Eli Lilly

ENERGY EFFICIENT DESIGN IN ACTION

Eli Lilly & Company is a research-based pharmaceutical company with more than 42,000 employees worldwide. It markets medicines in 158 countries.

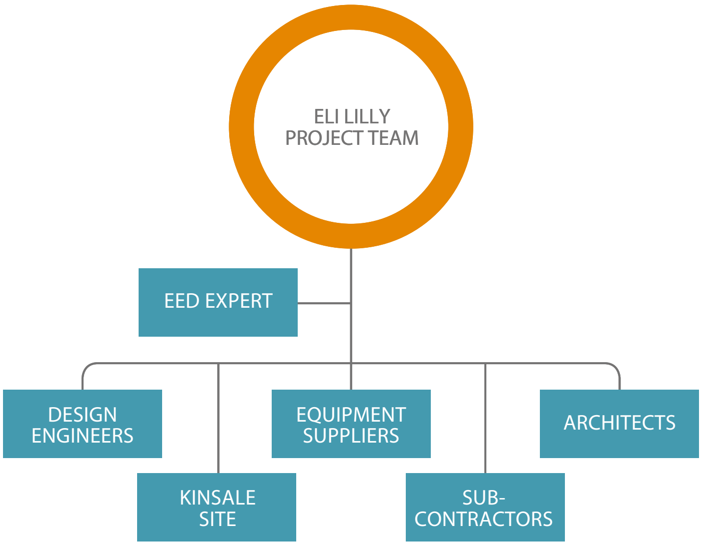
Eli Lilly S.A., based in Kinsale, Co Cork, is a bulk manufacturing plant that employs around 430 people. It manufactures a range of products, which are exported to fill-finish plants supplying worldwide markets.

EED APPLIED AS NEW FACILITY PLANNED

In 2007, Eli Lilly Ireland incorporated an Energy Efficient Design (EED) methodology into the design for a new facility in Kinsale. The IE42 Biotech Manufacturing facility is intended for operation in 2010. An energy committee was set up and, through this structure and communication with SEI on the Energy Agreements Programme and the IS 393 energy management standard, Eli Lilly was introduced to EED. The timing of this lined up well with the IE42 design effort and Eli Lilly was enthusiastic about this initiative.

The key to the success of this project was that the EED organisation was seen as a unit, independent from the design engineers. This allowed proposals to be developed in consultation with the user representatives, followed by the project team. This in turn enabled an independent review of the conceptual design, using 'fresh eyes' which were not affected by project-imposed constraints of schedule and budget.

Organisation of IE42 project



Eli Lilly plant in Kinsale, Co Cork

The scope of the EED was to improve the energy performance of the facility substantially, using the following measures:

- reduction of core-process energy demands;
- reduction of utility systems energy demands;
- use of best available technology for the pharmaceutical industry;
- waste-heat recovery;
- use of energy-efficient components (fans, pumps, etc).

The measures listed above were considered paramount during the basic and detailed design phases, which were collaborative efforts by Eli Lilly's resources, design engineers and a dedicated EED team.

EED SAVINGS CATALOGUE: ACCRUED ANNUAL SAVINGS

Opportunities are reported in the format of a Savings Catalogue. EED saving initiatives within the catalogue are quantified independently from each other so that the design team can consider the impact of each individually.

The *EED catalogue accrued savings* (the total savings when all the EED initiatives are added up) is a theoretical and not necessarily an achievable value, since initiatives are linked to each other. The actual potential savings need to be calculated from the actual initiatives that the design team considers for integration into the project.

The EED savings accrued within the savings catalogue are as follows:

CO_2 (tonnes/year)	9,170
Water (m^3/year)	26,096
Water (m^3/year)	43,000 (IE30 existing facility)

All the savings initiatives outlined within the EED savings catalogue use technology already well established in industry. There is no need for 'rocket science' or volatile technology that would require Eli Lilly to risk unproven technology or initiatives based on inadequate demonstration data. If Eli Lilly decides not to integrate an EED savings opportunity, this is because of a calculated product quality risk; corporate policy; an internal stakeholder barrier; an unacceptable project schedule, or budgetary constraints.

The figures in the accrued savings catalogue figures represent an 82% savings over the initial estimates of the annual operational emissions for the IE42 Biotech facility. The EED measures require just a small investment and cause no delay in the design project.

This project demonstrates that the potential for savings identified through the EED process is high when it is incorporated as early as possible in the design stages. Retrofitting during plant operation is much more expensive and is often no longer feasible.

From an accrued savings catalogue of 82% of the baseline IE42 CO_2 emissions, 15% of the savings have already been implemented. Some EED initiatives were decided not to pursue in this particular project, however if the remaining pending initiatives are implemented, the total savings will rise to 34%.

This Energy Efficient Design project was part-funded by SEI under its Industrial Best Practice Initiative.

THE PROJECT PHASES

This EED was started after a conceptual design of the new facility, which did not take into account the energy efficiency measures outlined above. The project activities were divided into three phases, as follows:

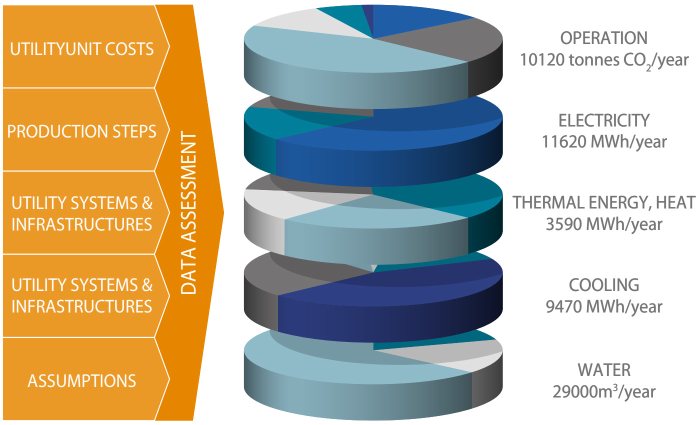
Phase 1: Review the project

- Map energy consumption data (baseline);
- Analyse project and energy needs;
- Identify/prioritise focus areas.

This phase defines the project baseline design, quantifies the environmental and energy costs of operation and forms the basis for EED decisions. It is essential for measuring the EED impact.

The objectives of this phase were to identify design criteria and to gather sufficient data in order to establish an energy and mass balance for the facility. The breakdown of energy consumption was used to identify a number of EED focus areas. An important element of baseline mapping was to establish the operating costs for the various utilities.

IE42 Baseline



Phase 2: Assess savings

- Analyse energy services and technology;
- Optimise process equipment and utility systems;
- Hand over the energy project to design engineers.

The outcome of this phase was a savings catalogue of energy-saving opportunities. This enabled the project owner to evaluate the individual initiatives for implementation. It is important to note that EED addresses all the principles and requirements of a new facility – for example, process requirements such as water quality – and not just energy efficiency.

Phase 3: QA and follow-up

- Input to tendering and contracts;
- Quality assurance of projects;
- Justification of savings achieved by EED.

The purpose of this phase is to monitor project implementation during tendering and contract negotiations. The EED input to this phase is effectively a handover from the EED organisation to the design organisation with a thorough explanation of all EED initiatives. This is to ensure that the appropriate technical solutions are incorporated and that expected energy savings will be achieved. This phase also identifies key performance indicators for the facility during operation.

THE BASELINES

Individual baselines were measured for the following sources:

Electricity

The total consumption was estimated at 11,600 MWh/year; approximately 40% of this relates to HVAC (heating, ventilation and air conditioning) and 25% relates to processes.

Heating

The total consumption was estimated at 3,590 MWh/year; most of this (90%) relates to water for injection (WFI) and HVAC.

Cooling

Cooling consumes 9,465 MWh/year; most of this (92%) relates to HVAC air cooling.

Water

Water consumption is 29,000 m^3/year; most of this (90%) is consumed by cooling towers.

CO_2

Based on the figures above, pre-EED CO_2 emissions were calculated at 10,180 tonnes/year. Most of this (7,728 tonnes) is indirect – relating to electricity use. The remainder (2,450 tonnes) is direct – emitted on site.

The above baselines give us:

Resource	Total
Energy consumption	15,190 MWh/year
Water consumption	29,000 m^3/year
CO_2 emissions	10,180 tonnes/year

UTILITIES REQUIRED FOR IE42

The following general utilities are required for IE42:

- 5°C and 0°C cooling;
- 20°C cooling;
- cooling tower water;
- plant air, process air and breathing air;
- plant steam;
- low-temperature hot water (LTHW) in an 82°C loop;
- O_2, CO_2 and N_2 for fermentation;
- water for operation.

The following clean utilities are required:

- cleaning in place (CIP);
- sterilisation in place (SIP);
- water for injection (WFI);
- clean steam.

EED MEASURES IDENTIFIED

In the savings catalogue, focus areas were identified where energy efficiency changes would be feasible and have the greatest impact. These areas, and the saving measures possible, are outlined below:

HVAC

The vast majority of the heating and cooling demand for this facility relates to HVAC. The following areas of saving have been addressed in the EED:

1. **Reduced heat supply temperature (to use waste-heat recovery system)**
   In the baseline design, the LTHW supply temperature was 82°C and was produced from plant steam. As the temperature requirements are actually quite modest (required inlet temperature of 17°C), it is possible to operate the HVAC heat supply at a lower temperature. This change is important to enable replacing the use of steam to LTHW generated by using waste heat.
2. **Increased temperature tolerance**
   The baseline design uses set temperatures and relative humidity (RH) settings with tight tolerances. This requires a higher energy input to maintain the conditioned air to these tight tolerances. The EED uses floating set points for the temperature and RH.
3. **Reduced air change rates**
   The design allows for the rate at which air is changed to be reduced for some air-handling units, thus reducing energy consumption for HVAC.
4. **Heat recovery for air-handling units (AHUs)**
   Reductions in the heat demand can be realised by recovering energy from the exhaust ducts of the ventilation system. This can be achieved through using either rotating heat exchangers or a water-based recovery circuit. The heat recovered will be used to replace LTHW.

Process

Significant sources of energy efficiency were identified in the processes used in the facility, as follows:

5. **Replace WFI with highly purified water (HPW)**
   WFI is only necessary for the final purification stage of the process. Under the baseline design, WFI was used throughout the facility, when HPW would have been sufficient for most applications. HPW cost to produce is just over 5% of WFI costs.
6. **Use LTHW instead of steam**
   Substituting LTHW for steam when heating certain processes (e.g. bag holders, tank preheat and bio-reactor tank jackets) will result in significant savings. This initiative will reduce CO_2 emissions by 0.34 kg/kWh.

CIP/SIP

CIP (cleaning in place) and SIP (sterilisation in place) are major users of water and energy, so major savings can be made here with some minor modifications, as follows:

7. **Replace WFI with HPW**
   Under the baseline design, water for injection (WFI) was used for CIP and SIP. HPW is used in the EED, except for equipment used in the final purification steps. The steam used in the production of WFI can now be reduced, resulting in a saving of 375 tonnes of CO_2 per annum.
8. **Use a rotating ball spray for CIP**
   Using rotating ball sprays (instead of static ball sprays) will reduce cleaning time, consumption of water, chemicals and energy, and will improve cleaning efficiency. This will reduce CO_2 emissions by 262 tonnes and water consumption by 70% per annum.

Utilities

9. **Energy recovery**
   The prime saver of energy in utilities is energy recovery. Recovering waste heat from chillers and air compressors will allow the facility to redirect heat (which would have otherwise ended up in the cooling tower) into valuable thermal energy (which would otherwise have been produced by electricity or oil on site). This initiative will result in the significant savings of 2,691 tonnes of CO_2 and 10,505 m^3 of water per annum.

THE POTENTIAL SAVINGS

The following table outlines the savings to be made by carrying out the most significant EED initiatives (outlined above). Other initiatives are included for calculation purposes, but not itemised.

Area	EED initiatives		Savings per annum	
	Catalogue No		*CO_2 [Tonnes]*	*Fresh water [m^3]*
HVAC	14	Reduce air change rates of ISO7 and ISO8 rooms	1,304	0
	15	Reduction of air change rates (fresh air intake)	214	211
	16	Heat recovery inlet/ outlet ducts	199	0
	17	Floating setpoints (temperature & RH)	934	1,073
	18	Use of ‘free’ cooling with CTW	N/A	N/A
	19	Waste heat recovery system for HVAC heating	1,251	5,000
	20	Mechanical specification of HVAC systems	N/A	N/A
	26	Variable make up air for AHU’s	TBD	TBD
		Subtotal	**3,902**	**6,285**

Area	EED initiatives		Savings per annum	
	Catalogue No		*CO_2 [Tonnes]*	*Fresh water [m³]*
Process	1	Use of Highly purified water vs. WFI	900	0
	2	Cooling circuit temperatures of 0°C/5°C/20°C/CTW	TBD	TBD
	3	substitution of steam with LTHW for process	0	0
	4	WFI production unit optimising (if WFI is maintained)	268	65
	5	Inactivation, biowaste and wastewater	45	185
		Subtotal	**1,213**	**250**
CIP/SIP	6	Substitution of WFI with HPW for CIP	375	0
	7	Temperature of CIP rinses and flush (use of LTHW)	N/A	N/A
	8	Use of rotating spray ball for CIP	262	2,449
	9	Reduced use of Once-through in CIP	TBD	TBD
	10	Reuse of last CIP flush as first flush	72	676
	11	CIP flush as water makeup for cooling tower water	0	4,182
	12	Optimising CIP sequence		
	13	Clean steam generator efficiency	595	1,750
		Subtotal	**1,305**	**9,057**
Utility	21	Energy recovery from utilities (chillers, air compressors etc)	2,691	10,505
	22	Reduction of cooling tower water temperature	TBD	TBD
	23	Review of lighting systems	TBD	TBD
	24	Ozone treatment for cooling tower water	TBD	TBD
	25	Hot tap water production from waste heat	60	0
	*27	Blow down from clean steam generator and WFI skids in IE30 as makeup water for site scrubber makeup and VOC incinerator	0	43,000
		Subtotal	**2,751**	**53,505**
		Total savings catalog	**9,171**	**69,096**

* Item 27 applies to the IE30 existing Kinsale plant identified through this EED project.

Here we can see just how significant these potential savings are:

Aggregated saving potential

	CO_2 [tonnes/year]	Fresh water [m³/year]
Baseline	**10,180**	**29,000**
Saving catalogue	9,170	69,096
Implemented	1,253	45,000
Pending	2,700	10,500

Some EED initiatives highlighted for the IE42 Biotech facility are practical to implement in the existing IE30 Kinsale facility. The savings table above include the total aggregated savings potential including extended actions to the existing plant in Kinsale.

Cost payback

	Cost savings [k€/year]	Investments [k€]	Payback [years]
Implemented	271	300	1.1
Pending	335	500	1.5

THE LESSONS LEARNED

Standard industrial design tends to focus on time and investment, and not to address long-term operating costs. Decisions on technology for design are taken without considering the impact of ongoing energy consumption for the production site. These shortcomings are addressed when EED principles are applied at the start of the initial design phase.

EED enabled Eli Lilly to establish the operation costs and carbon footprint of the facility at an early stage of design; this is a significant weakness of design projects that do not look into this factor. Through the application of proven technologies and solutions, EED enables substantial energy savings

This application of EED is an excellent example of how sustainable development and corporate social responsibility make sound business sense.

One major drawback faced by the design team was that some quality-assurance requirements were found to be stringent and conservative, and that significant work was needed to change standards (e.g. HVAC) to take advantage of energy savings. This meant that some of the initiatives raised in the EED were not feasible.

The lessons learned by Eli Lilly during the EED process include:

- Significant advantages are gained by concentrating on energy efficiency early in the design process.;
- The EED process did not have any adverse impact on the overall project execution plan;
- There are significant advantages from having energy standards in place;
- It is important to get corporate Global Facilities Delivery and corporate Environmental Health and Safety groups to support project delivery.

"Funding from the SEI initiative gave Lilly the impetus to pilot EED for the IE42 project, which hadn't been done before."

"In addition to the significant savings potential identified, the project has given greater focus to energy efficiency at design phase in both corporate and local projects delivered onsite."

Stella Griffin,
Eli Lilly

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