Energy Efficient Design – a methodology applied in major international projects

Peter Maagøe Petersen
M.Sc., Ph.D., Partner
Viegand Maagoe
Nr. Farimagsgade 37
DK-1364 Copenhagen K
Denmark
pmp@vmas.dk

John O'Sullivan
Program Manager
Sustainable Energy Authority of Ireland
Wilton Park House
Wilton Place
Dublin 2
Ireland
John.OSulivan@seai.ie

Keywords

industrial processes, design process, energy end-use efficiency, industrial energy saving, system design

Abstract

Energy Efficient Design (EED) of new industrial facilities has been an important focus area in Danish and Irish energy efficiency programs. Significant energy savings have been achieved by applying a systematic approach from the very early stages of the design process. Even well-designed plants have achieved energy savings of the magnitude 30 % or more applying EED.

The basic methodology – based on the "the Onion" diagram – aims at targeting all aspects related to energy efficient operation of a future plant. The methodology includes systematic analysis of user requirements (URS), planned process types, detailed plant and utility designs, control strategy as well as maintenance and housekeeping-activities. The methodology details specific activities to implement during the design process on a phase-by-phase basis.

This paper describes which barriers towards energy efficiency are typically encountered when planning and designing a new industrial facility, and how the methodology deals with these barriers. In addition, recommended EED-activities are described during the planning and design stages on a phase-by-phase basis. The design of an autoclave system in a healthcare industry, including the associated utility systems, is used as a comprehensive example.

The paper further describes experiences gained from a number of projects carried out in Western Europe since 2000 including how to organize EED work and which practical experiences have been gained. A number of case studies are described including identified savings, payback periods and the degree of implementation in the final design.

The paper finally describes requirements for EED in the IPPC directive and which efforts that shall be carried out regarding EED according to the BAT note on energy efficiency for new industrial sites.

Introduction

It has been experienced during numerous energy audits of industrial facilities that energy saving opportunities would be significantly higher if basic design parameters could be reconsidered and if utility systems and production processes could be redesigned for maximum energy efficiency. Energy savings would be much higher this way and investments would be much lower in comparison with the cost of rehabilitating an industrial plant already in operation.

This fact was addressed in the Danish CO_2 Agreement Scheme for energy intensive industries developed during the 1990s (/1/) which stipulated that companies joining the scheme must introduce EED procedures to ensure that major new investments in process plants and utility systems were designed for maximum energy efficiency. This obligation still exists.

In the late 1990s the Danish Energy Agency launched a comprehensive EED program to develop methods and procedures for various project types as well as supporting guidelines, tools and pilot projects (/2/).

Also in Ireland a significant focus has been put on EED as a part of the SEAI Agreement Scheme (/3/). Several pilot projects have been carried out, and a number of working groups comprising design engineering companies and industrial companies have developed guidelines and tools in this area (/4/).

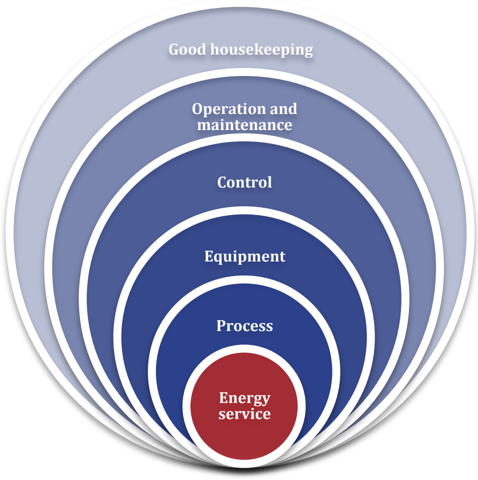

Figure 1. The "Onion"(Venn) diagram (/5/).

In both Denmark and Ireland emphasis has been put on the following 3 aspects of EED:

1. To develop an approach where all aspects of energy efficiency are considered in the design process
2. To establish procedures so as energy efficiency is in focus through all phases of a design project
3. To implement pilot and demonstration project proving that the concept works well.

This paper reports experiences from these 3 areas.

Best Practice Approach to Energy Efficiency – The "Onion" (Venn) Diagram

The "Onion" diagram also called the Venn diagram (/5/) was originally introduced for energy efficiency purposes as a part of process integration studies (/6/) and later refined and expanded under the Danish CO_2 Agreement Scheme (/1/), see Figure 1.

The diagram aims to target all aspects of energy efficiency from the "energy service" specified by the basic planning and design parameters to "operator behaviour", and is divided into logical steps in order to establish a structured way to approach energy efficiency.

Each layer of the diagram deals with specific issues relating to energy efficiency:

- The "energy service" is the core reason why energy is required for a specific area or process. For example, an "energy service" can be a "clean room" or a required "quality of a cleaning process (CIP/SIP)" in a pharmaceutical facility.

  Such design parameters are often stated in the User Requirement Specification (URS) for a new production facility, and are most often interpreted as a "legal requirement" by the design team.
- The "energy service" can always be challenged. For example, if it is necessary to maintain a very high standard in the "clean room", can the reasons why the room is not clean be isolated or removed?
- The "process" is the type of process selected to achieve the energy service – most commonly the "process" for a clean room is "filtration of air using filters".

  Alternatives should be identified for every layer in the diagram. For example, can "filtration of air" and air circulation with a high level of air changes (and high energy consumption) be replaced by "electrostatic filters", or can other and more energy efficient solutions be proposed?
- The "equipment" layer deals with the type and efficiency of the equipment to be installed in order to fulfil the "process".

  Numerous aspects can be optimised in large HVAC systems for clean rooms including the amount of recirculation, the type and efficiency of heat recovery, and the efficiency of fan installation (SFP), etc. Several of these aspects may be closely related to the utility design of the entire facility, for example the establishment of systems for utilizing waste heat for heating of air in HVAC systems.
- The "control" layer deals with the accuracy of control systems required to optimise plant operation in order to minimise energy consumption when loads vary and the demands for the "energy service" change.

  VSD control and selection of band widths will also be important areas to analyse when designing an energy efficient control strategy for HVAC systems for example. Often KPIs must be established to ensure that control strategies are operating correctly.
- The "operation and maintenance" layer must ensure that utility systems and process equipment all have a structured maintenance plan to ensure that the energy efficiency conforms to the level established at the design stage.

  For example, experience has shown that regular cleaning of heat exchangers is often not implemented in many sectors with the result that the energy efficiency of carefully designed utility systems and heat recovery systems (all with low delta Ts) is significantly impaired over time.
- The "good housekeeping" layer comprises a wide variety of focus areas to ensure that a facility is operated for optimum energy efficiency.

  Although housekeeping procedures can comprise basic instructions to switch off lights when leaving an empty room, areas like operator training related to cleaning stations (CIP) and production processes are much more significant factors for the energy efficient operation of a facility.

An energy saving analysis based on the "Onion" diagram can often identify significant energy saving potential during the design phase. Difficult issues will often be raised. For example, whether the company applies a consistent "corporate standards" policy across production plants all over the world, or whether these are defined by regulatory authorities. This typically happens in the pharmaceutical industry and in the food and beverage sector.

Challenging such design parameters may be time consuming, so it is crucial that a design methodology based on the "Onion" diagram" is early on in the planning and design process because that is the only time that the project owner and design organisation will be open for discussions on these aspects.

One of the main reasons why the "Onion" diagram is successfully used is that minimisation of the "energy service" often leads to smaller and therefore also cheaper utility systems. Systematically reducing the energy requirements by establishing a better design baseline results in a lower investment to supply the energy. This design approach might also be called an "inside-out" approach.

A real life example of the use of the "Onion" (Venn) Diagram

An example of the use of the "Onion" diagram for the autoclave system is shown in Figure 2.

The autoclave is designed for the sterilisation of small "stents" to be inserted into the human body during surgery. After production the stents are placed in a plastic bag with sterile water and the bag is placed on a tray in an autoclave for heating to 120 °C for 50 minutes. After removal from the autoclave, the bags are manually put in boxes and sent to hospitals for use during surgery.

To operate the system a large steam boiler station delivers heat to the autoclaves and a compressed air system maintains a stable pressure in the autoclaves to prevent the bags from exploding when heated to 120 °C (above the atmospheric boiling point for water at 100 °C).

An "Onion" analysis of this design reveals numerous and significant energy saving opportunities that can be taken into consideration during the planning and design stages of a new autoclave system:

- *Energy service.* The energy service (the core reason why energy is used) is obviously to "kill" bacteria on the stents so that remain sterile when unwrapped during surgery in a hospital. However, good design practice will also address the following issues, namely:
  - It does not appear logical that although they are sterilised in the production facility the stents are subsequently packed manually in a non-sterile environment. Therefore is it should not be necessary to sterilise the plastic bags in the production process when, in reality, the bags are re-sterilised during surgery?
  - Further it does not appear logical that sterile water is used when filling the bags because in reality this water is sterilized 3 times when also taking the sterilisation in hospital into account.
- *Process.* The product developers and the clients in this example have chosen a process in which the stents are sterilized by thermal treatment in a bag filled with sterile water. Nonetheless, alternative processes can be considered:
  - For example, it might be possible to use other and maybe more energy efficient sterilisation methods such as chemical sterilisation, microwaves, X-rays, vacuum packed tubes, etc. This is a "delicate" question to raise during a design process, but nevertheless crucial when evaluating the efficiency of the overall process from an energy point of view.
- *Equipment.* Once the decision has been taken to use thermal sterilisation as the preferred process, alternative methods could be evaluated. Alternative methods could be:
  - Hot water or warm air system. Hot water sterilisation is widely used in the food industry, however mostly at temperatures below 100 °C which means that systems do not have to be pressurized. The advantage of a hot water solution is that the heat from sterilisation can be recovered relatively easily, allowing the heat supplied for one batch to be recovered and used for the next batch, thereby keeping thermal energy consumption at an absolute minimum. This is not possible with a steam based system, which means that energy consumption will be at least 50 % higher.
- *Control.* The control of the process aims to ensure that all bags reach their target temperature of 120 °C for a period of 3 minutes or more. Digital tags are placed on each tray so

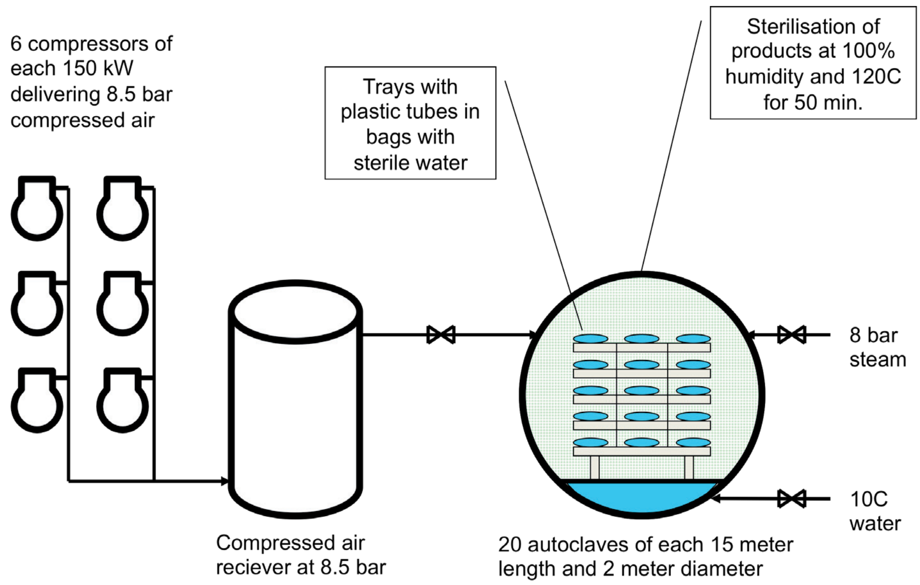

Figure 2. Autoclave for sterilisation of healthcare products.

temperatures can be logged and products traced after production. Nonetheless, important process parameters can be considered:

- The sterilisation time of 50 minutes is very high when compared with the required 3 minutes so it is realistic to ask whether the process design and control system can be improved. Actually a pressurized hot water system as proposed above would ensure a better heat transfer thus allowing for a shorter process time.
- The compressed air pressure of 8½ bars is significantly higher than the boiling pressure in the plastic bags of approximately 2.1 bars. This results in very high power consumption by the compressed air plant. Power consumption by the compressed air system could be reduced by more than 70 % if the system is designed to operate at a pressure closer to what is needed by the process. Another benefit is that a much smaller compressor station could be installed, thereby reducing the investment costs.

• *Operation and Maintenance.* The main questions related to operation and maintenance of the system is how leaks of air and heat can be avoided and how the idle load of compressors and boilers can be kept at a minimum.

- It is essential that the system is delivered with ready-to-use maintenance instructions to cover areas such as leak detection etc. Enquiries should also be made to see whether monitoring systems (e.g. air meters, steam meters, etc.) can be used to provide information about key aspects of the process.

• *Good Housekeeping.* Recommendations regarding "good housekeeping" are usually more generic, but because these often influence operator behaviour they can have a significant impact on energy efficiency.

- In the autoclave system several aspects relating to operator behaviour can be questioned including: how are autoclaves managed (filling, venting, cleaning), etc.?

Because the approach outlined above might be considered to be a little "academic" and many of the questions impossible to answer, it may be that engineering design consultants will often not want to consider such aspects during the design process, where "safety" is a crucial question. However, reviewing the questions raised above one by one identifies several simple solutions, which could lead to a significant reduction of operating costs for the future system. Following a careful mapping of the energy consumption for the autoclave system illustrated in Figure 2, operating costs for energy appeared to be as high as 0.5 mill. Euro per year. This came as a big surprise to the facility owner.

Barriers towards energy efficiency when planning and designing industrial facilities

Even though industry is increasingly aware of sustainability issues, energy efficiency of new industrial facilities still encounter major barriers, by example:

- *Lack of priority.* Energy costs and sustainability is an area of low interest during the design process – cost control, production logistics and "time-to-market" etc. are considered key aspects to watch during the design process. Future operating costs for energy is usually of less importance.
- *Time constraints.* The planning and design process is usually hurried – especially after the initial planning stages where overall project scope is defined. Once the detailed design phase is initiated, project engineers will be reluctant to introduce new solutions and to risk using any alternatives to well proven technologies.
- *Lack of data.* It is most often unclear how much energy a new facility will use in the future – and therefore it is unclear which issues need to have special attention until after the design project is well under way at the detailed design phase. At that time it is often too late to influence most of the design work. Utility systems are therefore frequently designed on inaccurate data and are therefore significantly over dimensioned for safety reasons.
- *Lack of knowledge.* Even though many specialists are involved in a typical design project, important decisions regarding process- and design parameters are often taken by project staff who are not experienced in energy efficiency – typically staff from the quality control department, or product specialists responsible for specifying production equipment. Staff such as these have no understanding of the consequences of operating a process with a higher air pressure or whether the process requires that glycol from a refrigeration system should be at a lower temperature.
- *Unclear responsibilities.* Often, there are no clear definitions as to who is responsible for energy efficiency in the design organisation. The project owner or the project manager

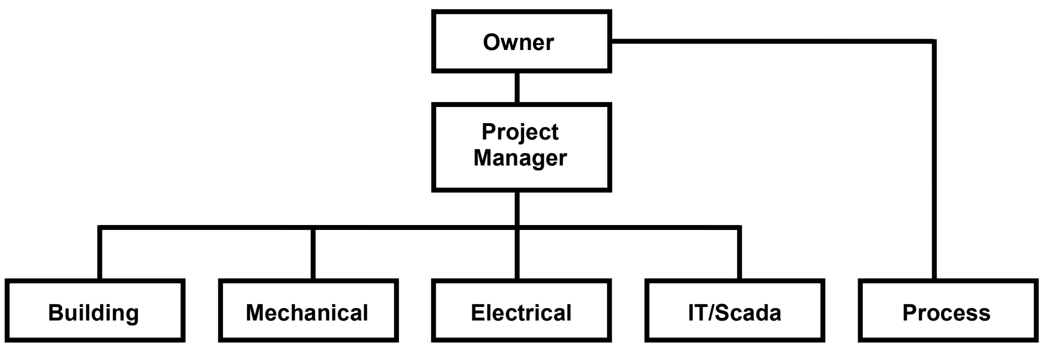

Figure 3. Typical design organisation for industrial facilities.

will typically expect utility engineers to be specialised in this area whereas the most important "energy parameters" should be defined by other parts of the organisation. Frequently, nobody dares challenge solutions proposed by manufactures when it comes to energy efficiency.

- *Budget constraints and value engineering.* More than ever, the success factor that determines new industrial facilities is considered to be the need to minimize investment costs. Even though "value engineering" phases are included in the design work with the aim of balancing investment costs and later operating costs, experience shows that such work usually only focuses on reducing investment costs and not on balancing investment costs and later operating costs over a fixed period (by example 2–3 years).

A description of the typical set-up of the design organisation, and which roles the design engineers take during planning and design of a new industrial facility is shown in Figure 3.

Typical Design Organisation

Figure 3 illustrates the typical structure of a project organisation with competence areas that is used for planning and designing a new industrial facility.

From an energy efficiency point of view the crucial aspects of this structure are:

- Staff members responsible for specifying processes and production machinery are often from the project owners own organisation (e.g. process specialists, staff from a quality department etc.). Employees in this category are mostly not experienced in energy efficiency except from sectors where energy costs constitute a significant fraction of the total operating costs (e.g. cement industry and refineries, etc.).
- Design engineers from consulting companies are typically responsible for civil engineering areas, and typically carry out work based on a User Requirements Specification (URS) prepared by the users/project owner and their specialists. Design engineers are not expected to challenge the URS.
- No part of the organisation is clearly responsible for energy efficiency and cross-organisational solutions (e.g. central heat recovery systems, selection of KPIs for energy management etc.). The mindset of the user/project owner is usually that the staff responsible for designing the boiler station and the refrigeration plans (utility systems) will also take care of energy efficiency – even though these persons often do not have any opportunity to influence design parameters fixed during the early project phases.

Based on the above considerations, the overall influence on energy efficiency in a planned, new industrial facility often is divided as illustrated in Figure 4.

According to Figure 4, consulting design engineers are often only responsible for a limited part of the future energy bill for a planned, new facility, whereas the project owners in-house staff and manufactures based on their being in control of important design parameters and various requirements influencing energy consumption will be responsible for a majority of the energy bill for the future plant.

Also legal requirements and regulatory authorities (e.g. FDA in the pharmaceutical sector) may have a significant influence on energy consumption in the new facility.

The pie chart in Figure 4 (e.g. showing who should be involved and where are the priorities for additional analysis) should be kept in mind when planning an effort to improve sustainability of a new industrial facility.

EED Methodology

Based on the aspects discussed above, the recommendation in the developed EED procedures in both the Danish and Irish programs, is that EED is best carried out by an independent energy expert with a kind of QA role in the design organisation as illustrated in Figure 5.

Most importantly the role of the energy expert is:

- *Data collection.* To establish an overview of the expected future energy consumption already during early project phases so as important focus areas and design parameters can be identified and receive priority before it is too late.

  For example challenging air change rates may take several months to complete, which means that by the detailed design phase (where HVAC engineers start to plan installations) it will be much too late to implement any modifications.
- *Review design parameters.* To review URS and design parameters during early project phases to identify issues that should be challenged, and eventually changed, involving the project owner's own organisation in order to minimize the energy requirements as well as to optimize important project parameters.

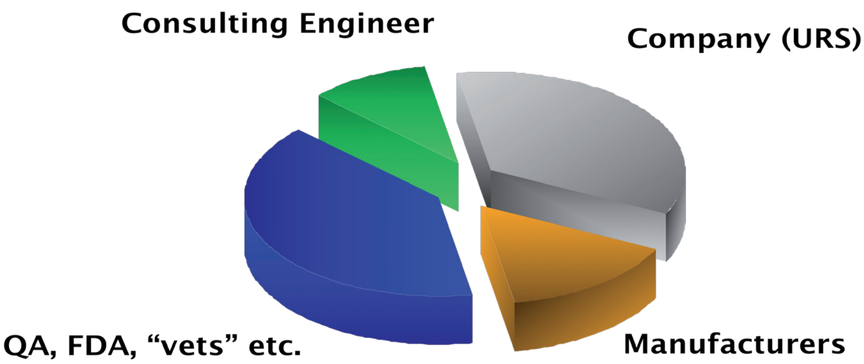

Figure 4. Who influences energy efficiency during design of a new industrial facility?

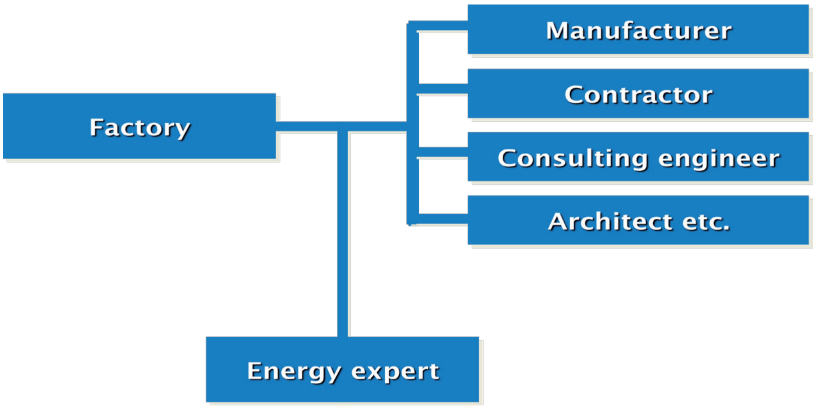

Figure 5. Recommended organisation for implementing an EED in Danish and Irish programs.

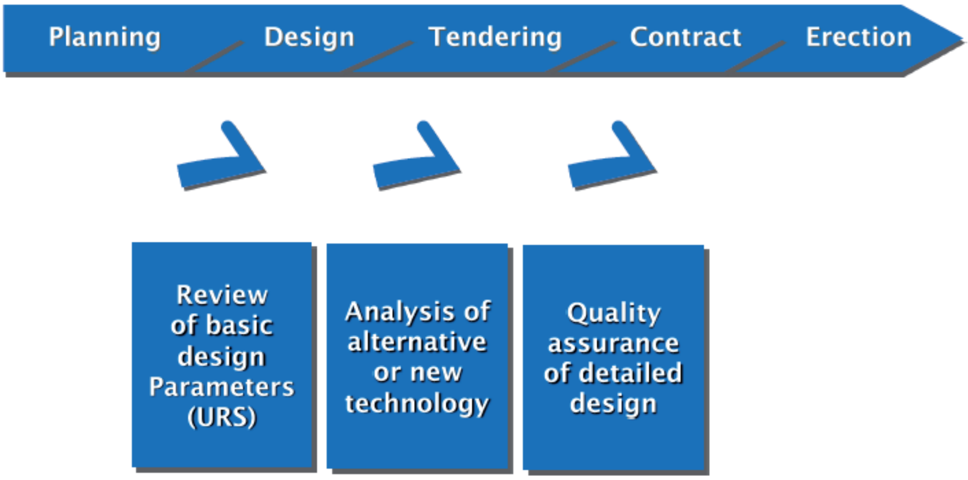

Figure 6. EED during the design phases.

Reviewing these parameters may involve several technical disciplines and requires a committed project manager to "carry" investigations from one part of the organisation to another.

- *Identify energy efficiency projects.* To identify important energy efficiency projects (e.g. Best Available Technology(BAT)) as early as possible in the design process and inspire owners, manufacturers and consulting design engineers to implement such improvements.

  Often, "cross-organisational" projects such as the utilisation of waste heat for heating purposes should be proposed at the early project phases in order to have such solutions introduced when detailed design begins.

- *Being a "terrier".* To pursue important energy aspects during the entire design process by continuing to address all unsolved questions or opportunities.

  A typical problem is that because manufacturers are reluctant to change solutions or supply more detailed information concerning energy aspects, somebody must pursue such questions if these are seen to be important during the initial data collection phase.

- *Elaborate business cases.* To prepare business cases for the most important extra investments and to assess IRR/payback for each of these during early project phases in order to ensure that these are not eliminated during Value Engineering.

  If data is not available, these must be advanced as "good ideas" although these are usually turned down if benefits from these can't be backed up by data.

- *Hand over projects.* To hand over important energy efficiency projects to the design organisation and to ensure that design engineers grasp ideas and are prepared to implement the appropriate design.

  The project owner will often play an important role in this phase because design engineers tend to be conservative and think "safety first" and therefore consider new solutions as "no go" areas.

Based on these core activities it is important to understand that the energy expert must have considerable interpersonal skills as well as significant experience with industrial energy efficiency. EED is a cross-organisational activity requiring dialogue across areas of potential conflict. Further the energy expert must possess a significant technical understanding.

In terms of the core activities it also appears that EED has to follow the design process during the various design phases, starting with the early project phases as illustrated in Figure 6.

Each of the design phases will comprise the main activities outlined in Table 1 (also including certain activities in later project phases).

The workflow described above is somewhat "standardised". Industrial design projects can be organised and carried out in many different ways and the EED actions should be adapted to various project types – typically by planning EED activities phase by phase.

Furthermore, it can be difficult to foresee exactly which input (man hours) is required by the energy expert when the EED project is planned. Specifying the man hour input phase by phase is always recommended. The further forward the design project gets the more concrete the EED actions become. Attempts to prepare EED budgets for the entire process during the initial phases usually fail as the project owner still considers the project as somehow abstract, and therefore finds is difficult to allocate significant budget for an activity that is also abstract.

The recommendation therefore is always to analyse the proposed design project carefully during the early stages in order to identify and give priority to areas where challenges must be expected due to economic constraints, due to lack of knowledge in the project organisation or due to commercial/technical conflicts between major participants in implementation of the project.

Experiences from large scale industrial Projects

The EED principles described above have been tested in a significant number of pilot projects carried out in Denmark and Ireland (e.g. see (/7/, /8/, /9/ and /10/)).

The energy savings achieved in these pilot projects have been carefully monitored to avoid reporting energy savings that are related to ongoing improvements in technology, so as to identify which results the "Onion" diagram has contributed to the project.

For example, the installation of VSDs for controlling air changes in HVAC systems has not be considered as an EED action in these pilot projects unless the project owner has directly specified that "VSDs are not required".

Table 2 summarizes the energy savings achieved in 4 of the pilot projects (/7/–/10/).

Table 2 shows that significant energy savings have been achieved in quite energy intensive industrial facilities, and in all cases overall payback times covering investments as well as consultancy fees for the energy expert are attractive.

The main results in each of the cases in Table 2 in relation to the use of the "Onion" diagram have been:

- Abattoir
  - Requirement for cleaning procedures has been reduced
  - Comprehensive waste heat recovery project established
  - New "mild" freezing process at higher temperature introduced
  - Sterilisation process eliminated.
- Ready meal company
  - Comprehensive waste heat recovery project established
  - Freezing process changed from nitrogen to ammonia
  - Ovens converted from electricity to natural gas.
- Pharmaceutical
  - Air change rates reduced
  - Comprehensive waste heat recovery project established
  - Wider band width introduced in operation of HVAC systems
  - Amount of recirculation in HVAC systems increased

Table 1. Main EED activities during design phases when planning a new industrial facility.

Design Phase	EED-Activity
Basic design/ Conceptual Design	Enforced data collection for energy usage in new facility (costs and pie-charts) Analysis of project organization and identification of responsibilities Review of basic design parameters (URS) influencing energy cons. Minimization of energy services Identification of Best Available Technology Preparation of draft business cases for most important areas
Detailed design	Design of optimal process plants and utility systems (composites) Process Integration/heat recovery systems (Pinch Technology "light") Assessment of needs for control and instrumentation Minimization of pressure losses, temperature losses etc. Selection of efficient motors, drives, pumps, ventilators etc. Specifications to tendering material regarding energy efficiency Hand-over of EED-projects to design engineers an manufacurers
Tendering process	Ask tenders and manufactures for more energy efficient solutions Quality control of plant designs and specifications in tenders Performance guarantees and KPIs Assistance in contract formulation
Construction and Erection	Follow-up detailed design of system design Quality control of specifications for installed equipment
Commissioning	Securing control of processes and utilities according to specifications
Operational phase	Energy audits Energy management Etc.

Table 2. Energy savings achieved in 4 EED pilot projects in Denmark and Ireland (*in this project, after energy savings, EED activities resulted in a much lower investment in utility systems, thereby reducing overall capital expenses and leading to a "negative" payback).

Industry	Implemented energy saving (Euro per year)	Implemented saving (%)	Extra EED investment (Euro)	Payback for EED investment (years)
Abattoir	2,000,000	30	4,000,000	2½
Ready meal company	1,000,000	50	2,000,000	2
Pharmaceutical	600,000	35	-10,000,000*	< 0
Laboratory	500,000	40	1,000,000	1½

- "Once-through" cleaning procedures (CIP) reduced
- Efficiency of "kill" process increased
- Quality of water reduced for certain purposes
- New utility structure introduced.

- Laboratory
  - Air change rates in HVAC systems reduced
  - Comprehensive waste heat recovery project established for heating the building
  - Standby consumption of equipment to be controlled.

From a methodology point of view, important lessons learnt from the projects are namely that:

- As stated above it is crucial to start EED input during the early project phases because it will take time to change any parameters linked to corporate standards.

  In general the "success rate for dealing with difficult issues" in the projects has been around 30 %, which is quite satisfying seen from the perspective that the energy savings from this approach usually have relatively short payback periods.

  The experience has sometimes been that questions "turned down" because of time constraints have actually been taken up later during a more general review of corporate standards. At least one American-based pharmaceutical company has changed its global standard for air change rates based on the findings in the EED projects.

  Handover of energy saving concepts to design engineers is problematic and should be headed up by the project owner and not the EED expert.

  For example, the design of waste heat recovery systems as part of an overall utility structure is considered to be a completely new technology by many design engineers. Consequently the focus is on risks and problems presented by such solutions rather that the significant cost savings the solutions will bring to the project owner.

  Turnkey projects end up being difficult and have important consequences in terms of energy efficiency. Once the contract for delivery is signed, the contractor will try to cut investment costs at every opportunity with the result that very poor designs have been encountered in such projects. This is simply because any equipment necessary to minimise energy consumption (e.g. meters, VSDs, etc.) can be eliminated from the design in order to reduce installation costs.

  Turnkey projects require special attention, and when negotiating contracts, specific requirements for energy efficiency should be included – either in the form of actual solutions required by the project owner or by describing a process in which the EED expert is allowed to scrutinize the detailed design and ask for improvements before installation begins.

- Budgets for the EED expert should be prepared and negotiated with the project owner phase by phase, and not at as a total lump sum covering the entire EED process. Depending on the scale of the design project, the following man hour inputs for EED are considered necessary for the types of projects summarised in Table 2:
  - Initial planning phase: 100–200 hours
  - Analysis during detailed design: 200–800 hours
  - QA and follow-up: 50–200 hours

  In all cases, the man hour input for EED is calculated to be 1–2 % of the total man hour input for design engineers.

- The EED expert should preferably be from an external company not connected with the project owner or any of the design companies involved on the project.

  An external person – given that he/she has the right profile and combines interpersonal skills with a significant insight in to technical questions and energy efficiency – brings "fresh eyes" to the project organisation and will be more free to address difficult issues.

Finally it is important to state, that the EED effort must be anchored at the top of the project owner's organisation. Several aspects of EED the work involve potential conflicts between the participants (e.g. when the EED expert asks the busy QA department to reconsider alternative design parameters or when a conservative design engineer is asked to design a new technical solution). In these situations, the project owner must be ready to back up the EED expert as this person has no real power in the organisational diagram shown in Figure 5.

EED as implemented in the IPPC directive

Already in 2006 steps were taken by EU to include the above positive experiences into the IPPC directive thus making EED evaluations mandatory for large industries regulated by this directive.

This was done by specifying the EED methodology as a "Best available technique" (/11/) to be considered for new investments.

A recent status update for this type of activity in Denmark (/12/) has shown that local authorities are not aware of this aspect of their inspection and approval work. Further design engineering companies are not aware of these requirements.

In Ireland more proactive actions have been taken because Enterprise Ireland (/13/) has applied EED experiences to promote Ireland as a sustainable environment to foreign companies investigating whether to base new production facilities in the country.

Development of an EED Methodology in Ireland

The Sustainable Energy Authority of Ireland (SEAI) has as an initiative of their Energy Agreements programme focussed on the EED process and its application for new plant and process. An objective is to further its utilisation and to standardise the process to maximise the potential for avoided energy savings with new investments (/18/).

SEAI EED METHODOLOGY – (SUSTAINABLE ENERGY AUTHORITY OF IRELAND)

The EED Methodology was developed and published originally by SEAI in 2010 and updated in 2011 (/5/). The methodology is aligned in many respects to the Danish experiences which was in effect a starting point in its development. The 'Onion Diagram' principle – referred to as the Energy Venn Diagram within its Methodology, is the underlying principle to determine new design challenges and opportunities throughout the design process. The SEAI EED Methodology was developed by an EED Working Group which collaborated with representation from large industrial energy using companies, engineering design companies and energy services companies – all operating from Ireland either as a multinational or an indigenous industry.

The common barriers identified and referenced within this paper are addressed by adhering to this methodology during a design project. It is comprised of two main aspects – organisational structure and EED process. An organisation structure is recommended which includes the EED-expert already referenced – and also a new role referred to as EED-Owner. The roles, responsibilities and lines of reporting and communication are defined within the overall project organisation structures of both the design and investor organisations. The process and organisational setting should (in theory) countermeasure the common risks of design decisions being made without appropriate investigation or effort conducted to determine viability. The process defined is a three-phase process with defined inputs & outputs for all phases. Figure 7 & 8 provides schematics of the organisation structure and process.

In addition, two new concepts are introduced – Design for Energy Management (DfEM) and Operations Optimisation using the EED Methodology. Design for Energy Management puts the planning for operational energy management on the design agenda. Operations optimisation applies the EED Methodology to smaller projects within an operational setting, i.e., EED principles are not just applicable to new large scale investments, the same principles can be applied to new processes, upgrades and retrofits.

INTEGRATION OF EED METHODOLOGY INTO ENERGY PROGRAMMES

The application of the EED Methodology has been integrated within the Irish Energy Agreements scheme as follows:

- The EED Methodology is proposed to be utilised when establishing requirements of *4.5.6 Design* and *4.5.7 Procurement of energy services, products, equipment and energy* within ISO 50001.
- The application of EED has become an objective to address for any sectoral or technology focussed Special Working Groups, e.g., HVAC, Food Beverage & Dairy, Data Centre and Commercial buildings Special Working Groups, (/19/, /20/, /21/).
- Relationship managers that are an important support mechanism provided to Energy Agreements members are trained in the application of the EED Methodology. They actively promote its use and assist where feasible in its implementation as an element of the SEAI support offering.
- The SEAI public sector partnership programme includes a service offering for EED reviews using assigned EED experts (/4/).

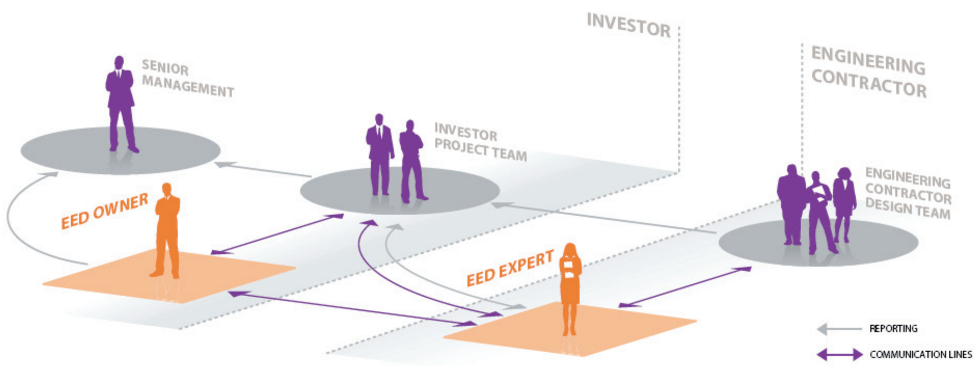

Figure 7. Project organisation for EED implementation.

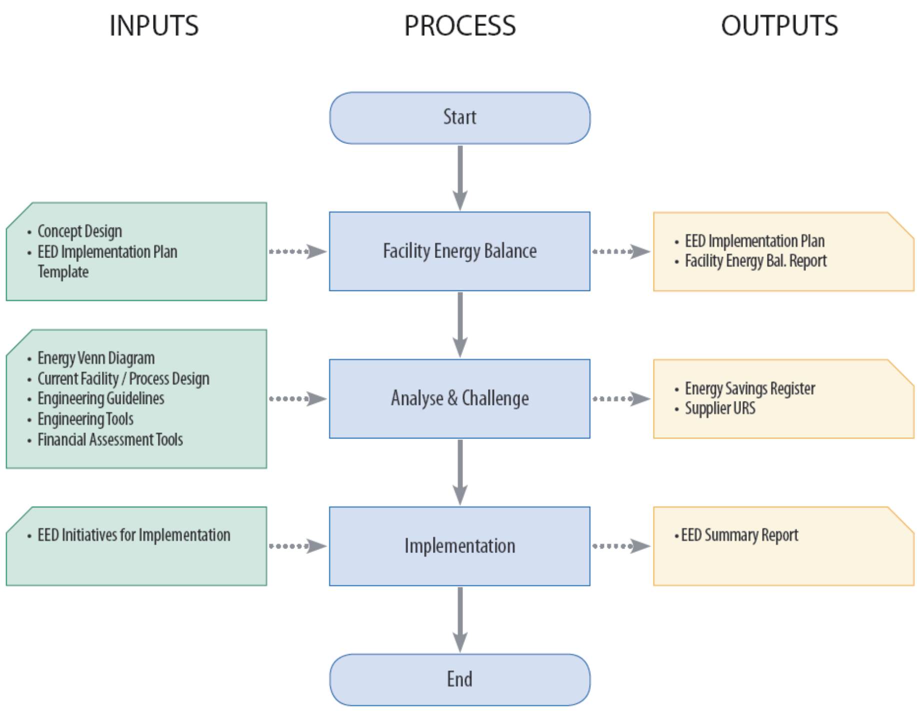

Figure 8. EED Methodology implementation process.

There are some indicators of success:

- Many companies have integrated the main principles of the EED Methodology with their ISO 50001 standard and some multinationals are adopting as a corporate standard.
- Some companies have re-developed their own version of the EED Methodology using their preferred language and providing some constraints on the process in order to fit company culture or protocol. These companies then impose the requirement from tendering through to commissioning and operation of new plant and process.
- Some Engineering design companies have adopted the EED Methodology as a strategy for EED as part of their business and tender proposals (/17/).
- The EED Methodology is being referenced with grant applications for the SEAI Better Energy Workplace grant schemes in 2011 & 2012 to highlight the source of the project investment decision having been derived as part of this process. Some examples are highlighted in Table 3.

STANDARDISATION OF THE EED METHODOLOGY IN IRELAND – FUTURE PLANS

Ireland is planning to develop an Irish Standard on EED utilising the SEAI Methodology as the blueprint. This work has been initiated already by SEAI in collaboration with the National Standards Authority of Ireland (NSAI). This step has been taken to ensure higher levels of use and to help standardise the process with the following additional value proposition:

- It can serve as an accompanying standard to ISO 50001 – design is a requirement within ISO 50001.
- A design standard for engineering design organisations.
- A design standard for energy service companies that provide design capability and support services.
- A design standard for any company to 'qualify' the application of best practice in EED during the design of new facility, new plant, new process and new projects.
- The standard can be used within a strategy for investing companies to challenge design norms and set criterion for new design contracts.
- The design standard can be utilised during a facilities life cycle with natural re-generation of product and process cycles.
- ISO 50001 focuses on energy management. This will focus on delivery of a more energy efficient facility with capability for better operational energy management considered during the design phases.
- The greatest potential for energy avoidance saving with the most attractive return of investment is available during the design process from concept to detailed design phases. It should therefore be structured by a management standard to optimise this potential.

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/1/ The Danish CO2 Agreement Scheme, see www.ens.dk
/2/ Danish homepage for EED materials, see www.energild-else.com
/3/ SEAI's homepage about Agreement Programme, see http://www.seai.ie/Your_Business/Large_Energy_Users/Energy_Agreements_Programme
/4/ SEAI's homepage about EED, see http://www.seai.ie/Your_Business/Public_Sector/Best_Practice/Energy_Efficient_Design

Table 3. Examples of new process investments applying an EED process.

Company	Description	Impact
HJ Heinz Frozen and Chilled Food Ltd. (Ireland). /14/, /16/.	Objective to install additional steam boilers as business continuity requirement. The EED process led to a fundamental review of steam usage using the Energy Venn Diagram. Energy service requirement, selected process and alternative technology was implemented. Existing steam boilers ultimately being utilised as a backup.	- 1.3 GWh annual gas savings - 20% reduction in steam/product KPI - 88% reduction in maintenance costs - Payback – 4 years - EED process is standardised for new process upgrades
Nypro /15, /16/.	Cleanroom upgrade project from whiteroom to ISO Class 8 cleanroom. A range of alternative design decisions were implemented.	- 23% savings compared to existing ISO Class 8 cleanrooms - Nypro design processes standardised locally - Experience shared with Nypro sites worldwide
Dog Food company	Drying process efficiency upgrade Cooking process efficiency upgrade Redesign of both drying and cooking processes.	- 45% reduction kWh/tonne for drying process - 57% reduction kWh/tonne for cooking process. - Process de-bottlenecking enabled through re-design, a significant additional non-energy benefit.

/5/ SEAI's homepage and reports about the Venn diagram, see http://www.seai.ie/Your_Business/Energy_Agreements/Special_Working_Groups/EED_SWG_2008/EED_Methodology.pdf

/6/ The "Onion" (Venn) diagram is described in the BREF document, see http://eippcb.jrc.es/reference/ene.html

/7/ EED at the Danish Crown abattoir, see http://www.ens.dk/da-DK/Info/Nyheder/faktaark/Documents/Danish%20Crown_dk.pdf

/8/ EED at the Danpo ready meal company, see http://www.energiledelse.com/db/filarkiv/4501/EP-temahaefte.pdf

/9/ SEAI's homepage with EED cases (Eli Lilly), see http://www.seai.ie/Your_Business/Large_Energy_Users/Special_Initiatives/Industrial_Best_Practice_Initiative

/10/ SEAI's homepage with EED cases (Wyeth Medica), see http://www.seai.ie/Your_Business/Large_Energy_Users/Special_Initiatives/Industrial_Best_Practice_Initiative

/11/Section 2.3 in http://eippcb.jrc.es/reference/BREF/ENE_Adopted_02-2009.pdf

/12/ "Mapping EED efforts based on the IPPC directive in Denmark". Report from The Danish Ministry of the Environment, April, 2012.

/13/ Homepage of Enterprise Ireland, see http://www.enterprise-ireland.com

/14/ HJ Heinz conference poster, Creating the right environment for ISO 50001 to thrive, SEAI, http://www.seai.ie/News_Events/Previous_SEAI_events/Creating_the_Right_Environment_for_ISO_50001/Heinz_ISO_poster.pdf

/15/ Nypro conference poster, Creating the right environment for ISO 50001 to thrive, SEAI, http://www.seai.ie/News_Events/Previous_SEAI_events/Creating_the_Right_Environment_for_ISO_50001/Nypro_ISI_poster.pdf

/16/ Large Industry Energy Network Annual report 2010, SEAI, http://www.seai.ie/Your_Business/Large_Energy_Users/LIEN/LIEN_Reports/LIEN_Annual_Report_2010.pdf

/17/ PM Group presentation, SEAI Energy Show 2011 seminars, http://www.seai.ie/News_Events/Energy_Show/Seminars/Con_Leddy.pdf

/18/ O'Sullivan, J. (2011), "Energy Efficiency in Industry, a holistic and integrated strategy from policy to results", ECEEE 2011 Summer Study, 2011.
/19/ Data Centre Energy Efficient Design Guide, Data Centre Special Working Group, SEAI, http://www.seai.ie/Your_Business/Large_Energy_Users/Special_Initiatives/Special_Working_Groups/Data_Centre_Special_Working_Group_SpinI/
/20/ Food & Dairy SWG Project Report, SEAI, http://www.seai.ie/Your_Business/Large_Energy_Users/Special_Initiatives/Special_Working_Groups/Food_Dairy_Special_Working_Group_SpinI/
/21/ HVAC System Optimisation Methodology, SEAI, http://www.seai.ie/Your_Business/Energy_Agreements/Special_Working_Groups/HVAC_SWG_2008/HVAC_Appendix_C.pdf