Investigation of prototype membrane based energy exchanger

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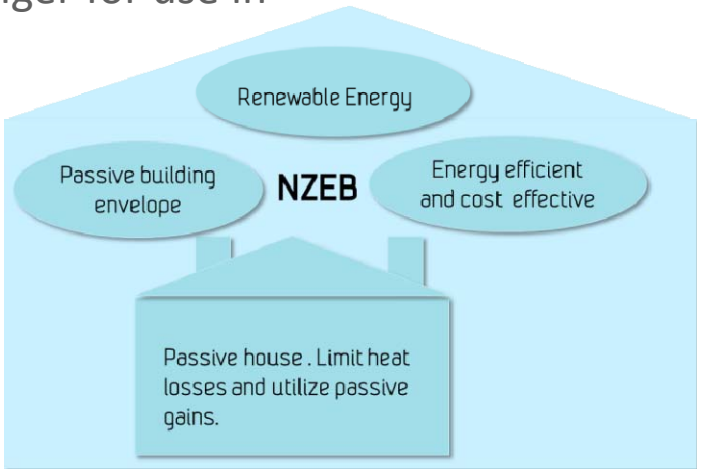
Background ZEB

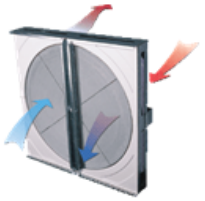
Net Zero Energy Buildings aim at reducing energy needs through technology measures, using efficient energy supply systems; and substituting non environmental-friendly sources

- Study focused on **NZEB apartment** placed in **Nordic countries**
- Common ventilation system for all the apartments within a given building.
- The requirements for an ideal air-to-air energy exchanger for use in NZEBs in Nordic countries are:
  - **high effectiveness and efficiency**,
  - **proper IAQ** and **avoid odours** spreading.

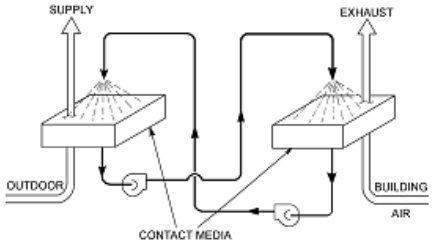


Common Recovery Systems

Flat Plate Exchanger (paper or membrane)



Energy (Enthalpy) Wheel



Twin-Tower Enthalpy Recovery Loop

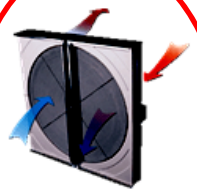
2004 ASHRAE Handbook—HVAC systems and equipment handbook. © American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Research Stage: Run-around, Membrane Energy Exchanger (RAMEE)

Energy Exchange – Adjacent Duct

Energy Exchange – Non-adjacent Duct

Heat Exchange – Adjacent Duct

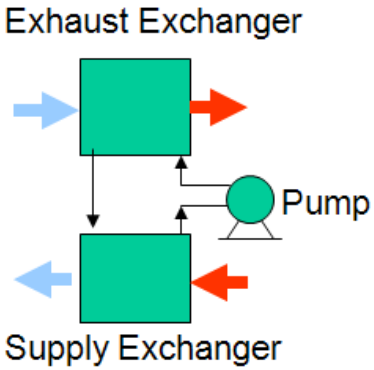


Heat Wheel

Heat Pipe

Flat Plate Exchanger (aluminum or solid plastic)

Heat Exchange – Non-adjacent Duct



Glycol Run-Around System

Most common types for residential ventilation

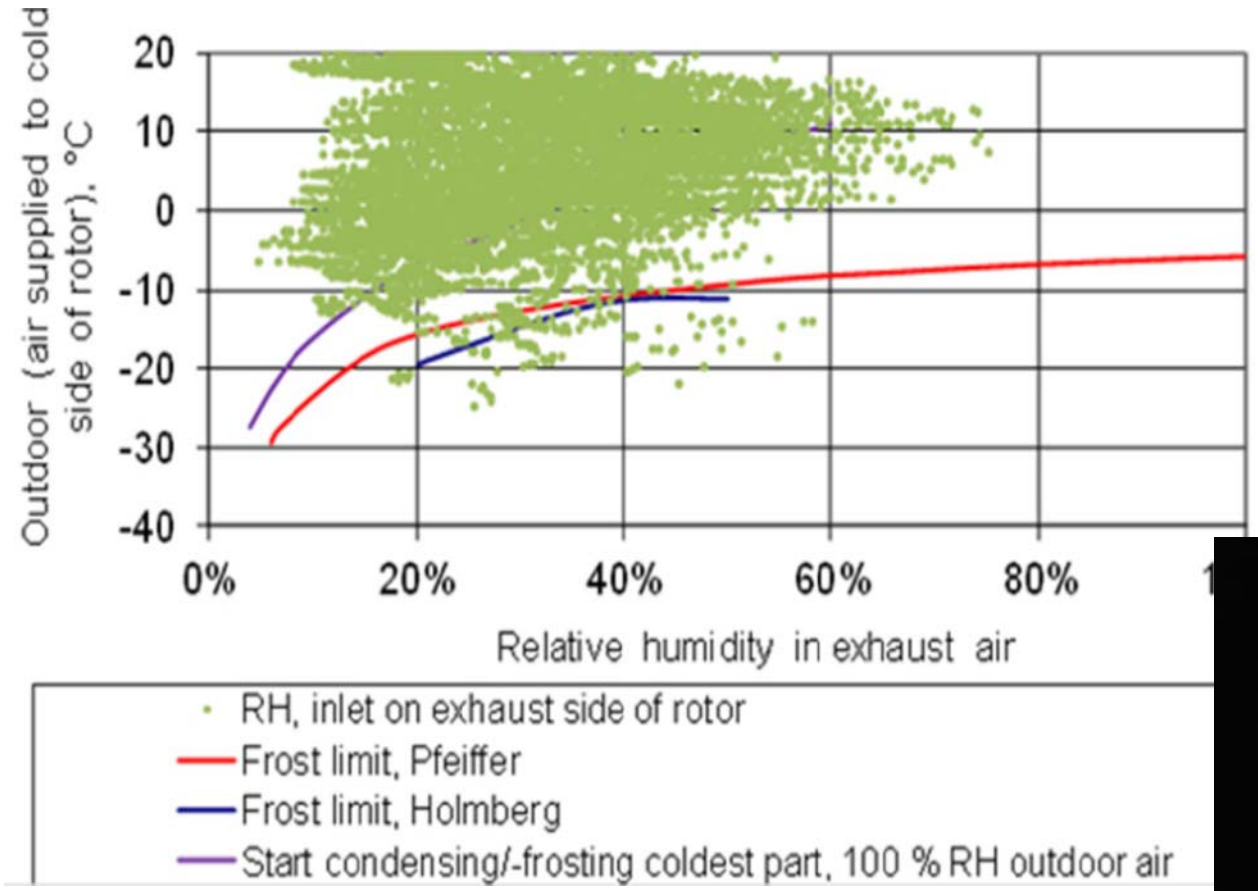
Heat wheels

+ High efficiency
+ No or small frost problems
+ Easy to control
- Transfer of odors from exhaust to fresh supply air

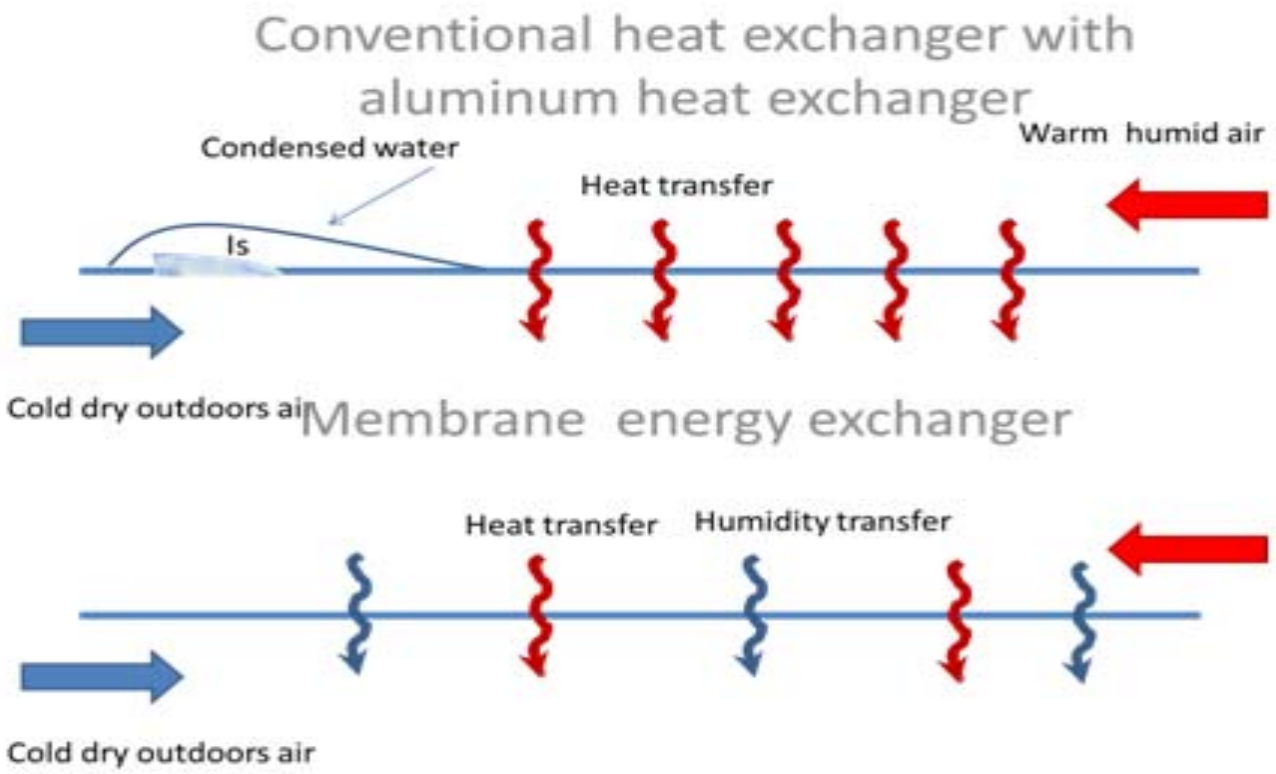
Ventilation of flats

Odors can spread from one flat to all others

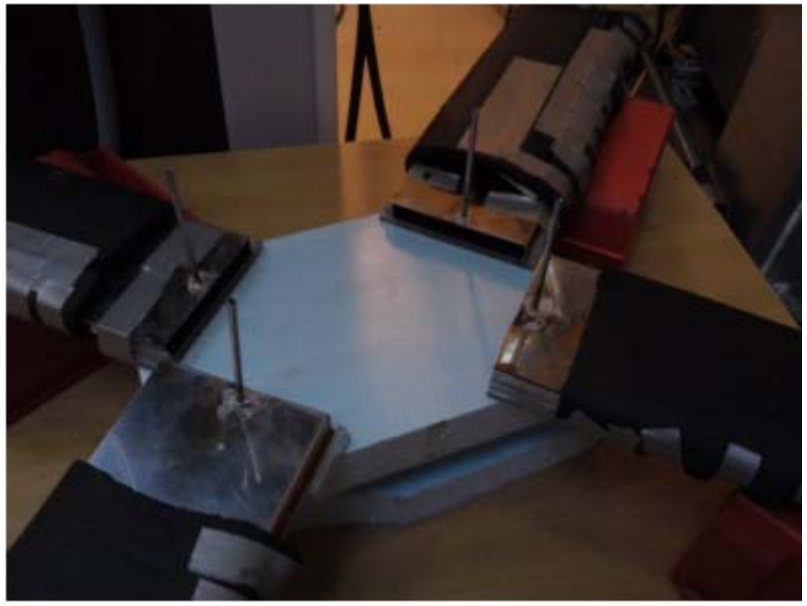
Frosting

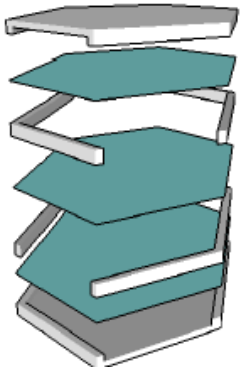

Outdoor (air supplied to cold side of rotor), °C
20
10
0
-10
-20
-30
-40
0%
20%
40%
60%
80%
Relative humidity in exhaust air
RH, inlet on exhaust side of rotor
Frost limit, Pfeiffer
Frost limit, Holmberg
Start condensing/-frosting coldest part, 100 % RH outdoor air

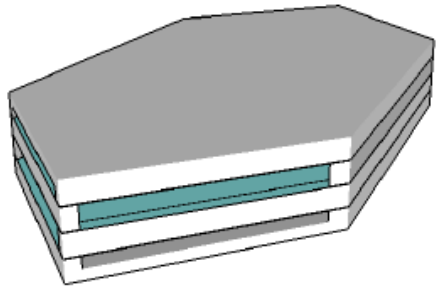
Counterflow flat plate exchangers



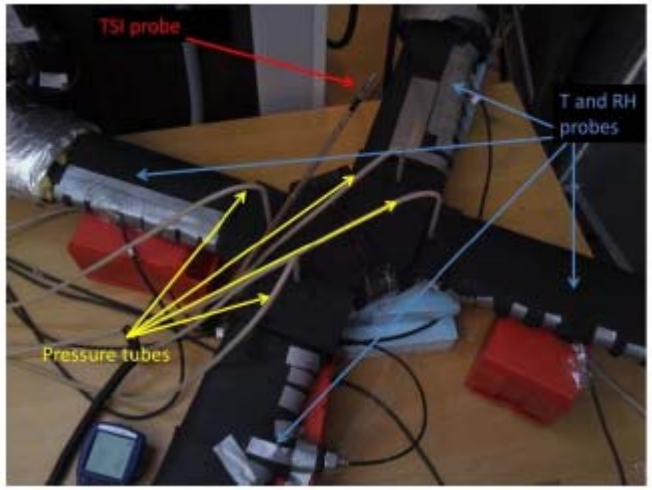
Heat exchanger prototype





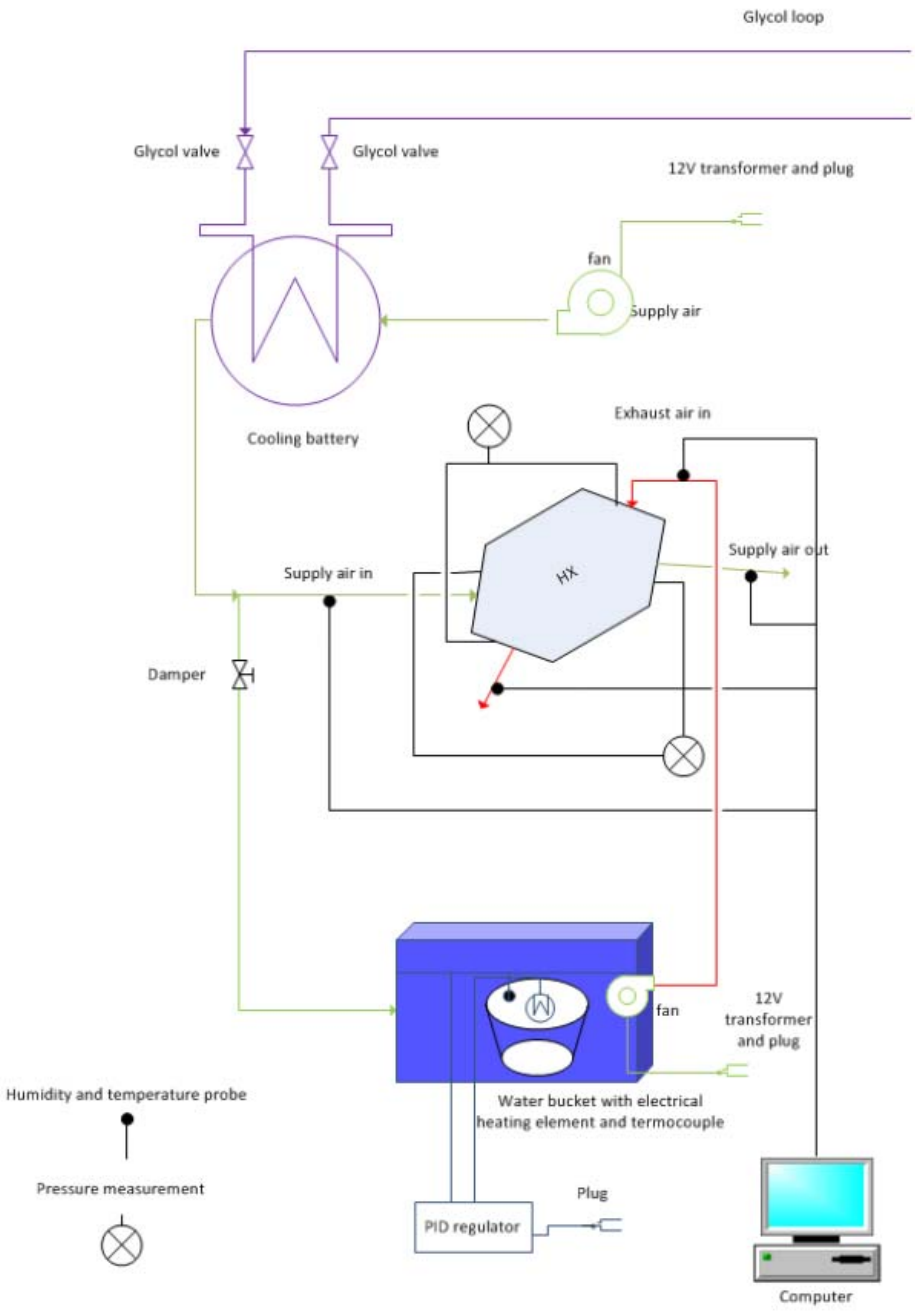


Experimental set up



Properties for the different tested plate materials.

Material	Water permeable	Elastic	Crumples in high humidity
Wrapping plastic	No	No	No
PP (polypropylene)	No	yes	no
Membrane X	yes	yes	yes

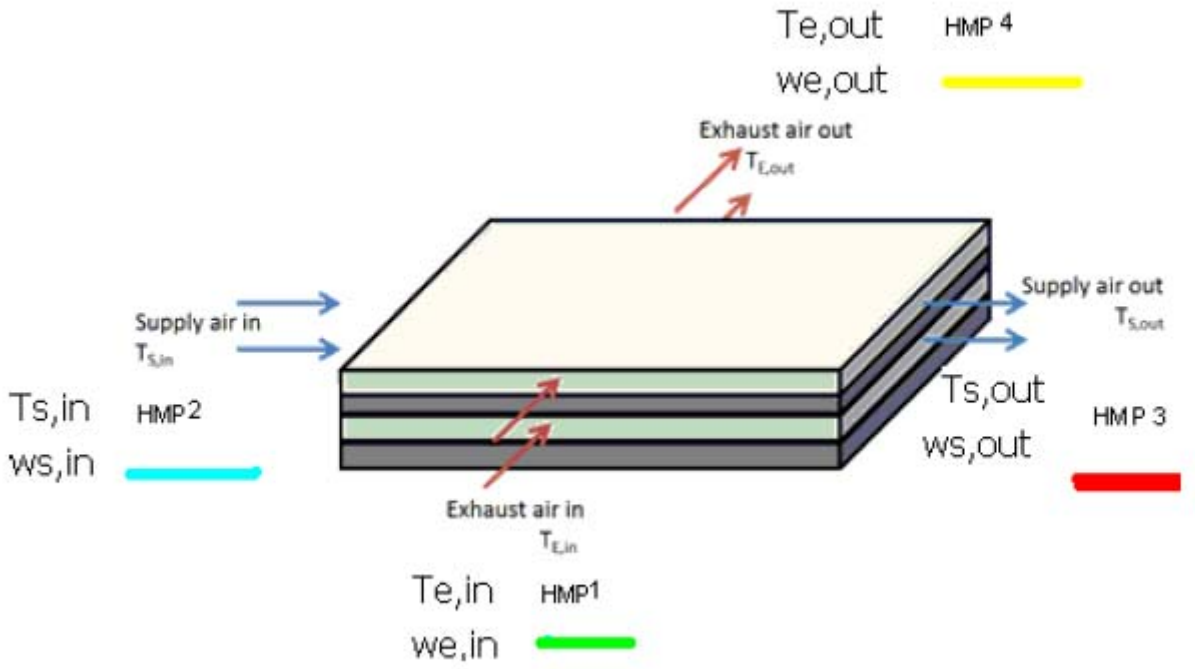


ZEB

ribute with emissions

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

Results


Te,out
HMP 4
we,out
Exhaust air out
$T_{E,out}$
Supply air out
$T_{S,out}$
Supply air in
$T_{S,in}$
Ts,in
HMP 2
ws,in
Ts,out
ws,out
HMP 3
Exhaust air in
$T_{E,in}$
Te,in
HMP1
we,in

Results

	Plate Material	$T_{s,in}$(c)	$T_{E,in}$(c)	$\Phi_{s,in}$(%)	$\Phi_{E,in}$(%)	ΔPs [Patel]	ΔPe [Patel]	Vs(m^3/h)	Ve(m^3/h)	η_T	η_T
	Wrap plastic	-5.27	1	27.4	43.6	2.4	2.55	1.58*	1.58	0.27	no moisture transfer
2	Wrap plastic	-8.05	20.85	33.6	39.3	3.95	5.79	1.66	1.05	0.37	no moisture transfer
3	Mem	-4.96	21.25	27.1	42.86	9.248	8.96	0.74	1.38	0.41	0.37
4	PP	-8.41	21.04	35.17	46.15	6.16	6.73	1.38	1.3	0.35	No moisture transfer
5	Mem	-0.23	22.91	39.02	45.25	10.47	9.85	1.53	1.33	0.54	0.49
6	Mem	-4.32	22.77	29.54	43.27	11.13	10.48	1.55	1.2	0.54	0.58
7	Mem	-10.5	23.21	41.04	37.27	27.19	25.6	2.6	0.6	0.6	0.91
8	Mem	-9.62	22.9	34.22	46.6	25.25	24.8	1.4*	0.6	0.61	0.88

Results

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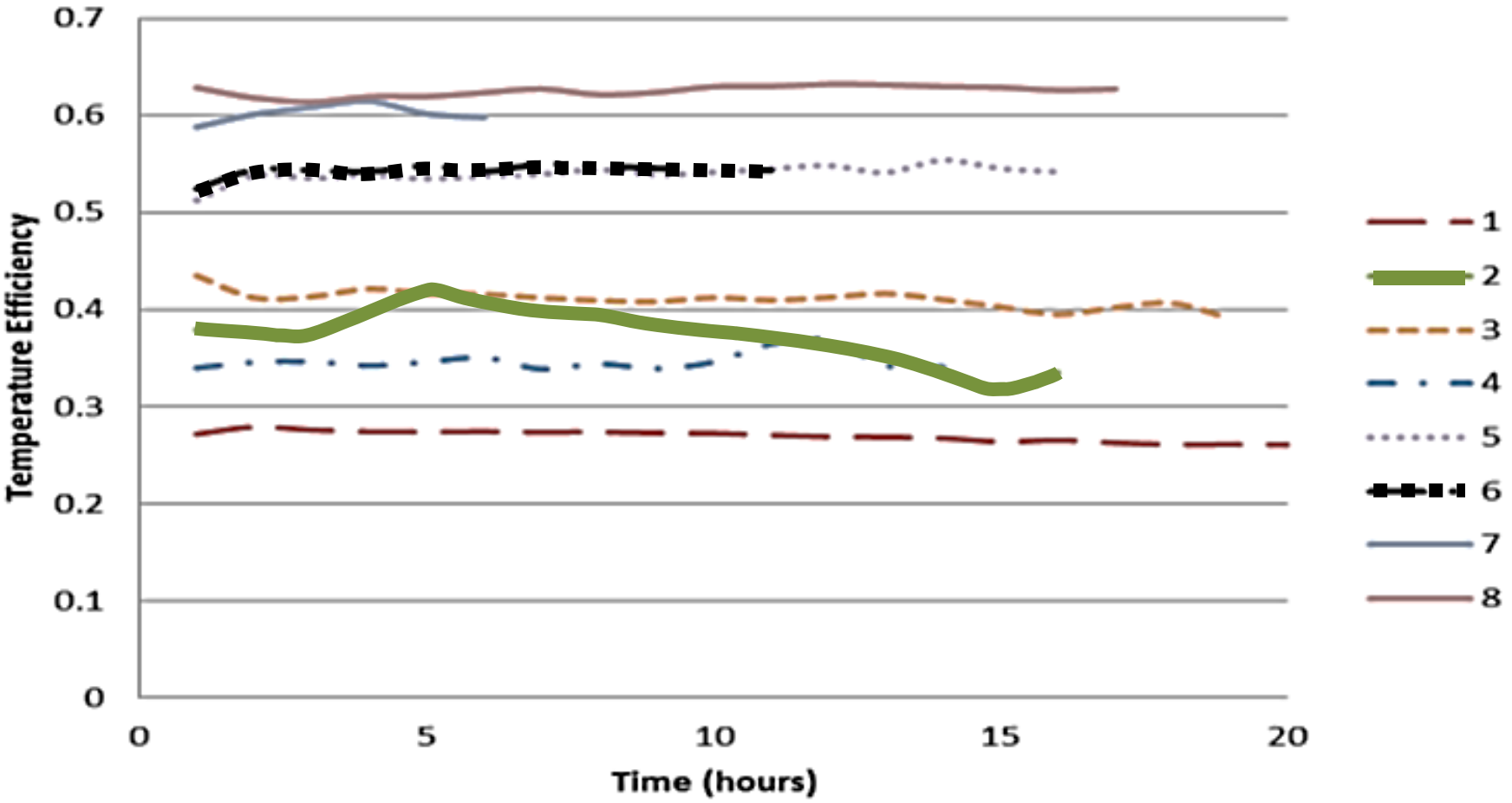
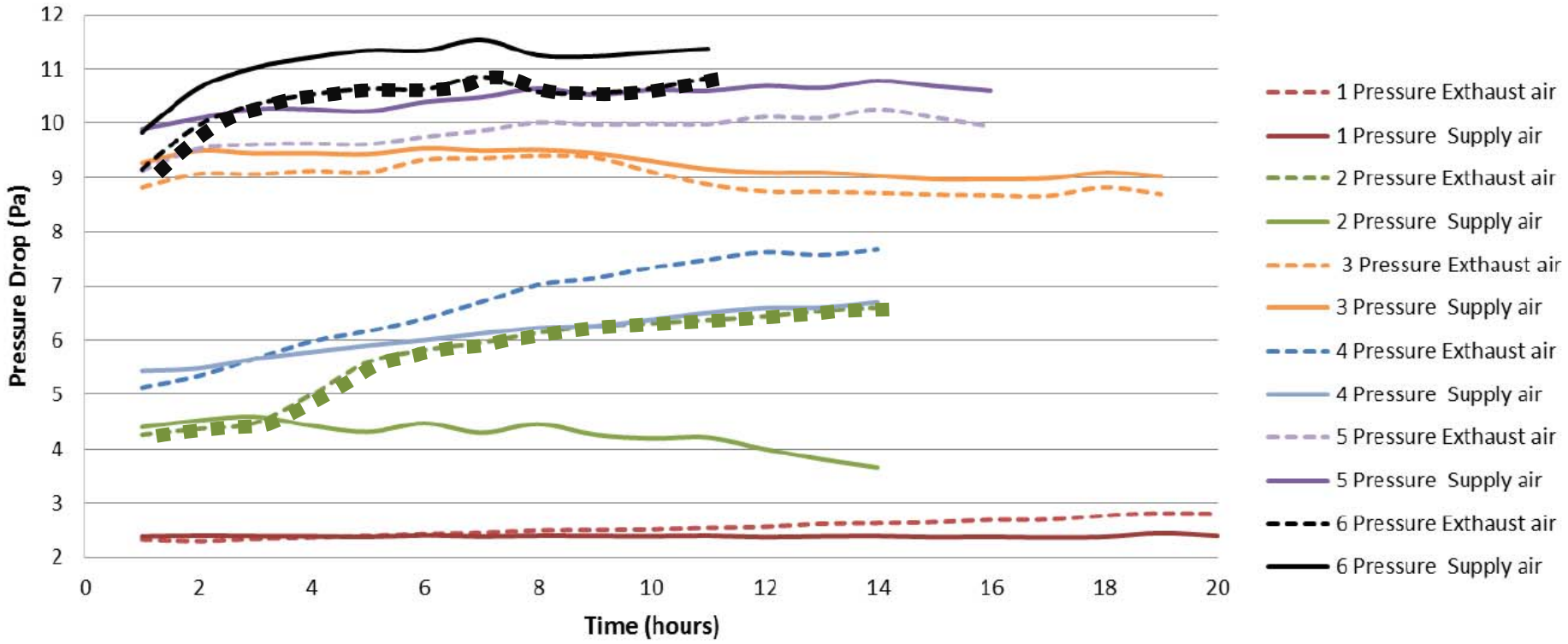
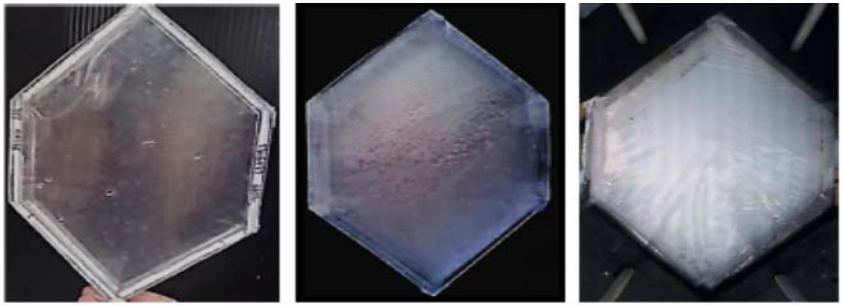
Temperature efficiency for all experiments

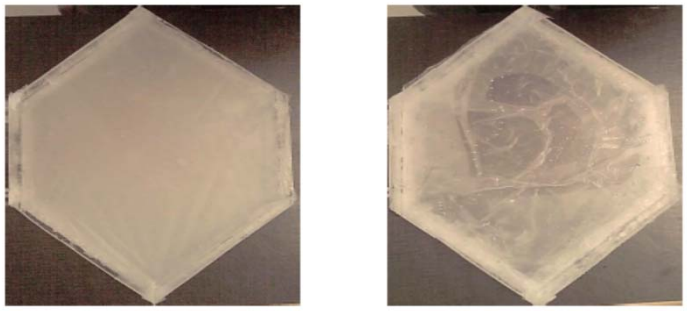


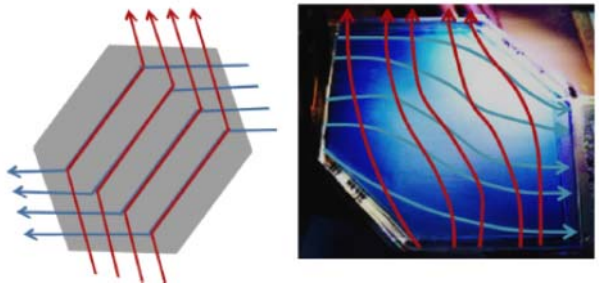


Pressure drop Experiments 1, 2 and 4 are plastic based while 3, 5, 6, 7, 8 are membrane based.

Membrane crumpling







Conclusions

- Frost formation on plastic prototypes in exhaust channels near outdoor air inlet side of the exchanger.
- Not found in hydrophilic membrane. However, in exhaust air inlet humidity (46.6 % RH), the membrane expanded and crumpled.
- Hydrophilic membrane superior to the two plastic materials regarding
  - water condensation
  - frost formation
- Pressure drop strongly influenced by membrane elasticity and not proportional to flow rate.
- Other types of membranes should also be tested.
- Test at supply air temperature about -10 °C. Lower temperature performance should be investigated
- These tests should be repeated in a full-scale prototype to avoid scaling effects.
- Membranes should also be tested for durability and pollution transfer

THANK YOU FOR YOUR ATTENTION