Life cycle cost analysis for AHUs in hot and humid climates

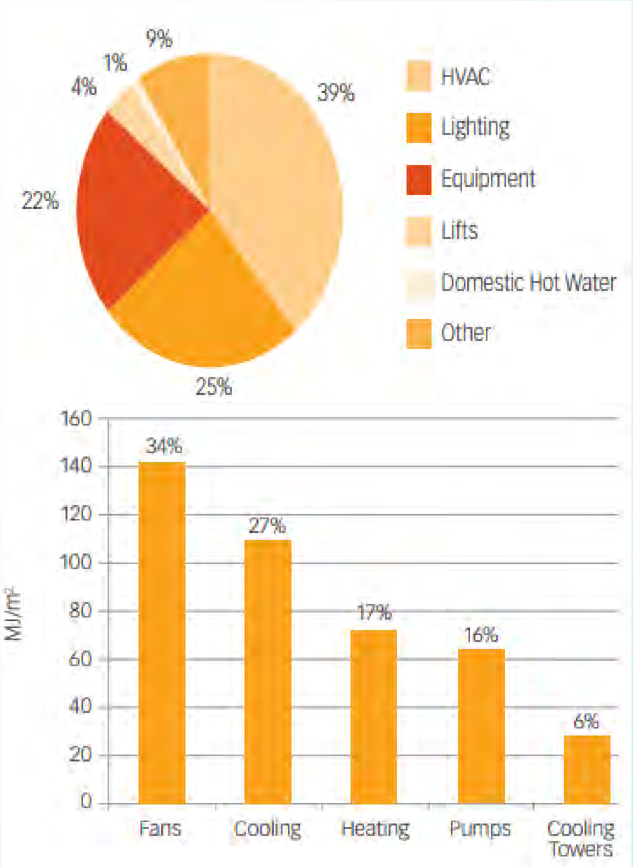
Mr Arvind Singh
Director
FläktGroup

Demand to Reduce Energy Consumption

- Floor area in the buildings sector worldwide is expected to increase 75% between 2020 and 2050, of which 80% would be in emerging markets and developing economies.
- In this regard, India is uniquely placed with three-quarters of the buildings, infrastructure and industrial capacity of India in 2050 yet to be built.
- Despite this demand growth the total Co2 emissions from the buildings sector need to decline by more than 95% by 2050. This would translate to more than 85% of buildings complying with zero-carbon-ready building energy codes by 2050.
- In addition, Air side load contributes approximately to 14% of the overall Building energy load. Under this scenario, an efficient airside in the HVAC sector becomes ever-important to ensure meeting these requirements while maintaining a high level of IAQ.

Buildings and their HVAC systems

- A typical HVAC account is generally responsible for approx. 40% of total building energy consumption.
- Essences involved in mechanical ventilation
- Indispensable in new and refurbished airtight buildings to ensure IAQ
- Air handling units have a major impact on energy consumption Air transport and heat recovery



Essential to Save Energy

Energy sources:

- Limited traditional energy sources (oil, gas, coal etc.)
- Increase of energy consumption (China, India)
- Increase of energy prices

The Environment:

- Global warming, CO_2
- Emissions, pollution

Legislation:

- Global and regional regulations/ restrictions

Product Certification - Importance of 3rd party

Selection Program Control*

Comparison of measured and declared values

Device test in an independent accredited laboratory

CERTIFY ALL

Audit of production plants

Compliance

EUROVENT CERTIFIED PERFORMANCE

Eurovent Certita CERTIFICATION

Independent certification body

More than 40 certification programs

A team of 60 highly qualified HVAC-R specialists and auditors

Cooperation with almost 30 accredited labs throughout Europe

AHU Certification Program

EUROVENT CERTIFIED PERFORMANCE

EN 1886

Mechanical properties

- Enclosure tightness
- Tightness of the filter Bypass
- Thermal transmittance
- Influence of thermal bridges
- Sound insulation

EN 13053

Performance characteristics

- Flow – Available pressure – Consumption
- Electrical power
- Sound power level (per channel)
- Sound power level (surroundings)
- Heating capacity
- Cooling capacity
- Heat recovery
- Water side pressure drop

cold climate

hot and humid climate

Reference parameters for energy classes
1) Air velocity
2) Heat recovery efficiency
3) Flow resistance
4) Fan efficiency

CLASS	All Units Velocity v_{class} [m/s]	Units for full or partial outdoor air at design winter temperature ≤ 9°C Heat recovery system η_{class} [%]	 Δp_{class} [Pa]	Fan Efficiency Grade $NG_{ref\text{-}class}$ [-]
A+ / A+Ϛ / A+↑	1.4	83	250	64
A / AϚ / A↑	1.6	78	230	62
B / BϚ / B↑	1.8	73	210	60
C / CϚ / C↑	2.0	68	190	57
D / DϚ / D↑	2.2	63	170	52
E / EϚ / E↑	No calculation required			No requirement

Table 6: Table for energy efficiency calculations

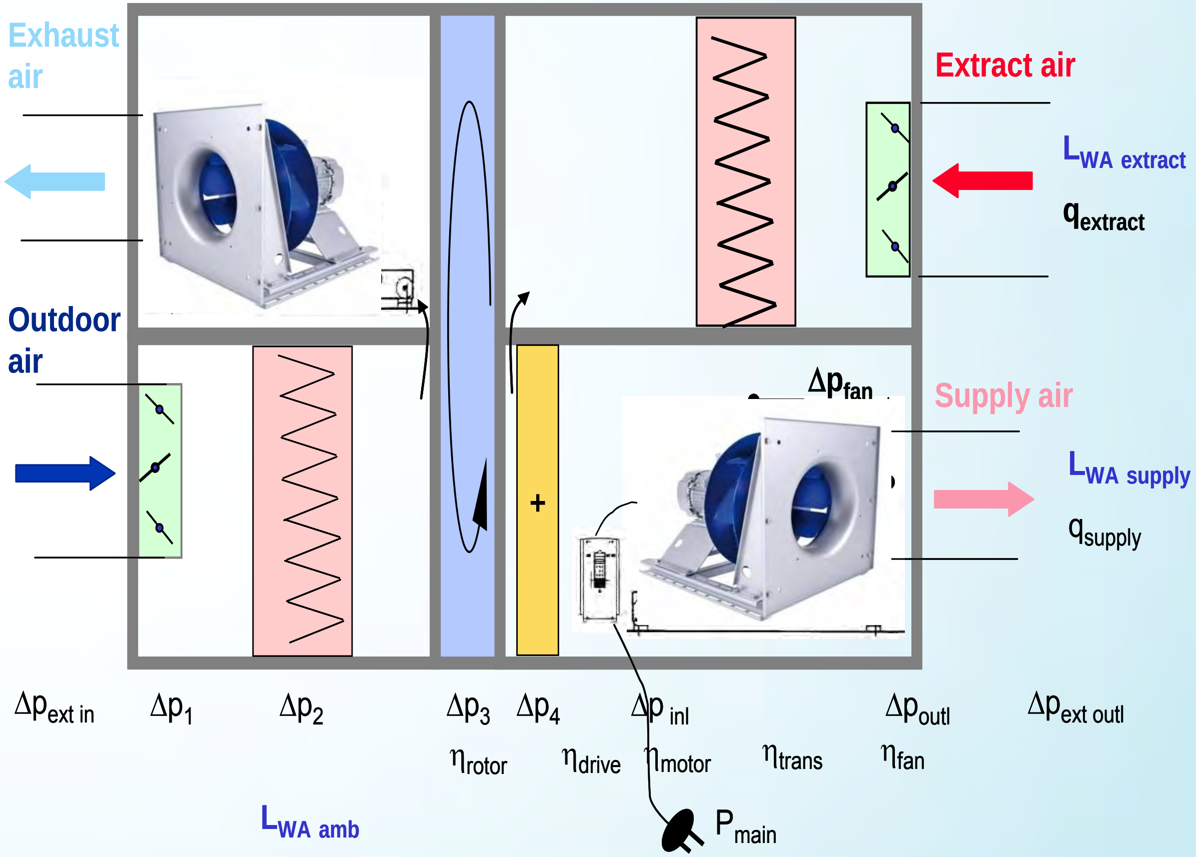
The lowest classes E, EϚ and E↑ have no requirements.

Data used to define the different factors:

- Climate Data: To determine the climate data methodology of the climate zones.
- Season of the year: The determination of the season is based on the " Heating and Cooling degree days".
- Heat Recovery Simulation: The simulations were hourly and all over the year. Two situations were made- Dry system with temperature control; Wet system with enthalpy control.
- Temperature design reference: The reference dry temperature and dew-point temperature derivate from ASHRAE 2013 data (summer criteria 2)

There are many components to be optimised in an AHU:

- Recovery system
- Fans
- Motors
- Frequency inverters
- Pressure drops
- Velocity
- Size
- External issues
- Etc.



Example: The Impact of The Pressure Drop

If we could reduce the pressure drop in the AHU by 1 Pa*:*

Data: 1 m³/s, 1 Pa, 3000 h, 13.5 INR/kWh

Energy Saving Result: 67.5 INR/Year, Not much ?

Another example:

Data: 10 m³/s, 100 Pa, 8760 h, 13.5 INR /kWh

Energy Saving Result: 1,97,000 INR/Year

$$P = \frac{\Delta p_t * q}{\eta} * 10^{-3} kW$$

Summary: The pressure drop has a huge impact on the electricity consumption

Estimation of excess electricity consumption

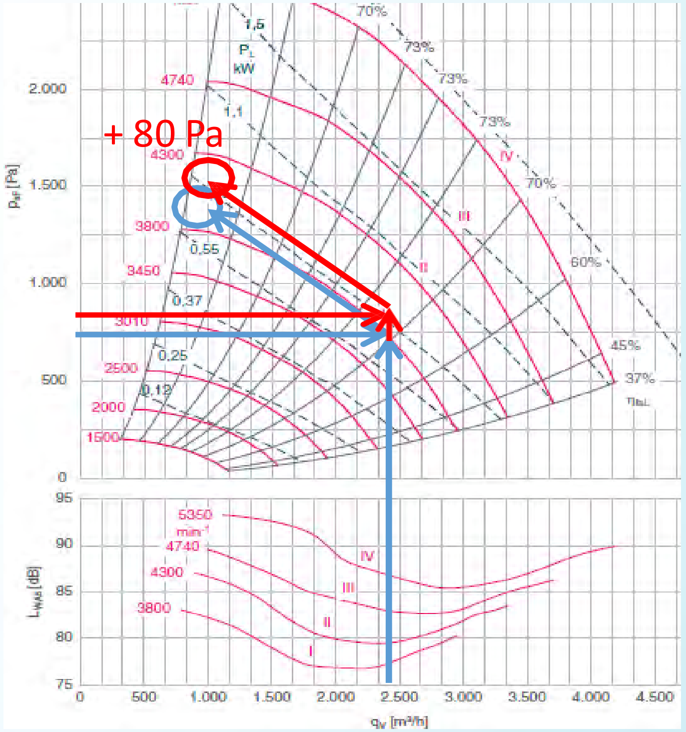
Actual internal resistance of the system higher by 80 Pa (Δ p)

Redundant fan power consumption:

P = q * Δ p / η = 2.78 m³/s * (80 Pa / 0.6) = 370 W

Excess annual electricity consumption (supply + exhaust)

E = 2 * 0.37 kW * 8760 h $\approx$ 6 482 kWh



Why is This Important For Us ?

Where can we reduce the energy consumption in an office building ?

- If we improve/change:
  - Heavier building +100 mm :benefit ~ -1 kWh/m²
  - More insulation +200 mm :benefit ~ -3 kWh/m²
  - Better windows (U-value) 1.4 > 1.0 :benefit ~ -5 kWh/m²
- Lets look at the Air handling unit

  Low speed AHU 2.5 > 1.6 m/s :benefit ~ **-7 kWh/m²**

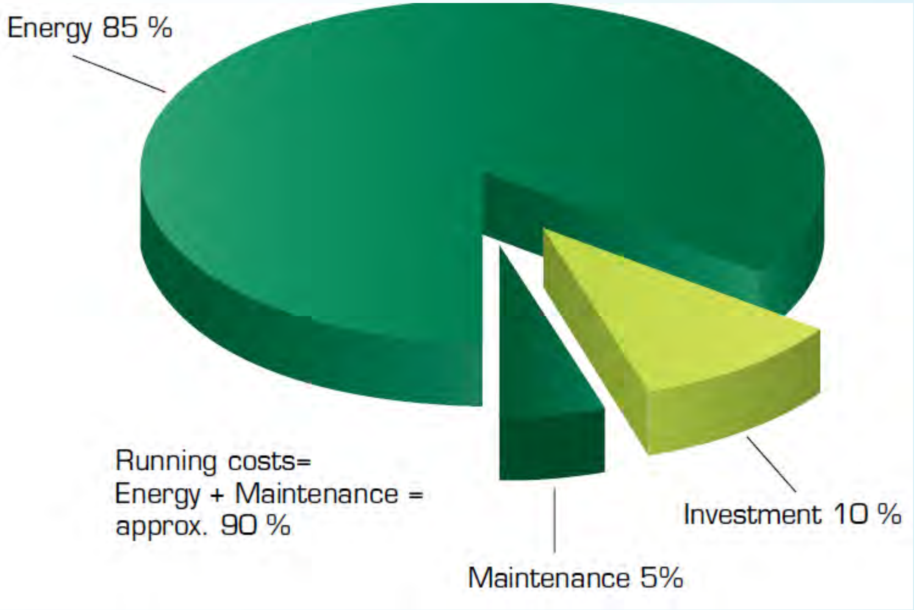
  Better efficiency 60% > 85% :benefit ~ **-16 kWh/m²**

A huge potential in our line of business !

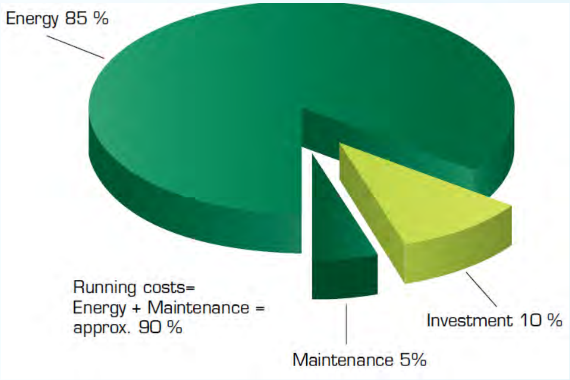
AHU Life Cycle Cost Analysis

The Life Cycle Costs of an Air Handling Unit

- If we are looking at the total costs for an air handling unit during it's lifetime, the impact of the energy costs are huge
- Aprox. 80-90% of the total costs are related to costs for energy (electricity, heating and cooling)
- Today it has become more and more important to be able to make LCC (life cycle costs) analyses for air handling units

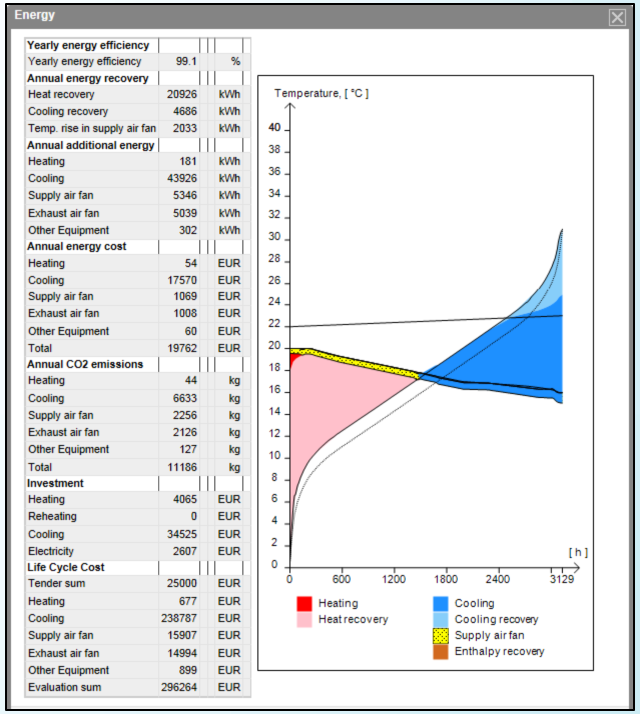


The Life Cycle Costs of an Air Handling Unit



$$LCC = Basic\ investment + LCCenergy\ + LCCmaintenance$$
$$+ LCC\ environment - recycling\ value$$

- The largest part of the total costs for the air handling unit is naturally the LCC_{energy}
- Therefore FlaktGroup has adopted an LCC_E- module (optional Basic investment) in the product selection program for AHU’s



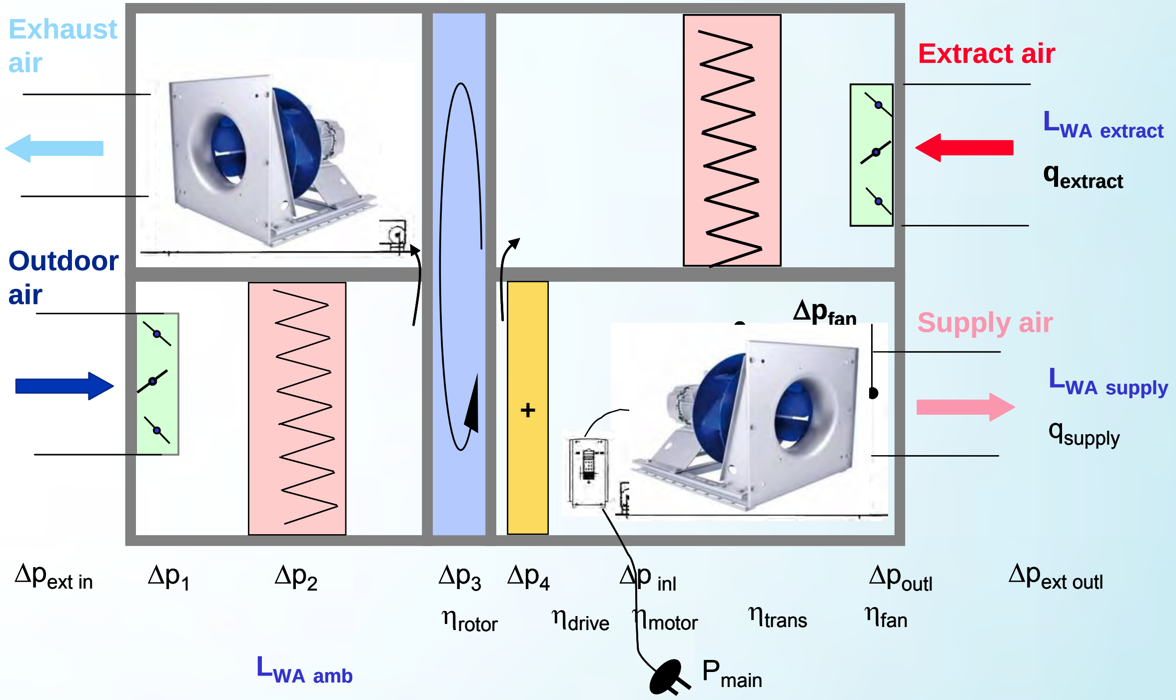
Energy

Yearly energy efficiency		
Yearly energy efficiency	99.1	%
Annual energy recovery		
Heat recovery	20926	kWh
Cooling recovery	4686	kWh
Temp. rise in supply air fan	2033	kWh
Annual additional energy		
Heating	181	kWh
Cooling	43926	kWh
Supply air fan	5346	kWh
Exhaust air fan	5039	kWh
Other Equipment	302	kWh
Annual energy cost		
Heating	54	EUR
Cooling	17570	EUR
Supply air fan	1069	EUR
Exhaust air fan	1008	EUR
Other Equipment	60	EUR
Total	19762	EUR
Annual CO2 emissions		
Heating	44	kg
Cooling	6633	kg
Supply air fan	2256	kg
Exhaust air fan	2126	kg
Other Equipment	127	kg
Total	11186	kg
Investment		
Heating	4065	EUR
Reheating	0	EUR
Cooling	34525	EUR
Electricity	2607	EUR
Life Cycle Cost		
Tender sum	25000	EUR
Heating	677	EUR
Cooling	238787	EUR
Supply air fan	15907	EUR
Exhaust air fan	14994	EUR
Other Equipment	899	EUR
Evaluation sum	296264	EUR

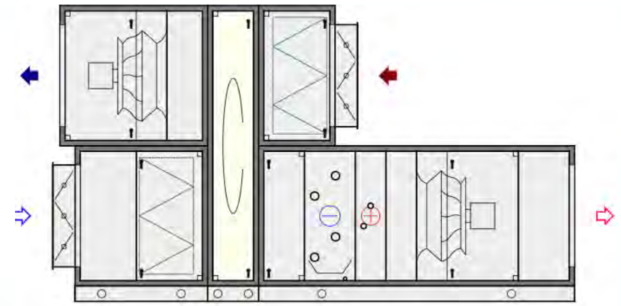
Influences of the LCC Calculation

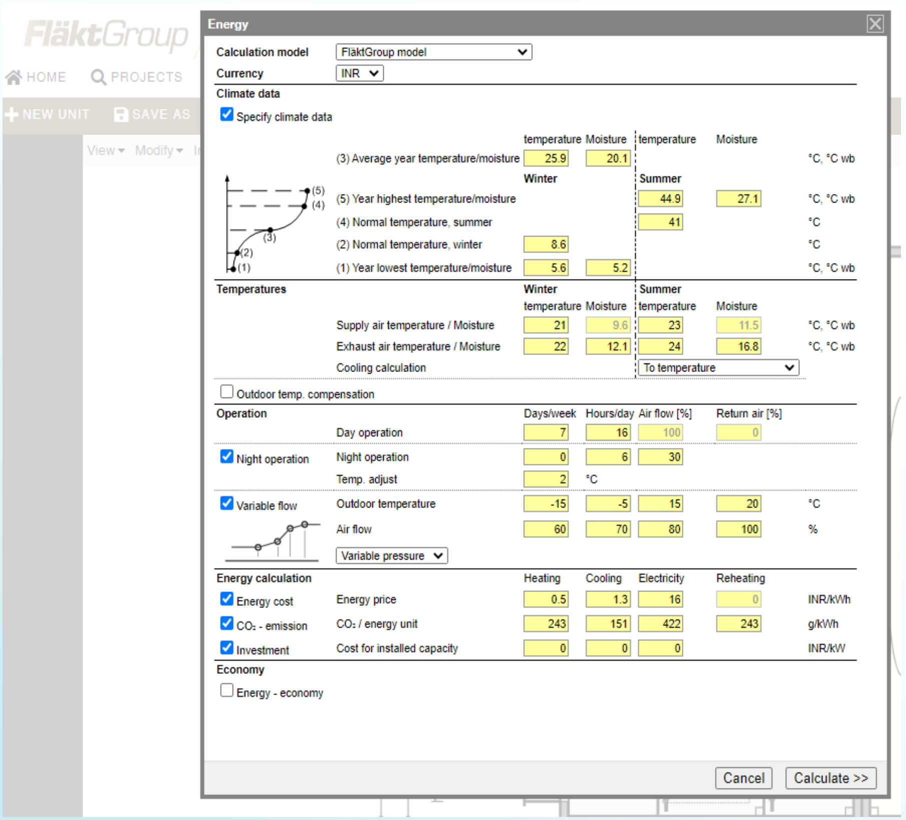
Component issues:

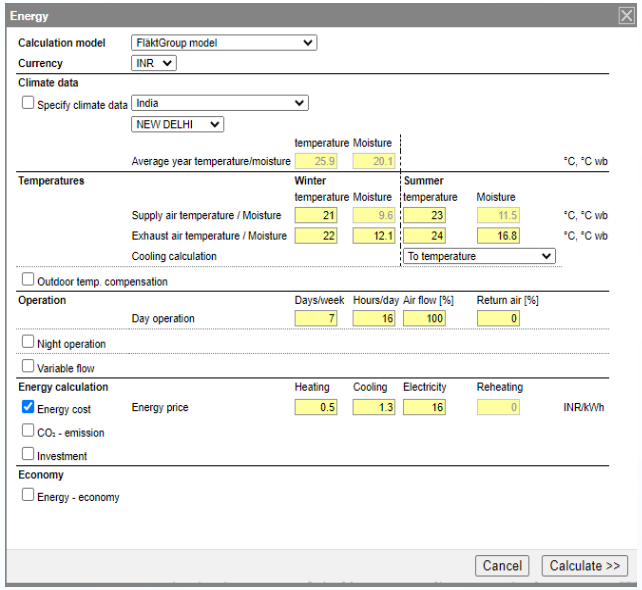
- Fan efficiency
- Motor efficiency
- Frequency Inverter efficiency
- Pump efficiency
- Energy recovery efficiency
- The relation between the energy efficency and the pressure loss of the recoverer
- Pressure losses of other components as filters, dampers, silencers, humidifiers, coils etc...

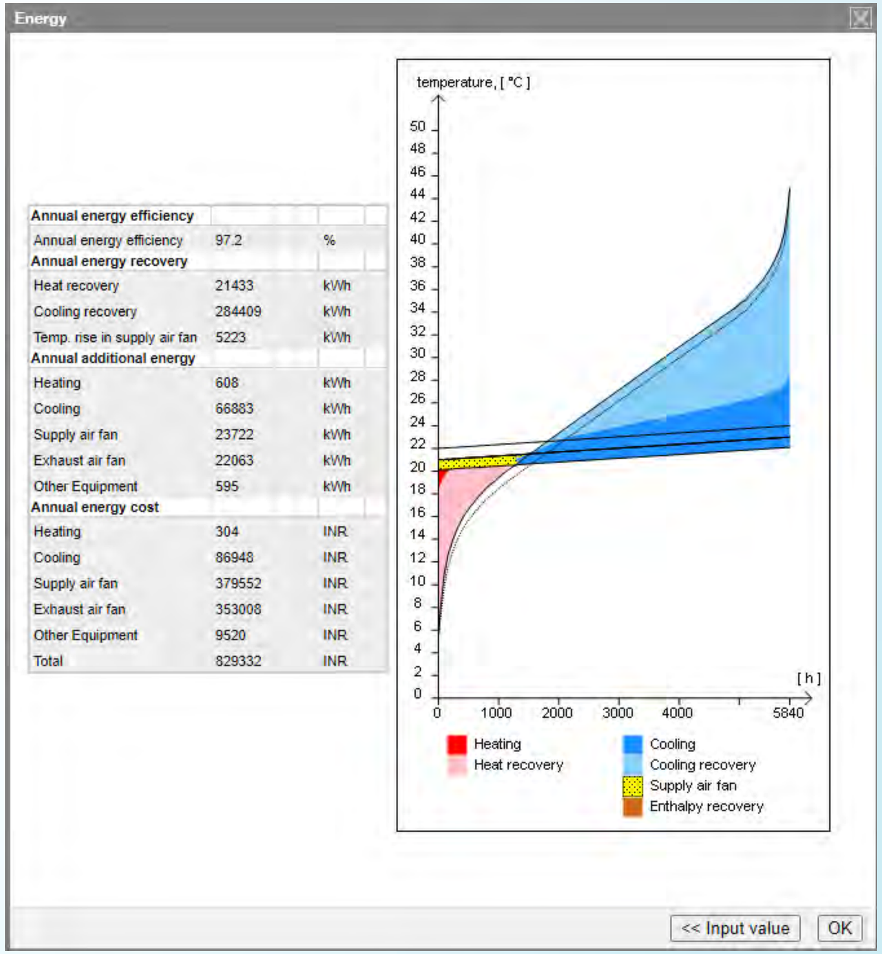


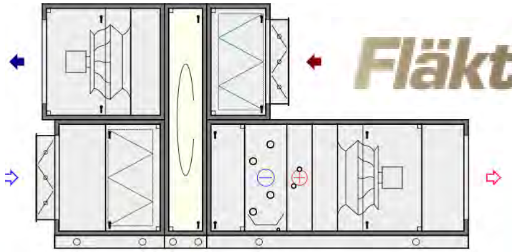
FläktGroup Selection tool for LCC calculation











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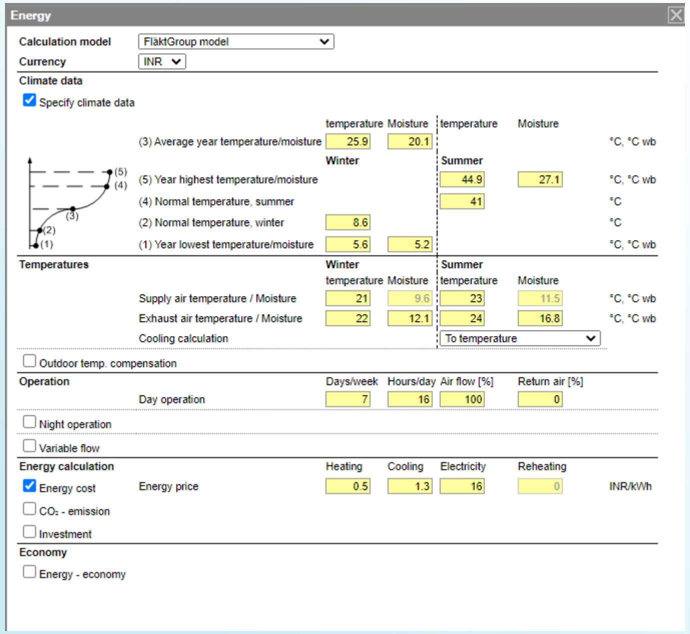
Airflow (CFM)	**8000**
Esp (Pa)	300
Location	Delhi



Energy

Calculation model: FläktGroup model
Currency: INR

Climate data

☑ Specify climate data

	Winter temperature	Winter Moisture	Summer temperature	Summer Moisture	
(3) Average year temperature/moisture	25.9	20.1			°C, °C wb
(5) Year highest temperature/moisture			44.9	27.1	°C, °C wb
(4) Normal temperature, summer			41		°C
(2) Normal temperature, winter	8.6				°C
(1) Year lowest temperature/moisture	5.6	5.2			°C, °C wb

Temperatures

	Winter temperature	Winter Moisture	Summer temperature	Summer Moisture	
Supply air temperature / Moisture	21	9.6	23	11.5	°C, °C wb
Exhaust air temperature / Moisture	22	12.1	24	16.8	°C, °C wb
Cooling calculation			To temperature		

☐ Outdoor temp. compensation

Operation

	Days/week	Hours/day	Air flow [%]	Return air [%]
Day operation	7	16	100	0

☐ Night operation

☐ Variable flow

Energy calculation

	Heating	Cooling	Electricity	Reheating	
☑ Energy cost — Energy price	0.5	1.3	16	0	INR/kWh

☐ CO_2 - emission

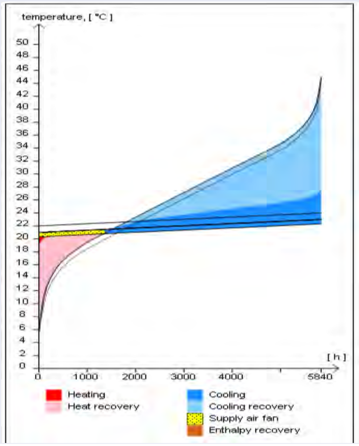
☐ Investment

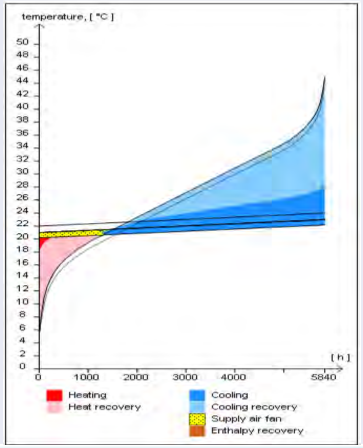
Economy

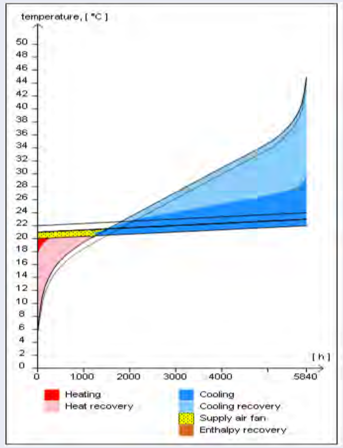
☐ Energy - economy

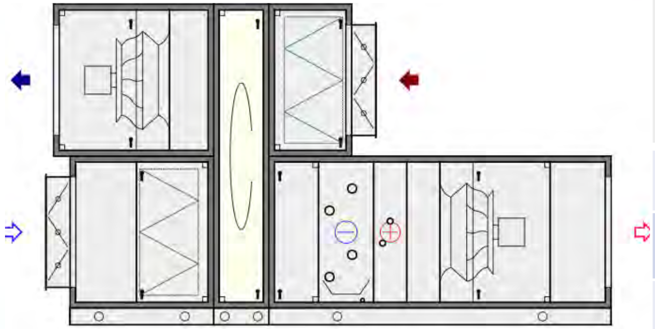
Energy Class

	A+		A		C	
Annual energy recovery						
Heat recovery	23072	kWh	21587	kWh	18951	kWh
Cooling recovery	321790	kWh	274777	kWh	229668	kWh
Temp. rise in supply air fan	4145	kWh	4829	kWh	5177	kWh
Annual additional energy						
Heating	331	kWh	829	kWh	998	kWh
Cooling	56335	kWh	67518	kWh	71740	kWh
Supply air fan	17968	kWh	21971	kWh	24819	kWh
Exhaust air fan	17318	kWh	21746	kWh	23842	kWh
Other Equipment	596	kWh	596	kWh	309	kWh
Annual energy cost						
Heating	166	INR	414	INR	499	INR
Cooling	73236	INR	87773	INR	93262	INR
Supply air fan	287488	INR	351536	INR	397104	INR
Exhaust air fan	277088	INR	347936	INR	381472	INR
Other Equipment	9536	INR	9536	INR	4944	INR
Total	647513	INR	797196	INR	877281	INR







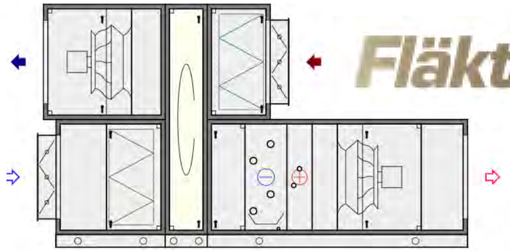


Airflow (CFM)	**8000**
Esp (Pa)	300
Location	Delhi

Summary:
Bigger AHU:

- Higher investment cost
- Lower air velocity
- More recovery
- More efficient fans
- Short pay back

FläktGroup		Energy Class		
		A+	A	C
Electric Energy (Fans)	kWh/a	35286	43717	45785
Heating energy (Heating Coil)	kWh/a	331	829	608
Cooling energy (cooling coil)	kWh/a	56335	67518	66883
Other Equipment	kWh/a	596	596	595
Total Energy cost	01 Unit (INR/a)	₹ 647,513	₹ 797,196	₹ 893,281
Cost difference to class A+ (INR/a)	01 Unit	-	₹ 149,683	₹ 245,768
Difference after 15* years to class A+ (INR/a)	01 Unit	-	₹ 2,245,245	₹ 3,686,520
Number of AHUs (INR/a)	20 Units	-	₹ 44,904,900	₹ 73,730,400
Price of Air handling unit (INR/)	01 Unit	₹3,037,388	₹2,441,965	₹2,112,882
				



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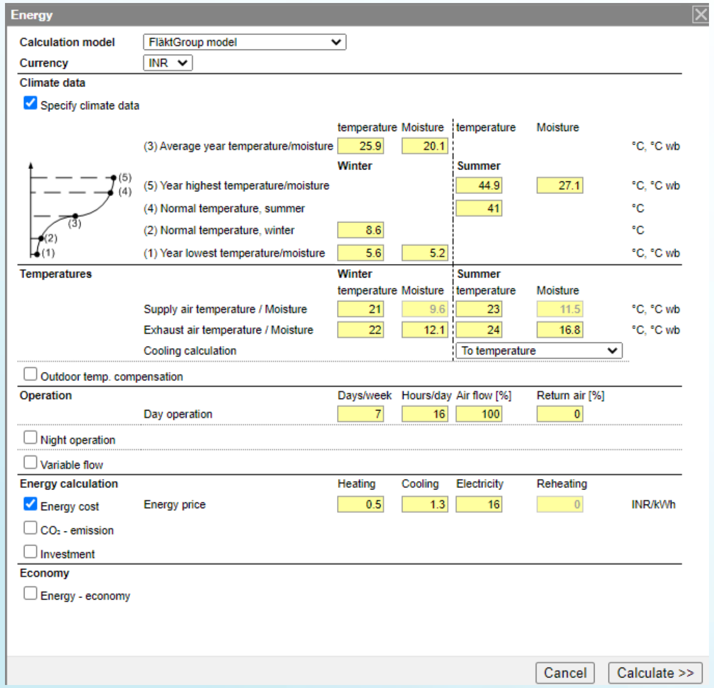
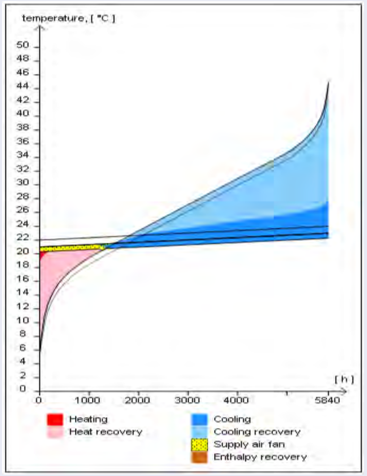
Airflow (CFM)	12000
Esp (Pa)	300
Location	Delhi



Energy Class

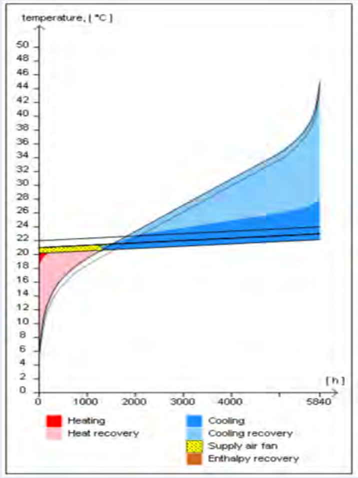
A+

Annual energy recovery		
Heat recovery	33836	kWh
Cooling recovery	467954	kWh
Temp. rise in supply air fan	6274	kWh
Annual additional energy		
Heating	653	kWh
Cooling	88298	kWh
Supply air fan	28627	kWh
Exhaust air fan	26679	kWh
Other Equipment	601	kWh
Annual energy cost		
Heating	326	INR
Cooling	114787	INR
Supply air fan	458032	INR
Exhaust air fan	426864	INR
Other Equipment	9616	INR
Total	1009626	INR



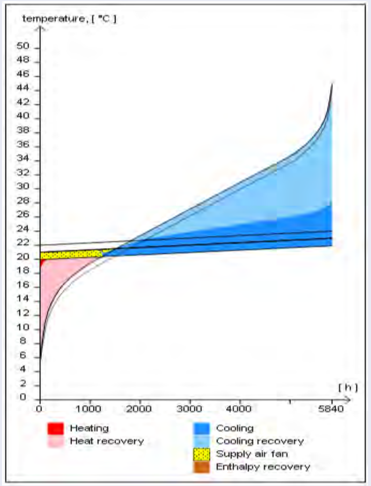
A

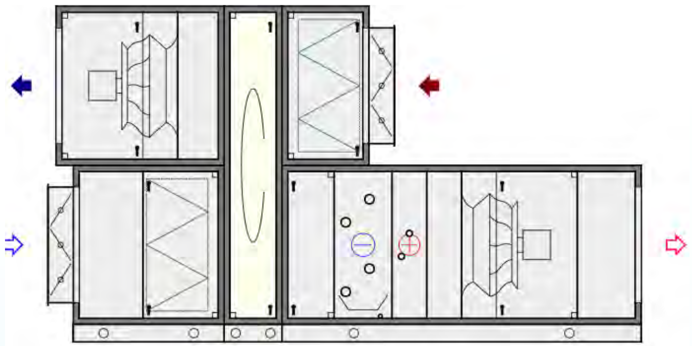
Annual energy recovery		
Heat recovery	32739	kWh
Cooling recovery	437991	kWh
Temp. rise in supply air fan	7233	kWh
Annual additional energy		
Heating	869	kWh
Cooling	96303	kWh
Supply air fan	32932	kWh
Exhaust air fan	29131	kWh
Other Equipment	602	kWh
Annual energy cost		
Heating	434	INR
Cooling	125194	INR
Supply air fan	526912	INR
Exhaust air fan	466096	INR
Other Equipment	9632	INR
Total	1128268	INR



C

Annual energy recovery		
Heat recovery	31003	kWh
Cooling recovery	417333	kWh
Temp. rise in supply air fan	8793	kWh
Annual additional energy		
Heating	485	kWh
Cooling	104434	kWh
Supply air fan	42314	kWh
Exhaust air fan	35704	kWh
Other Equipment	607	kWh
Annual energy cost		
Heating	242	INR
Cooling	135764	INR
Supply air fan	677024	INR
Exhaust air fan	571264	INR
Other Equipment	9712	INR
Total	1394007	INR





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Bigger AHU:

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- More efficient fans
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FläktGroup		Energy Class		
		A+	A	C
Electric Energy (Fans)	kWh/a	55306	62063	78018
Heating energy (Heating Coil)	kWh/a	653	869	485
Cooling energy (cooling coil)	kWh/a	88298	96303	104434
Other Equipment	kWh/a	601	602	607
Total Energy cost	01 Unit (INR/a)	₹ 1,009,626	₹ 1,128,268	₹ 1,394,007
Cost difference to class A+ (INR/a)	01 Unit	-	₹ 118,642	₹ 384,381
Difference after 15* years to class A+ (INR/a)	01 Unit	-	₹ 1,779,630	₹ 5,765,715
Number of AHUs (INR/a)	20 Units	-	₹ 35,592,600	₹ 1,15,143,300
Price of Air handling unit (INR)	01 Unit	₹ 3,558,263	₹ 3,115,165	₹ 2,840,612

Thank You!

Mr Arvind Singh
Director
FläktGroup