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Green economy with natural refrigerants

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Benchmarking on refrigeration system solutions

by

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Objectives of today

- respond and improve to acquire new business
  - how to become solution provider from supplier
    - introduction of techniques on assisting Client at making decision on refrigeration system

Comparative advantage to the competitors

- we hold capabilities of different refrigeration technologies, hence we are not impelled by only one kind of solution
  - we deliver more potential solutions for implementing the specific job and remaining the choice to our Clients.

Client needs to prove which solution is right (appropriate: suitable for him?)?

Two ways of evaluation:

- on measurements (existing systems)
  - not aid on decision making in advance
  - extensive and time consuming
  - expensive
  - not eliminate and *detecting eventual* errors in measurement or operation
- calculation: though every company could create his own calculation but...:

  final output depends on the model created and formulas applied

  - benefits:
    - predictable
    - comparable
  - concerns:
    - uncertainties
      - plausibility,
      - reliability
    - development needs extra resources

a commonly available calculation tool with representative outputs desired *which will be presented now*!

3 systems …..real case study not just models

Why not the example from the retail business?

retail market depleting in Hungary

Analysis on economical environment and market situation

- subsidiaries plays dominant role in present investments
  - threats:
    - hazard to distort the competence ownership decision
      - “artificial” shaping on domestic energy prices
      - return of investment less importance
  - opportunities:
    - energy efficiency, heat recovery, sustainable solution are mark-up points

A business case from the food processing industry

- contradictional time in food processing sector
  - stake holders, property structure changed significantly
    - traditional local players lost position
    - financial institutes become owner (after indebted owner)
    - new investors enter (sometime local government to salvage the workplace)…
    - start-up companies after spontaneous growth
  - not all regulations, industrial standards are fully observed…

⇨ no “respect” on “conventional industrial” solutions

- as a consequence, a kind of “trade-off” can be observed when making individual decision of refrigeration
- attracting Client is even though work

unless the alternative options are presented to the Client !

by calculation tools one can be enabled to make alternative options comparable

The business case: a poultry slaughtering plant before step change

Attitude of the client

- diverse property structure
- entertainment as result of spontaneous growth
  - Integrated enterprise: growing crops, breeding poultries and processing to semifinal fresh products
  - in the top ten of poultry processing plants
    - new supply contracts
    - concerns on quality and operation safety

⇨ Decision: new blast chiller with conveyor needed (the core to quality product)!

  - unique mixtures of production equipment (eg. refrigeration: condensing units and small racks with R22, R404A, R134a and R407C)
  - utilities (electricity, gas, water): used up under tight control but not efficiently
- thus the client is not fully educated in pure economics rules
  - but uses explicitly by good sense and follow them unintentionally
  - he realise the need for "step change": essential need to good refrigeration for the technology

our goal is for business relationship to find Clients with prudent thinking and work together on "viable" technical solutions

Beforehand the proposed solutions: useful hints for engineers preparing technical solutions eager for success but tend not to work in vain.

- Client owe to increase expenditures only until increasing benefits can be obtained in the certain service in respect of:
  - value of goods
  - AND time preference

  ⇨ clearly price up the service in the market

- Client will allocate the expenditures in such way that the ratio between the benefits (yield) and expenditure is equal to that for every other good or service he can get

  ⇨ competitiveness with other sectors, service providers
  - (eg. heat production, heat utilization on various ways)
  - AND true for external liabilities, as well (standards, regulations, inspection – as far as authorities intervene)

Create and observe KPI (key performance indicators) based on the Clients' objectives

- evolve solution on total lifecycle if concerned
  - TCO (total cost of ownership): hard to list all the incurred costs

    economic environment hold greatest uncertainty!

    - typical lifecycle cost calculation include
      - implementation
        - first costs of equipment
        - adherent costs? (building services, permissions, etc.)
      - operation:
        - costs of utilities (electricity, water, gas, chemical)
        - maintenance and service
        - indirect costs associated with the ownership or operation? (administration – eg. F-gas rules)
        - (and liquidation!)

- determination of lifetime:
  - what is the economical ground?
    - how can be the change in surrounding legislative condition incorporated (eg. F-Gas rule)
  - how it could be uniform while investigating on different solution?
    - residual value?
- determination of payback time
  - rate of interest
  - inflation ? – alternative cost of capital?

Declaration: we are not involved in any way in the development nor have any commercial interest in the calculation tool going to be introduced now.

- Simply, as users, we are glad to have a freware tool, named the ”Pack Calculation II.” for our specific purpose.

Pack Calculation is:

- for comparing the yearly energy consumption of refrigeration plants
- makes the comparison based on a geographical location

Initiatives

Cooling loads - existing plant and the planned blast chiller

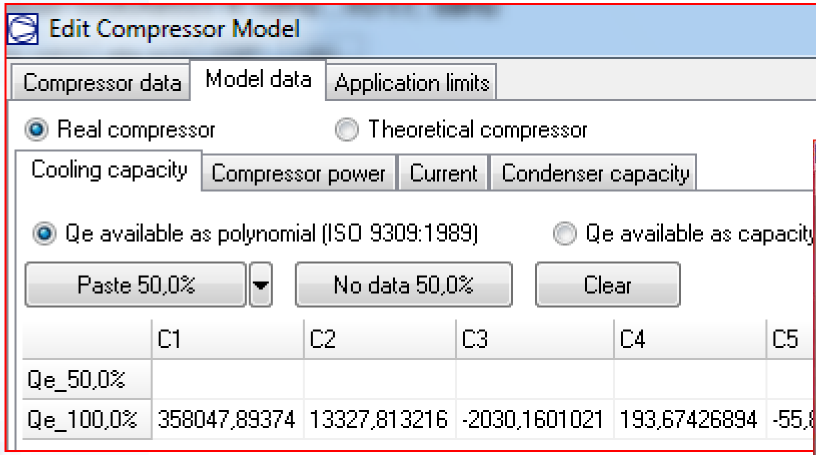
	Q0 @ 0°C/+45°C	Q0 @ -10°C/+45°C	Q0 @ - 0°C/+45°C	original refrigerant
Blast chiller		397 kWR		
Freezer Store I.			6 kWR	R404A
Freezer Store II.			14 kWR	R404A
Chiller Store – Packed products		25 kWR		R22
Chiller Store – Bulk products		8.5 kWR		R404A
Freezer Room			23 kWR	R404A
Chilled Preparation room	48 kWR			R22
Air handling unit	20 kWR			R22
Garbage Store		~~45 kWR~~		R22
Fresh water chiller	20 kWR			R407C
Freezer Store III.			3 kWR	R22
Disposable Chiller Store		3 kWR		R404A
Legs, Heads Chiller store		3 kWR		R404A
Dispatching room	7 kWR			R404A
Total =	**95 kWR**	**436.5 kWR**	**46 kWR**	

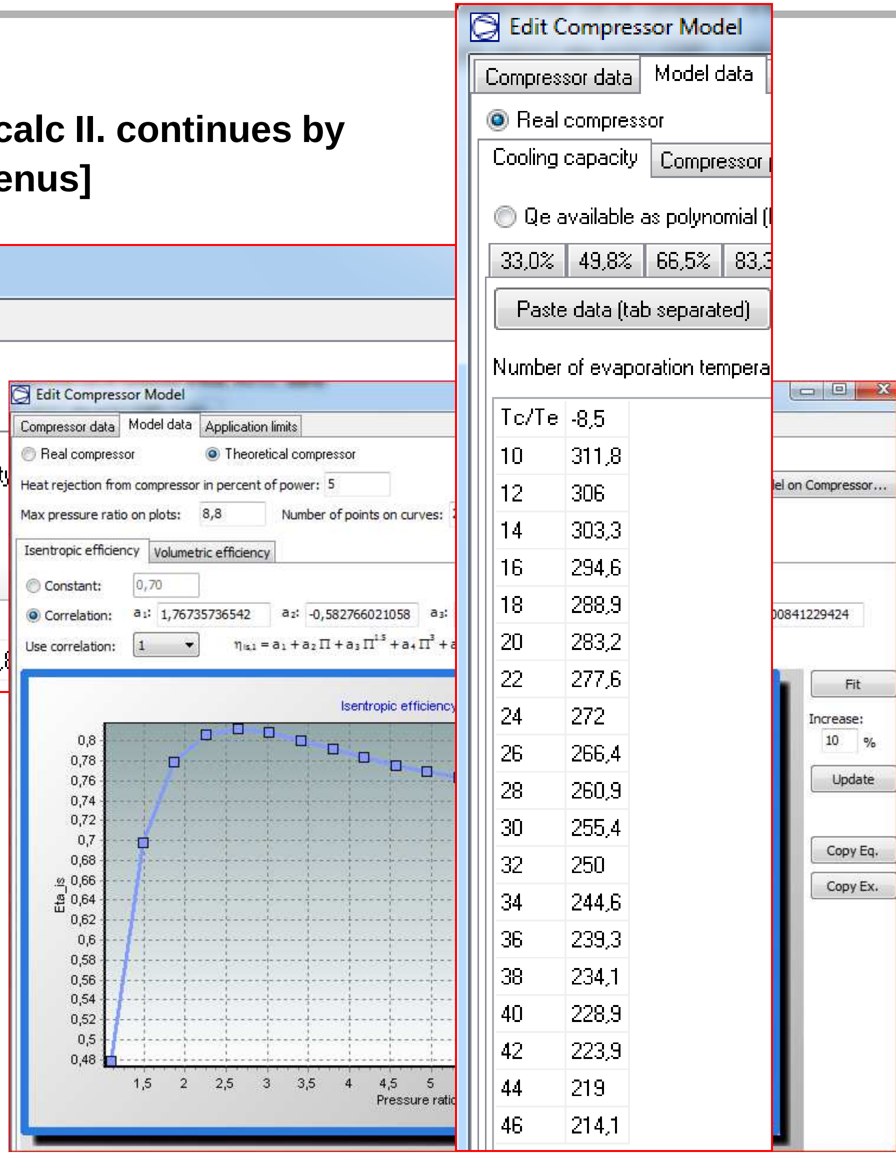
Fresh warm water needs @ +40°C (partly for further heating): 300m3/h (!)

First step of retrofitting: normal range

Processing the calculation

[if the conditions allow introduction of Packcalc II. continues by running the software and browsing in the menus]





1. Definition of compressors on 3 ways

- by polynomial
- isentropic and volumetric curves
- table

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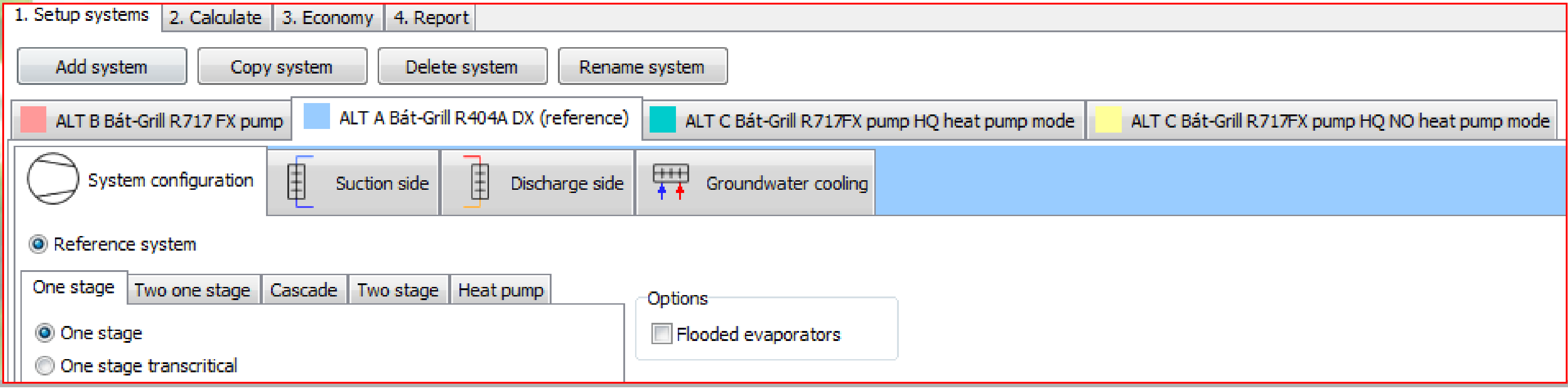
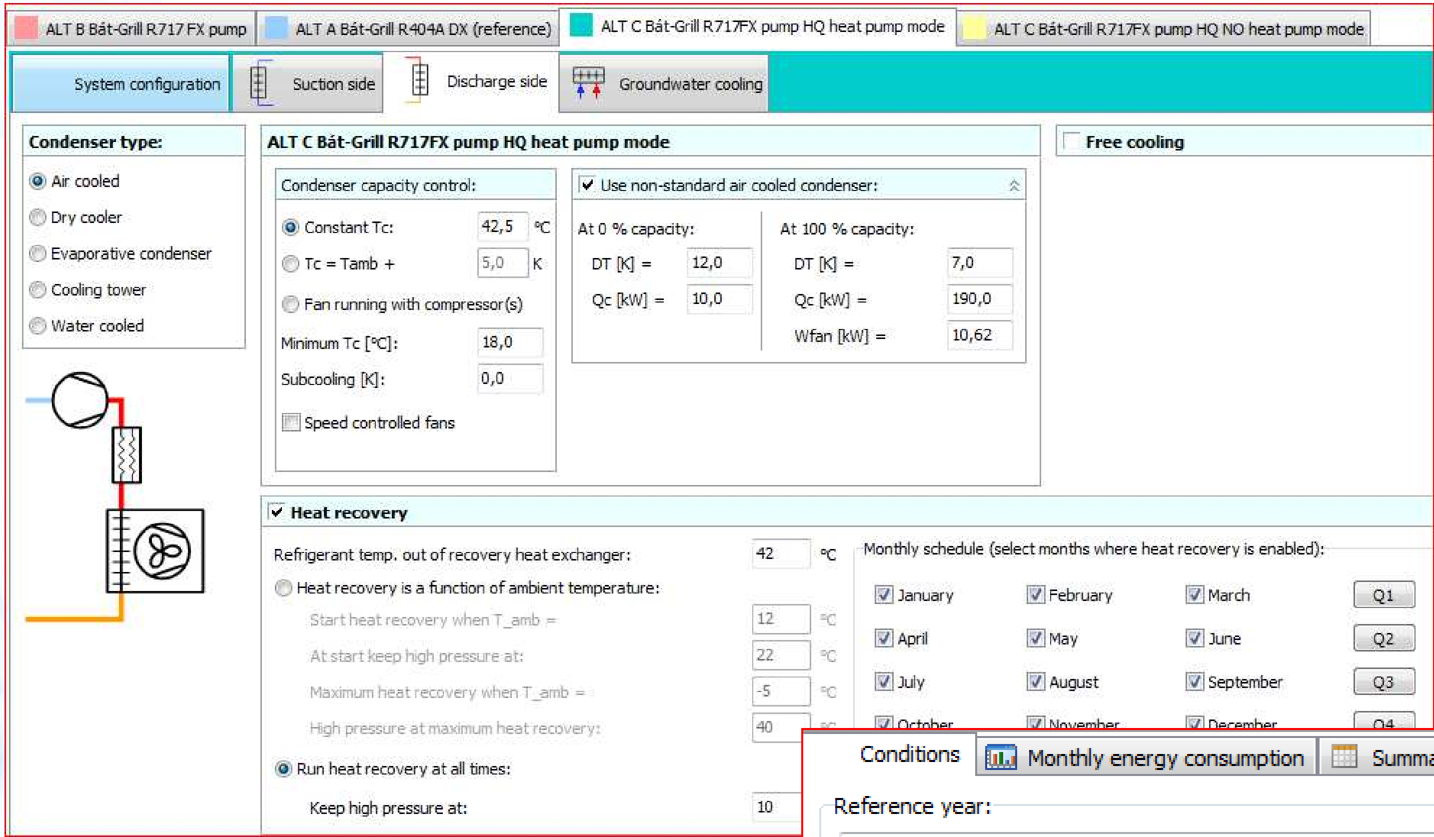
2. creating models

- In the present example we create 4 models to simulate 3 systems in 4 operation mode:
  - Model 1 (reference):
    - R404A screw (2 compressors, lead compressor frequency driven, dry condenser, partial heat reclaim of superheated discharge gas)
  - Model 2
    - R717 screw (2 compressors, lead compressor frequency driven, evaporative condenser, partial heat reclaim of superheated discharge gas)
  - R717 reciprocating (2 compressors, dry condenser) for dual operation
    - Model 3 (partial heat reclaim of superheated discharge gas)
    - Model 4 (total condensing heat reclaim for the total warm process water needs and dry condenser for partial load)

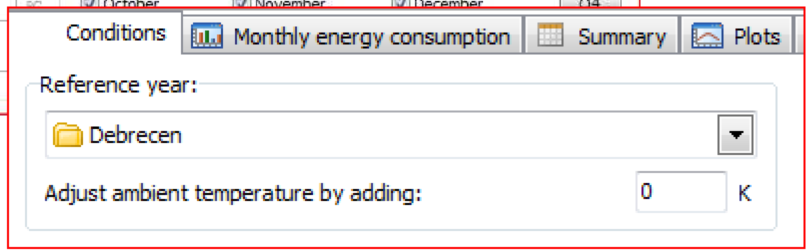


3. defining particular design and operation parameters

- Among the others, eg. details of heat reclaim (model 4)



4. defining geographic location



5. Results

- Bargraphs

- summary tables

Conditions | Monthly energy consumption | Summary | Plots | Table | Warnings

	ALT B Bát-Grill R717 FX pump	ALT A Bát-Grill R404A DX (reference)	ALT C Bát-Grill R717FX pump HQ heat pump mode	ALT C Bát-Grill R717FX pump HQ NO heat pump mode
Load fulfillment				
% of time:	90,4	100,0	100,0	100,0
% of energy:	99,5	100,0	100,0	100,0
COP				
Average COP [-]:	4,45	3,11	2,96	5,17
Energy consumption				
Pumps and fans [kWh]:	31 189	33 384	780	1 972
Compressor [kWh]:	282 245	417 797	473 169	268 897
Total [kWh]:	313 433	451 181	473 948	270 869
HeatRecovery				
Total [kWh]:	122 028	150 488	1 850 527	113 991
Savings				
Yearly energy savings [kWh]:	137 748	-	-22 767	180 312
Yearly energy savings [%]:	30,5	-	-5,0	40,0

(economy)

1. Setup systems | 2. Calculate | 3. Economy | 4. Report

Life Cycle Costs | CO2 Equivalent Emissions

Currency: EUR

Expected average interest rate [%]: 4

Expected average inflation rate [%]: 2

Expected average energy cost [EUR/kWh]: 0,1

Expected lifetime [years]: 10

Update

Initial cost:

	ALT B Bát-Grill R717 FX pump	ALT A Bát-Grill R404A DX	ALT C Bát-Grill R717FX pump HQ heat pump mode	ALT C Bát-Grill R717FX pump HQ NO l
Cost of equipment [EUR]	183 584	141 894	182 417	182 417
Cost of installation [EUR]	50 000	35 000	50 000	50 000

Annual operating cost:

	ALT B Bát-Grill R717 FX pump	ALT A Bát-Grill R404A DX	ALT C Bát-Grill R717FX
Energy consumption [kWh]	313433,45 (-137 748)	451180,98	473948,47 (+22 767)
Cost of maintenance [EUR]	1 317	6 112	-89 999

	ALT B Bát-Grill R717 FX pump	ALT A Bát-Grill R404A DX	ALT C Bát-Grill R717FX pump HQ heat pump mode	ALT C Bát-Grill R717FX pump HQ NO heat pump mode
Effective interest rate [%]	1,96	1,96	1,96	1,96
Internal rate of return [%]	30,46	-	168,99	35,79
Total annual cost [EUR]	32 660 (-18 570)	51 230	-42 604 (-93 834)	30 381 (-20 849)
Payback time [years]	3,1	-	0,6	2,7
Total initial cost [EUR]	233 584 (44%)	176 894 (28%)	232 417 (-154%)	232 417 (46%)
Present value of maintenance cost [EUR]	11 854 (2%)	55 014 (9%)	-810 085 (536%)	29 649 (6%)
Present value of energy cost [EUR]	282 123 (54%)	406 110 (63%)	426 603 (-282%)	243 810 (48%)
Life cycle cost [EUR]	527 561 (-110 457)	638 018	-151 065 (-789 083)	505 877 (-132 142)

(carbon footprint)

1. Setup systems | 2. Calculate | 3. Economy | 4. Report

Life Cycle Costs | CO2 Equivalent Emissions

CO2 release, electricity generation [kg/kWh]: 0,53

Update

	ALT B Bát-Grill R717 FX pump (R717)	ALT A Bát-Grill R404A DX (R404A)	ALT C Bát-Grill R717FX pump HQ heat pump mode (R717)	ALT C Bát-Grill R717FX pump HQ NO heat pump mode (R717)
Refrigerant charge [kg]	1000,00	500,00	1000,00	1000,00
Recycle rate [%]	90,0	95,0	90,0	90,0
Leakage rate [%/year]	5,0	10,0	5,0	5,0

	Leakage [kg CO2]	Recycle loss [kg CO2]	Indirect [kg CO2]	Total [kg CO2]
ALT B Bát-Grill R717 FX pump	250 (0,0%)	50 (0,0%)	1 661 197 (100,0%)	1 661 497
ALT A Bát-Grill R404A DX	1 961 000 (44,1%)	98 050 (2,2%)	2 391 259 (53,7%)	4 450 309
ALT C Bát-Grill R717FX pump HQ heat pump mode	250 (0,0%)	50 (0,0%)	2 511 927 (100,0%)	2 512 227
ALT C Bát-Grill R717FX pump HQ NO heat pump mode	250 (0,0%)	50 (0,0%)	1 435 605 (100,0%)	1 435 905

Presentation to the Client

- by gaining the particular data from the software

Energy consumption data	ALT A Bát-Grill R404A screw DX (reference)	ALT B Bát-Grill R717 screw FX	ALT C Bát-Grill FX recip. „heat pump” mode	ALT C Bát-Grill FX recip. „cooling” mode
Avarage „cooling” COP el*	2.64	3.78	2.52	4.39
Avarage „cooling + heat reclaim+ COP el (primary side only) *	2.93	4.11	5.83	4.75
Consumptions on fans and pumps (primary side only, lwo. aircoolers) [kWh] *	39 275	36 693	918	2 320
Consumptions on compressors [kWh] *	491 526	332 053	556 669	316 349
Consumptions Total [kWh]:	530 801	368 746	557 587	318 669
Heat reclaim Total [kWh] (40°C/50°C):	150 488	122 028	*1 850 527*	113 991
Annual energy savings [%]:	-	35%	*440%*	46%
*cos fi=	0.85			

Presentation to the Client [cont.]

- completing the missing utilities (fresh water)
- calculating alternative costs of heating (gas vs. „heat pump")
  - interesting: ratio of electricity and gas costs

Estimation on operating costs over the electricity	ALT A Bát-Grill R404A screw DX (reference)	ALT B Bát-Grill R717 screw FX	ALT C Bát-Grill FX recip. „heat pump" mode	ALT C Bát-Grill FX recip. „cooling" mode
Specific costs of gas [Euro/kWh]	0.05			
Saving on heating [Euro/yr]	-7 987	-6 476	*-98 212*	-6 050
Water consumption [m3/yr]		351.1		
Costs of treated water [Euro/yr]		595		
Maintenance and service fee [Euro/yr]	8 000	6 000	*6 000*	6 000
Total operating costs over the electricity [Euro/yr]	13	470	*-92 212*	-50

Remarks to the Packcalc tool:

+ valuable tool

+ structure easy to operate

- inconsistencies:
  - condensing temp. calculation in heat reclaim mode
  - unclear error with model 2 in load calculation

  - fields to develop:
    - further models (eg. subcooled liquid LT circuits,
    - heat reclaim variations (for process eating…)
    - alternative costs of heating
    - water consumptions on evaporative towers and condensers
    - cooling positions, defrost mode etc.