SETatWork Good Practice
Sustainable Design of a new manufacturing facility – Pharmaceutical, China

Setting	
Country	China
Location	Tianjin
Project start date	2008
Project end date	2010
Technology keywords	Energy management, Industrial technologies, Heat recovery & storage
Host sector	Manufacturing Industry (Pharmaceutical)

Technical summary of the project

Objective of the project	The objective of the project has been to reduce the energy consumption of a new green field manufacturing filling facility. By introducing Sustainable Design activities during the design and engineering phases of the new facility significant savings of the future energy demand and investment could be achieved.

Project description

Introduction to Novo Nordisk
Novo Nordisk is a healthcare company and a world leader in diabetes care. In addition, Novo Nordisk has a leading position within areas such as haemostasis management, growth hormone therapy and hormone replacement therapy.

Novo Nordisk manufactures and markets pharmaceutical products and services that make a significant difference to patients, the medical profession and society. With headquarters in Denmark, Novo Nordisk employs more than 27,000 employees in 81 countries, and markets its products in 179 countries.

Position on Climate Change
Novo Nordisk is committed to conducting its business in a financially, environmentally and socially responsible way. As climate change has global implications on all three dimensions, taking steps to reduce the company's impact is both an act of critical risk mitigation and corporate responsibility.

Recognising that climate change – as the diabetes pandemic – is related to the consumption and lifestyle trends of high and middle income economies, climate change is also an unprecedented opportunity to bring the world on a healthier, more sustainable course.

In 2006 Novo Nordisk became a member of the World Wide Fund for Nature (WWF) Climate Savers programme. Novo Nordisk's climate strategy links to this agreement, according to which the company has set an ambitious target for its CO2 emissions from production: To achieve an absolute reduction of 10% by 2014 compared with 2004 emission levels while still growing the business.

In terms of the GHG protocol, Novo Nordisk's first priority is to get its own house in order, focusing on the areas in which the company has direct control over performance. Thus, the current scope of the company's climate strategy is to reduce emissions from production which accounts for the most significant part of Novo Nordisk's global carbon footprint. Strategies and action plans for reducing emissions from the remaining part of Novo Nordisk's activities will be framed during 2009-2010.

Designing with energy consumption in mind pays off
During the design of a new manufacturing facility for insulin products, Sustainable Design was introduced as an independent for improving the environmental performance of the future facility located in the northern China.

The facility is a green field aseptic filling plant for insulin products and the Sustainable Design activities were conducted throughout the Basic design phase in 2008.

The results achieved are substantial and may be applied in other manufacturing industries disregard country and industrial sector.

Compared to the original design, prior to introducing Sustainable Design, greenhouse gas emissions have been reduced and the operation costs have been reduced.

Also the investments have been reduced as a consequence of the project activity due the possibility for downsizing the required capacity of utility systems.

The potential for saving energy on HVAC is much larger at design stage than when the system is build. Saving energy challenges old engineering habits. Not imposing or not meeting this challenge means that our industry will lose money and contribute more to global warming than necessary for a given production. Involving the installation contractors and ensuring their commitment takes the savings potential further than what is possible for the designers / customer.

Targeting saving opportunities
Due to the nature of the energy consumption profile, the energy consumption related to HVAC for clean spaces is the dominant energy user. For this purpose the Sustainable Design activities have focused on HVAC in order to achieve the highest cost saving potential and reduction of greenhouse gas emissions.

HVAC is by far the single largest energy consumer in most aseptic productions. The major factors defining unit HVAC energy consumption or unit HVAC carbon footprint are:

1. Process choice
2. GMP interpretation
3. Production efficiency
4. HVAC design
5. Climatic conditions at production location

HVAC system design
The choice of design: whether recirculation or full fresh air is used and for systems with recirculation how the supply of fresh air into the system is controlled has a large impact on the energy consumption of a system. In all cases less energy is used if there are low system pressure drops and generally it is beneficial to use recirculation of air.

Three different HVAC set ups have been compared:

1. An existing “once through” system as applied in a Danish filling facility
2. A recirculation system with passive pre-conditioner
3. A recirculation system with active pre-conditioner

The facility has classified as well as non classified areas. This article focuses on the classified areas, but many of the conclusions hold also for non classified areas.

Figure 1 shows a very simple diagram for the three different systems that are compared.

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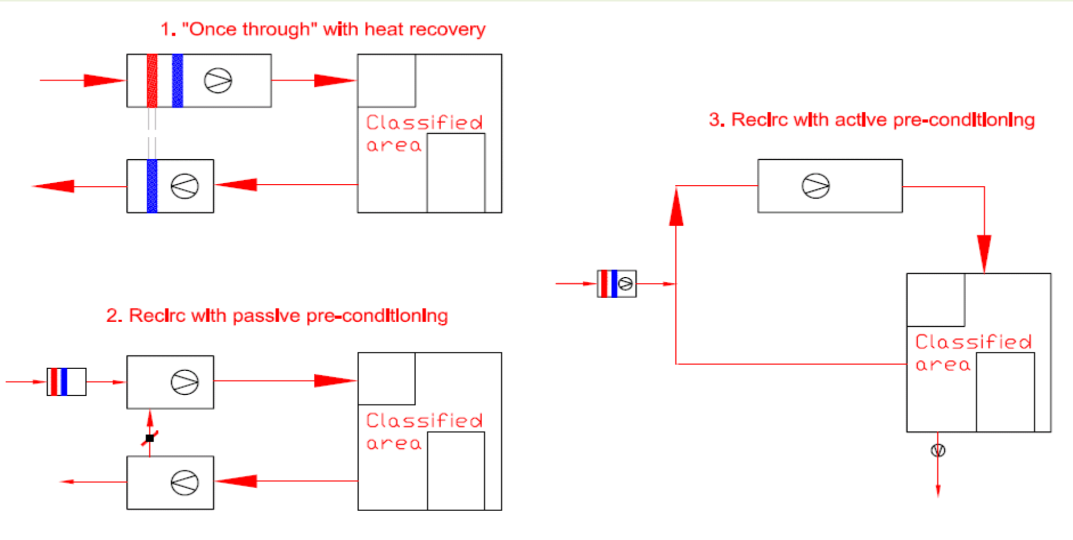

Figure 1: Schematic drawing of three HVAC designs

The "once through" system is expensive in terms of air conditioning – heating, cooling and (de)humidification - in adverse climates. The system with passive pre-conditioner is expensive in electrical energy because a large pressure drop on the recirculation flow is used to control the fresh air supply and the exhaust volume of air.

The different yearly energy consumptions for the three systems are illustrated in figure 2 which shows the energy used pr 10.000m^3/h.

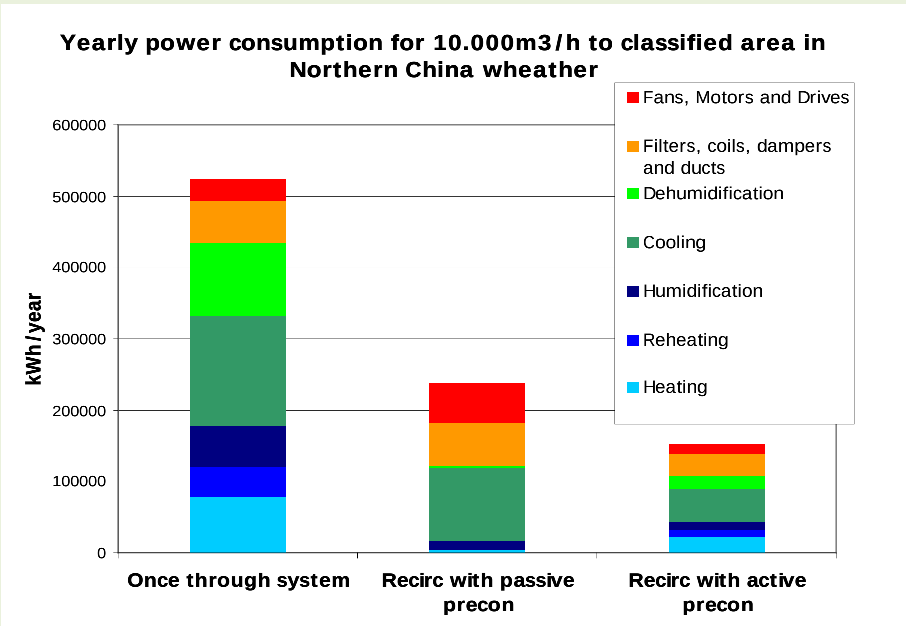

Figure 2: Yearly energy consumption for 10.000m3/h for the three different HVAC set ups

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The once through system uses considerably more energy than the two recirculation set ups. Electrical energy is used for:

- fans, motors and drives (difference between 100% efficiency and the actual efficiency)
- filters, coils, dampers and ducts
- dehumidification and cooling

while steam is used for:

- humidification
- heating
- reheating

In figure 3 the energy *costs* that the three systems generate are compared. The relation between carbon emission from steam and electricity generation is approximately equal to the relation between the prices for this specific location. Therefore the graph also demonstrates the relative carbon footprint of the three different systems.

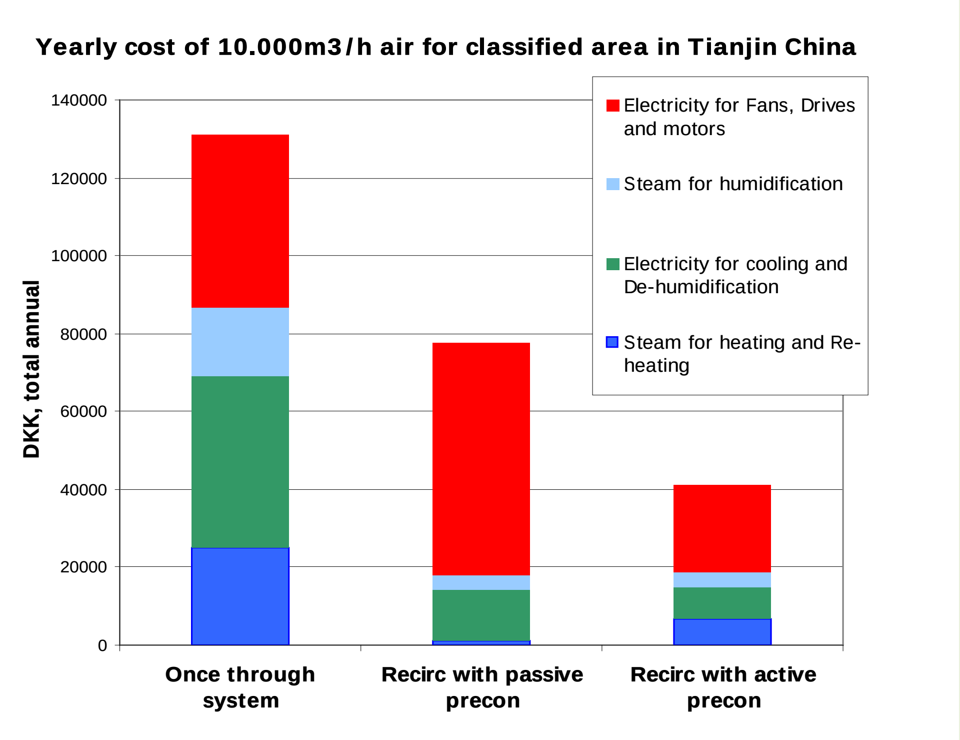

Figure 3: Yearly energy cost for 10.000m^3/h for three different HVAC set ups

Duct pressure drop

We have specified a maximum pressure drop of 0.75Pa pr meter straight duct for the *index* run. The index run is the duct run with the furthest distance between Air Handling Unit (AHU) and point of delivery or the duct run with the most intricate and least straight run.

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It is obvious, that optimizing pressure drop on a 25 meter branch of a system with another branch that is 100 meters long is not relevant.

Filter pressure drops

In our minds the nominal pressures drops / the nominal air volume pr filter in the filter supplier catalogues should not be used. Reducing the air volume pr filter not only reduces energy consumption it also:

- increases the service life of filters so the plant can run at longer intervals between filter change
- increases the filtering efficiency thus improving the air quality and reducing the load on subsequent filters if there are such.

Fans, drives, motors and VSDs

We have analysed 5 existing systems and found the efficiency of each component and more importantly that the overall efficiency of them in all 5 cases was at least 70% which is considerably better than what is often used by design engineers. Allowing for fans not always being at their optimal working point and motors not always being sized precisely we end up with 65 - 70%% efficiency requirement.
See figure 4 for a full list of component electrical efficiencies specified.

Filters start and end pressure drop

F7:	100 / 200Pa
F9:	125 / 250Pa
H14:	125 / 250Pa

Coil and wheel pressure drops

Heat recovery coil	130 Pa
Heating coil	35 Pa
Cooling coil	150 Pa
Re-heating coil	30 Pa
Heat recovery wheel	200 Pa

Duct pressure drops

Maximum 0.75Pa /m for straight duct runs

Fans, drives, motors and VSDs

Fan	79 - 81% efficiency build in
Belt and pulleys	98%
Motor	EFF1 or better
VSD	98%

In total for fans, drives, motors and VSDs: 65 – 70%

Figure 4: Required efficiency of components

Most of the choices regarding electrical efficiency of components are made during the design stage and cannot be altered at a later stage without major extra investments. One exception is filters. While the face areas of the filters cannot be changed the type of filter can be optimised so larger filter media area or better quality filter media is used to ensure lower energy consumption / better filtering efficiency.

Fines and rewards for electrical energy efficiency

Combining the design and the efficiency of components we then predict the SFP and write this into the tender material as well as the component efficiencies. If the installation does not live up to the requirement the supplier is fined with the value of 2 years extra energy consumption.

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To enhance supplier engagement in making an energy efficient installation we do not only use the whip but also promise rewards for good energy performance. If the energy consumption is less than 90% of the requirement the supplier is rewarded for the saving below 90% with the value of 2 years energy cost. This way we ensure the supplier has a vested interest in making the best possible installation also down to the detail where duct components are chosen and installed.

Both fines and rewards are based on two years saved or extra expended energy consumption which is a fairly low factor to use considering the overall Novo decision that all energy saving initiatives with less than 5 years pay back time should be carried out. Once we have gained experience with this fine – reward methodology we are likely to increase both fines and rewards.

Humidity and temperature parameters
Just how much the requirements for humidity influence the energy consumption is probably not always know to the people who specify very strict requirements. We have made a comparison of different intervals for temperature and humidity for a classified area in Northern China, see figure 5. The calculations are based on ~80% recirculation and the heat load of the fan is included in the calculations:

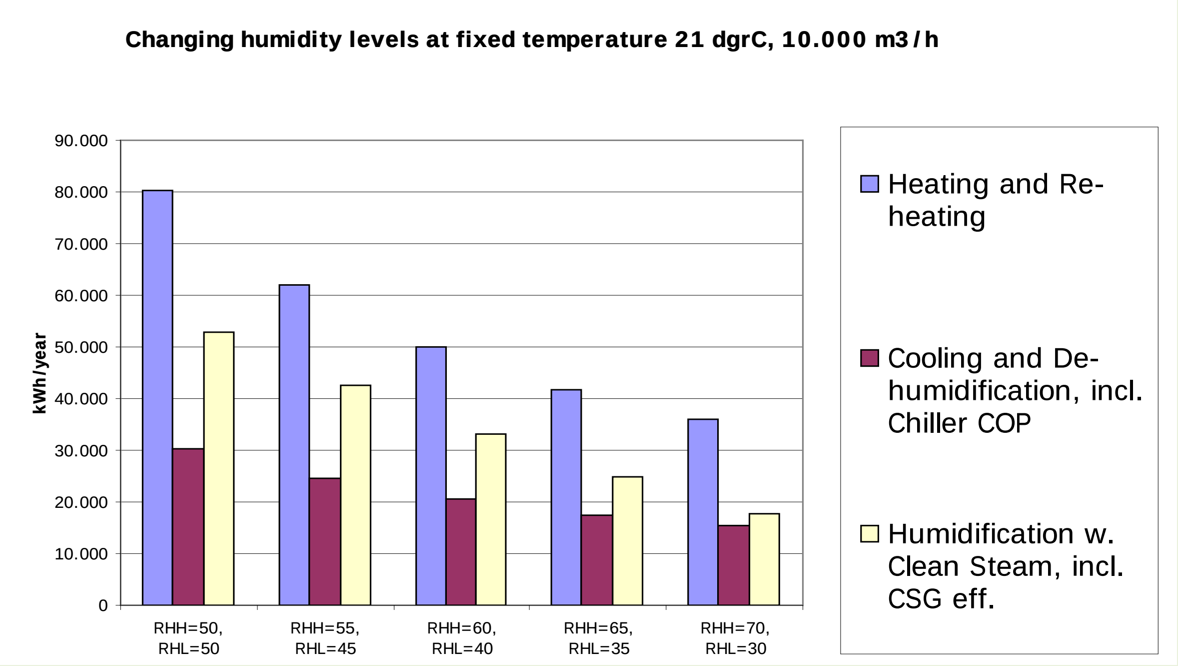

Figure 5: Energy consumption related to different intervals for temperature and humidity.

From a fixed set point of 50%rH to an interval of 30 – 70%rH there is:

- 55% reduction in heating costs
- 47% reduction in cooling and dehumidification cost
- 66% reduction in humidification cost

Energy wise it is beneficial to also allow the temperature to wary, but the effects are not as dramatic (figure 6).

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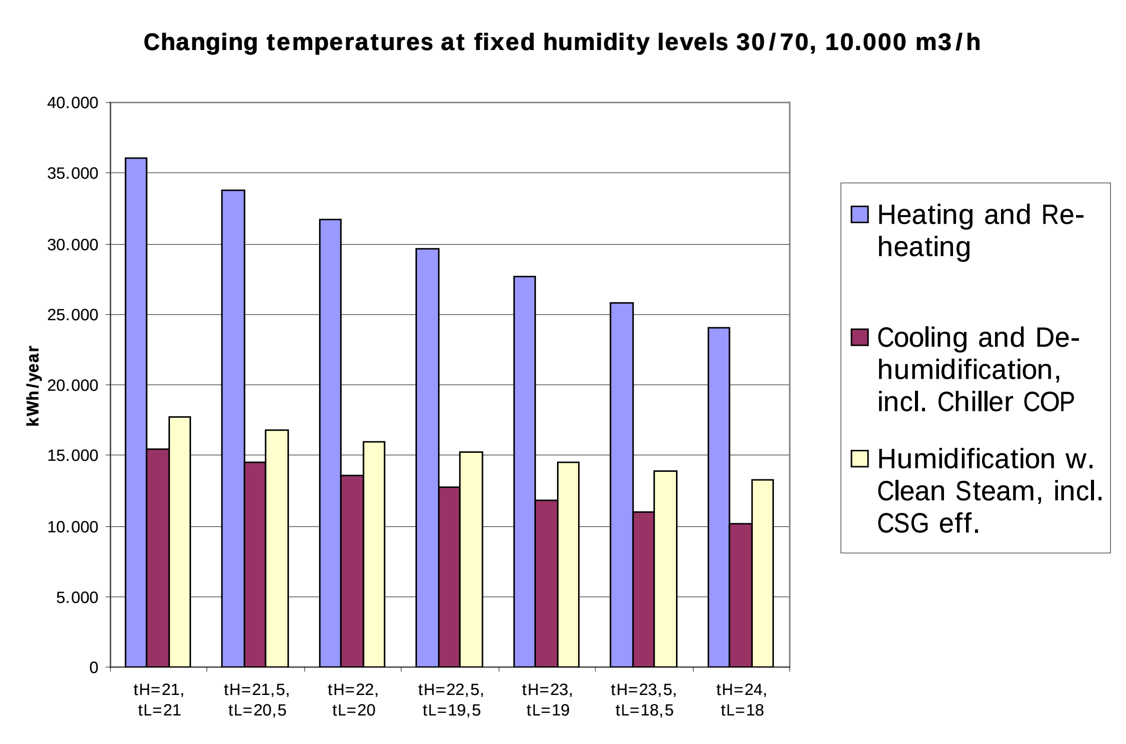

Figure 6: The effect of allowing intervals for temperature

The extent to which temperature and humidity are allowed to float within intervals must be defined with process people and QA. The company's experience with a large classified area where humidity has been allowed to float from 32 to 68% has been very good – detailed analysis of the environmental monitoring results have shown no detrimental effects of this change.

The choice of ~30 – 70% is based on an estimation of what we could do without harming the aseptic conditions and also on human comfort, but the issues is not fully analysed yet. For the new facility we consider only making the upper limit a GMP parameter so we can freely set the low limit according to personnel comfort. It appears that the experts in HVAC and human comfort cannot clearly define the "comfort limit" for relative humidity and calculations show, that reducing the lower limit below 30% is actually quite productive in terms of saving energy.

Ventilation on demand
For the classified areas of the facility we apply "ventilation on demand" to a small extent and for the offices, packaging areas, tech areas etc much more so. The number of air changes varies both according to time of the day (occupancy) and need based on temperature requirements. Since many areas of the facility is only occupied 5*8 hours a week and since air change, temperature and humidity demands can be lowered most of the time the potential saving through variations vs. 24/7 is very large.

For the classified area of the facility there will be no extended periods without activity so the variations have to be based on need analysis and process and QA personnel must be involved.

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Ventilation on demand can successfully be applied after the system has been installed but the potential is larger and the costs are lower if it is integrated at design stage.

Dealing with variable flow - in the future

It is always a challenge to design so fans and motors are working at their best operating point – there is a tendency to add a little at every turn (air change rate, pressure drops, installed electrical capacity…) so on existing installations that have not been subject to "squeezing the extra m3's out of the system" when modifying or extending the plant we are more likely to find the fan and motor working below their optimal range than within it. The consequence is quite remarkable although often understated by experts (for example VSD advocates) and disregarded by practicians. In figure 7 the effect of running at part load and torque for a standard motor is demonstrated:

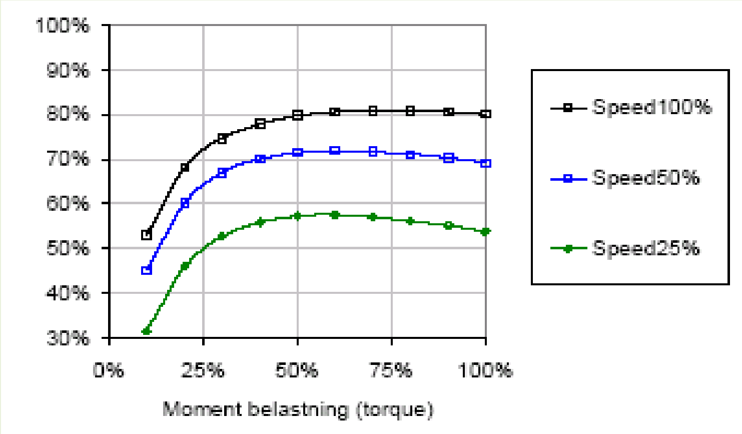

Figure 7: Running a standard motor outside of its optimal range. It is the "VSD pitfall" because some designers believe they without consequence can add a "little extra" since the flow finally can be adjusted with the VSD. The graphs are from measurements on pumps done 5 years ago, but the relations are the same for fans.

When we apply "ventilation on demand" we have to design for the maximum air change rate but maybe we will only use it a fraction of the time. The result is that most of the time we are not getting the highest efficiency on fans and motors. [1]

Two possible ways of dealing with this issue – ensuring high efficiency over a wider operation range – will be suggested here.

In the US the CES group has for some years manufactured Air Handling Units with a "fan wall" with numerous small fans replacing the common large fan. The benefit in terms of energy is that if 20 fans are installed and only 10 are needed only 10 will run, so it is ensured they will be used in their optimal interval, which is probably more efficient than running a large fan with a higher optimal efficiency outside of its preferred range. So it seems this technology lends itself very well to systems with variable flow.

Another development that is under way is replacing the standard asynchronous motors with synchronous motors. These should be able to run in a much wider interval without compromising efficiency.

[1] Please note: although the fan and motor efficiency declines it is always energy saving to reduce air change rate.

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Environmental and social benefits	
(Estimate of) Greenhouse Gases abated (in metric tons of CO_2-equivalent)	Not known
Number of reduction units (EAU, CER, ERU, AAU)	Not applicable
Socio-economic aspects What social and economic effects can be attributed to the project and which would not have occurred in a comparable situation without that project?	Not known
Methodology used (if applicable: approved baseline methodology or study done – refer to this; and monitoring organisation)	Sustainable Design methodology for improving environmental performance at the design stage of an investment project.

Economic data	
Capital costs	Not Applicable
Financing scheme	Not Applicable
Financing organisation (if third party)	Not Applicable

Project developer	
Name of the project developer	Not Applicable
E-mail and/or web address	Not Applicable
Contact person	Not Applicable

Host organisation	
Name of Host organisation	Novo Nordisk A/S
E-mail and/or web address	www.novonordisk.com
Contact person	Ulla Thomsen – utho@novonordisk.com

Technology provider	
Name of Technology provider	Not Applicable
E-mail and/or web address	Not Applicable
Contact person	Not Applicable

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