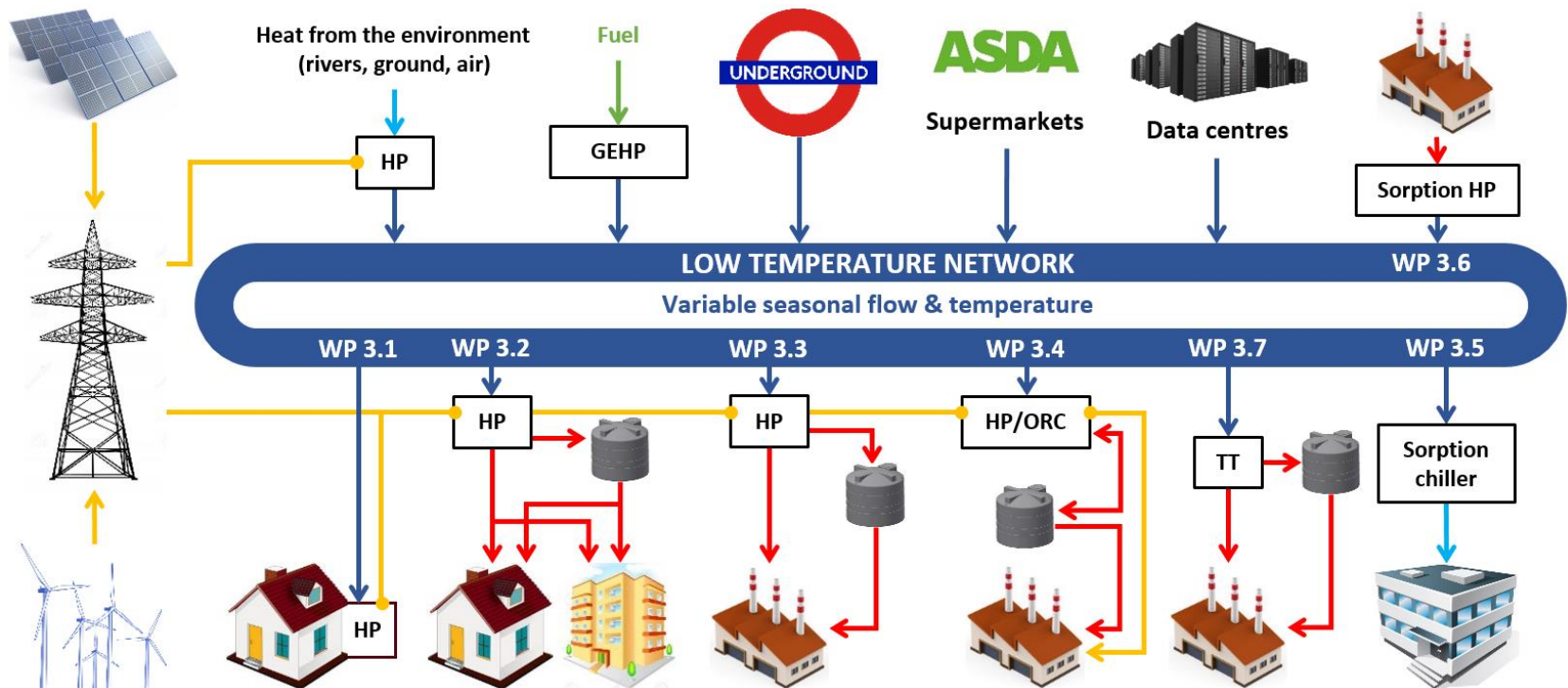
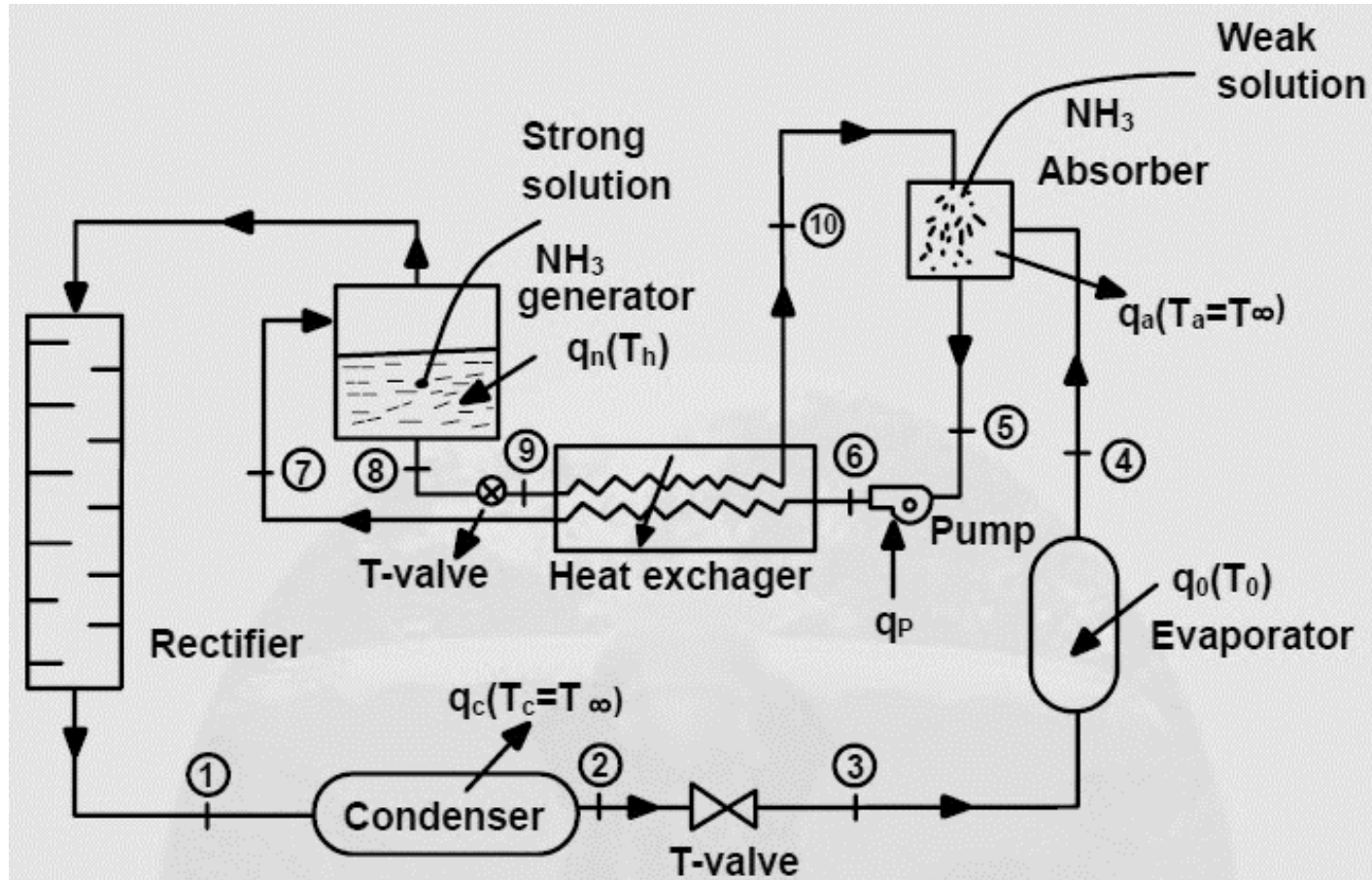


LoT-NET research focuses on the integration of low temperature (LT) networks with heat pumps and thermal storage technologies to maximise waste and ambient heat utilisation in low or zero-carbon heating and cooling solutions.



## **WP2.1 – Distribution medium, method**

# Absorption machines: example $\text{H}_2\text{O}/\text{NH}_3$



# Thermochemical district networks:

Thermochemical district networks are a new technology for district networks that can provide heating and cooling in one **heat loss-free** multiservice network.

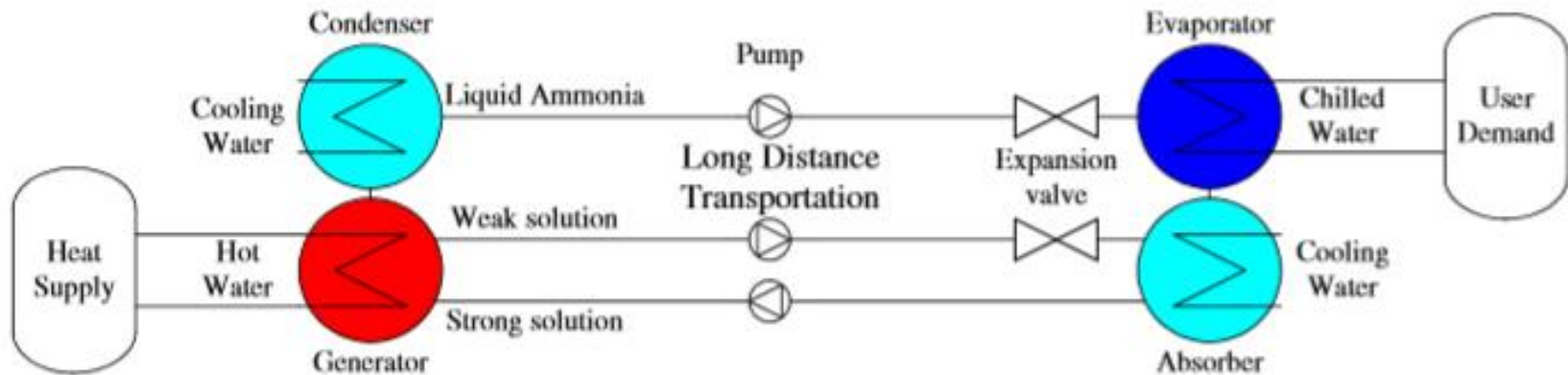
The innovation is the use of thermochemical fluids as transport medium (concentrated salt solutions).

The chemical potential is used to generate useful heat or cold from ambient heat at the place and time of demand.

Advantages: heat loss free

- Less investment (no insulation, smaller pipe diameters)
- Longer distances

# Thermochemical district networks: Example schematics



## Requirements for residential space heating:

- Evaporating with air as heat source preferably until  $-15^{\circ}\text{C}$
- Condensation between  $30$  and  $60^{\circ}\text{C}$
- Fluid vapour pressures between  $0.1$  and  $10$  bar

# Thermochemical fluids (water based)

Different groups of substances such as salts, alkalis, acids, organic compounds and ionic liquids can be used as absorbents.

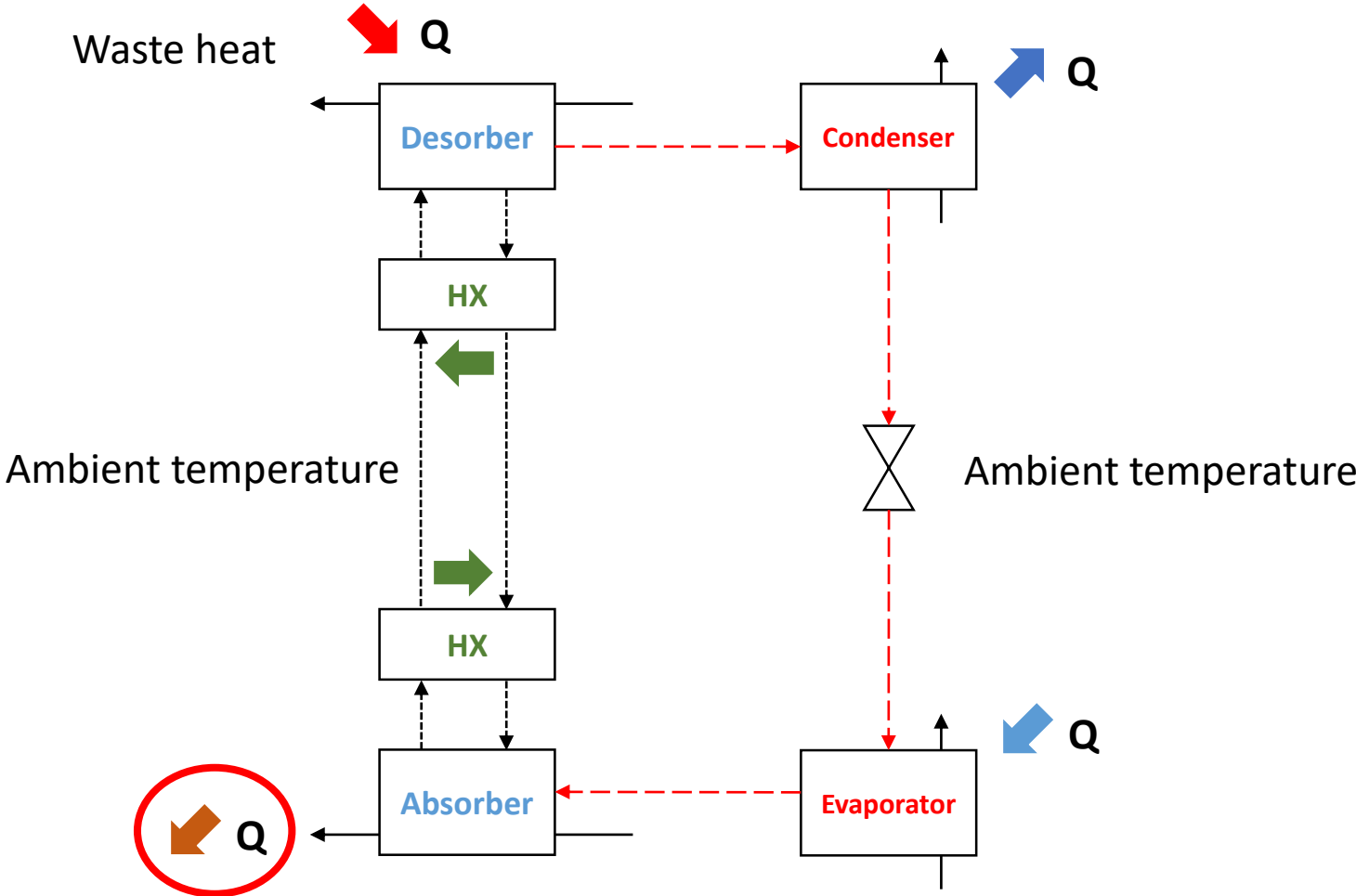
In addition to thermodynamic properties, the following criteria must be considered for the selection of the thermochemical fluid:

- Availability
- Price
- Environmental compatibility
- Recyclability
- Toxicity
- Chemical stability

# Thermochemical fluids (water based)

Desiccant	Comments
Lithium bromide (LiBr)	Common in absorption plants (chillers), but not suitable in thermochemical network due to the high price.
Lithium chloride (LiCl)	common in dehumidification systems, but not suitable in thermochemical network due to the high price.
Calcium chloride (CaCl <sub>2</sub> )	High efficiency.
Magnesium chloride (MgCl <sub>2</sub> )	High efficiency.
Calcium nitrate Ca(NO <sub>3</sub> ) <sub>2</sub>	Not corrosive. Low efficiency at low temperatures and high efficiency at high temperatures.
Sodium hydroxide (NaOH)	Very high efficiency. Not suitable in open processes.

# Example: LiBr – H<sub>2</sub>O

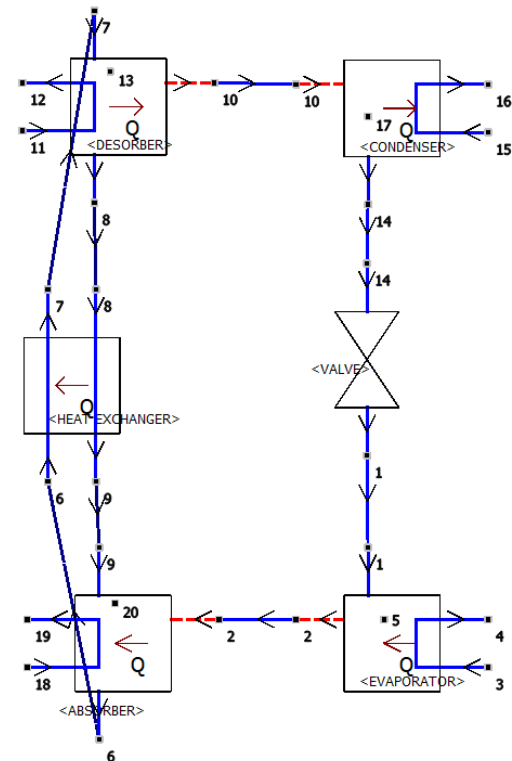




# SorpSim – Sorption System simulation program (Oak Ridge National Laboratory)

Sorption system simulation tool to evaluate different thermally activated cooling and heating technologies.

## Single-effect LiBr-water chiller



# SorpLib – Dynamic library (Oak Ridge National Laboratory)

A dynamic library for isotherm correlation of sorption working pairs.

Available pairs (32) data include:

- Water (14)

- LiBr
- LiBr:CH<sub>3</sub>COOK
- LiBr:CH<sub>3</sub>CH(OH)COONa
- LiBr:H<sub>2</sub>N(CH<sub>2</sub>)<sub>2</sub>OH
- LiBr:HO(CH<sub>2</sub>)<sub>3</sub>OH
- LiBr:LiNO<sub>3</sub>-LiI-LiCl
- LiBr:LiI-OH(CH<sub>2</sub>)<sub>3</sub>OH
- LiBr:LiNO<sub>3</sub>-LiI-LiCl
- LiCl
- CaCl<sub>2</sub>
- Zeolite:5A
- Zeolite:13X
- SilicaGel
- NaOH:KOH-CsOH

- CO<sub>2</sub> (5)

- Zeolite:5A
- Zeolite:13X
- Carbon:ACF(A-20)
- Carbon:AC-MaxsorbIII
- SilicaGel

- Propylene (5)

- Zeolite:4A
- Zeolite:13X
- Zeolite:5A-crystal
- Zeolite:5A-pellets
- Carbon:MolecularSieve

Available equation of state of pure components (1) include: Water

- Propane (5)

- Zeolite:4A
- Zeolite:13X
- Zeolite:5A-crystal
- Zeolite:5A-pellets
- Carbon:MolecularSieve

- Butene (1)

- Zeolite:13X

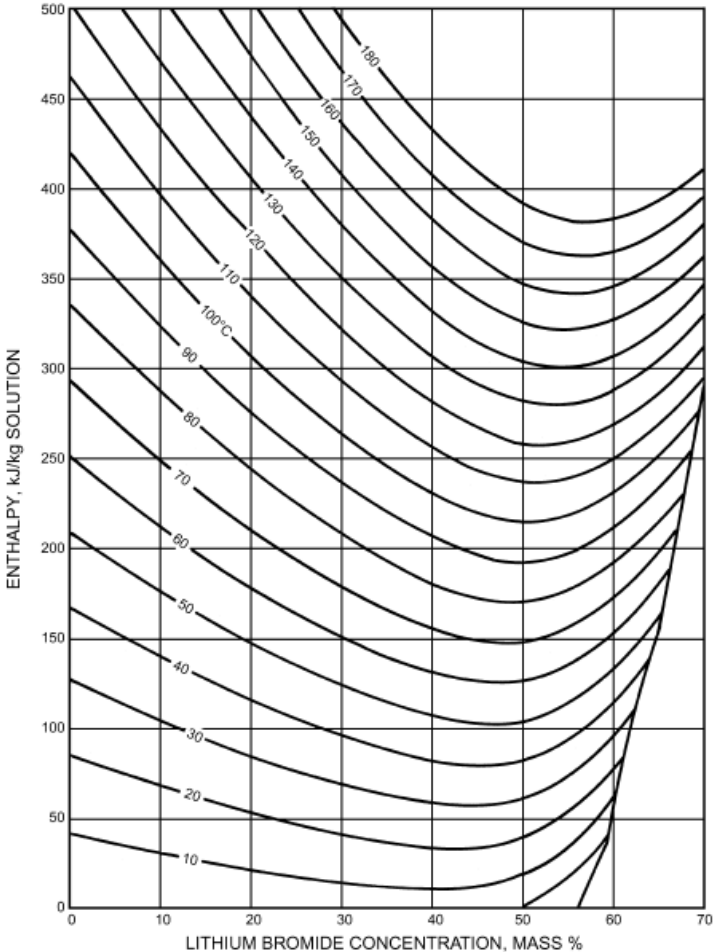
- HFO1234ze (1)

- Carbon:AC-MaxsorbIII

- HFC134a (1)

- Carbon:AC-MaxsorbIII

# LiBr – H<sub>2</sub>O properties (ASHRAE)

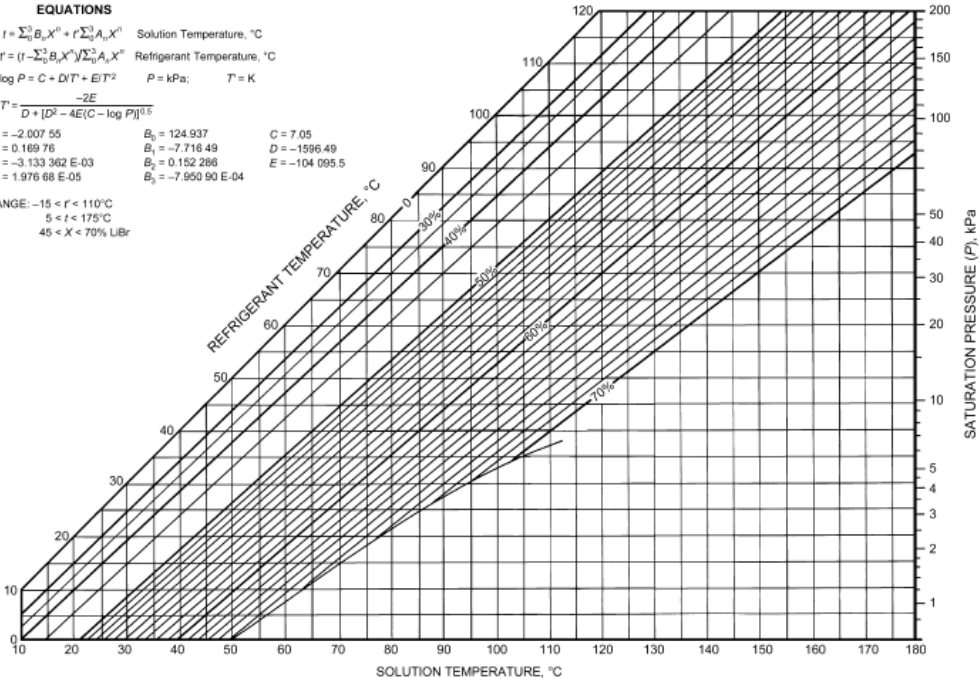
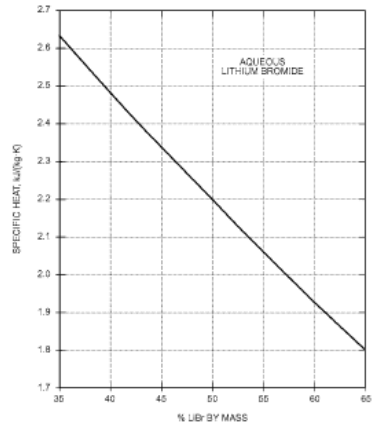


**EQUATIONS**

- $t = \sum_{i=0}^3 B_i X^i + r \sum_{i=0}^3 A_i X^i$  Solution Temperature, °C
- $r = (t - \sum_{i=0}^3 B_i X^i) / \sum_{i=0}^3 A_i X^i$  Refrigerant Temperature, °C
- $\log P = C + D/T + E/T^2$   $P = \text{kPa}; T = \text{K}$
- $T = \frac{-2E}{D + [D^2 - 4E(C - \log P)]^{0.5}}$

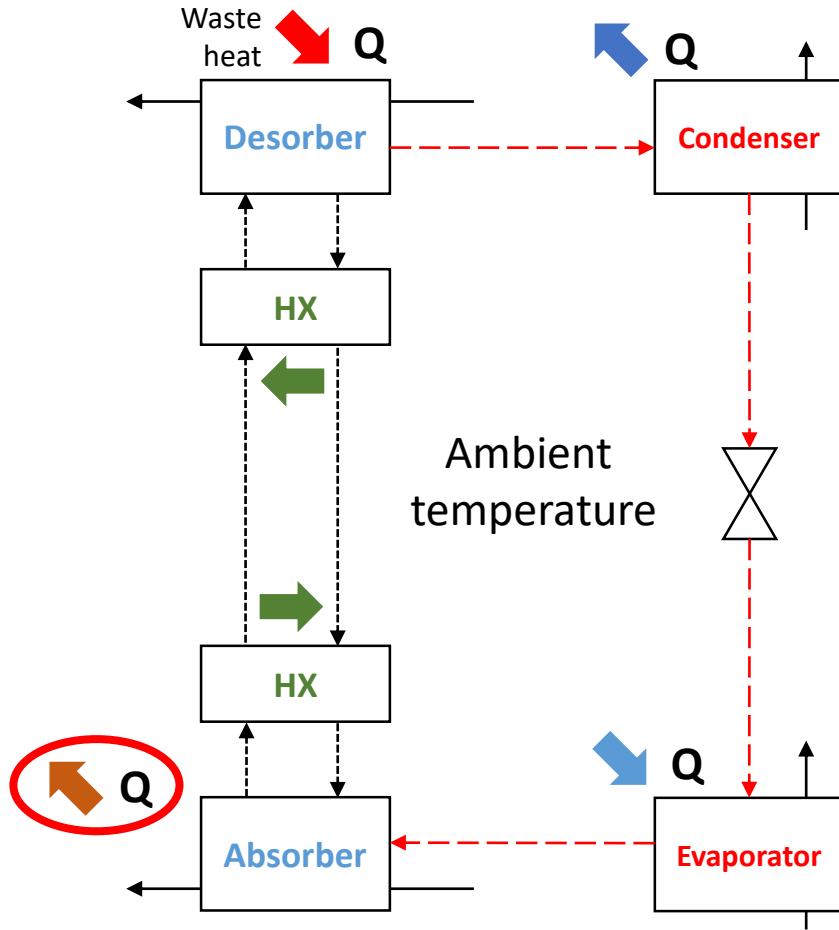
$A_0 = -2.00755$	$B_0 = 124.937$	$C = 7.05$
$A_1 = 0.16976$	$B_1 = -7.71649$	$D = -1596.49$
$A_2 = -3.133362 \text{ E-}03$	$B_2 = 0.152266$	$E = -104.0955$
$A_3 = 1.97666 \text{ E-}05$	$B_3 = -7.95090 \text{ E-}04$	

RANGE:  $-15 < r < 110^\circ\text{C}$   
 $5 < t < 175^\circ\text{C}$   
 $45 < X < 70\% \text{ LiBr}$



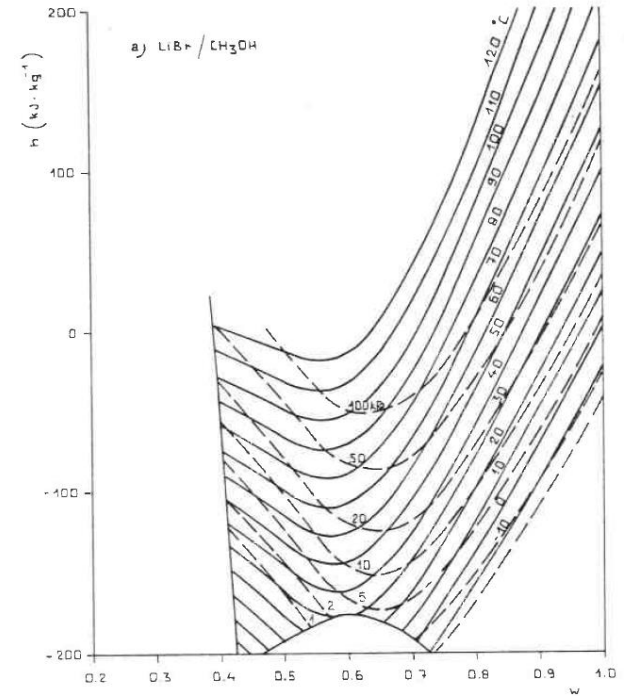
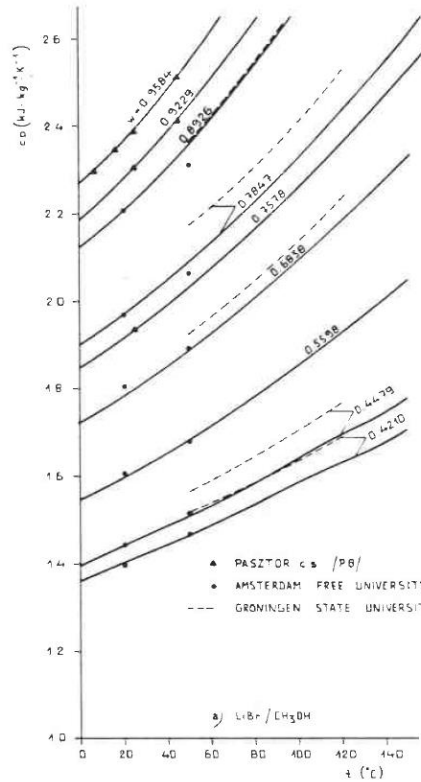
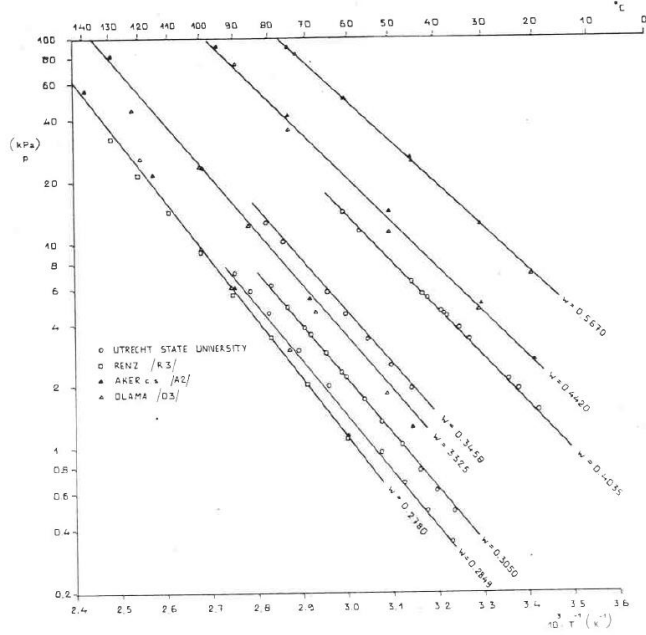
# Example: LiBr – H<sub>2</sub>O

## Matlab program



Tamb (C)	Tabs (C)	Tdes (C)	Abs/Des	$\Delta T_{eq} \text{ H}_2\text{O}$
5	30	35	0.80	44.59
5	30	40	0.86	89.67
5	30	45	0.88	131.60
5	40	45	0.74	42.98
5	40	50	0.82	88.52
5	40	55	0.85	130.96
5	50	55	0.68	41.30
10	30	35	0.83	45.55
10	30	40	0.88	90.28
10	30	45	0.90	131.61
10	40	45	0.77	43.55
10	40	50	0.84	88.68
10	40	55	0.87	130.74
10	50	55	0.71	42.01
10	50	60	0.80	87.54
15	30	35	0.87	46.97
15	30	40	0.91	91.62
15	30	45	0.92	132.44
15	40	45	0.80	44.29
15	40	50	0.86	88.98
15	40	55	0.88	130.49
15	50	55	0.73	42.58
15	50	60	0.81	81.04
15	50	65	0.84	116.70
15	60	65	0.64	32.90
15	60	70	0.75	68.26

# LiBr – CH<sub>3</sub>OH properties (Iedema thesis 1984)



# CH<sub>3</sub>OH properties (The enthalpy of methanol, Yerlett)

THE ENTHALPY OF METHANOL

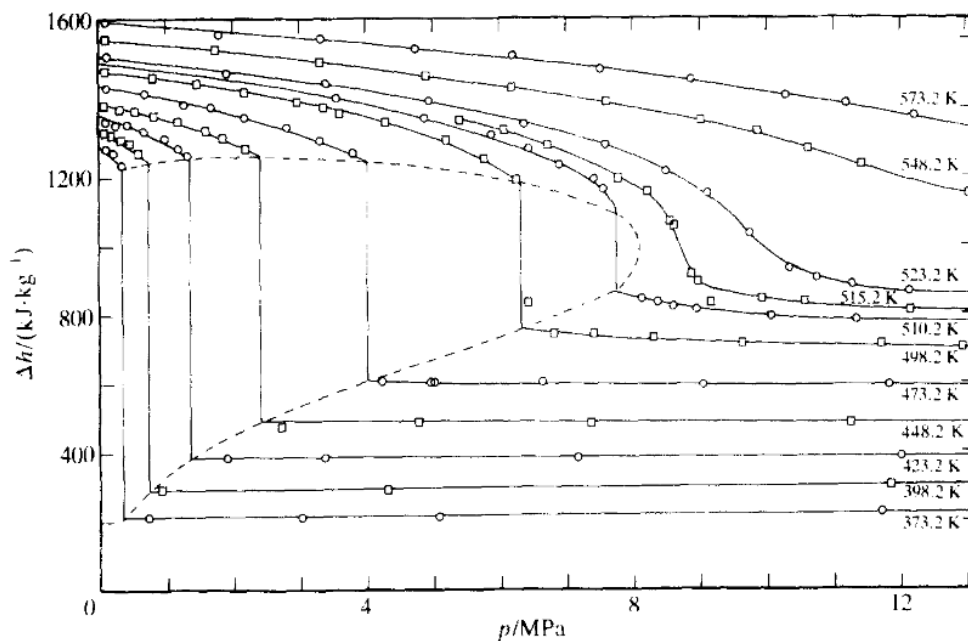
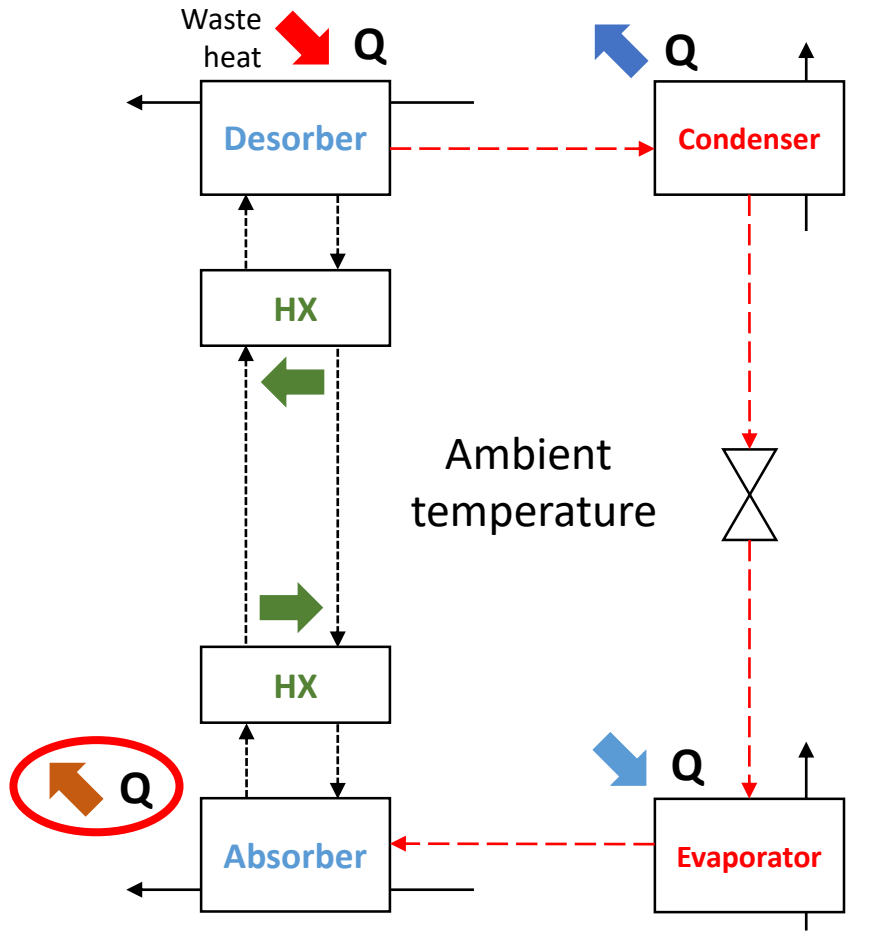


TABLE 1. Measurements of the specific enthalpy of methanol. The enthalpy increment  $\Delta h$  was calculated using equation (2) as described in the text.  $\Delta h = 0$  for liquid methanol at 298.15 K and the saturation pressure

T K	$\Delta h$		$\Delta h$		$\Delta h$		$\Delta h$		$\Delta h$	
	p MPa	kJ·kg <sup>-1</sup>	p MPa	kJ·kg <sup>-1</sup>	p MPa	kJ·kg <sup>-1</sup>	p MPa	kJ·kg <sup>-1</sup>	p MPa	kJ·kg <sup>-1</sup>
373.2	0.10	1284.6	0.34	1237.9	3.02	214.5	11.72	222.5		
	0.21	1273.9	0.74	212.1	5.07	213.2				
398.2	0.10	1334.2	0.34	1311.6	0.59	1273.0	4.30	292.1		
	0.18	1326.9	0.46	1302.2	0.90	295.7	11.84	301.3		
423.2	0.10	1367.8	0.68	1336.5	1.20	1282.2	1.89	389.4	7.16	388.3
	0.27	1356.1	0.99	1314.7	1.32	1265.1	3.36	389.7	12.00	389.5
	0.44	1358.3								
448.2	0.10	1412.5	0.82	1381.7	1.85	1317.5	2.73	479.3	7.36	488.3
	0.33	1400.2	1.20	1364.8	2.19	1288.4	4.78	490.1	11.25	484.8
	0.56	1399.1	1.58	1337.8						
473.2	0.10	1464.4	1.68	1402.0	3.30	1309.3	4.94	602.5	9.04	596.2
	0.68	1447.9	2.20	1377.6	3.78	1272.4	4.98	605.7	11.83	591.9
	1.27	1414.4	2.82	1342.1	4.23	606.9	6.63	602.8		
498.2	0.10	1513.1	2.98	1422.0	5.20	1304.2	6.80	743.8	9.64	717.7
	0.83	1495.5	3.38	1403.9	5.75	1254.0	7.39	741.2	11.70	711.2
	1.47	1477.5	3.60	1389.4	6.25	1191.0	8.30	732.0	12.92	702.4
510.2	2.18	1449.9	4.30	1360.6	6.42	836.5				
	3.56	1433.4	6.45	1282.0	7.55	1163.1	8.60	825.2	10.05	793.6
	4.86	1371.0	6.90	1236.4	8.12	847.9	8.95	815.8	11.35	781.3
515.2	5.88	1320.9	7.40	1192.7	8.37	838.2				
	5.42	1363.4	7.77	1201.8	8.58	1057.1	9.16	835.3	10.55	828.1
	6.08	1336.2	8.22	1151.5	8.87	909.0	9.92	831.3	12.13	809.7
523.2	6.72	1294.2	8.54	1066.8	8.95	892.0				
	0.10	1554.8	4.94	1422.9	8.50	1218.3	10.33	931.4	11.29	883.6
	1.91	1504.9	6.36	1355.7	9.12	1152.7	10.74	904.7	12.14	868.3
548.2	3.40	1473.3	7.58	1293.9	9.74	1036.6				
	0.10	1603.7	4.91	1498.9	7.60	1420.7	9.86	1331.5	11.42	1238.0
	1.74	1572.9	6.18	1462.8	9.02	1365.6	10.64	1280.4	13.04	1150.4
573.2	3.30	1534.8								
	0.10	1653.0	4.74	1573.6	7.52	1512.2	10.28	1438.5	12.23	1375.3
	1.80	1620.2	6.20	1550.6	8.90	1481.0	11.18	1413.0	13.64	1326.5
	3.33	1604.4								

# Example: LiBr – CH<sub>3</sub>OH

## Matlab program



Tamb (C)	Tabs (C)	Tdes (C)	Abs/Des	$\Delta T_{eq} H_2O$
5	30	35		
5	30	40		
5	30	45		
5	40	45		
5	40	50		
5	40	55		
5	50	55		
5	50	60		
5	50	65		
5	60	65		
5	60	70		
5	60	75		
10	30	35		
10	30	40		
10	30	45		
10	40	45		
10	40	50		
10	40	55		
10	50	55		
10	50	60		
10	50	65		
10	60	65		
10	60	70		
10	60	75		
15	30	35		
15	30	40		
15	30	45		
15	40	45		
15	40	50		
15	40	55		
15	50	55		
15	50	60		
15	50	65		
15	60	65		
15	60	70		
15	60	75		

**Thank you**

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**LoT-NET** 