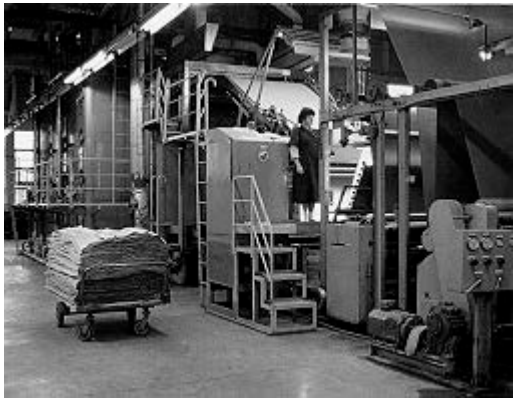
Bedste alternativ – Energiudnyttelse



Indhold

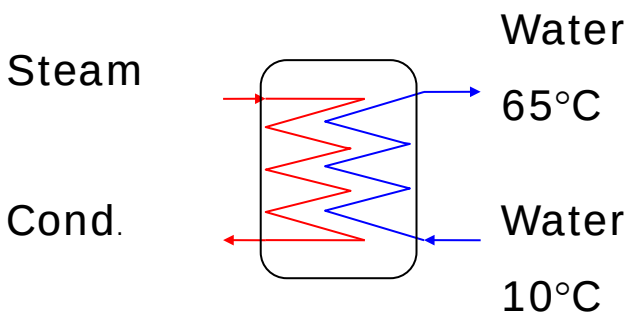
- Potentielle besparelser
  - Udnyttelse af overskudsvarme
- **Analyseværktøjer**
  - **Muligheder**
    - **Pinchanalyse**
    - **Exergianalyse**
    - **Udvidelser**
- Varmepumper

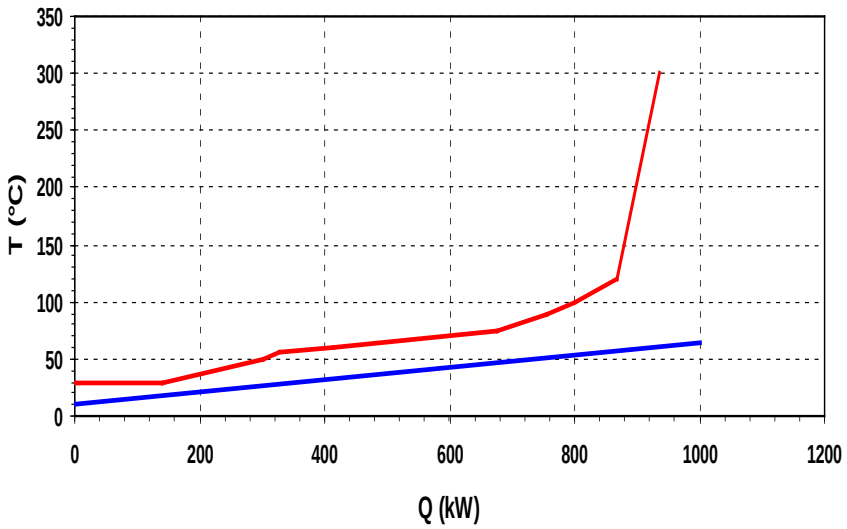




Procesintegration (energipinch)

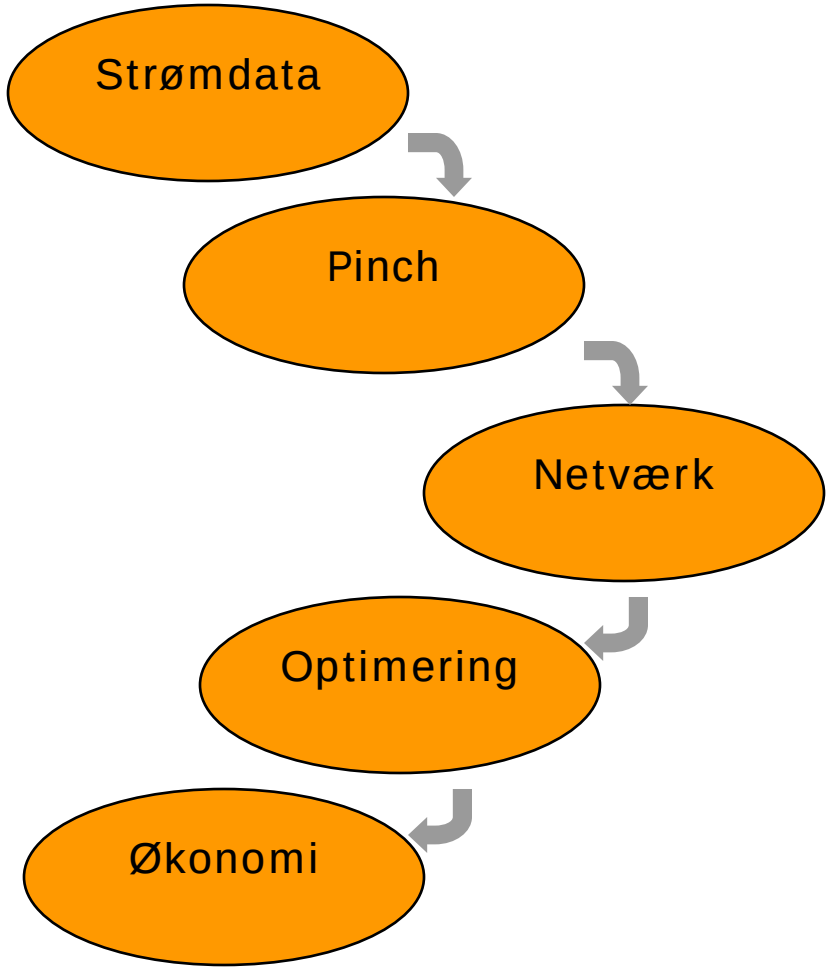
- Fx. udveksling af varme og ”kulde”





Varmevekslernetværk - Procesintegration

- Skab overblik
  - indsamle procesdata
  - sorter i data
  - opstil potentialer
- Analyse
  - Fastsættelse af mål ved brug af pinch-analyse
  - generer netværk
- Optimer
  - Udregn priser
  - Indhent priser



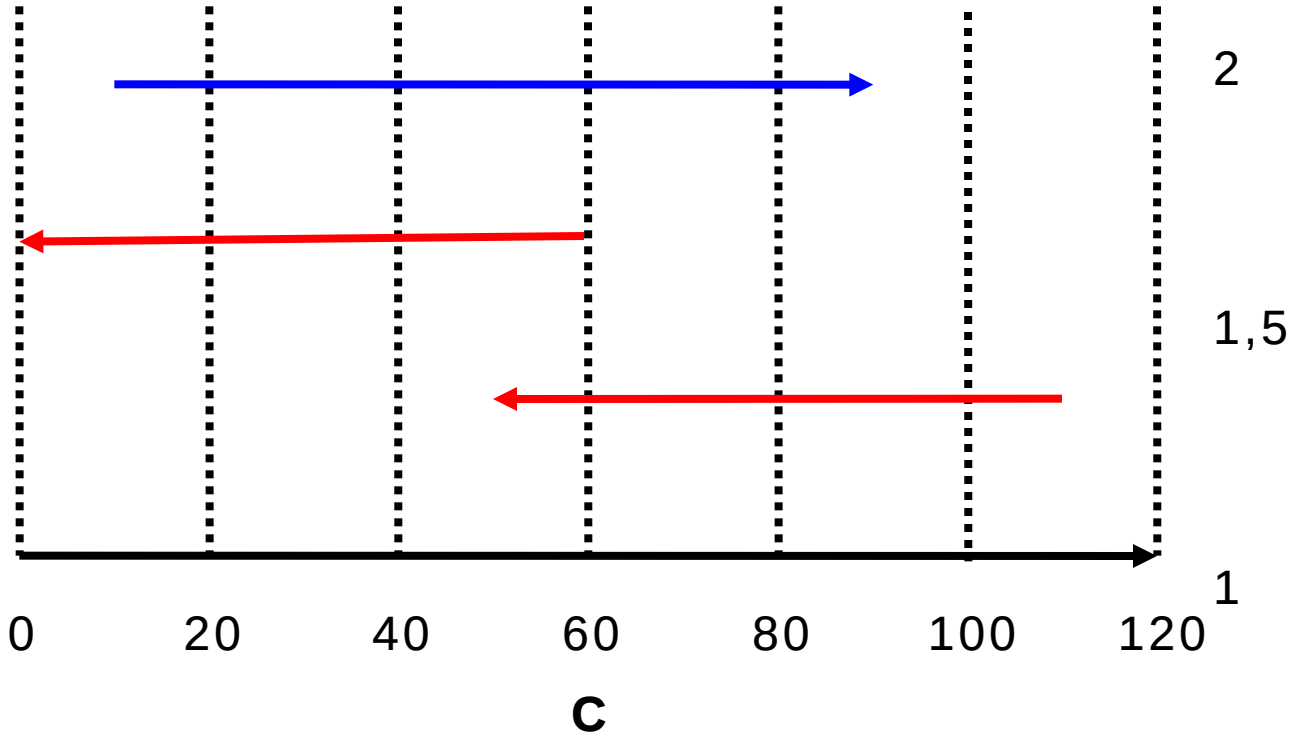
Strømdata

- Overblik skabes ved at samle strømdata.

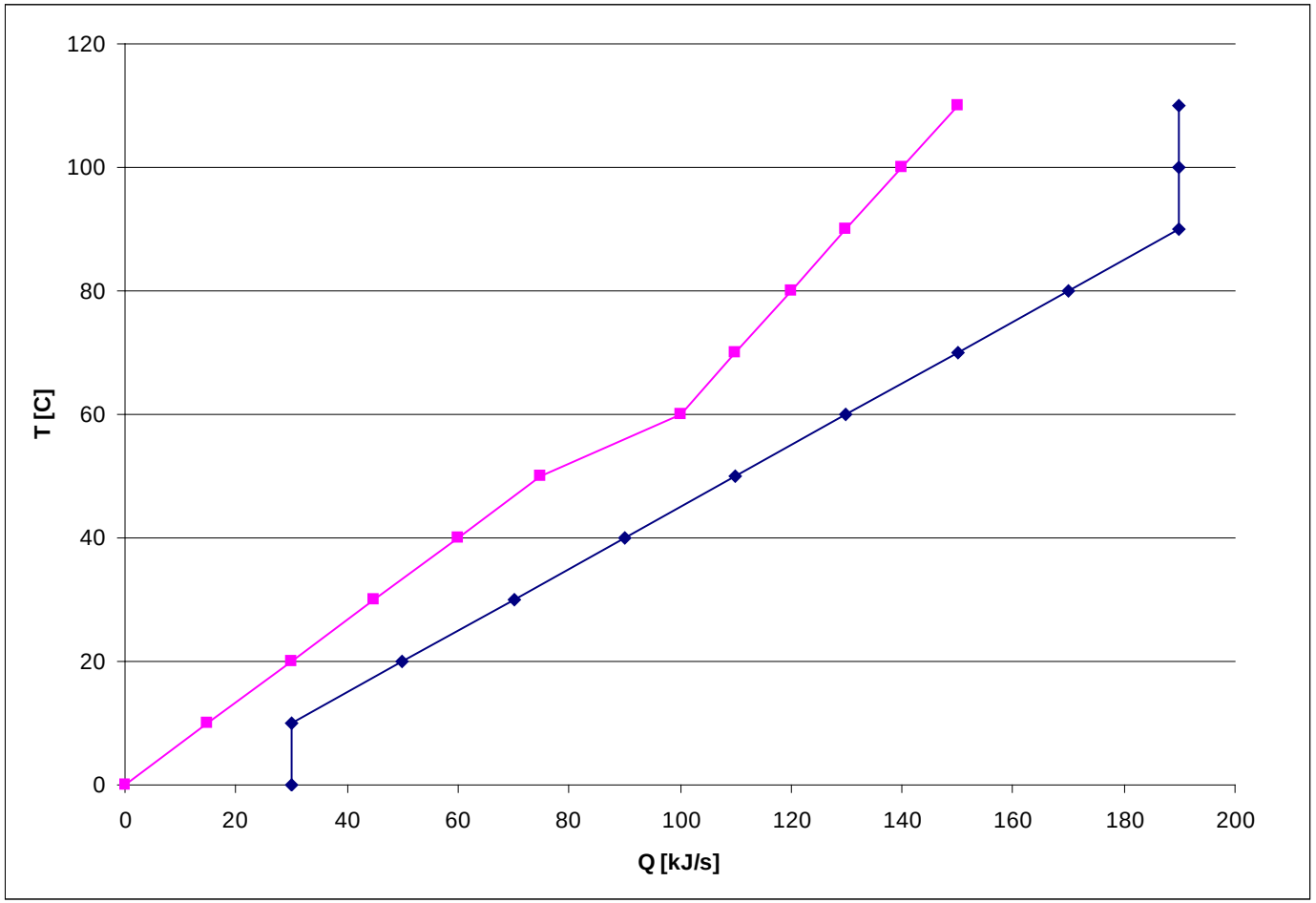
Process Name	T_{start} (°C)	T_{target} (°C)	Heat Capacity (kW/°C)
1. Air to thermofixing	20	190	0.67
2. Air from thermofixing a	160	42	0.81
3. Air from thermofixing b	42	40	5.75
4. Air to drying in themofixing	20	140	0.83
5. Air from drying in thermofixing	120	40	0.94
6. Air to drying	20	140	2.70
7. Air from drying a	120	52	3.38
8. Air from drying b	52	40	23.74
9. Domestic water	5	60	1.38
10. Water for 3 washing machines	5	40	13.94
11. Water for 3 washing machines	5	40	13.94
12. Boiler: Feeding water	70	100	17.16
13. Boiler: Make up water	5	16	8.62
14. Blowdown water (steam boiler)	150	15	0.89
15. Water for boiling machines	5	70	0.10
16. Air from decatizing machine(1a)	65	55	0.83
17. Air from decatizing machine(1b)	55	40	5.20
18. Air from decatizing machine(2a)	65	50	1.21
19. Air from decatizing machine(2b)	55	40	9.50
20. Water for other purposes	5	40	0.35
21. Water from washing machines	37	15	27.88
22. Condensate from thermofixing.	70	15	0.36
23. Condensate from thermofixing	70	15	0.37

Pinch-eksempel

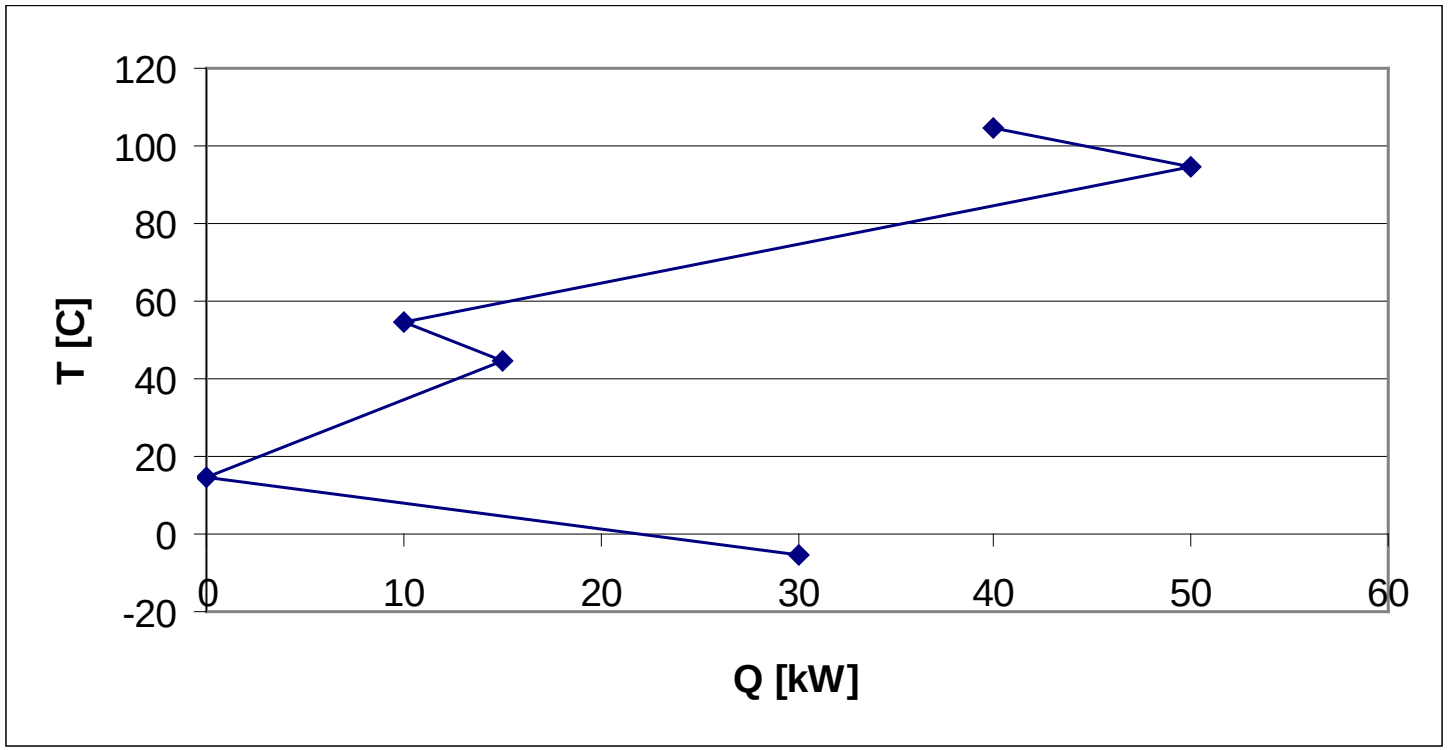
Nr.	Type	Start (^{O}C)	Slut (^{O}C)	Kap.strøm (kJ/s*^{o}C)
1	kold	10	90	2
2	varm	60	0	1,5
3	varm	110	50	1



Lille kompositkurve for $\Delta T = 10^{\circ}$ C

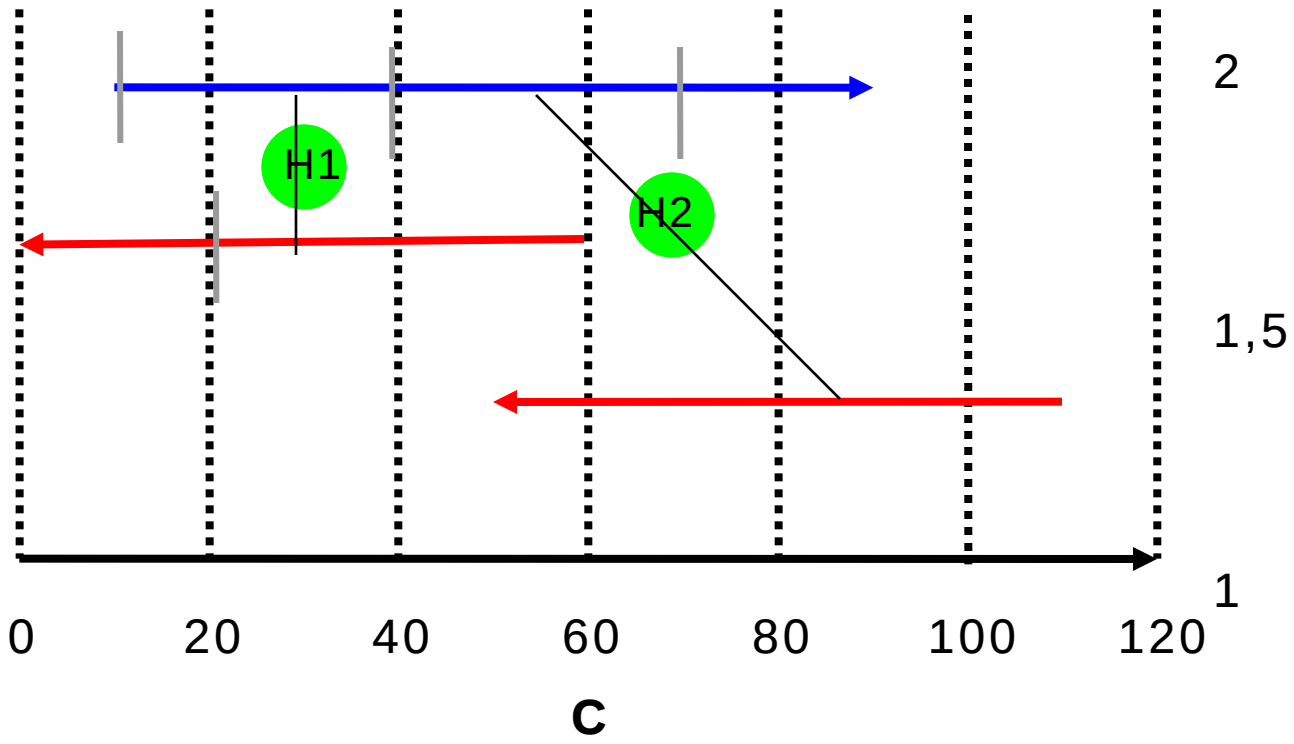


Stor kompositkurve $\Delta T_{min} = 10^{o}C$



Pinch-eksempel

Nr.	Type	Start (^{O}C)	Stut (^{O}C)	Kap.strøm (kJ/s*^{o}C)
1	kold	10	90	2
2	varm	60	0	1,5
3	varm	110	50	1



Andre analyser

- Pinchanalyse
  - Kortlægning og udnyttelse af varmegenvindingspotentiale
  - Udfordringer:
    - Tid
    - Afstand
    - Økonomi som kriterium
  - Udvidelser
    - Avancerede: Total site, Vand og energi,…
    - Simplificeringer: Screening, usikkerhedsrobust,…
  - En deludgave af exergianalyse
- Exergianalyse
  - Komplet analyse af termodynamiske uudnyttede potentialer
    - Varmetab, varmeoverføring, friktion, køling,…
- Exergoøkonomi
  - Kombineret optimering af uudnyttet potentiale og økonomi

Indhold

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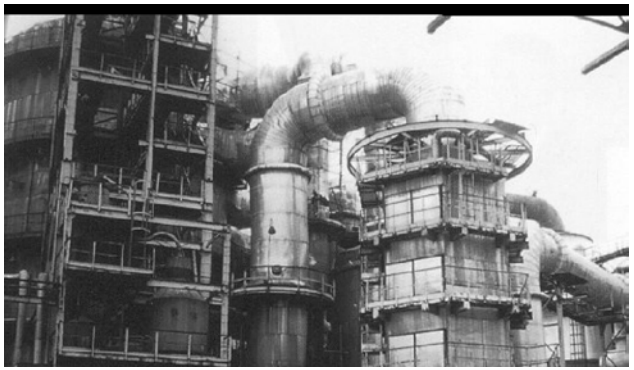
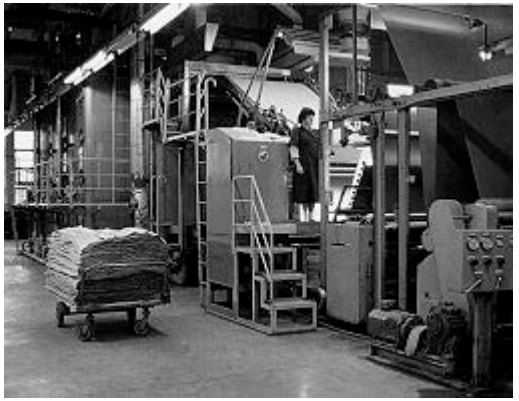
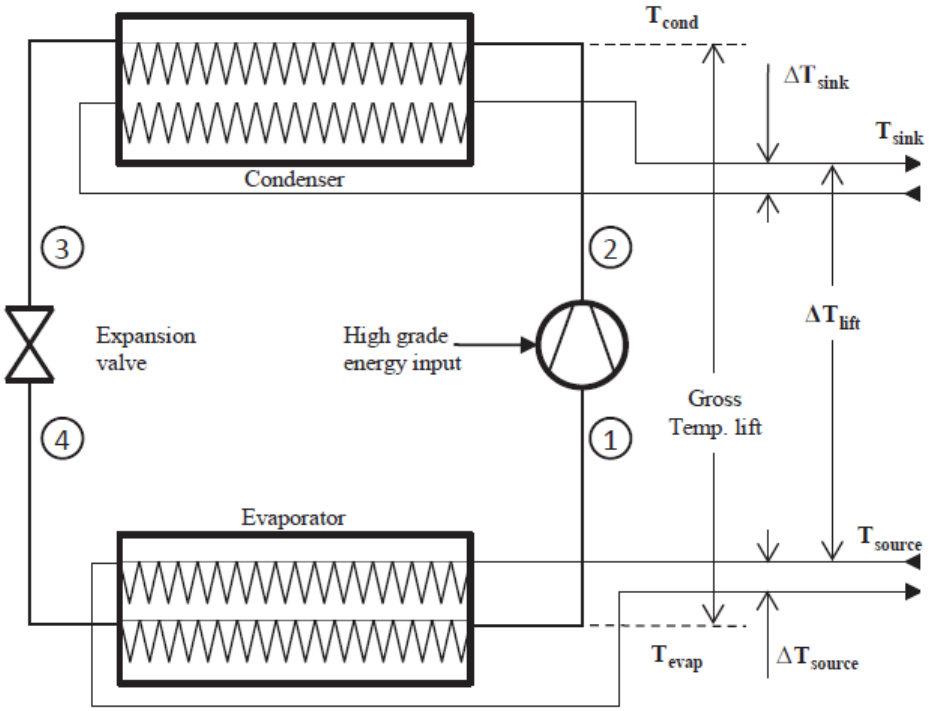
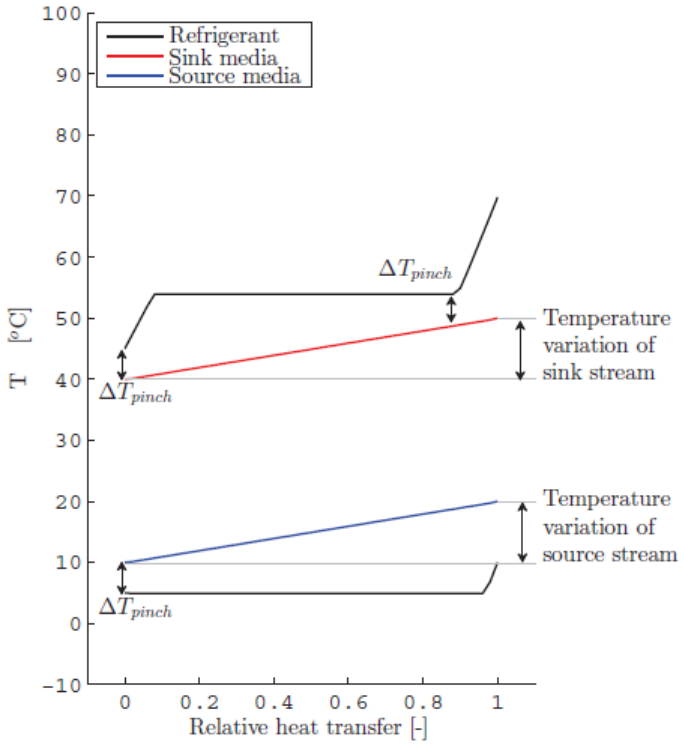




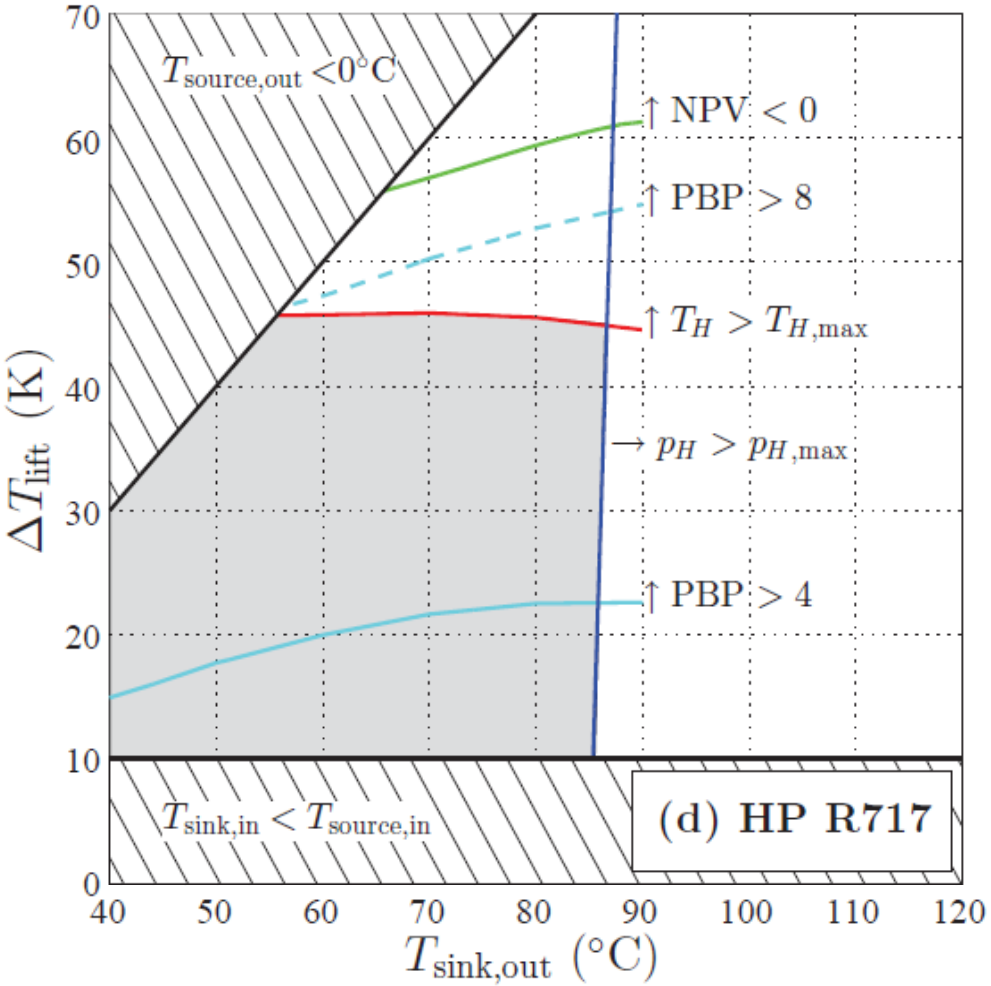
Varmepumpe definition



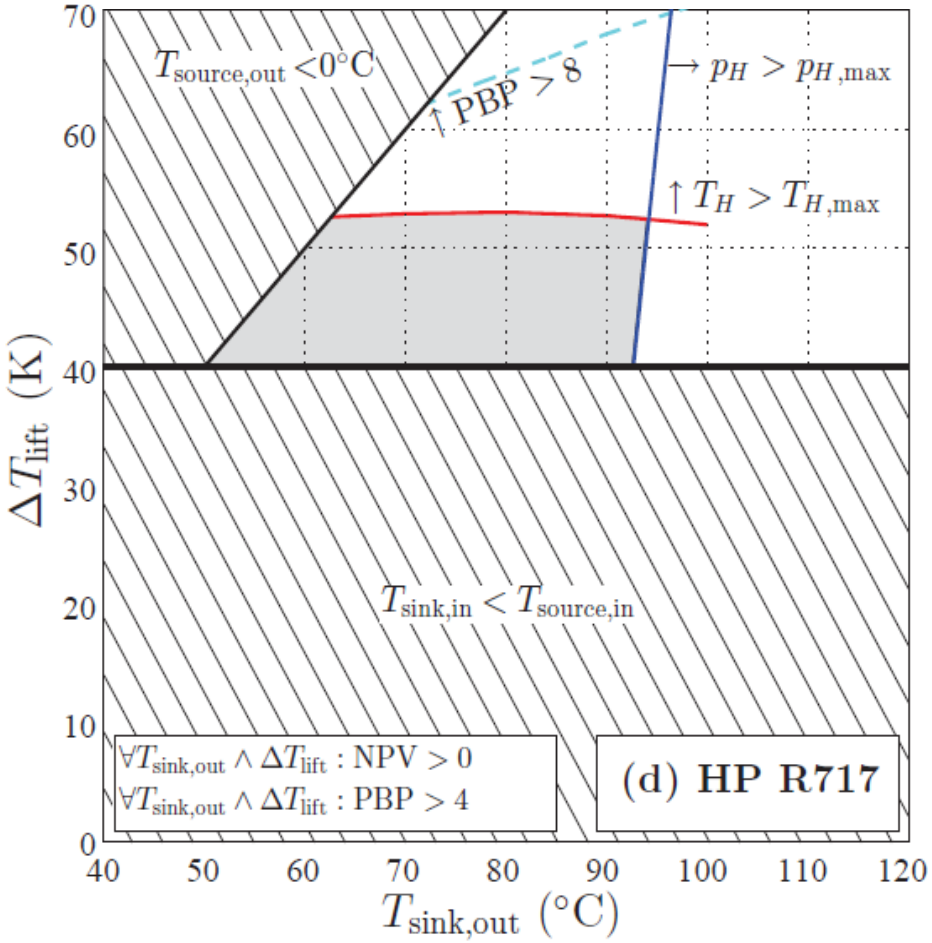


Ref: Ommen et al. " Technical and Economic Working Domains of Industrial Heat Pumps: Part 1 - Vapour Compression Heat Pumps", Jensen et al. " Technical and Economic Working Domains of Industrial Heat Pumps: Part 2- Ammonia-Water Hybrid Absorption-Compression Heat Pumps". 11th IIR Gustav Lorentzen Conference on Natural Refrigerants.

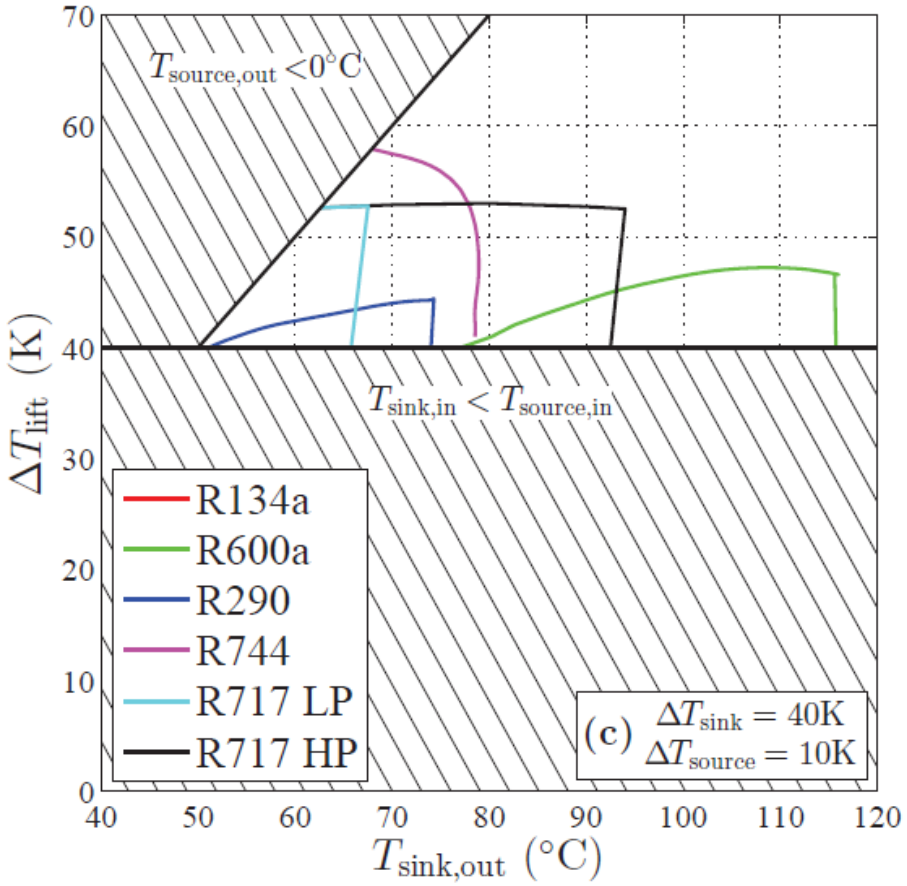
Driftdomæner $\Delta T_{kilde} = 10$ K, $\Delta T_{dræn} = 10$ K



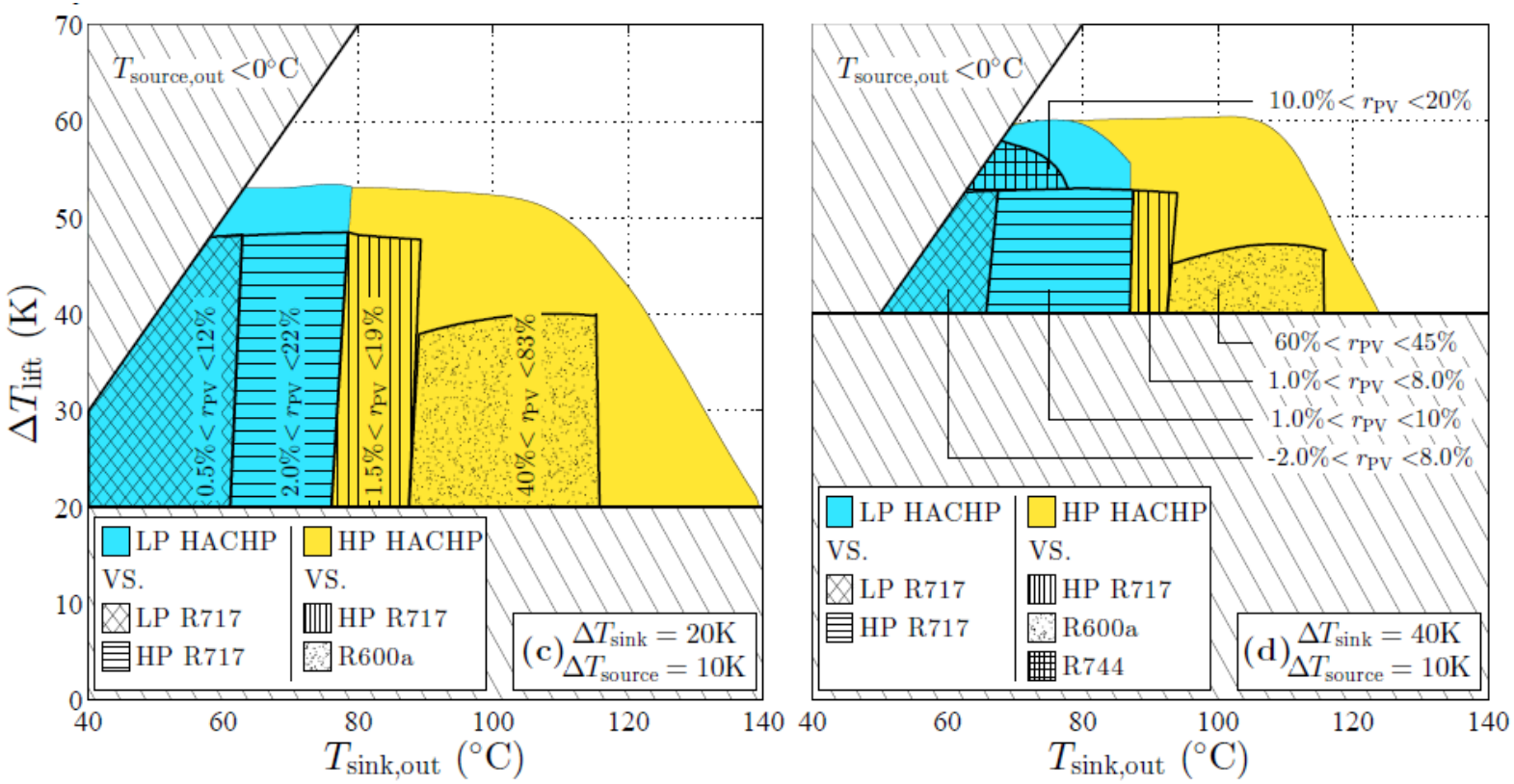
Driftdomæner $\Delta T_{kilde} = 10$ K, $\Delta T_{dræn} = 40$ K



Optimal varmepumpe



Optimal varmepumpe med hybrid



Afrunding

- Stort potentiale for genvinding ved procesintegration

- Stærke analyseværktøjer findes
  - Og udvikles løbende videre
  - Udfordringer ved anvendelse
    - Krav til proceskortlægning
    - Krav til økonomi
    - Krav til produktkvalitet
    - Krav til gennemsigtighed