# CAD/CAE systems and cost engineering

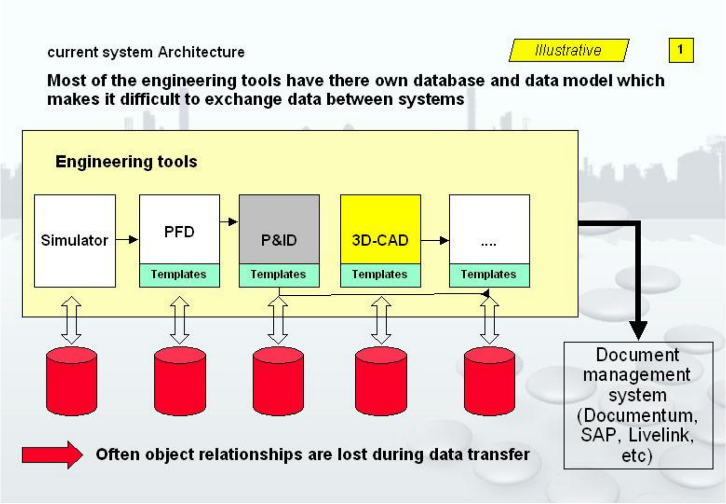
The purpose of this article is to explain how total life-cycle solutions can help engineering procurement and construction and plant owner companies meet today's business challenges. They consist of the following elements:

- standard or modular approach to plant design to enable faster and more accurate bidding and retain knowledge for subsequent use;
- design optimization through quality improvements and thorough front-end definition;
- better cost information at all stages;
- distributed (global) execution;
- improved efficiency of project execution (execute as sold);
- supply chain integration; and
- improved data hand-over to clients in neutral industry format (STEP, XML) that lasts the life of the asset.

In short, this article demonstrates that by adopting a new cross functional approach to data handling, companies can reduce cost and get more accurate bids for their projects.

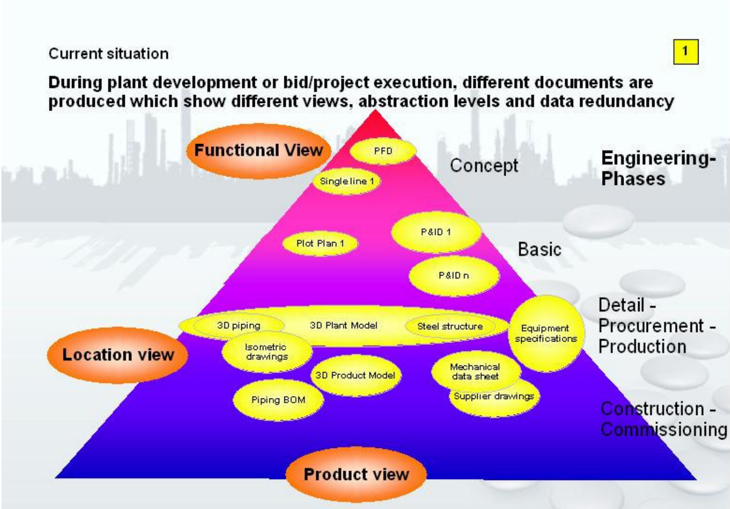
**The business challenge**
Pressure has never been greater for engineering procurement, construction contractors, and owners to protect or improve market share and profitability, in a marketplace where they are required to undertake complex international projects and also work globally in alliance with other contractors.
They are expected to take more risk with projects while also providing improvements of as much as 30 percent in total installed cost (TIC) or life cycle costs (LCC).
On top of this, project schedules are generally under pressure, and there is significant competition from contractors with access to lower cost labor markets.

**Re-using data reduces costs**
Electronic delivery of data in an industry standard format enables information to be accessed and reused in other applications at various stages of a project, while also reducing data creation and transfer costs. For the EPC it also allows to reuse some data from one executed project to the next. In the long term, it also can lead to a reduction in the cost of handling and maintaining information over an asset's life cycle.
This is why many companies now take a proactive approach by providing some level of standardization of data in plant design, whether a contract calls for a power plant or cracking unit or only to a simpler level, just ensuring that suppliers of pumps, compressors etc., conform to a common standard.



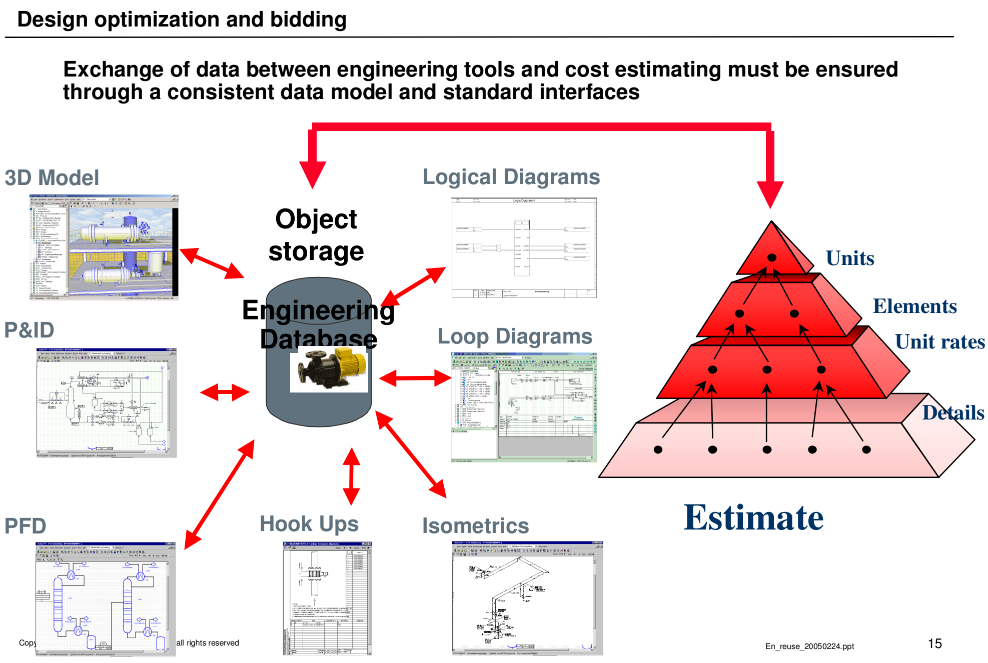

**Importance of information management**
More than 70 percent of CAPEX and OPEX costs relate to information processing and handling. More than 80 percent of the information is technical. Company strategies to significantly improve business performance rely heavily on information technology (IT), with the focus on point solutions to boost productivity and increase quality. However, such solutions will not deliver the 30 percent- plus cost savings required.
The key to success lies in the fact that most data creation tasks are now performed with the help of CAD/CAE and office automation software. These tools provide a rich source of data – and the companies that prove to be

smarter, work faster, and more cheaply, will be those that can manage this information effectively with better integration, standardization, and re-use.




**From documents to information management**

Information management today is still based primarily on data creation applications producing document deliverables. Although documents will remain an important medium for the transfer of information in the foreseeable future, they are not capable of meeting the many complex challenges facing the process industry. Today several CAD/CAE engineering software suppliers provide solution allowing such data centric engineering workflows (see figure below)




**Enabling technologies for exchange of industry-standard data**

Several key technologies must be put into place to create systems and methods that will enable the exchange of electronic plant data in neutral, industry-standard formats(e.g. defined XML).

Standards for data definition and exchange must be enforced. Every major project involves many stake-holders, from the plant owner to engineering contractors, fabricators, consultants, regulatory authorities, equipment suppliers, and so on. All of these stakeholders need to share and exchange information.

IT-systems allowing object oriented data models and following an accepted world wide Reference Data Library (e.g as defined in section 4 of ISO 15926). The data created in these systems must be accessible trough interface which are described and opened allowing two way data transfers.

**Design standardization – a management overview**

To date, attempts at standardization in the process industries have not been very successful when compared with what has happened in the automotive and aerospace industries. There are several reasons for this.

Client specifications have driven plant designs to a very large and detailed degree. This had significantly affected the ability of companies to standardize on design, material, and equipment specifications and suppliers.

However, the situation is changing as owner/ operators experience greater cost pressures. Initiatives such as CRINE and ACTIVE represent a significant opportunity to drive forward standardization to reduce costs.

**Design optimization and bidding**

Design optimization is only effective during the front-end engineering and design (FEED) phase of a project where 80 percent of the plant's cost is determined. At this stage, the design is dynamic and design decisions are interrelated.

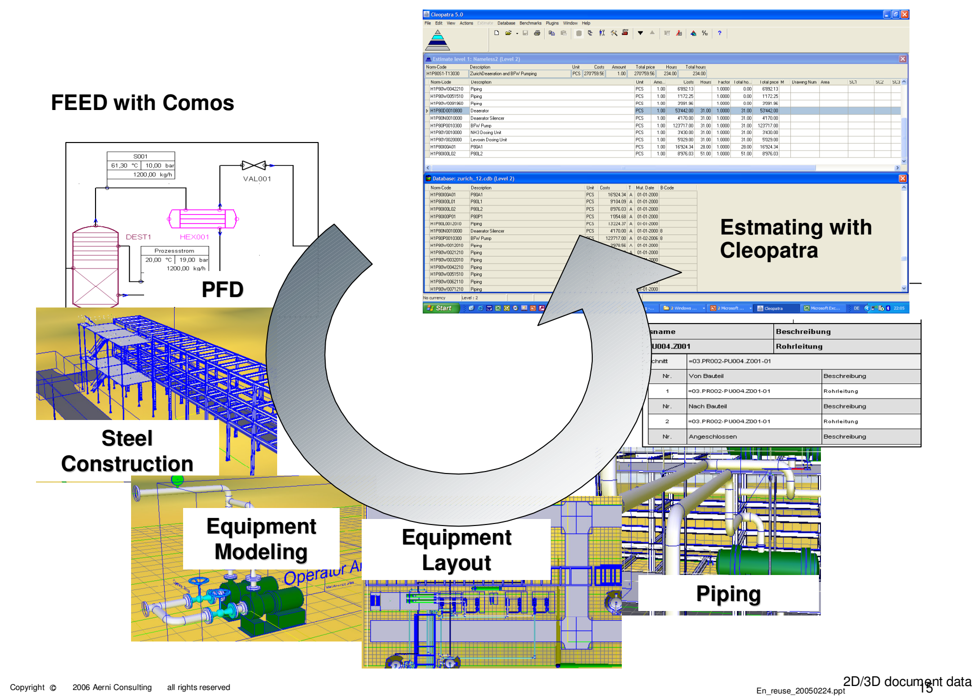
The ability to look at and compare options quickly, and the assurance that the design data, Bill Of Materials (BOMs) and cost are accurate, is important. The cost of the designs is based on materials and labor, not drawings. Tying the design and cost together is critical.

Working from standard plant configurations with the ability to search and reference similar past projects (with full knowledge of BOMs), one can quickly and precisely evaluate supplier options for material, equipment and modify standard configurations. This should save enough time to enable exploration of alternative arrangements, which is important for true project optimization.

Optimization requires fast access to information to BOMs and cost and that the information is organized in a structured way. Managing this process through a drawing tool is difficult. For example, if a change to a process specification is made, the effect of that change on equipment, costs, and materials requires an analysis of equipment items and their relationships, not simply of the drawing on which the equipment is shown.

Linking standard plant configurations that can be stored in a Product Data Management application (PDM /PLM) together with cost engineering data, provides an integrated bidding system. Procurement, cost, and scheduling information, held within a Enterprise Resource Planning applications (ERP), can be related to the PDM structure. By applying the rules, methods and the defined workflows, the relationships between the two systems can be built. As the project is technically defined, the bid information (cost, schedule, bid documents) is automatically created. Project specific BOMs are either created by copying CAD/CAE objects from past jobs and/or by creating new objects in a FEED-tool and transferring the complete project configuration through XML to a cost estimating tool (e.g. Cleopatra) which contains the prices and the unit rates information for completing a detailed estimate with little resources. Queries containing BOMs from that detailed estimate can also be sent to suppliers to update prices and unit rates. It allows also to compare suppliers for a specific project.

The only precondition for such a workflow to work is to have an multi-functional integrated data model allowing to have the same objects in the CAD/CAE tool than in the cost estimating tool than in the cost control tool during project execution.



**Executing as sold – bringing change under control**

Change control is a very real challenge for companies. Areas of concern associated with change include:

- taking too long to assess the effect of a change (i.e. technical, schedule and cost);
- changes occurring without proper effect assessment;
- authorized changes taking too long to be communicated to other parts of an operation, creating unnecessary rework;
- not tracking changes properly; and
- missing and avoiding potential claims.

Assessing the effect of changes means understanding the relationship between logical and/or physical objects in the plant, but not only for the technical aspects, but also for for the cost and time schedule aspects. Many changes are related to processes or vendors.

Good control of the P&ID line information and equipment data is a prerequisite to managing change better. For example, if process engineering wants to change in a line size, the impact assessment and implementation of that change must be done at the object level, not the drawing level. (Knowing the P&ID changed does not help identify the specific change.)

Because an asset information management system stores the plant structure at an object level and relates objects through their development from PFD stream to P&ID line to 3D line model to isometric drawings to material requisition, asset information management provides the platform for significant improvement in change control. It enables the following:

- faster impact assessment for more informed decision-making;
- early warning of potential changes (P&ID change control);
- management of change control procedure including impact on cost (for authorization and claims).

**Data handover and data warehousing**

Data handover to operators/owners has to be defined already in the RFQ to the EPC companies and data models of EPCs have to consider that need in order to be capable of delivering that data in a timely and resource optimal way at the end of the design and built project. Most of the key plant objects are the same for EPCs and Owner/operators except the attributes (e.g. after 24'000 equivalent operating hours exchange of the 2 first raw of blades and vanes of a gas turbine). some more detailed objects will need to be defined which are important for the optimum operation and maintenance of the plant like spare parts (e.g. gas turbine blades and vanes).

The National Institute of Standards and Technology (NIST) of the U.S. Department of Commerce Technology Administration estimated the cost of inadequate interoperability to 15.8 billion US $ in the U.S capital facilities industry. Interoperability is only a part of above challenges which means that the potential improvements for information management as a whole for the industry from suppliers to owners/operator are just gigantic.

The effect of data and information management leads to direct bottom-line improvements. An effective information management strategy requires a standardized product data model and strong supporting solutions – resulting in step function improvement in productivity. The decision to move from a document-centric paradigm to an object-centric paradigm is necessary to:

- ensure maximum advantage of now available technologies;
- provide and use detailed cost engineering data;
- support business strategies that will deliver 30 percent-plus project savings; and
- do not only talk about it, just start to do it in the areas you think most promising!

**What we have learned**

Today a lot of companies are working in the area of information management, implementing data centric IT application in the engineering processes, or implementing common project and material management platforms across multi-national sites. These IT-projects are usually under the responsibility of a business function (e.g. project management, finance, engineering, etc), but seldom is there a clear cross-functional approach in which the huge opportunities of a common data models between the functions are used. On the contrary, you can argue that the complexity of data and workflow integration within the different disciplines of the engineering (e.g. process, mechanical, electrical, instrumentation etc.) are already a sufficient large challenge for an organization. Nevertheless, we would like to argue that companies could be better off by tackling first some cross functional areas like process design with layout design (FEED) integrated with cost estimating allowing real Life Cycle Cost optimization. Unfortunately, the way most companies are organized and managers measured is along functions which does not support the approach. The second element is that IT suppliers (for previous good reasons) are also focussed towards functions (e.g SAP for ERP-functions and CAD/CAE suppliers towards engineering functions).

No one in the industry having dealt with BOMs and cost estimating would argue that to be accurate in cost estimating for plant design optimization, one would need BOMs from executed projects with modifications to fit the specific project process/layout design and actual prices and unit rates for this project. Integration of CAD tools for FEED (e.g. FEED and detailed cost estimating tools (e.g. Cleopatra from Cost Engineering) allow to use validated detailed estimates from executed project (BOM as built) in combination with actual prices and unit rates and delta BOMs coming from the FEED tools without overrunning the traditional frame of the bid phase in terms of time and resources needed, but definitively with a better choice for the best alternative and a better accuracy.

In order to implement the above described workflows, methods and structures, companies must decide on an overall system architecture. Figure 5 shows such an architecture. A few years will be needed to implement the described vision. The technology is available but the change happens through people and workflows which is clearly the two critical factors for implementation beside the normal challenges of some new technologies.