Desalination process comparison and future trend

- Current status of desalination technology
- Major development
-Future trends
-Advantages and disadvantages

Current status of desalination technology

- Major development

-Future trends

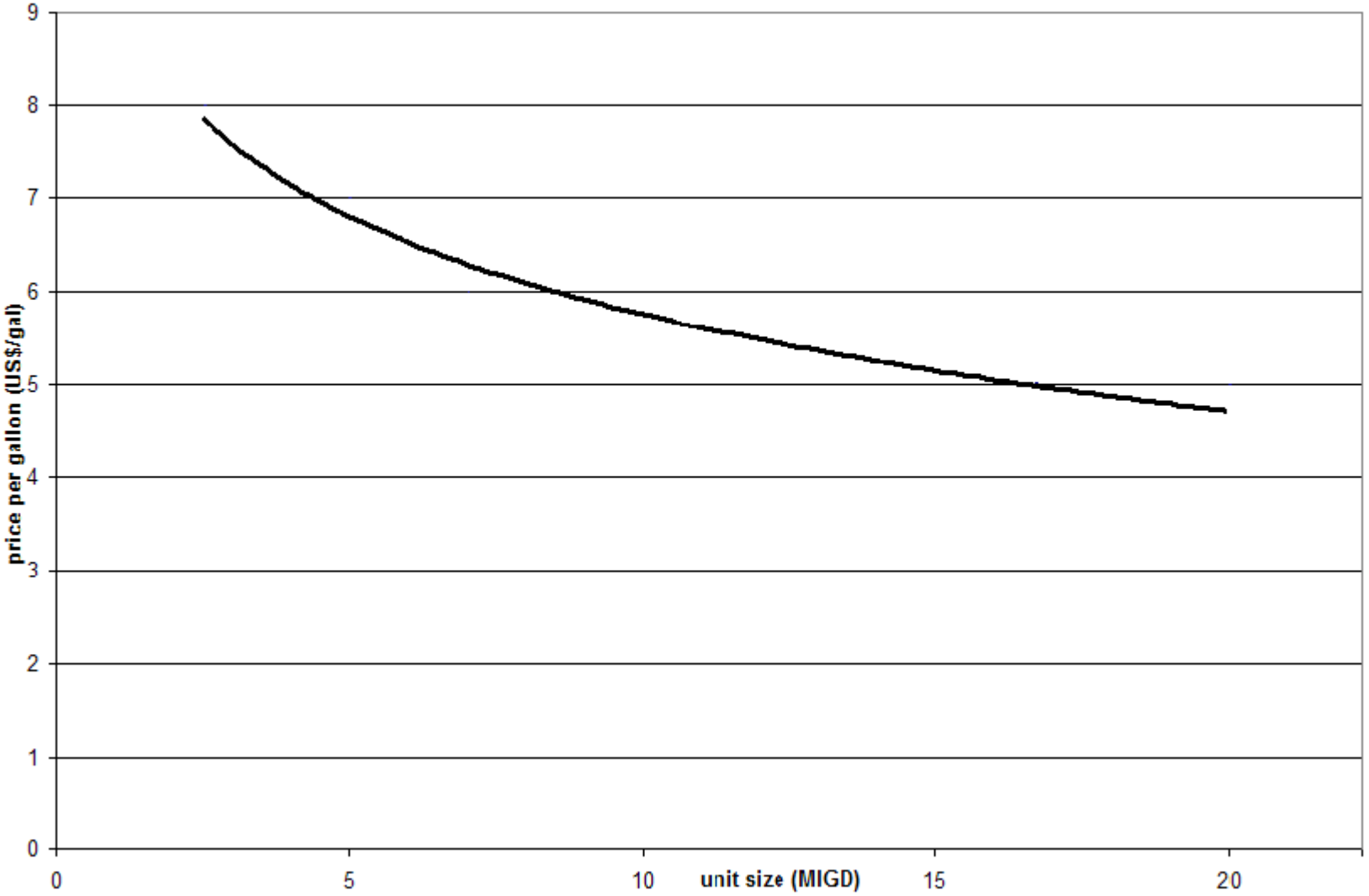
-Advantages and disadvantages

MSF technology

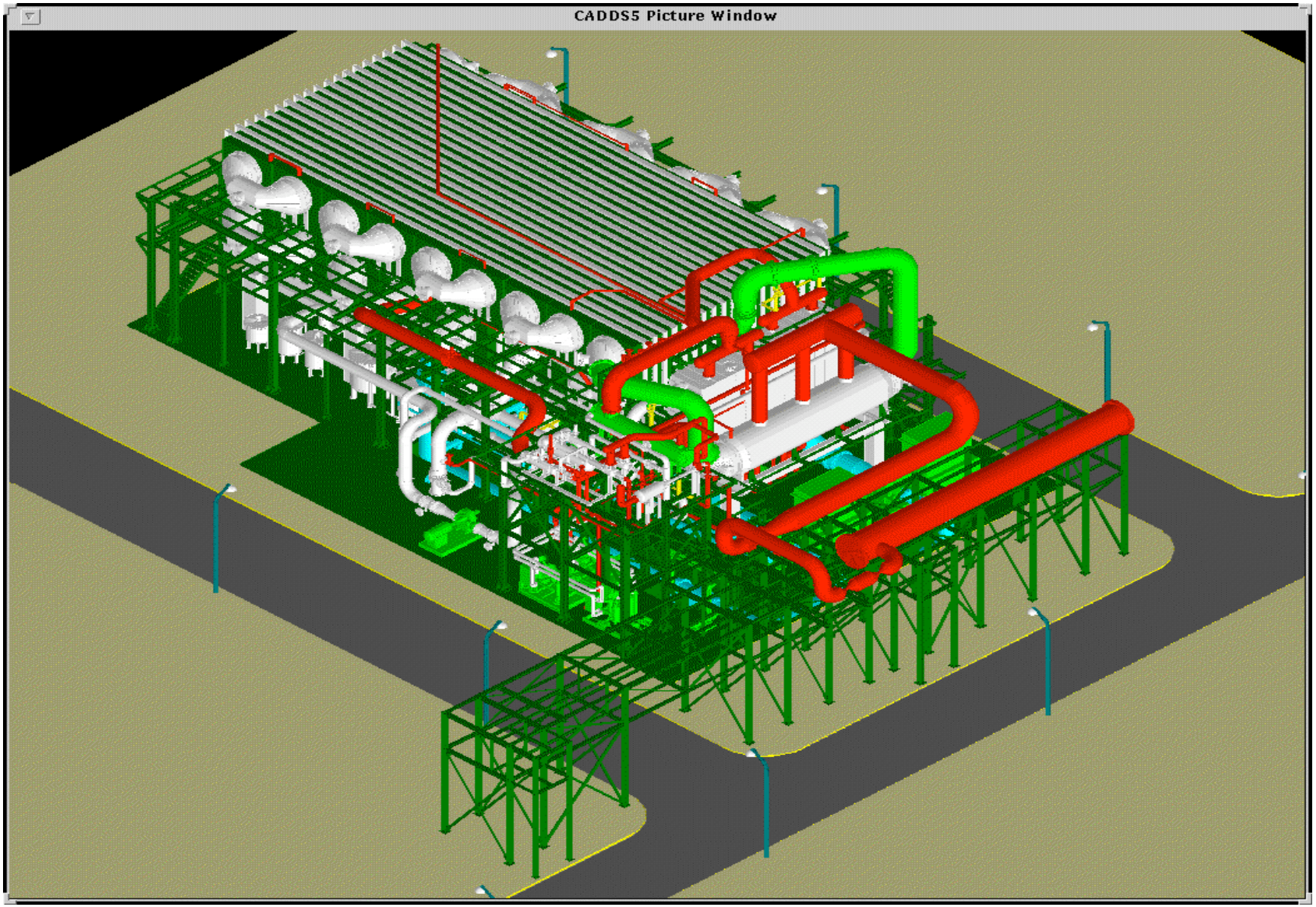
The main areas where a sharp optimisation was achieved have been :

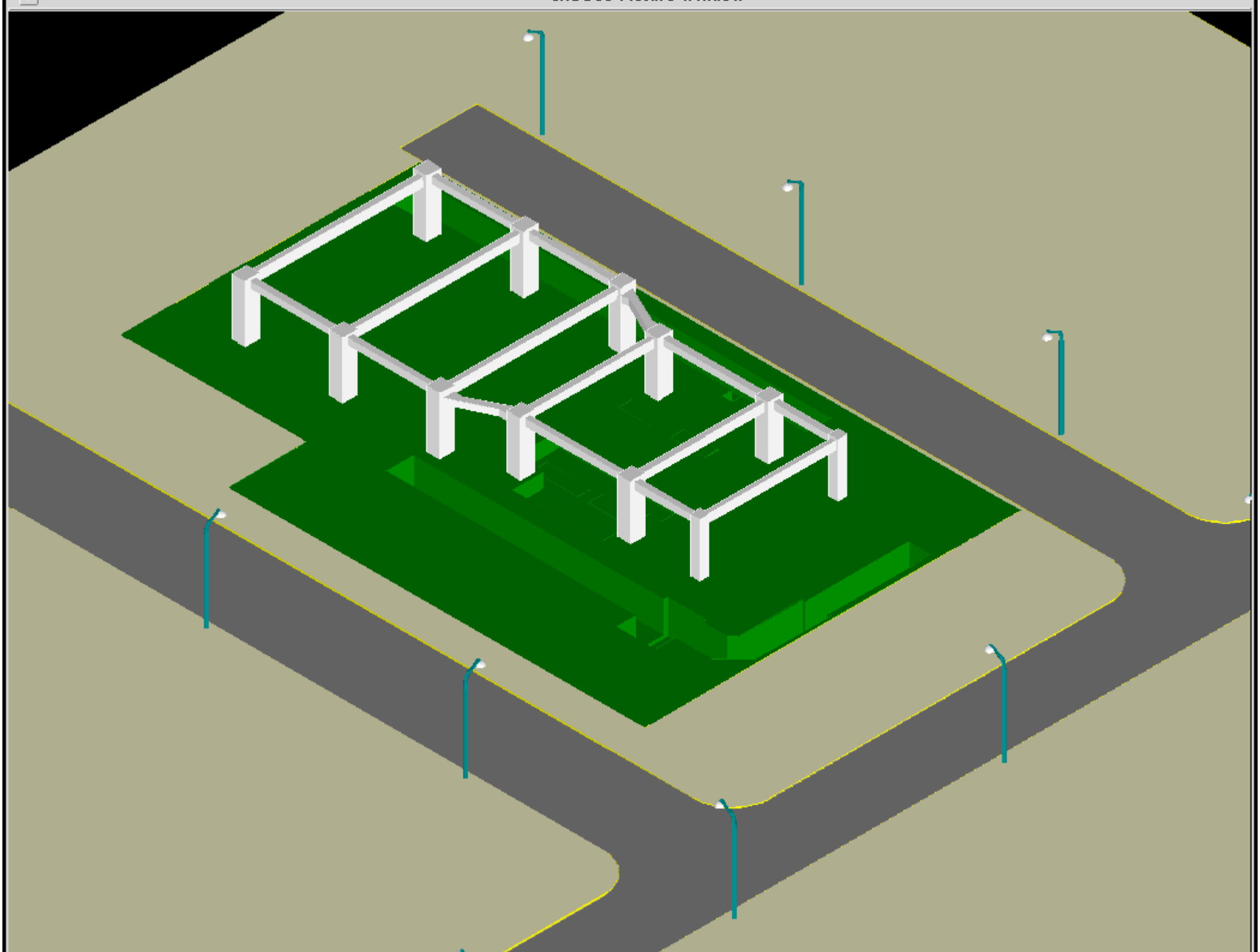
- Equipment design and configuration
- Thermodynamic design
- Material selection and structural aspects
- Construction and transportation technique
- Size and Scale factor
- Standardisation in Engineering

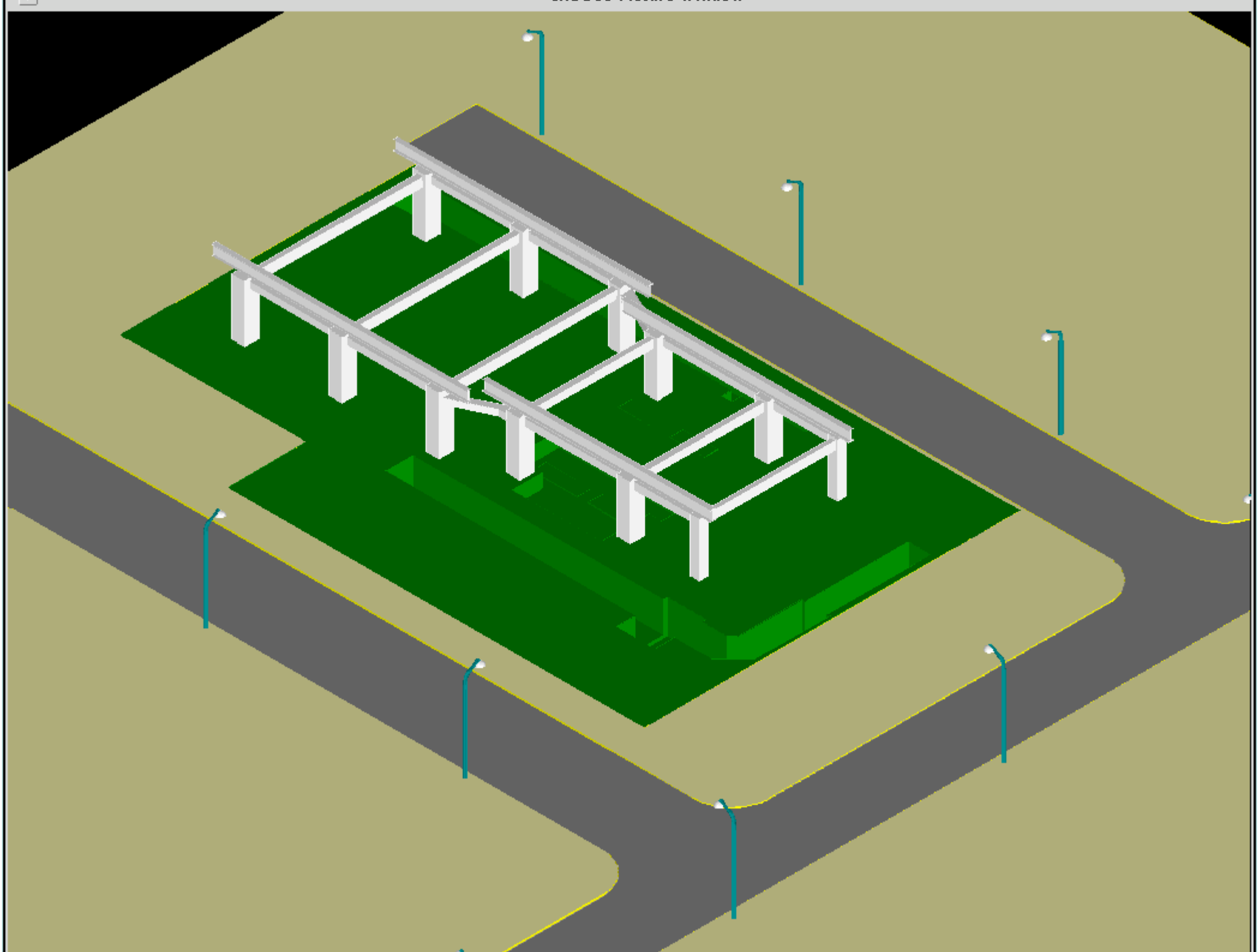
MSF plant and scale effect

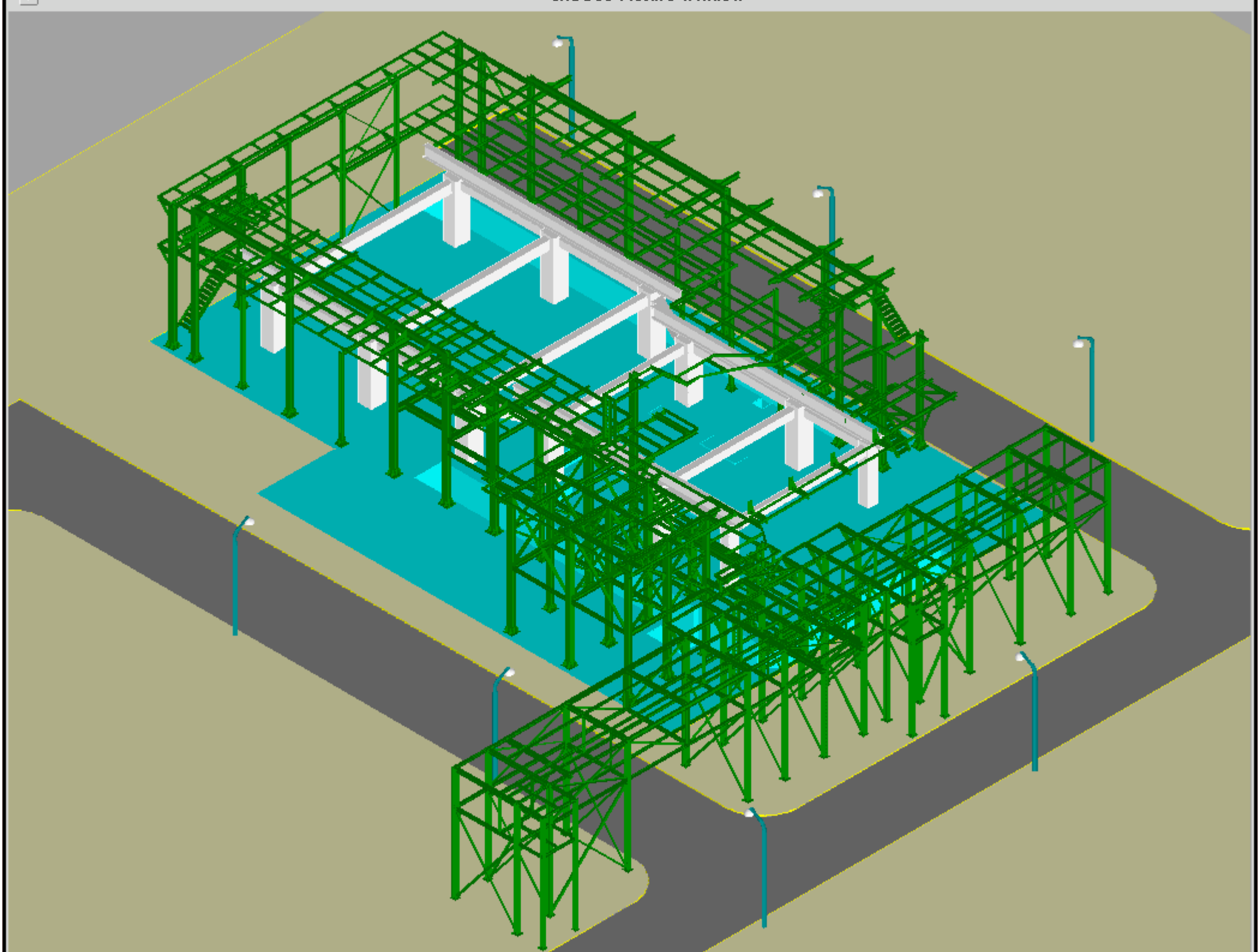


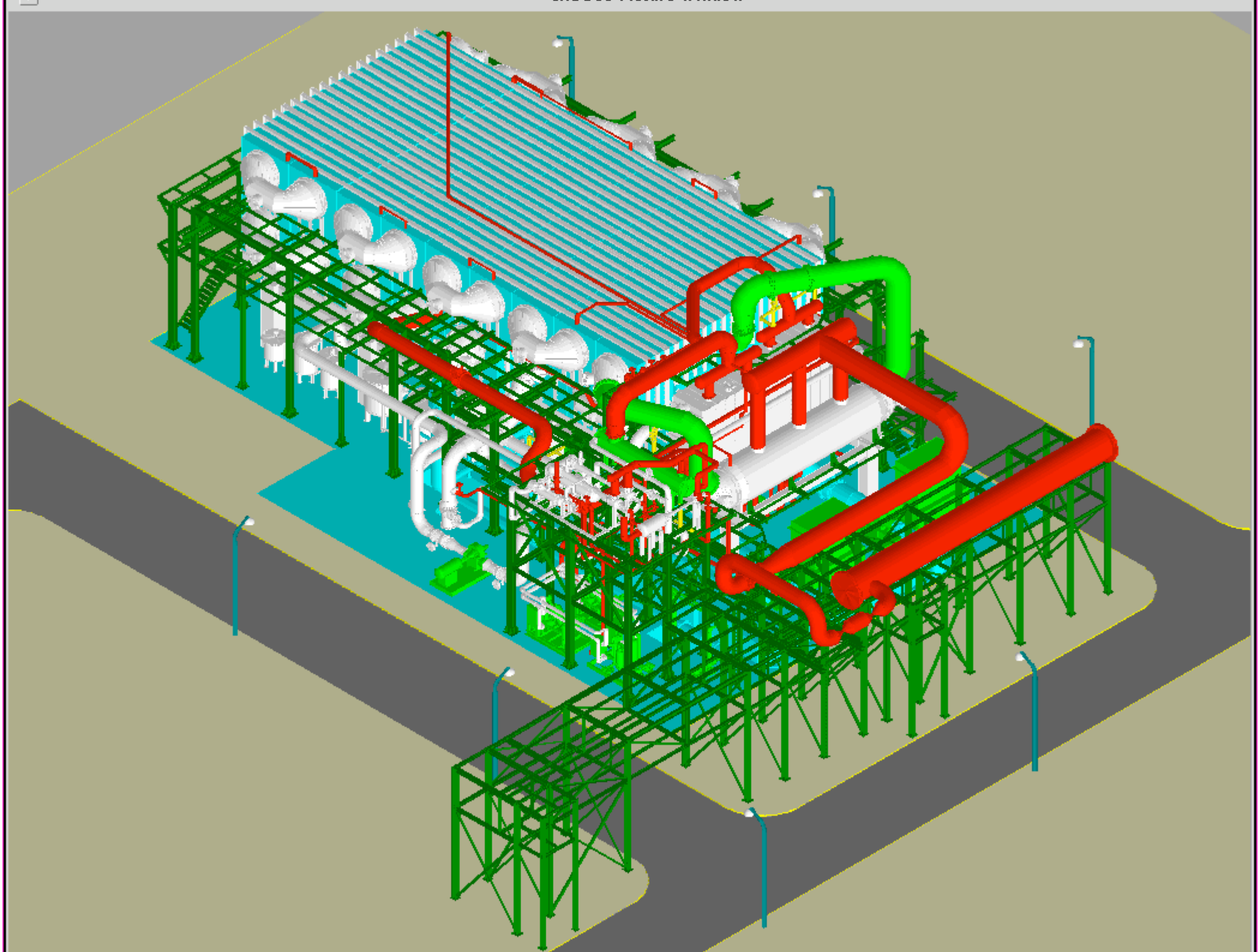
MSF engineering standardisation

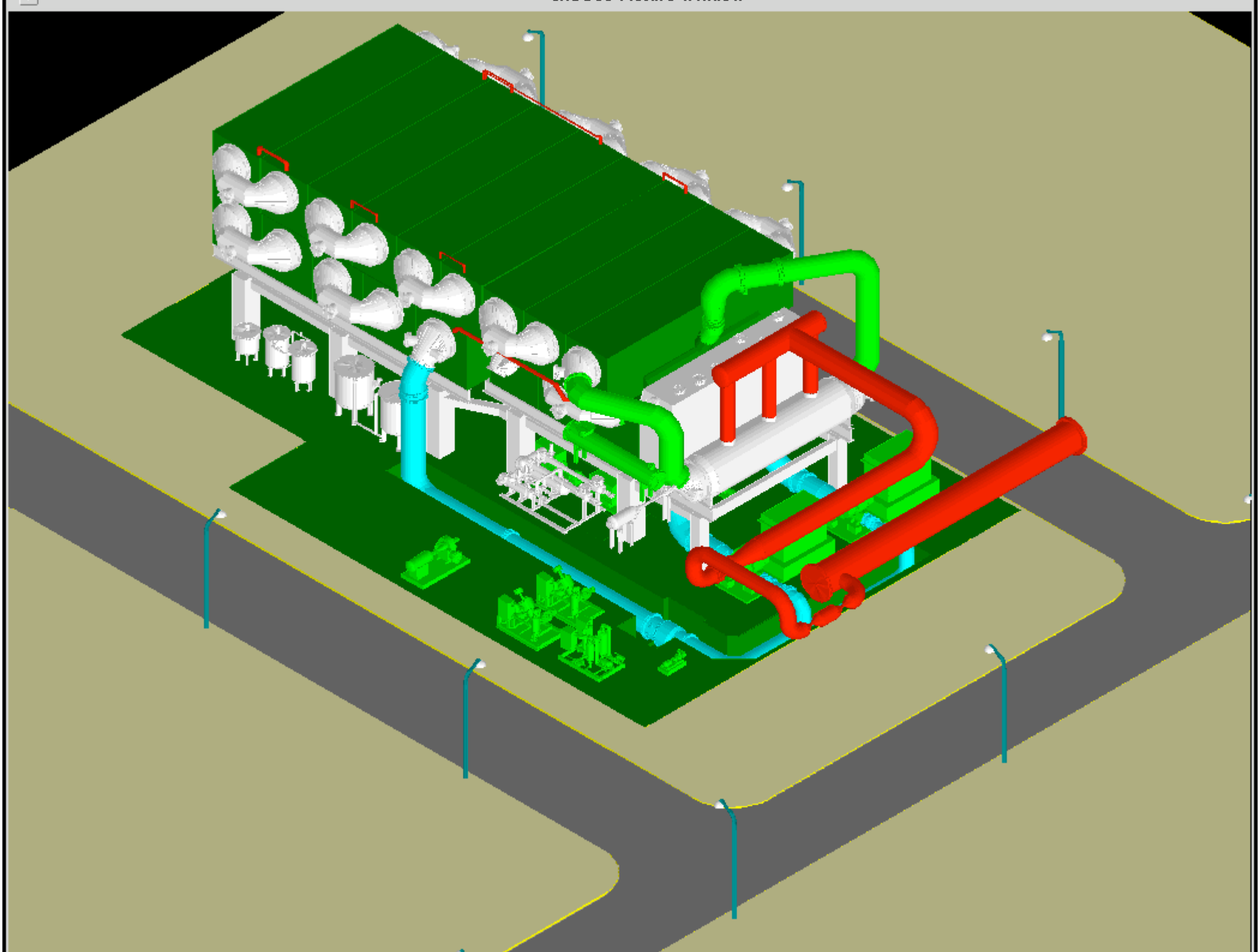


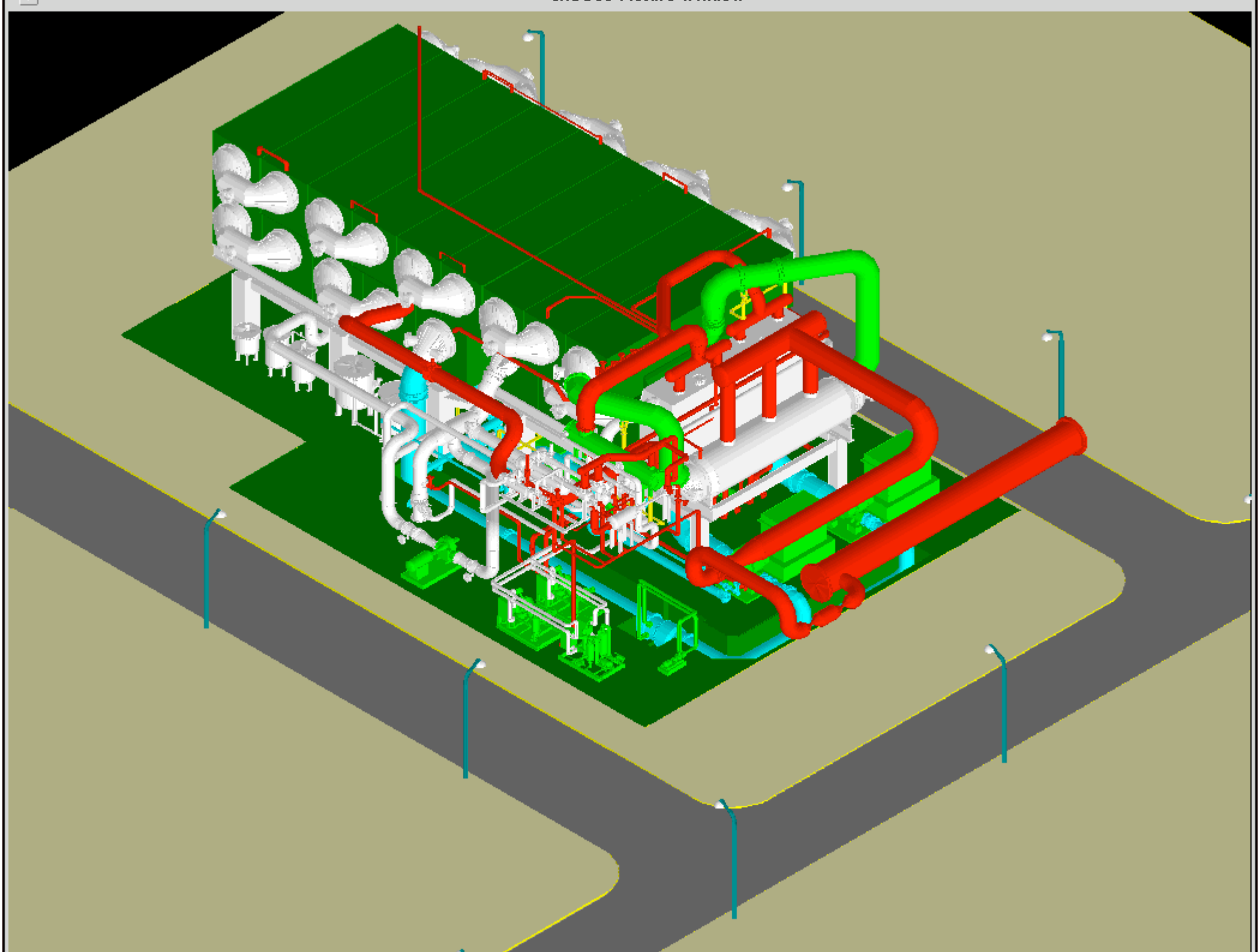


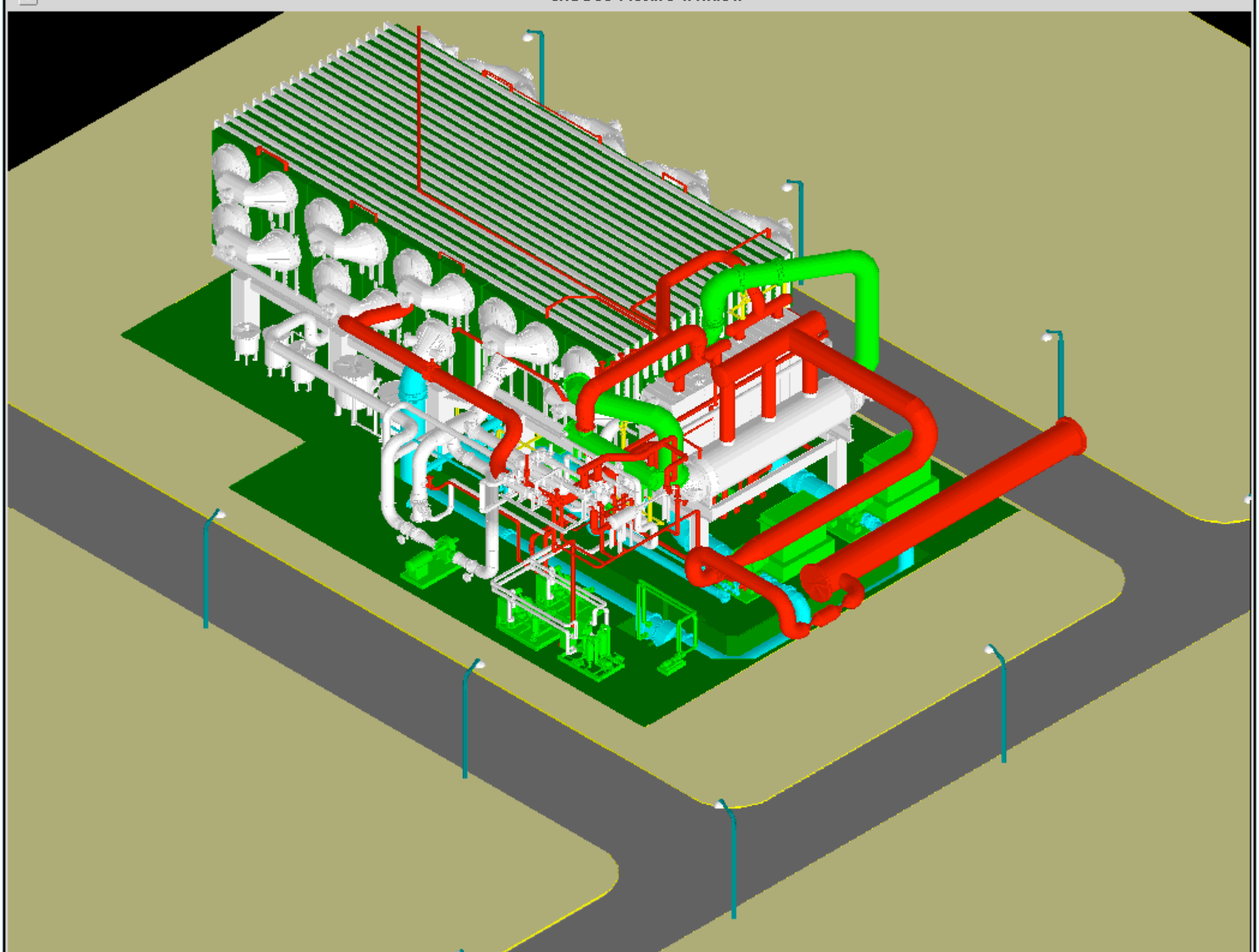


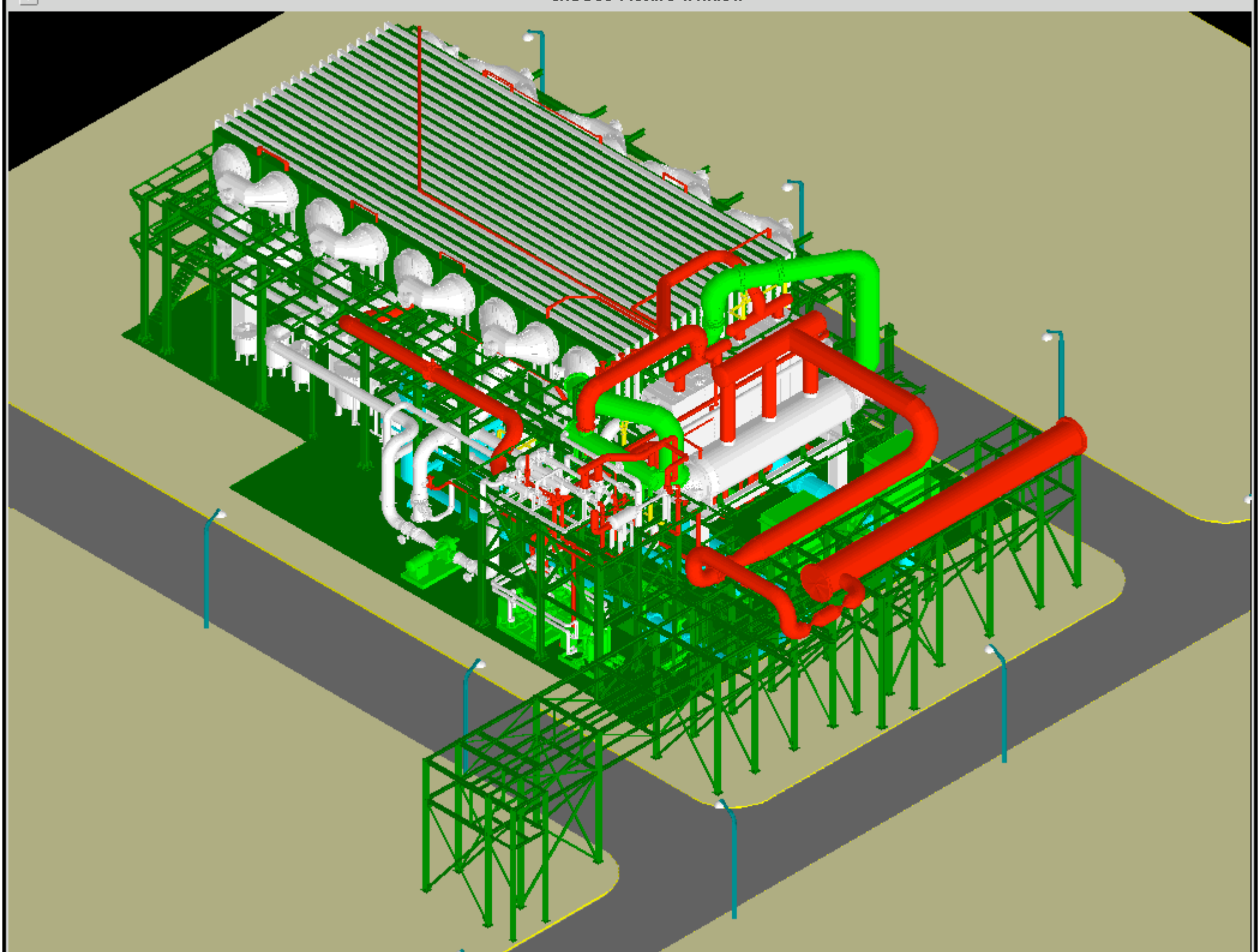


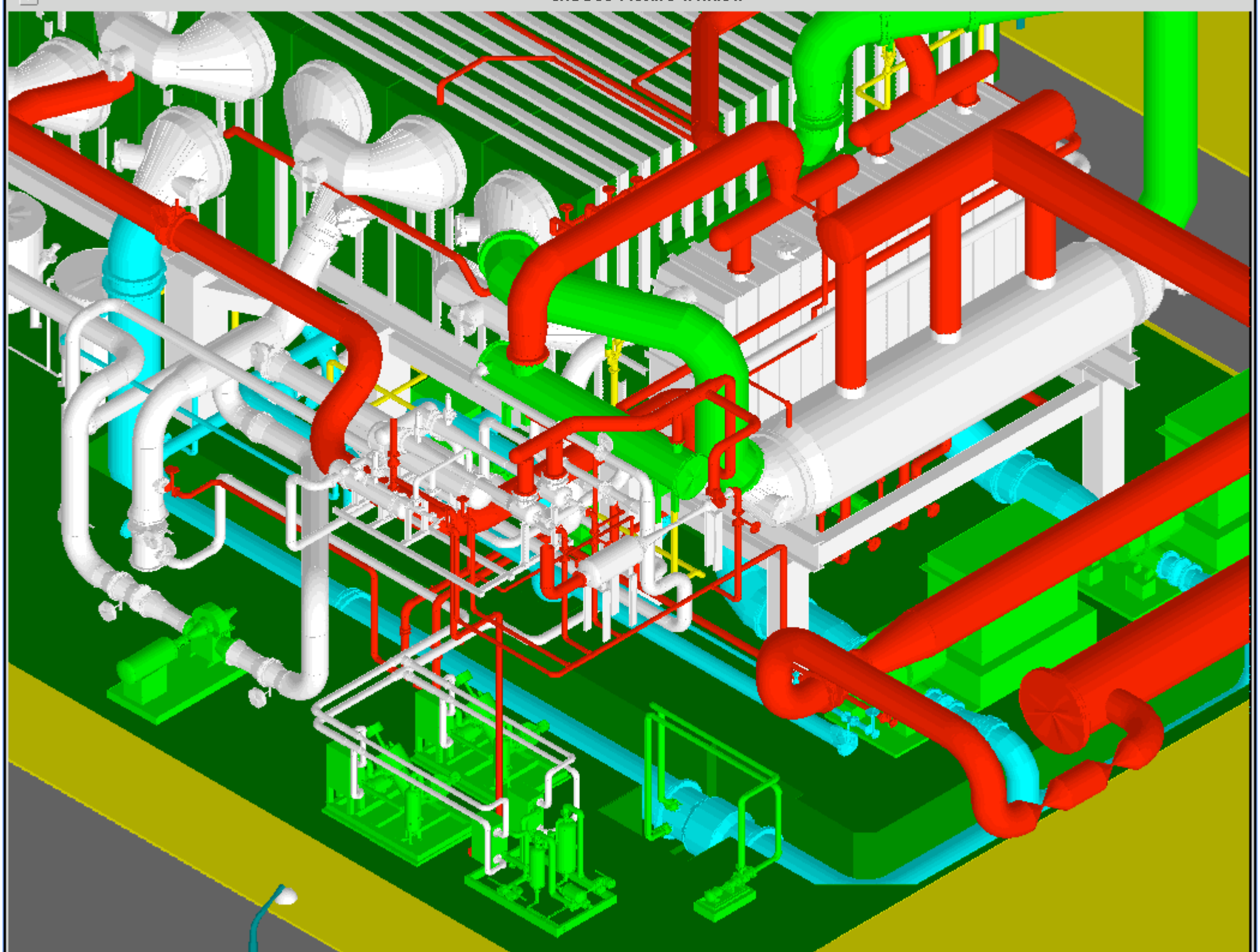




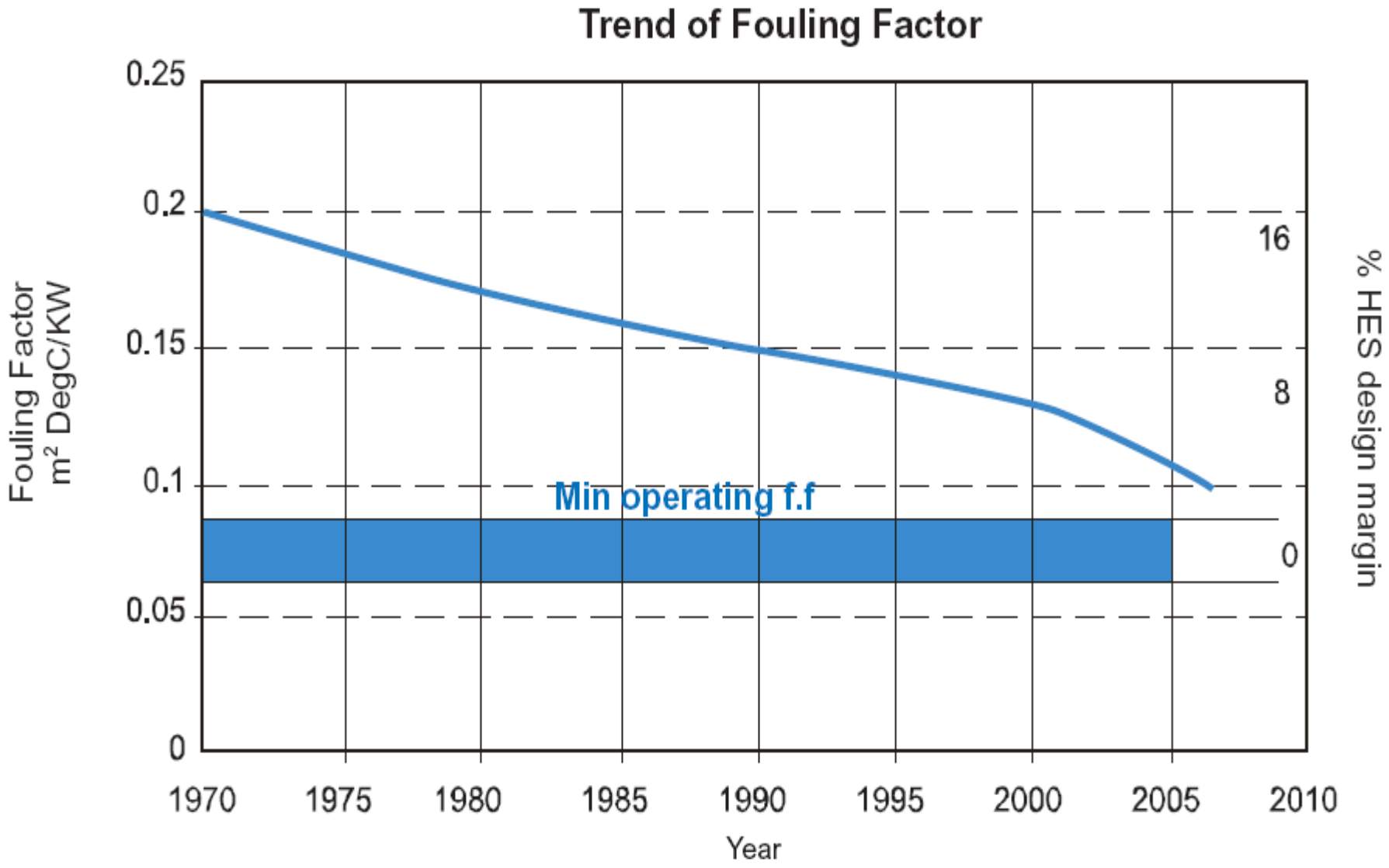




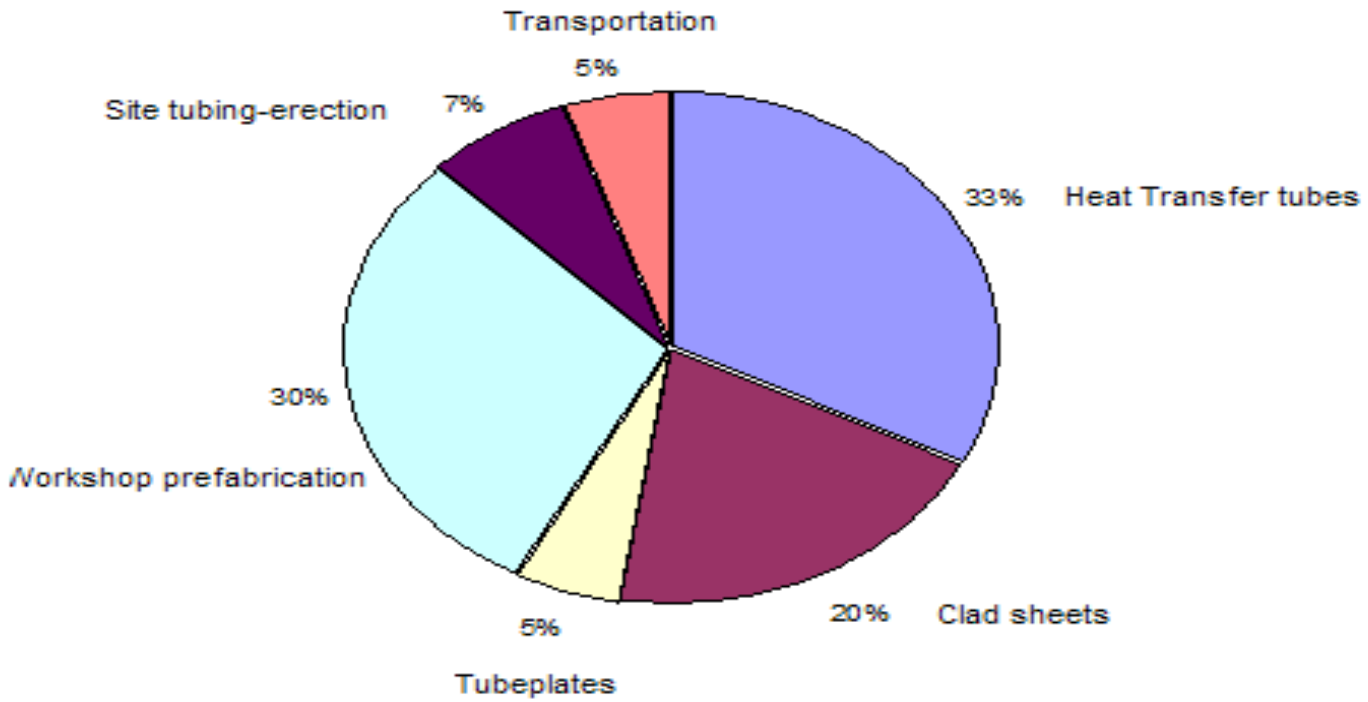


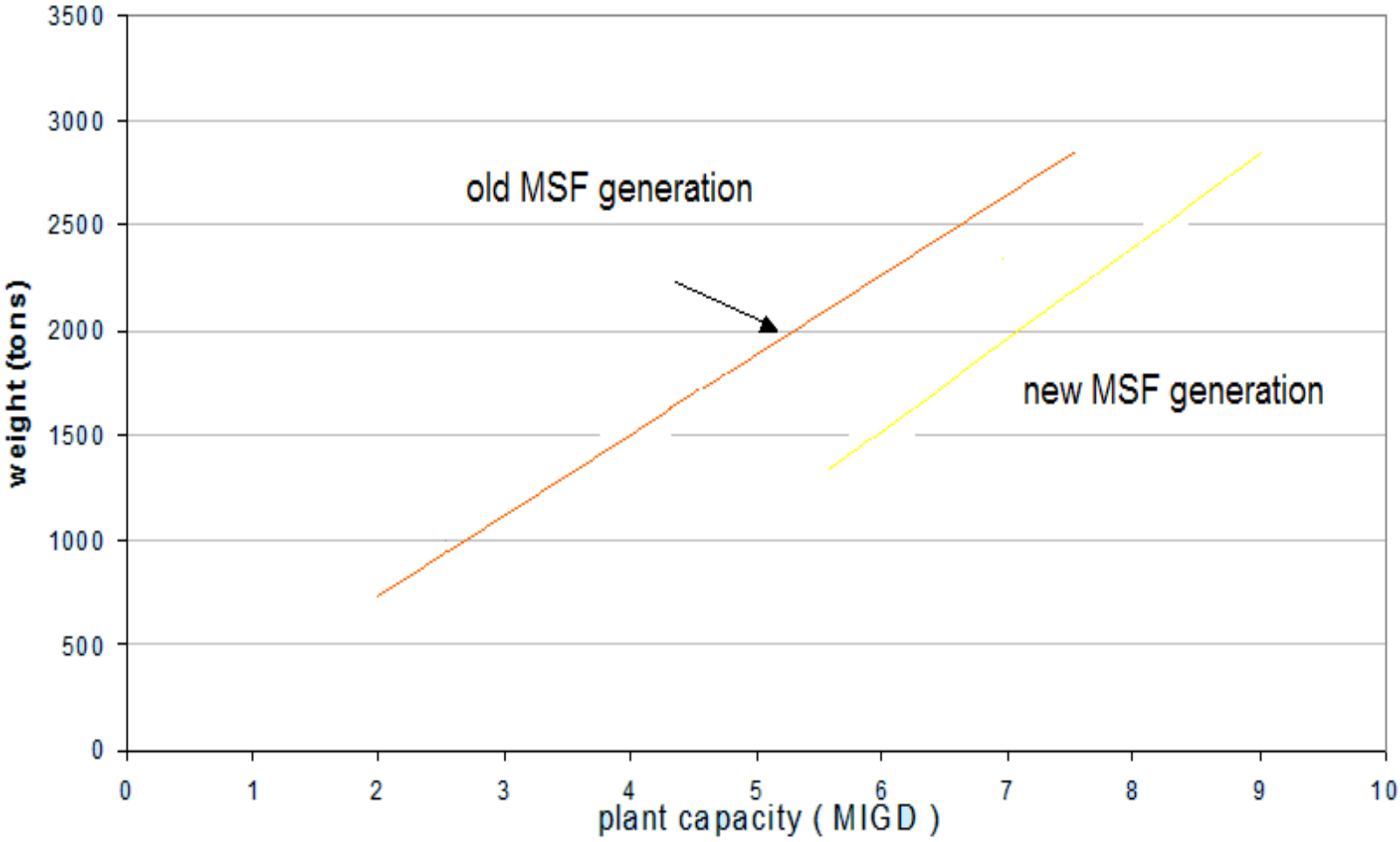


Thermodynamic calculation



It has been estimated that for a reduction in the fouling factor by 16.66% the margin of the heat transfer surface area will be approximately 4%.



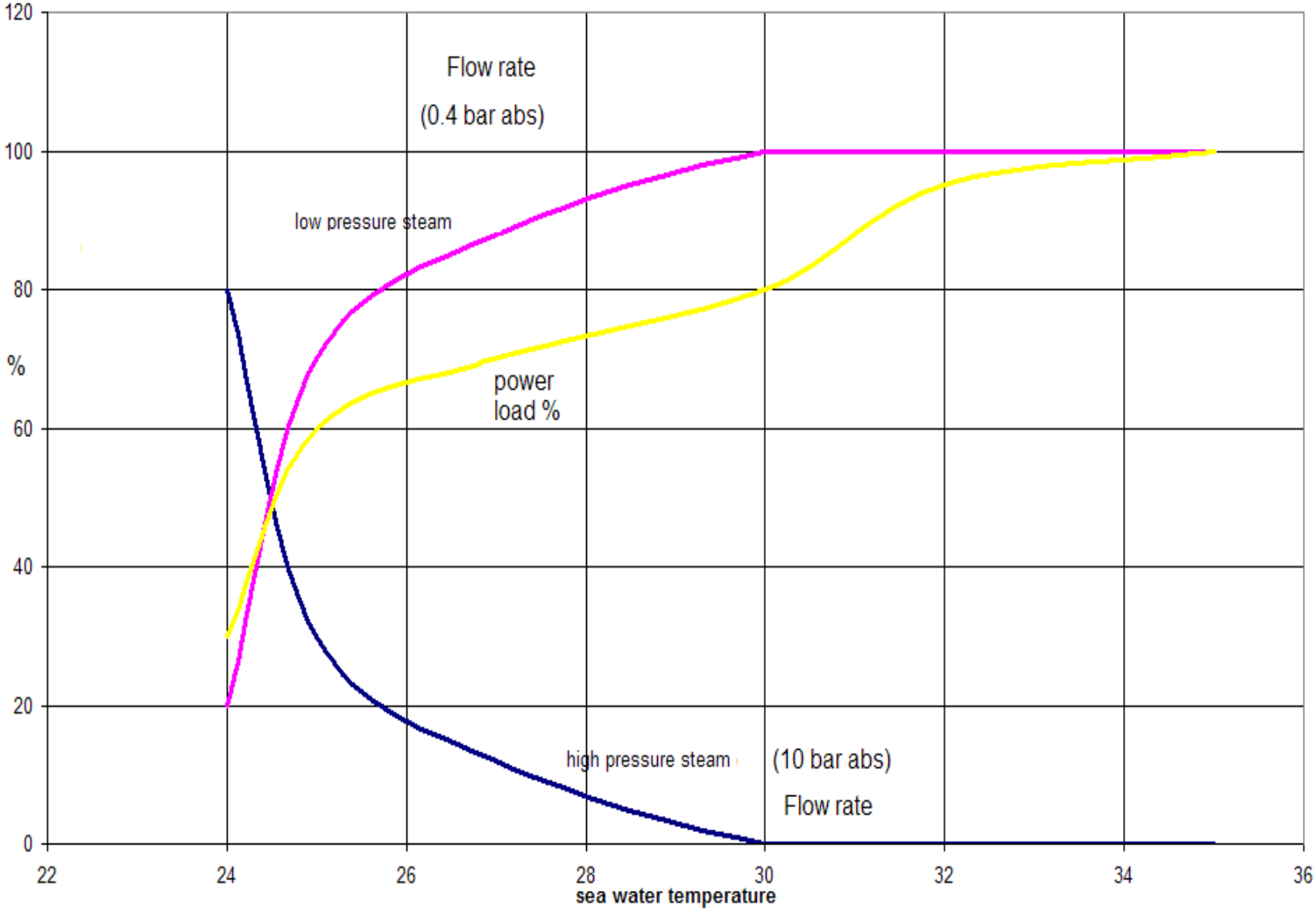

3500
3000
2500
2000
1500
1000
500
0
weight (tons)
old MSF generation
new MSF generation
0
1
2
3
4
5
6
7
8
9
10
plant capacity (MIGD)

MED technology

Recent MED process developments

As MED technology has entered recently large-scale industrial application there it is expected also more room for technical improvement from a process point of view.

Multiple effect technology is moving toward larger unit area. The increase in unit will support a further reduction turnkey and operation and maintenance costs for this technology.



Mott MacDonald

Innovations have been achieved by adjusting the ratio between the flow rate of the medium pressure steam to the thermo compressor (i.e. 10 bar abs) and the flow rate of the low-pressure steam condensing in the first effect according to the power load.

RO technology

RO membrane developments

Some 50 years ago RO process was considered as a laboratory or pilot plant process. But now it is being looked as one of the major processes in desalination business. This has come a long way and a quick glance and the major landmarks are discussed below.

As a result of a continuous technical improvement in membrane recovery ratio, a reduction in membrane costs and replacement rate, reverse osmosis operating costs have been drastically reduced in the years.

RO membrane developments

The membrane process has seen many forms. The main are:

- Plate and frame type
- Hollow Fine Fibre
- Spiral wound Type

The main materials of manufacturing are:

- Cellulose acetate
- Polyamide

RO membrane developments

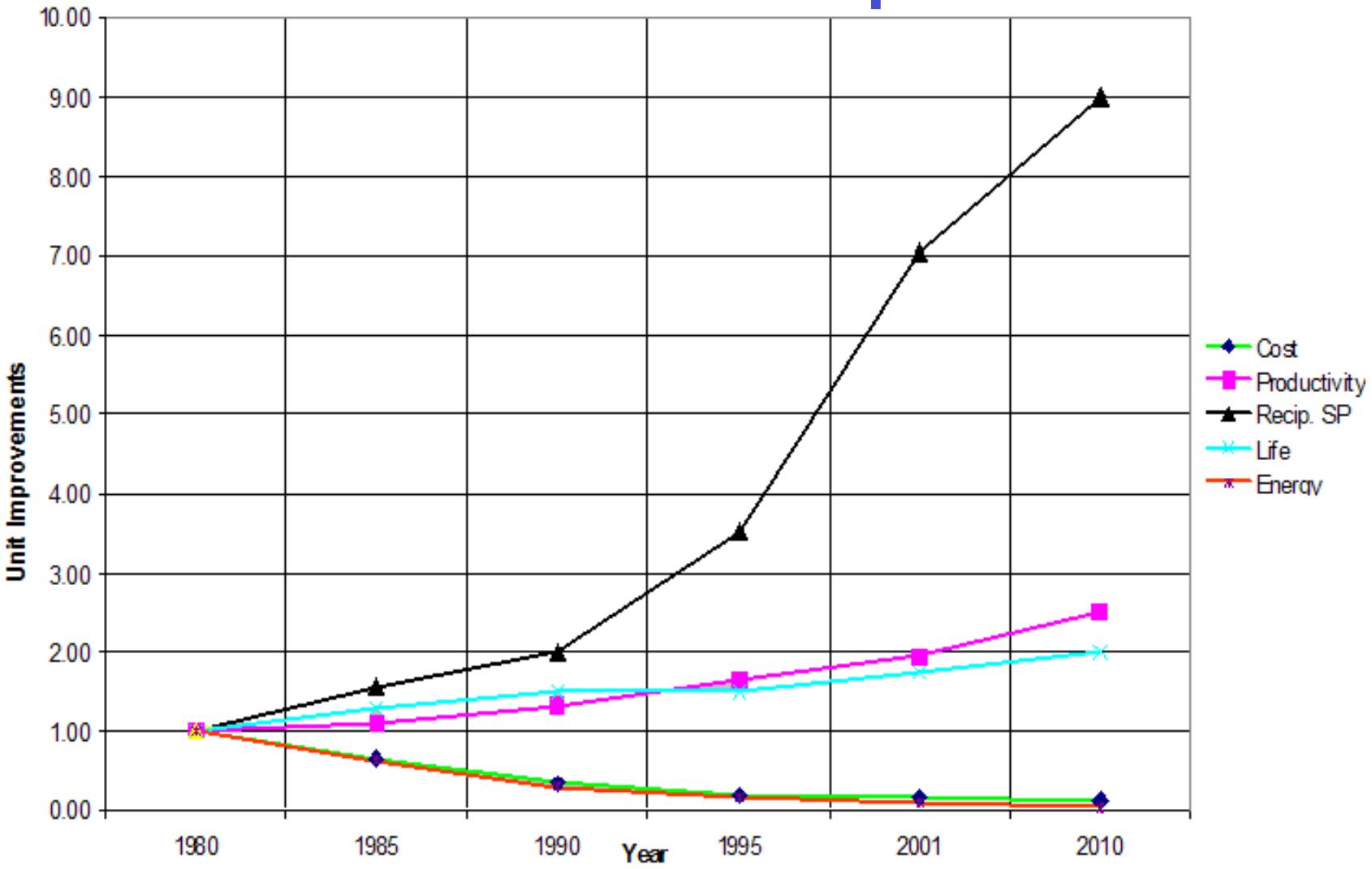
Main areas where RO technology has developed in the recent years have been:

- Salt rejection
- Recovery ratio
- Energy recovery
- Membrane costs
- Membrane life
- Capacity to work at higher pressure

Development in RO membrane performances

Descript.	Value	1980	1990	2000
Product TDS	mg/l	500	300	100
Recovery ratio	%	25-35	35	40-45
Power consumption	Kwh/m^3	15	12	6

RO membrane developments



RO membrane developments

The current efforts from membrane manufacturers are focusing on the design and developments of new membrane types with enhanced productivity.

These include for instance

- Increased flux rate
- Increased recovery ratio
- Larger membrane surface

RO membrane developments

End User perspective

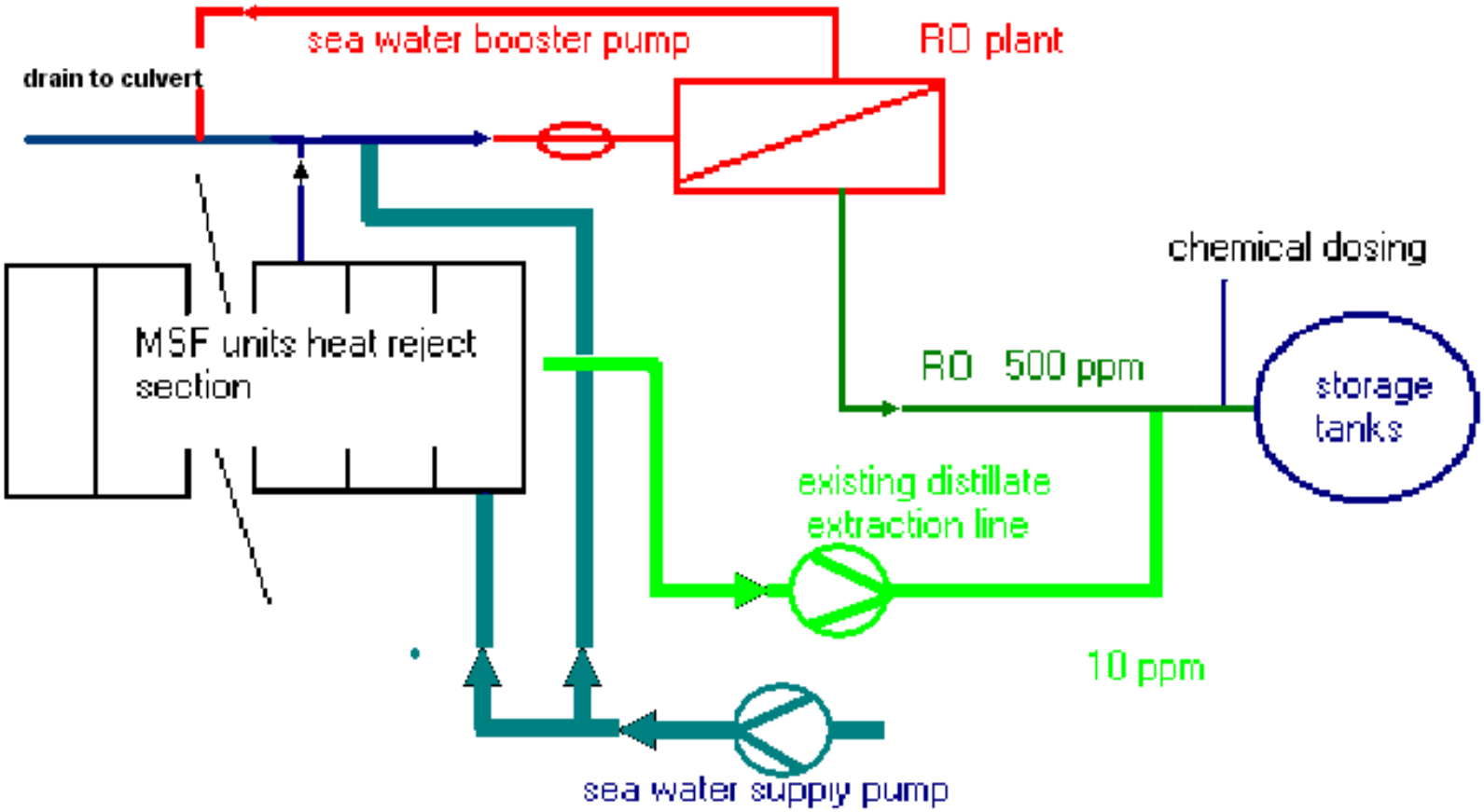
Improvement in reliability service factor and robustness in general are required

This includes the development of products with:

Higher tolerance to SDI/Oil/Bio-fouling

- Longer life
- Lower replacement rate
- Longer intervals between cleanings.

Development needs for hybrid plants



Hybrid options requirements

The development of “hybrid” desalination plants would suggest further research and progress in optimising compatibility between thermal and RO desalination.

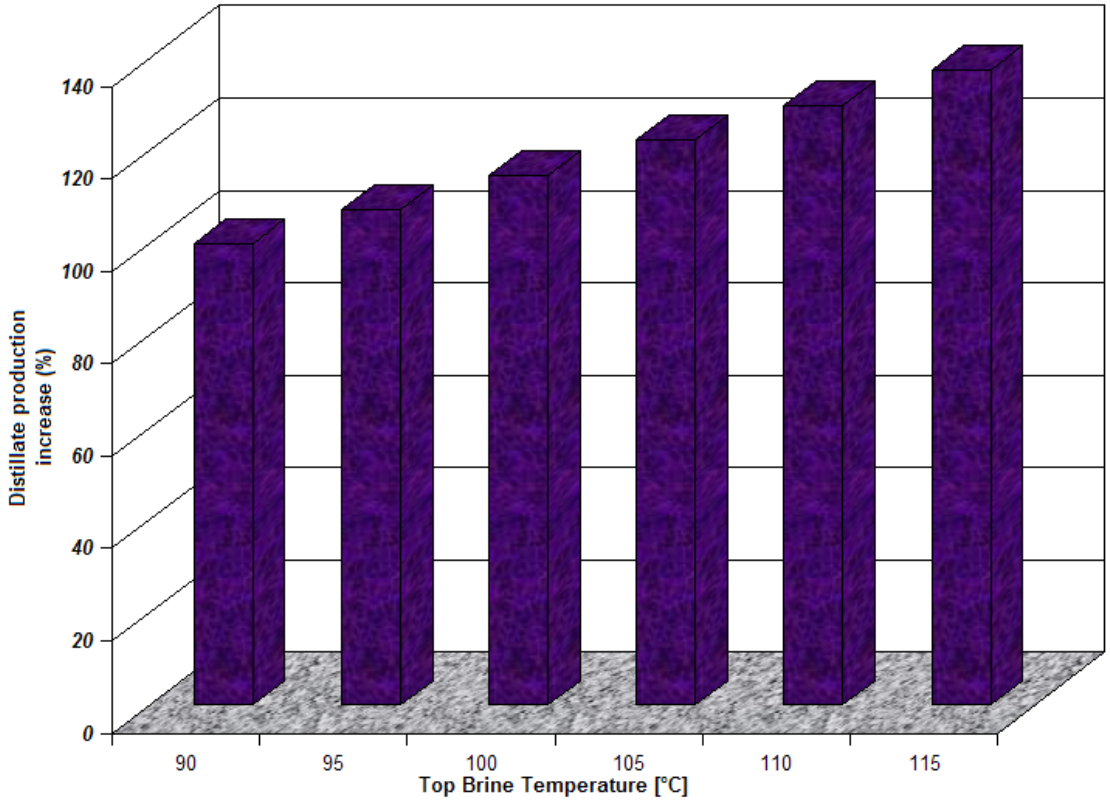
This would include both the design of RO membranes capable of sustained operation at high temperature (38 – 42^{o}C) and the development of chlorination techniques compatible for both thermal & membranes process.

The possibility to take full advantage of the MSF heat reject stream as a feed for RO project can involve a substantial energy recovery, capital cost savings and lower environmental impact.

However, this requires membrane sustained operation at temperatures above 40^{o}C during summer seasons and feed water to the process continuously chlorinated.

Nano filtration

There is a sharp advantage in increasing the operating temperature of thermal desalination plants. Both MED and MSF productivity is extremely sensitive to the increase in the flashing range.



MARGIN FOR TECHNOLOGICAL IMPROVEMENTS

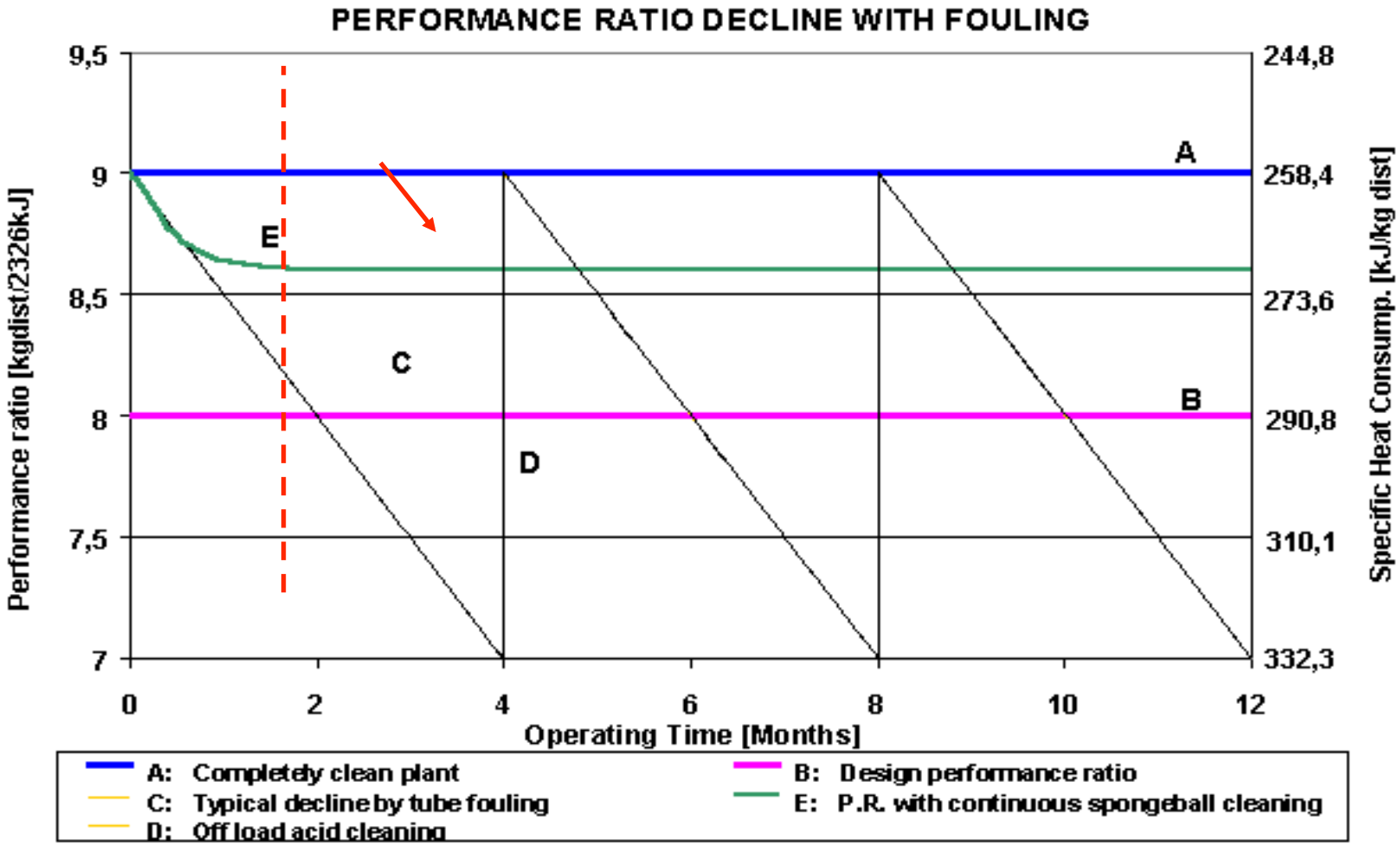
MSF	MED	Seawater RO	Combination Hybrid Combination power
LOW	HIGH	VERY HIGH	VERY HIGH

TECHNOLOGY AND RISK PERCEPTION

CRITERIA	MSF	MED	Seawater RO
Reliability	Demonstrated reliability for over 50 years in installation worldwide	Demonstrated reliability for small scale unit and increasing reliability for large scale	Initially low. In the recent year reliability is increasing due to the development in membrane manufacturing
Capacity	Large production capacities	Medium Production capacities	Attaining large capacities lately
Capital Costs	High	Medium to low	Medium
Operating Costs	Medium	Low	Low
Operational Flexibility	Excellent	Excellent	Fair
Operational Tolerance	Excellent	Good	Poor
Operational Experience in Middle East	Excellent	High	Poor
Operational experience worldwide	Excellent	Excellent	Good

Back ground on thermal desalination

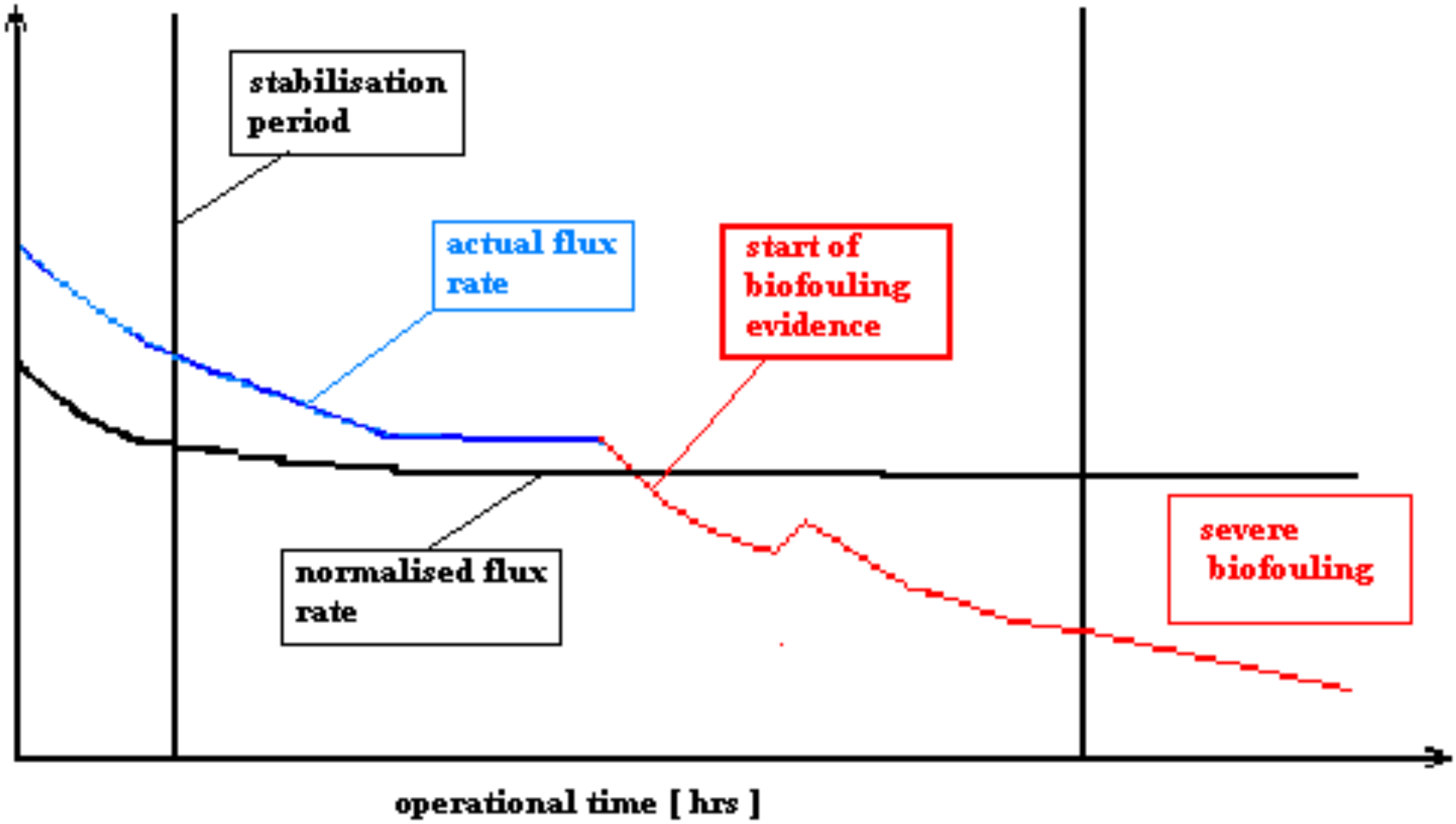
After two months of stabilisation little or no performance declines are expected



Why thermal desalination are considered more reliable than RO processes in the Middle East ?

- In this situation EPC contractor carries all the performance risks
- **Liquidated damages** are an effective mean for the Owner protection against performance shortcomings
- Easy life for project company and O&M contractor

For RO technology performance decline can occur at any time after the initial stabilisation period as indicated in this example



Why thermal desalination are considered more reliable than RO processes in the Middle East ?

Period	Period Description	Possibilities of decline in performances	
		Thermal Desalination	RO Desalination
A	Start up to P.A.C	Rapid adjustment of performance ratio due to scale film formation	After initial membrane stabilisation (3-5 day) stable operation
B	P.A.C Guarantee Period	No or little possibilities of performance drop	High Backwash or cleaning frequency may increase membrane replacement
C	F.A.C Ten years	No or little possibilities of performance drop	Insurgence of biofouling problems

The business environment

- Different players involved in project development

-Technology market segmentation

- Legislation and permits

- The Business environment

Public corporations are directly responsible to provide water to the utilities and for initiating and promoting the construction of new plants for water generation.

Public corporation relate for this task to international advisors who evaluate the demand and prepare specification and Tender documents for the construction of new plants.

In a subsequent stage Public Corporations either issue contracts to Turn Key Contractors or concessions or to International Developers with long-term water purchase agreements.

- The Business environment

A) The sponsors of the projects

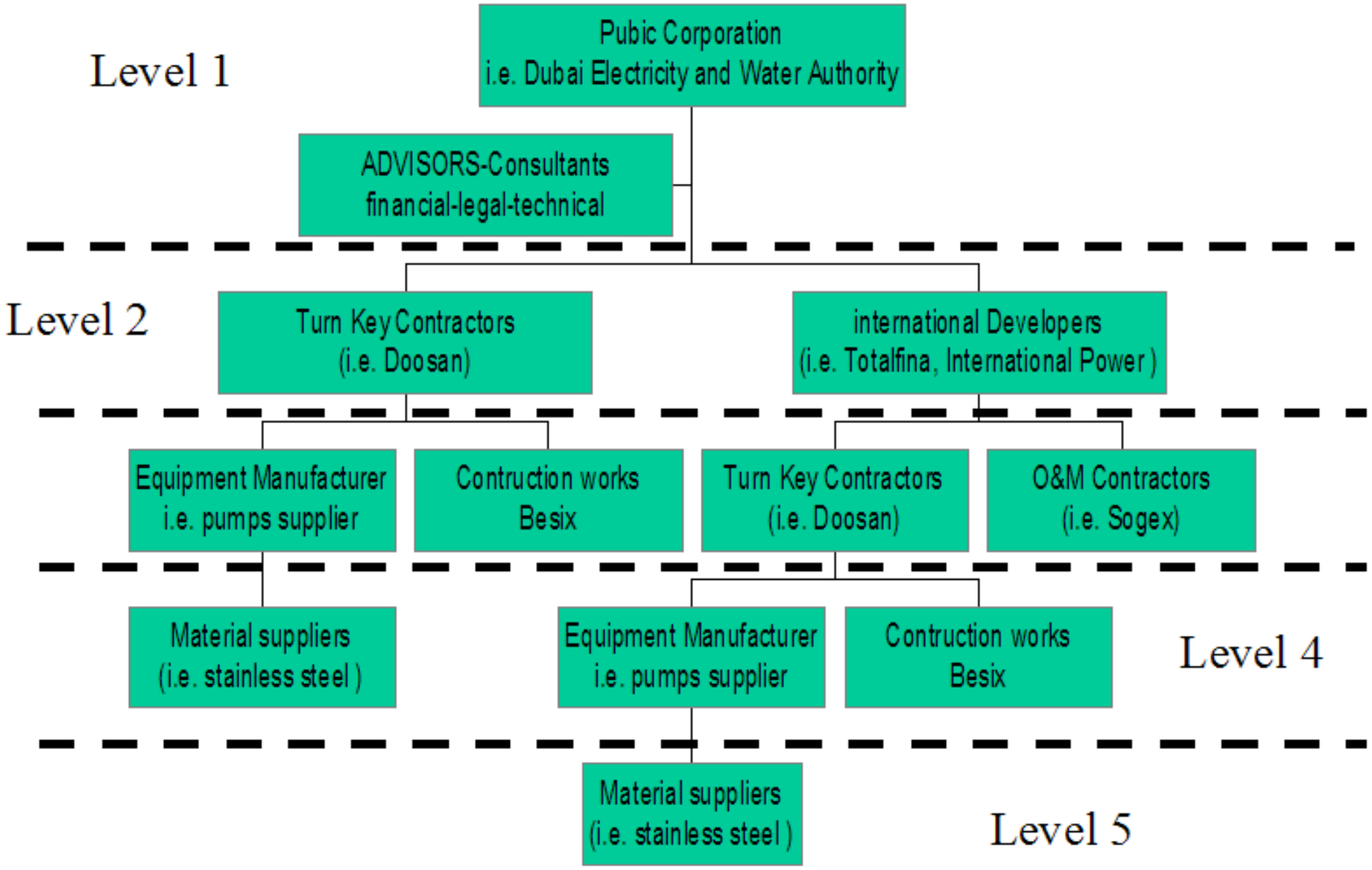
- Traditional power companies
- Oil companies
- Water and utilities companies
- Engineering companies

B) The Off-taker(s) The off-taker(s) is generally the originator of the project and an administrative entity or a state-owned/controlled company. Its activity (water/electricity distribution) may be a state-monopoly.

C) The Government – The government is generally either the originator of the project or interested in the successful completion of the project for political or financial reasons.

D) The Lenders - water treatment of desalination plants are large capital-intensive projects and particularly if the private sector is involved, Lenders are involved.

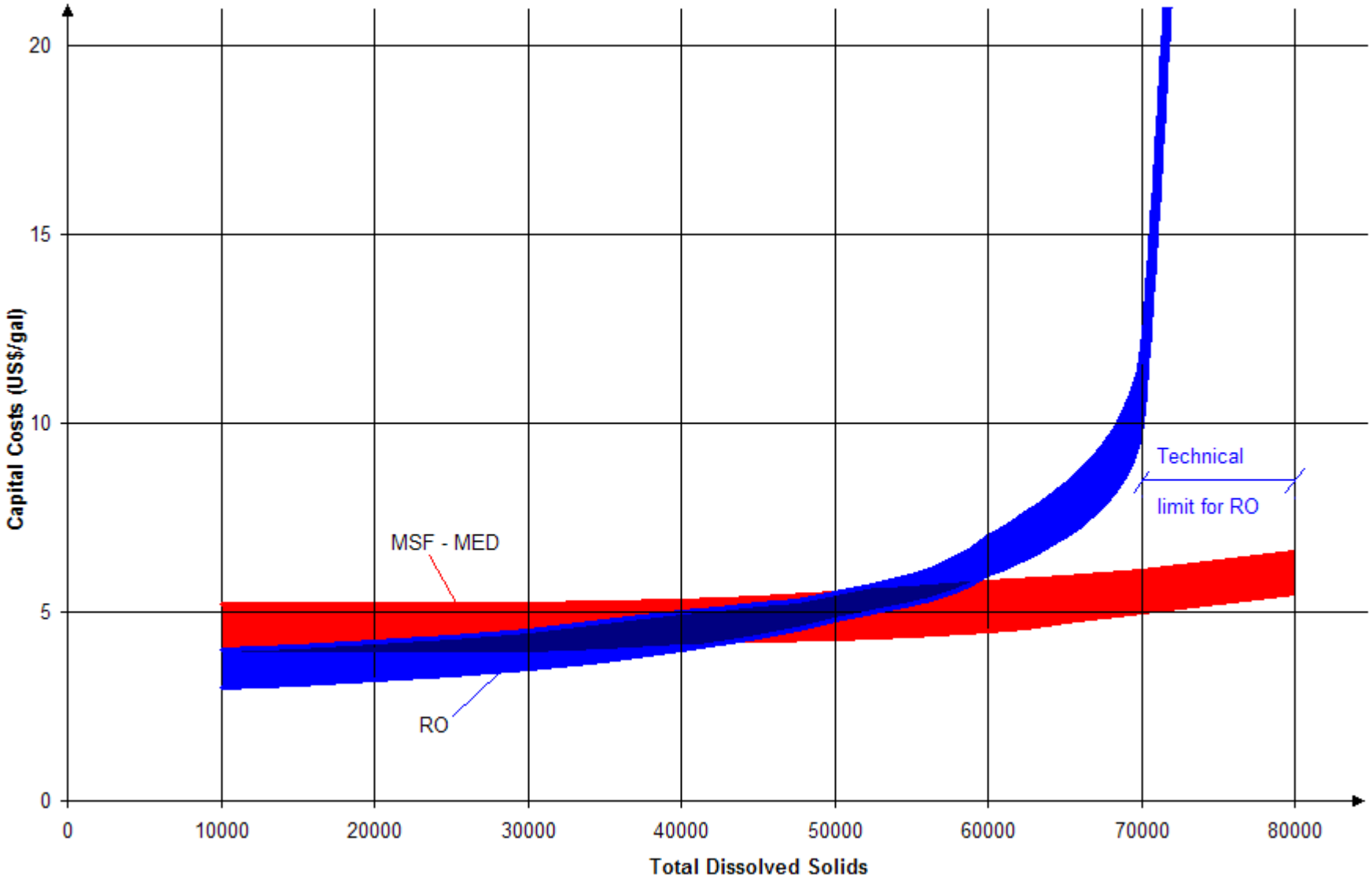
- The Business environment



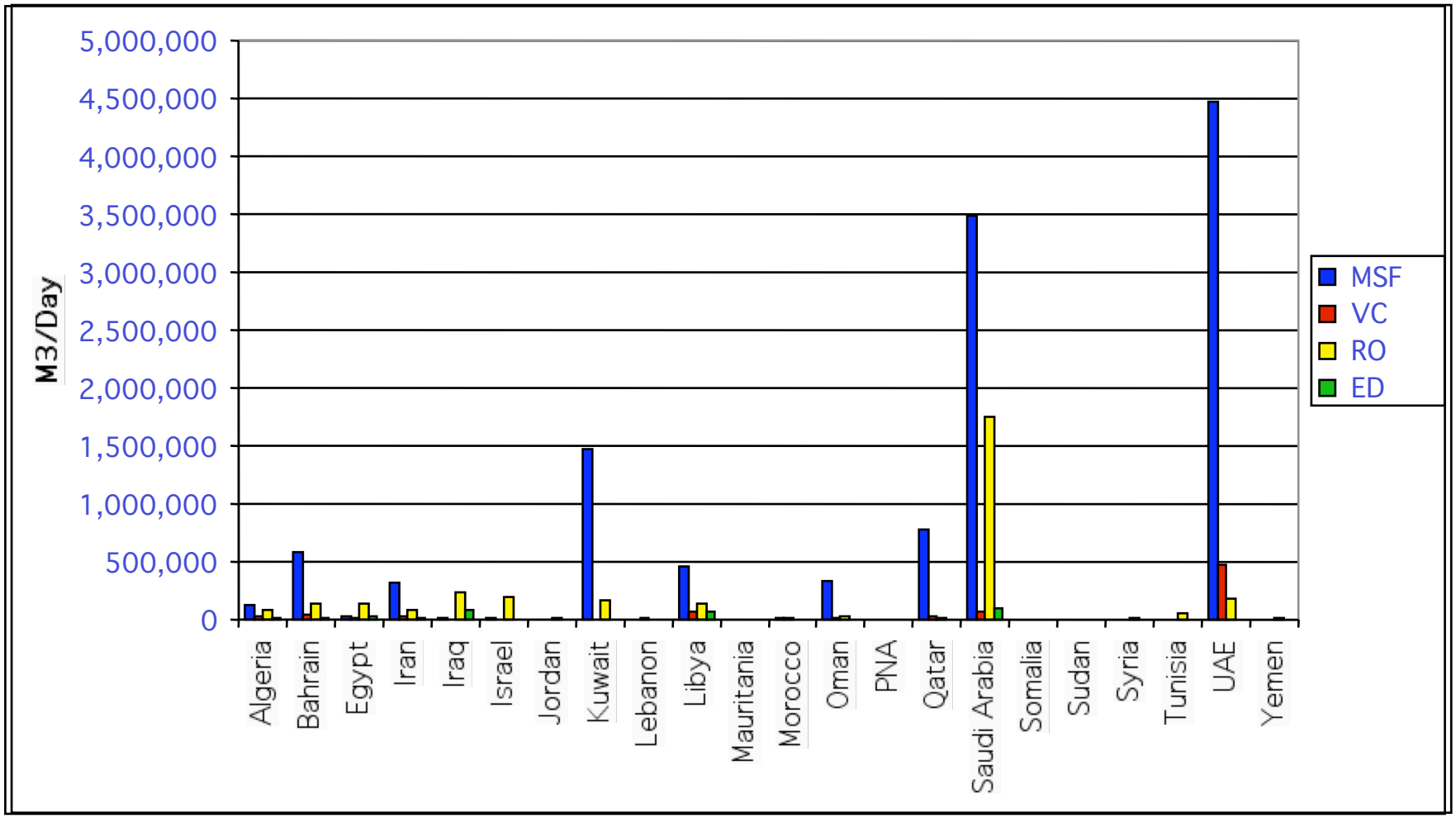
- The Market segmentation

Technology	Seawater high TDS		Seawater low TDS		Brackish Water	Waste Water
	Single Purpose	Double Purpose	Single Purpose	Double Purpose	Single Purpose	Double Purpose
SS	X	N.A	X	N.A		
MED	X	X	X	X		
MSF	X	X		X		
TVC/MVC	X	X		X		(*)
RO		X Hybrid	X	X	X	
ED					X	
MF-UF	Pilot					X

- The Market segmentation

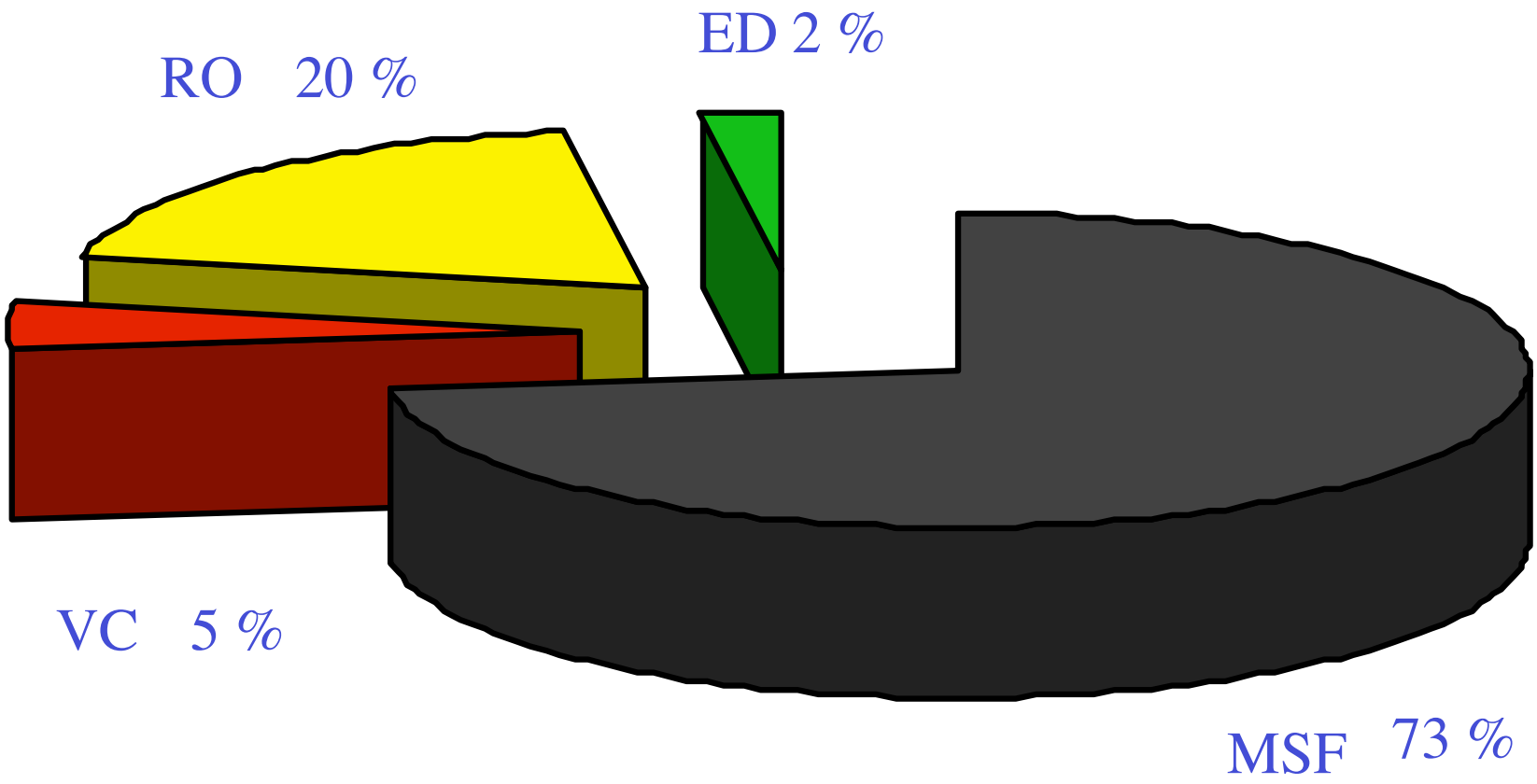


- The Market segmentation
  Desalination Capacity by Country & Process

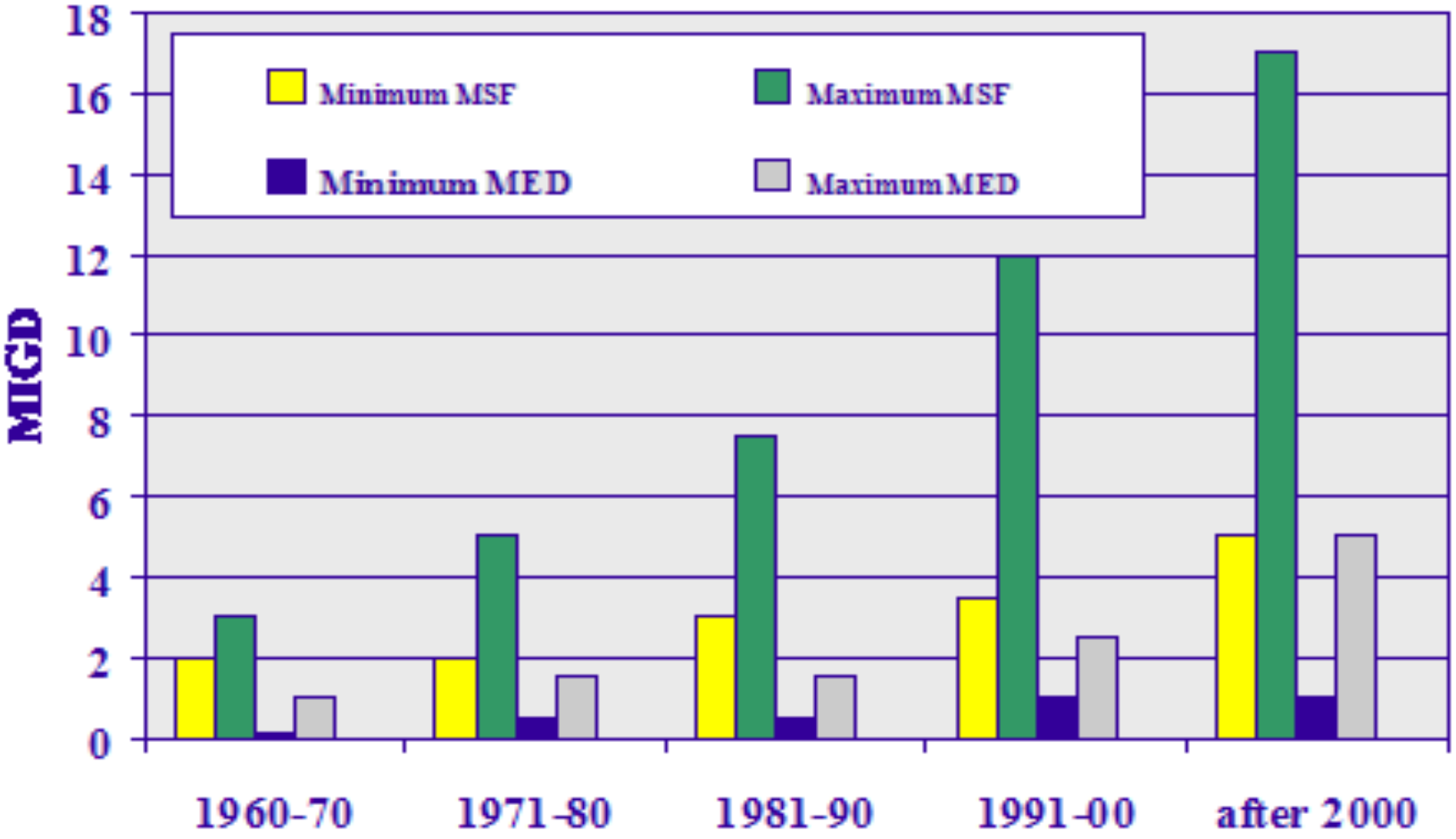


K. Wangnick 2000

- The Market segmentation
  Desalination Capacity by Country & Process



- Thermal desalination plants evolution history



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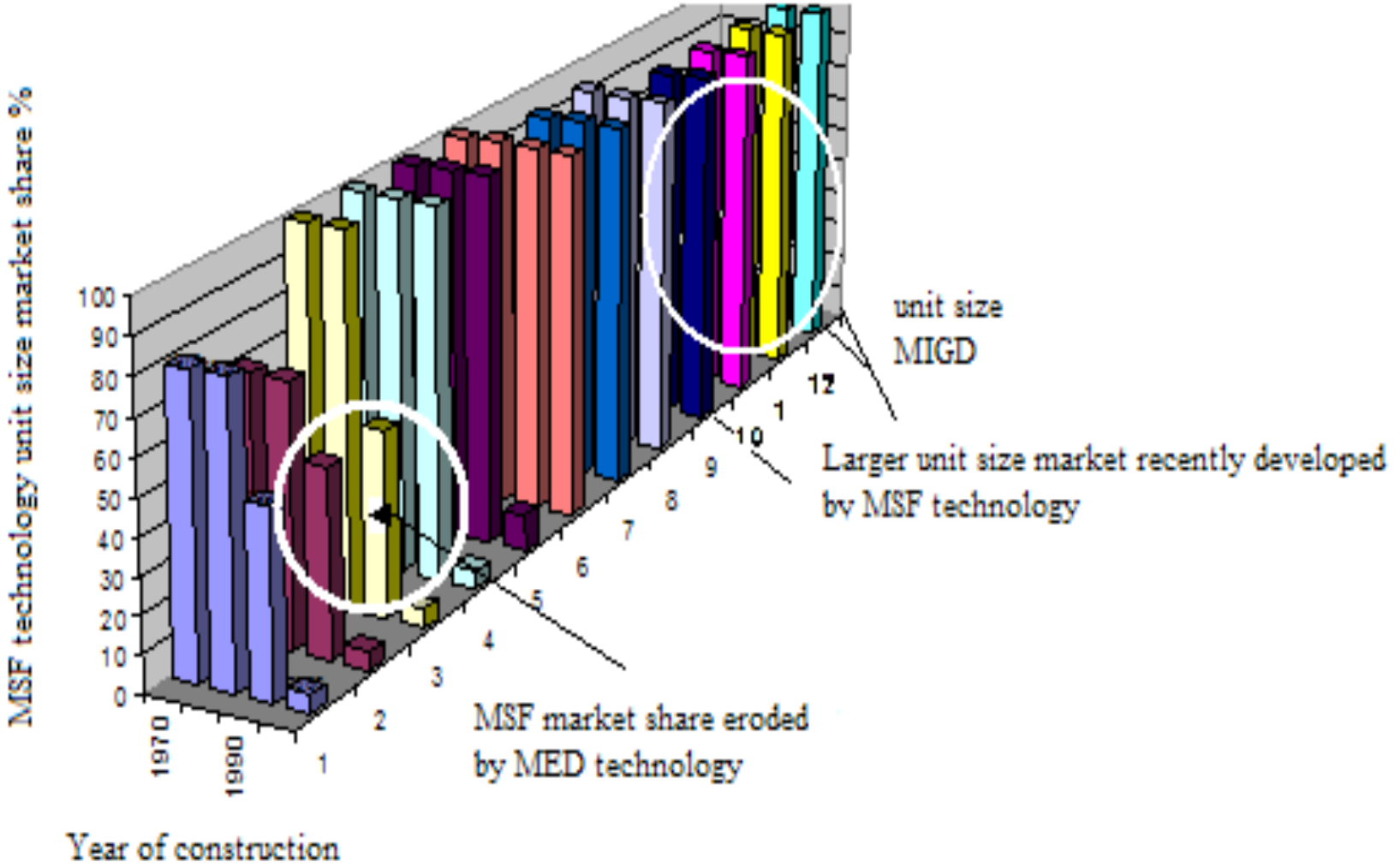
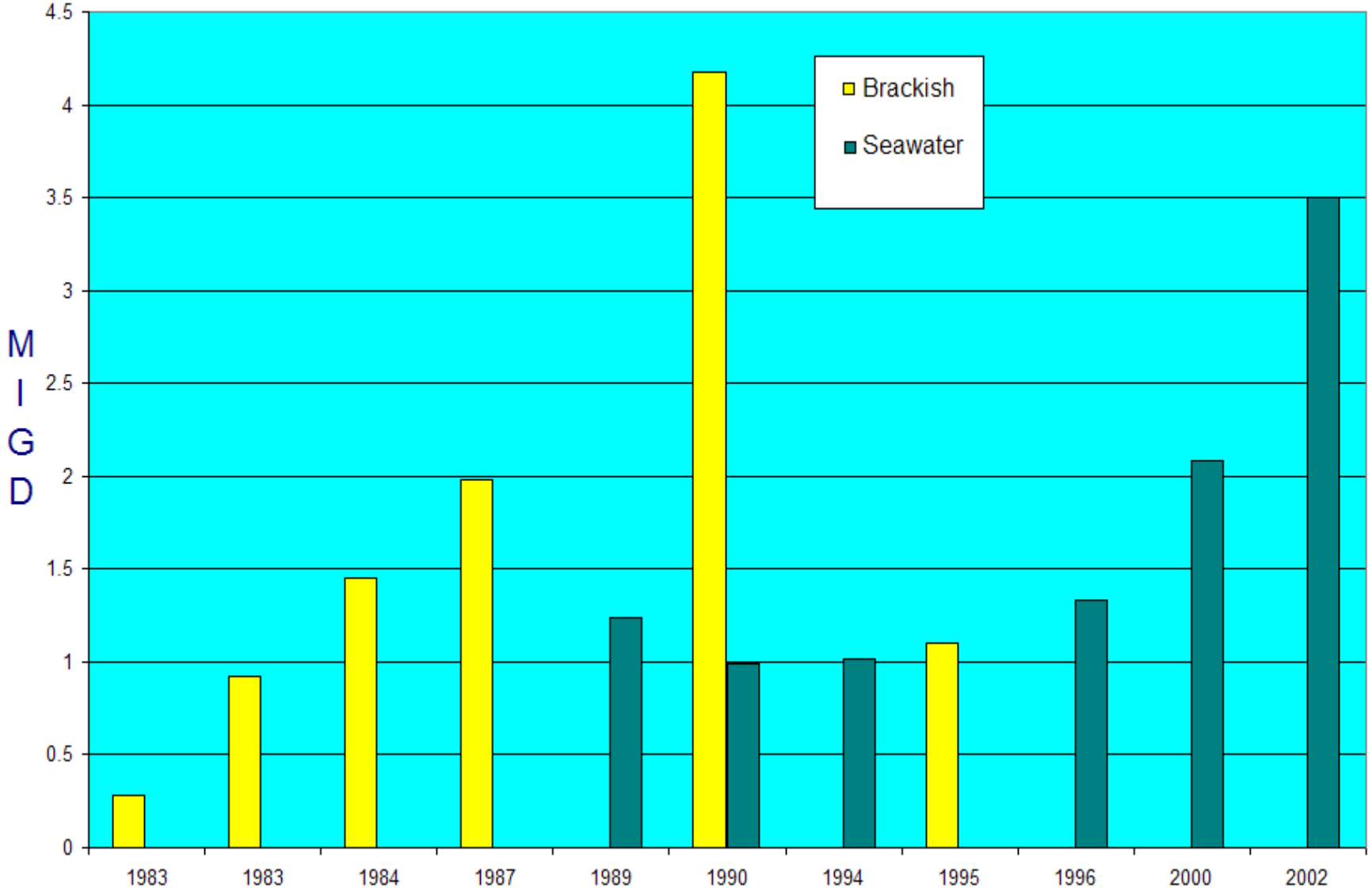


- RO desalination plants evolution history



Managing water demand

- Forecasting and planning
- Managing project delivery mechanisms
- Private projects

- Forecasting and planning

  - Demand forecast
  - Capacity required
- Capacity available (retirement scenarios)
  - Capacity shortfall

• Demand forecast

In Middle East all growth in water demand is satisfied by seawater desalination

There is no buffer storage or natural resource

Desalination are long term delivery plants (12-24 months)

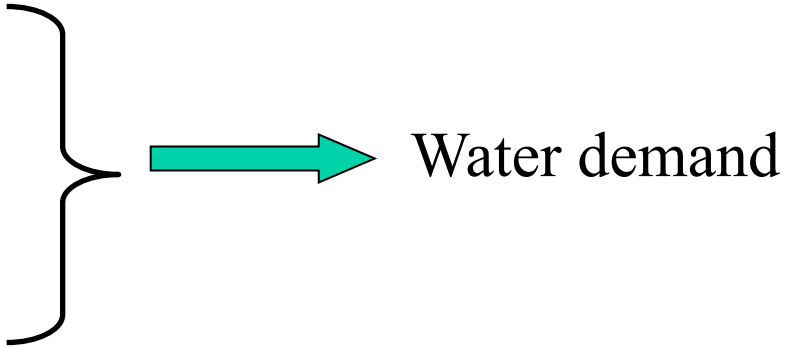
Proper Planning is both critical and essential !!!

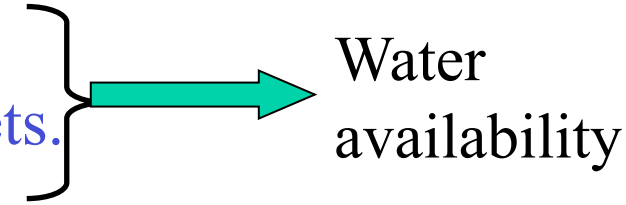
• Demand forecast

First step in planning is the production of “water master plan”

To be effective a water master plan should contain the following information's :

- Demographic growth
- Industrial growth
- Agricultural growth
- Technology development
- Availability of local resources
- Status of existing water production assets.





• Demand forecast

The comparison of the two provides the water capacity to be developed

What is the timescale ? 20-25 years

What are the conclusions of the mater plants ?

Capacity required

Technology options based on

Delivery times Site features Previous operating history

Parallel master plans (I.e power)

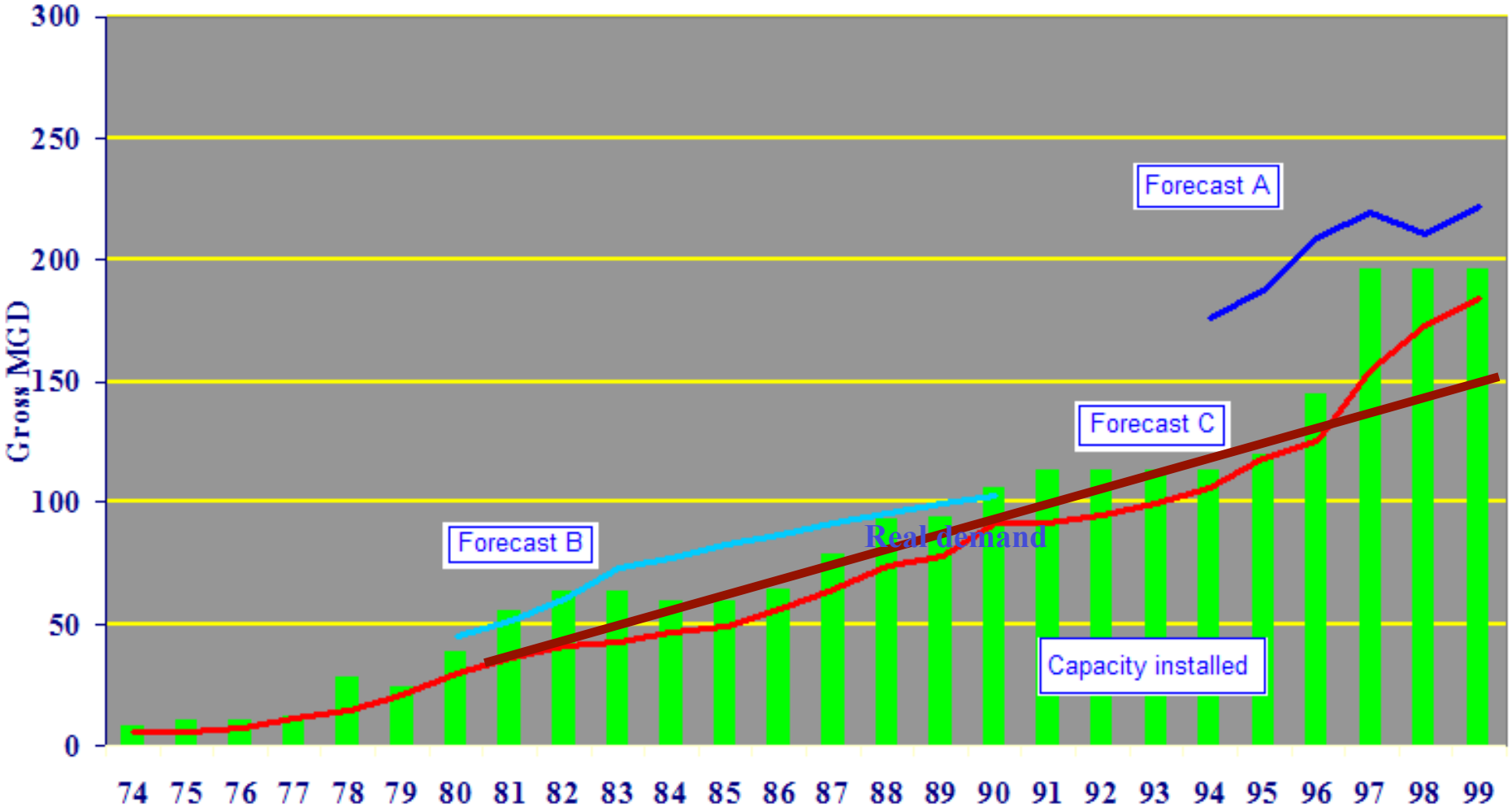
• Demand forecast

Things to be considered in Forecasting and planning:

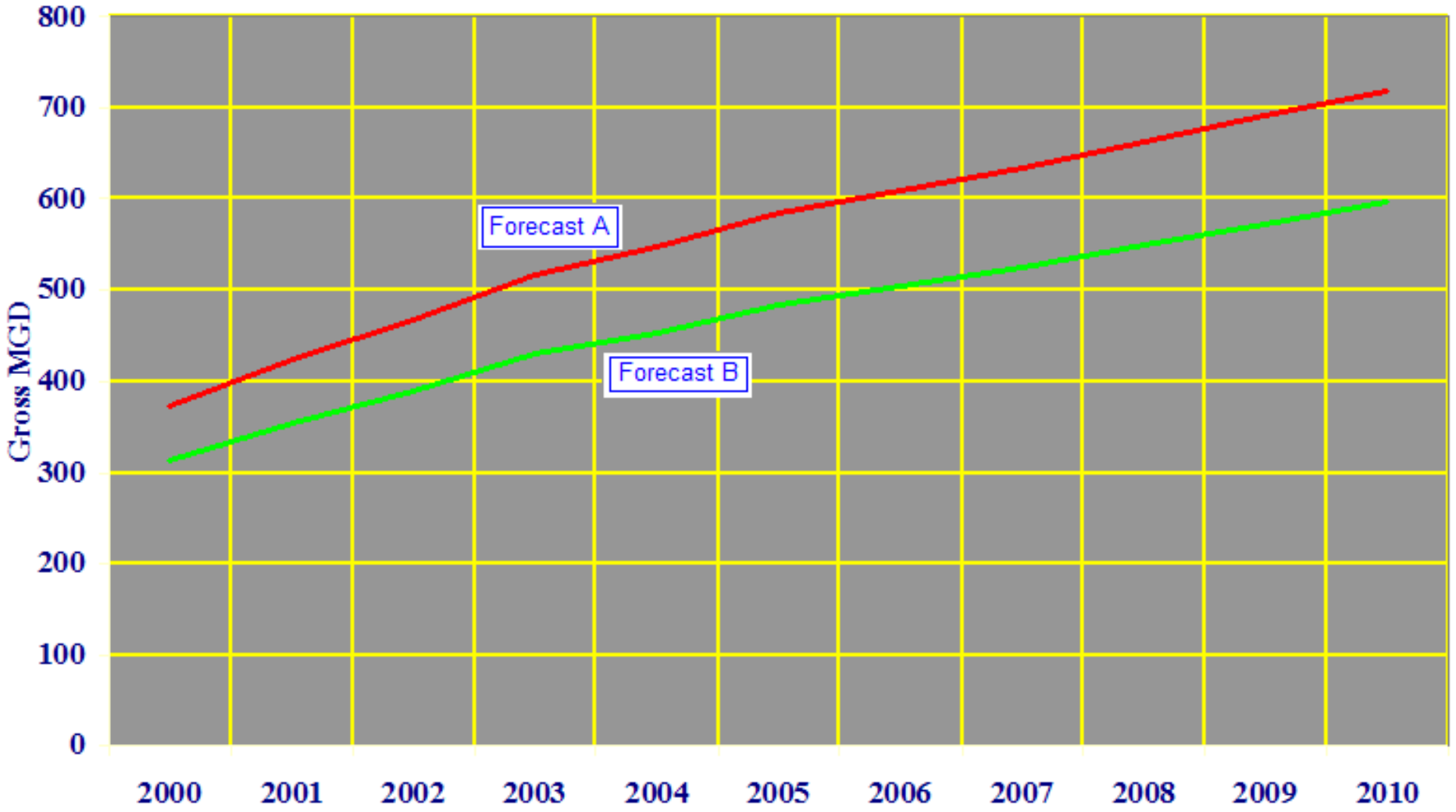
- History of the demand growth
- Demand forecast
- Capacity required
- Capacity available and plant retirement scenarios
- New capacity under construction and firm planning

Capacity shortfall

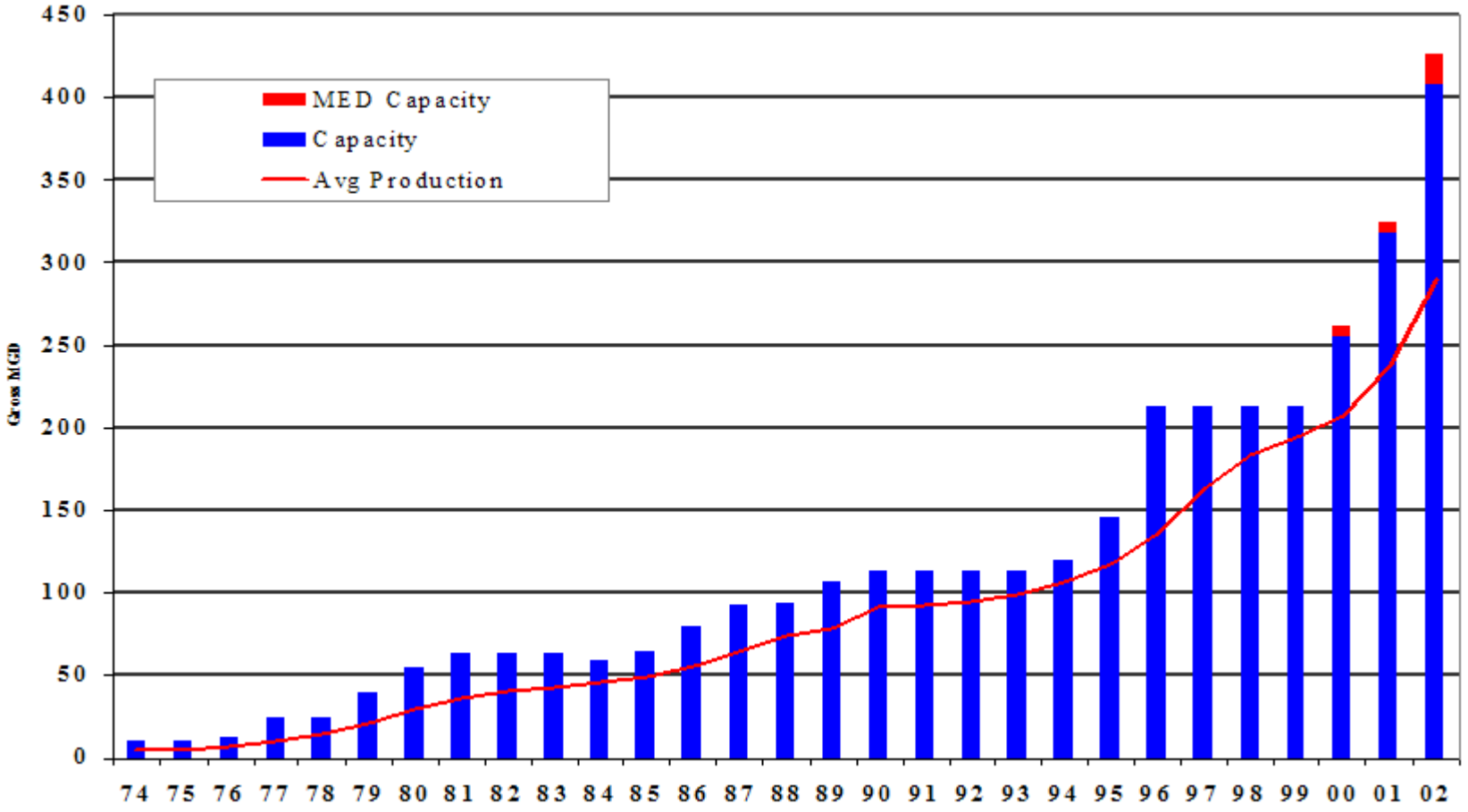
- History of the demand growth



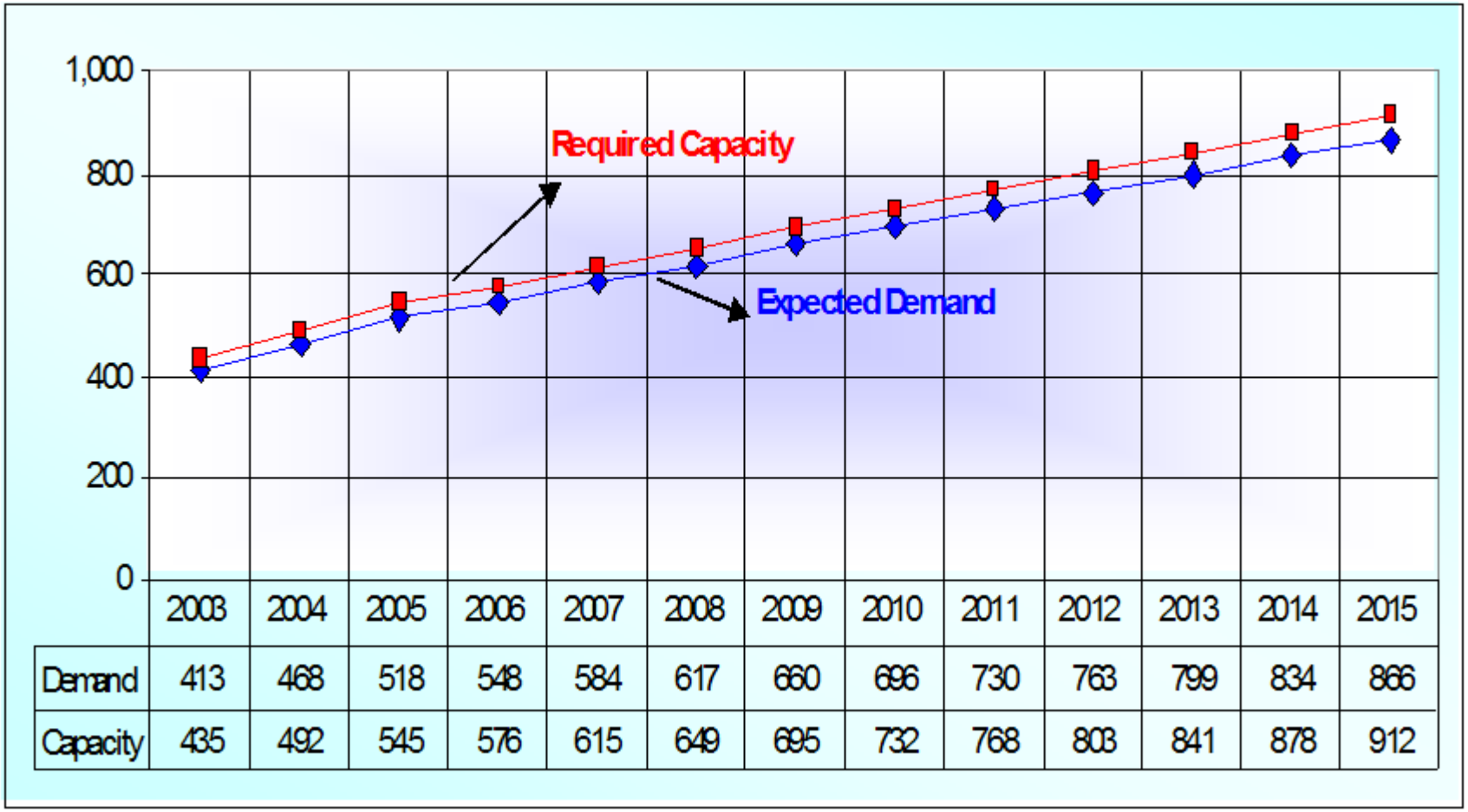
- Capacity demand forecast



- Capacity demand forecast

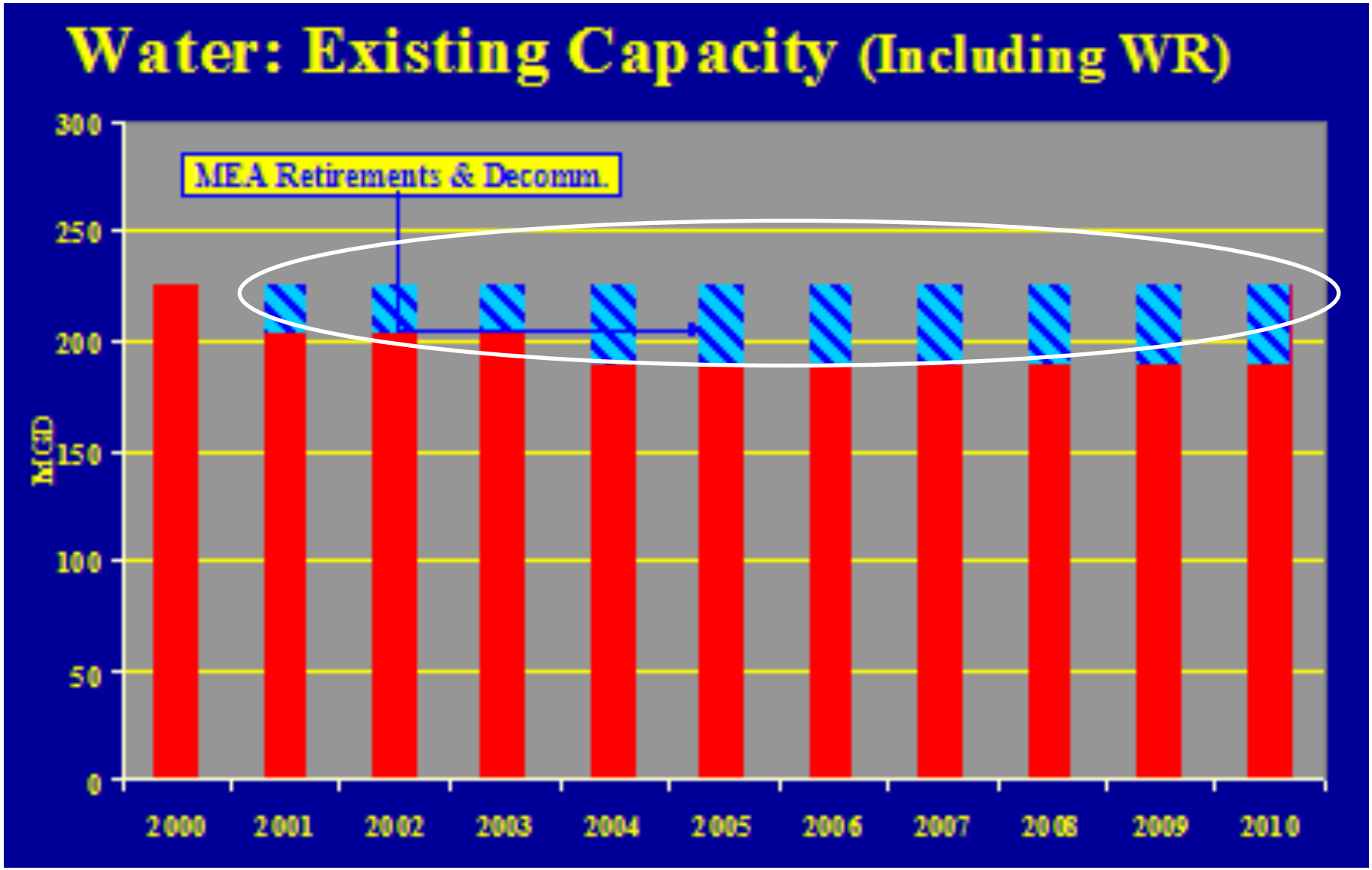


- Demand installed capacity forecast

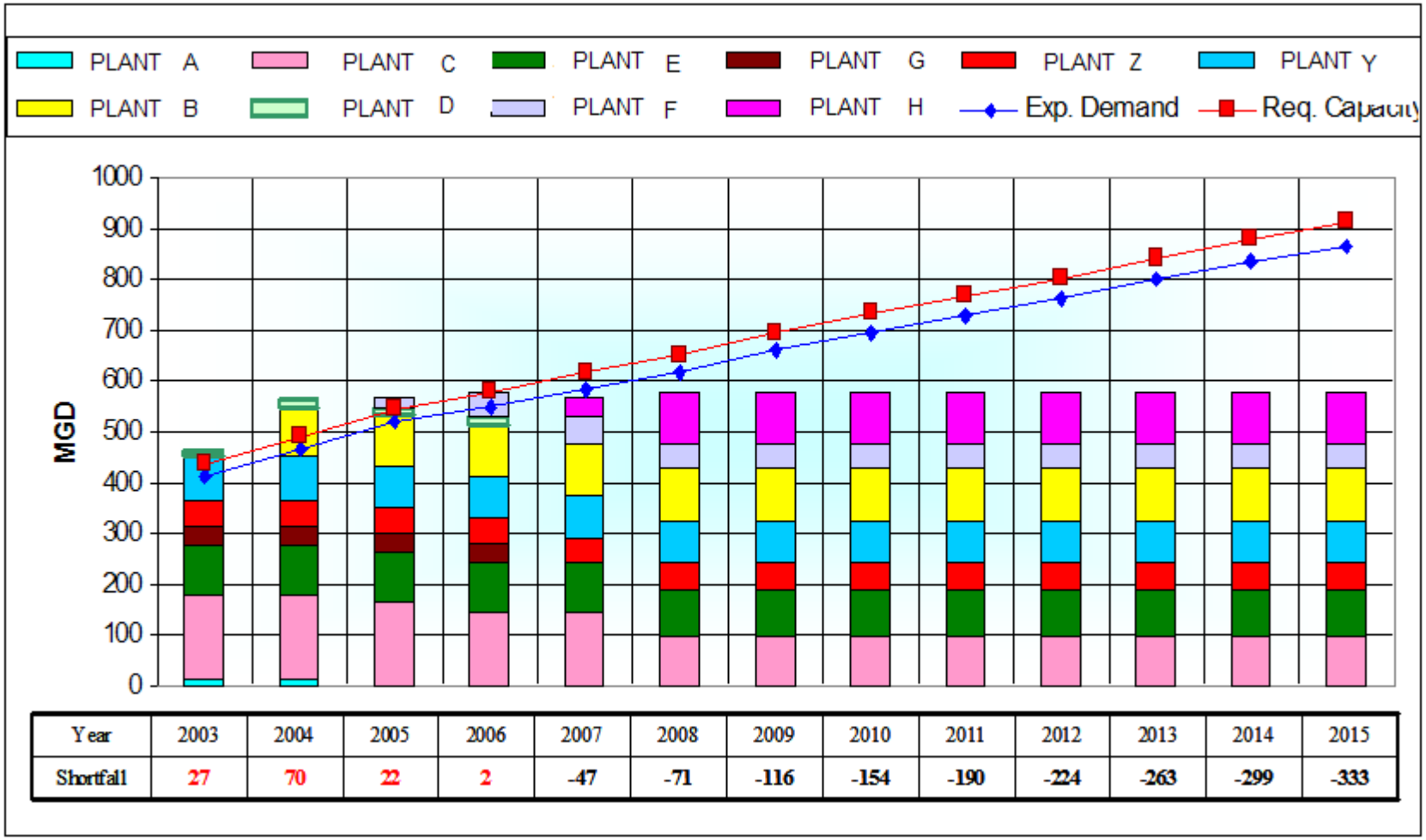


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Demand	413	468	518	548	584	617	660	696	730	763	799	834	866
Capacity	435	492	545	576	615	649	695	732	768	803	841	878	912

- Available resources, retirement scenarios



- Individual plant retirement scenario demand forecast and installation



Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Shortfall	27	70	22	2	-47	-71	-116	-154	-190	-224	-263	-299	-333

- Managing project delivery mechanism

  - Multiple contracts
  - Turnkey contract
  - Private projects
  - Public versus private

Steps in delivery mechanisms

In general the project delivery management is very delicate and requires several intermediate steps.

1. Receipt of Expression of interest
2. Request for pre- qualifications documents
3. Requests for proposals to pre-qualified turnkey Contractor or developers
4. Bid evaluation
5. Tender award

Objectives

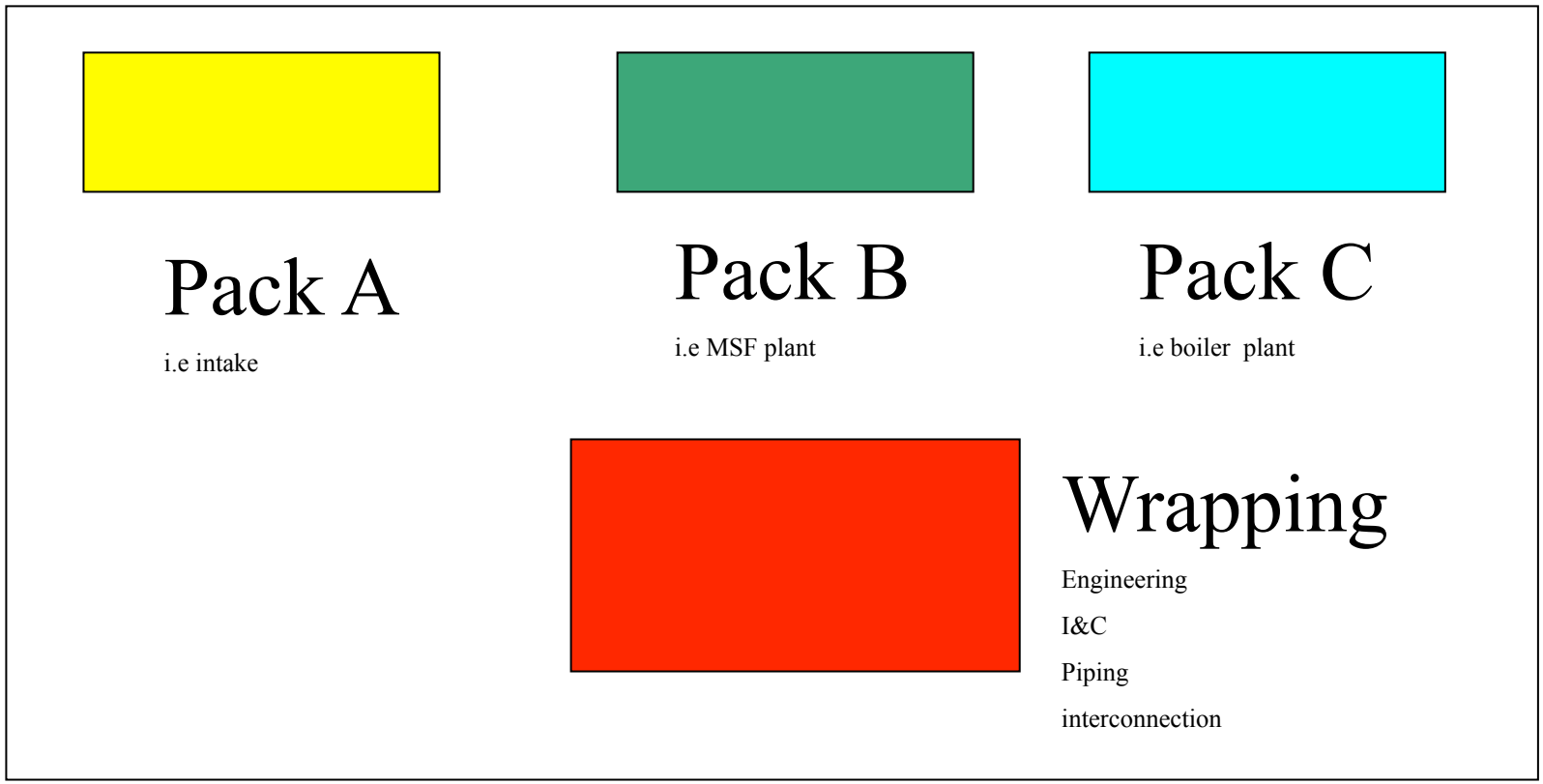
The objectives also include realization of a **fair** and transparent bid process that will be crucial to achieve competitive bids and therefore low water tariffs.

The evaluation process for each Project will have the objective of identifying the most technically conforming and commercially responsive proposal at the lowest price for Water (and Power if it is a cogeneration plant) capacity and output.

Objectives

- Multi-contract, traditionally specified
- Turnkey contracts, traditionally specified
- IWP-IWPP (Independent Water Projects-Independent Water and Power Projects)

Multi contracts (nicknamed shopping around)



Several work packages awarded to different companies

Multi contracts

Cheap

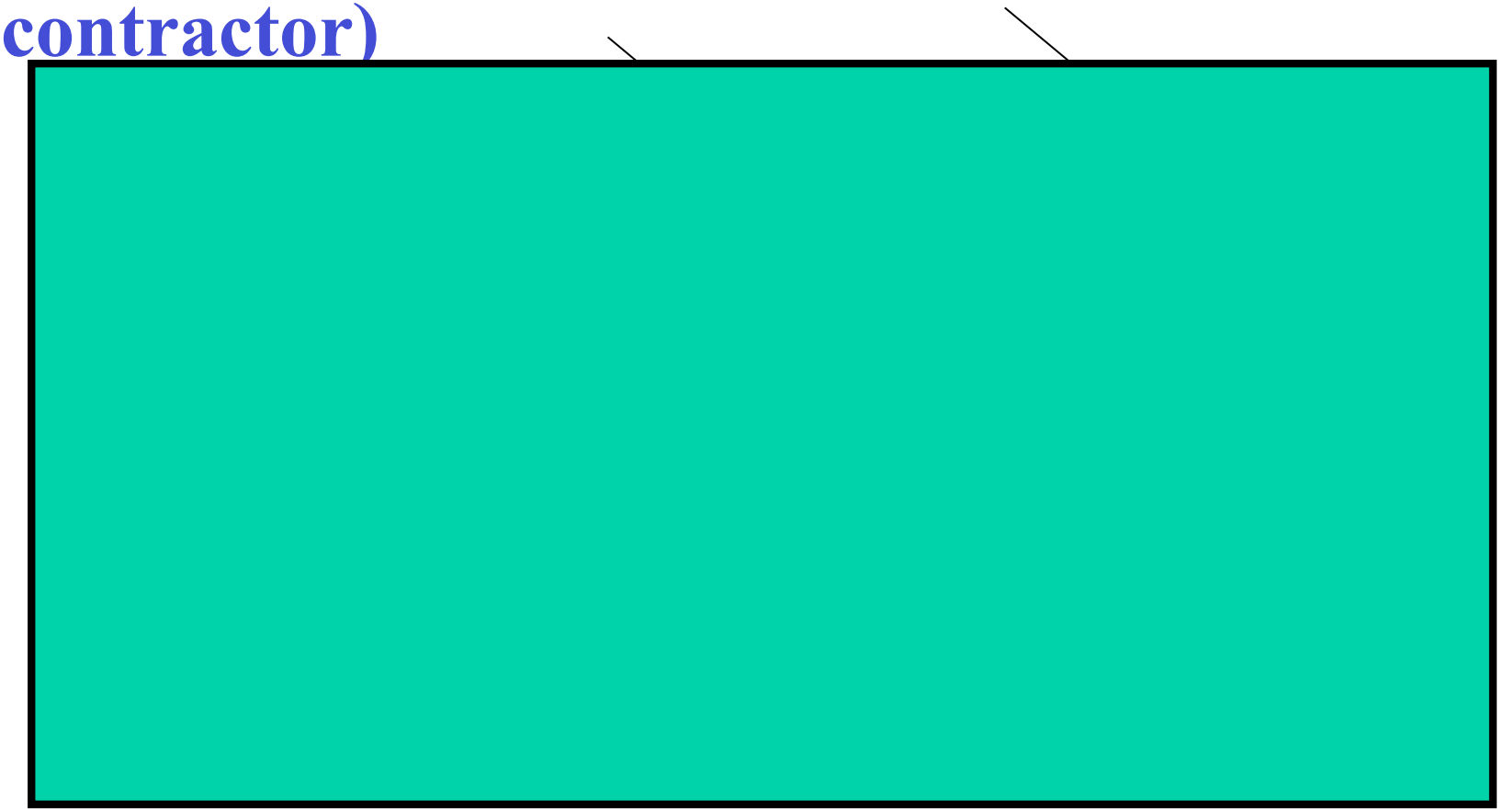
Risky

-Time

- cost overrun

-Performance

Turnkey contracts (nicknamed screw the contractor)



One single best Tenderer carries out all the work

Turkey contract

More expensive

Performance risk with the Contractor

-Time

- cost overrun

-Performance

- Private projects

  - Key agreements
  - Typical structure
- Risk management and allocation

• Private projects

- The main driver is “lack of funds”
- Requirement :
  - Long term solid agreement
  - Good track record

Key interfaces:

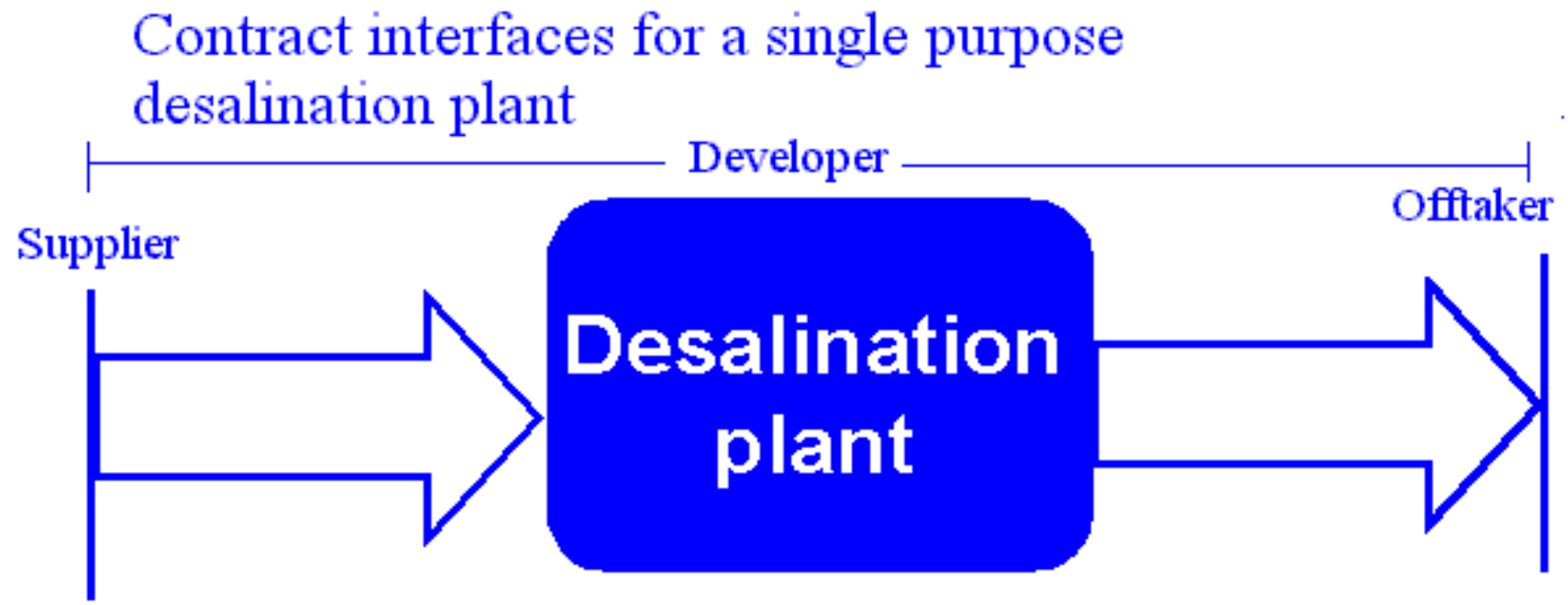
- Incoming saline water: Especially for Reverse Osmosis projects Saline water quality (in particular with reference to microelement and contaminants) is difficult to predict accurately. Projects have to be tolerant to the widest range of expected seawater quality expected over the project life.

- Product water. The output quality of desalinated water can be engineered to a wide range of specification depending on the purpose of the product water – for example potable quality, irrigation use or for blending with other water such that an overall supply is of potable quality

Heat input, from the associated power plant

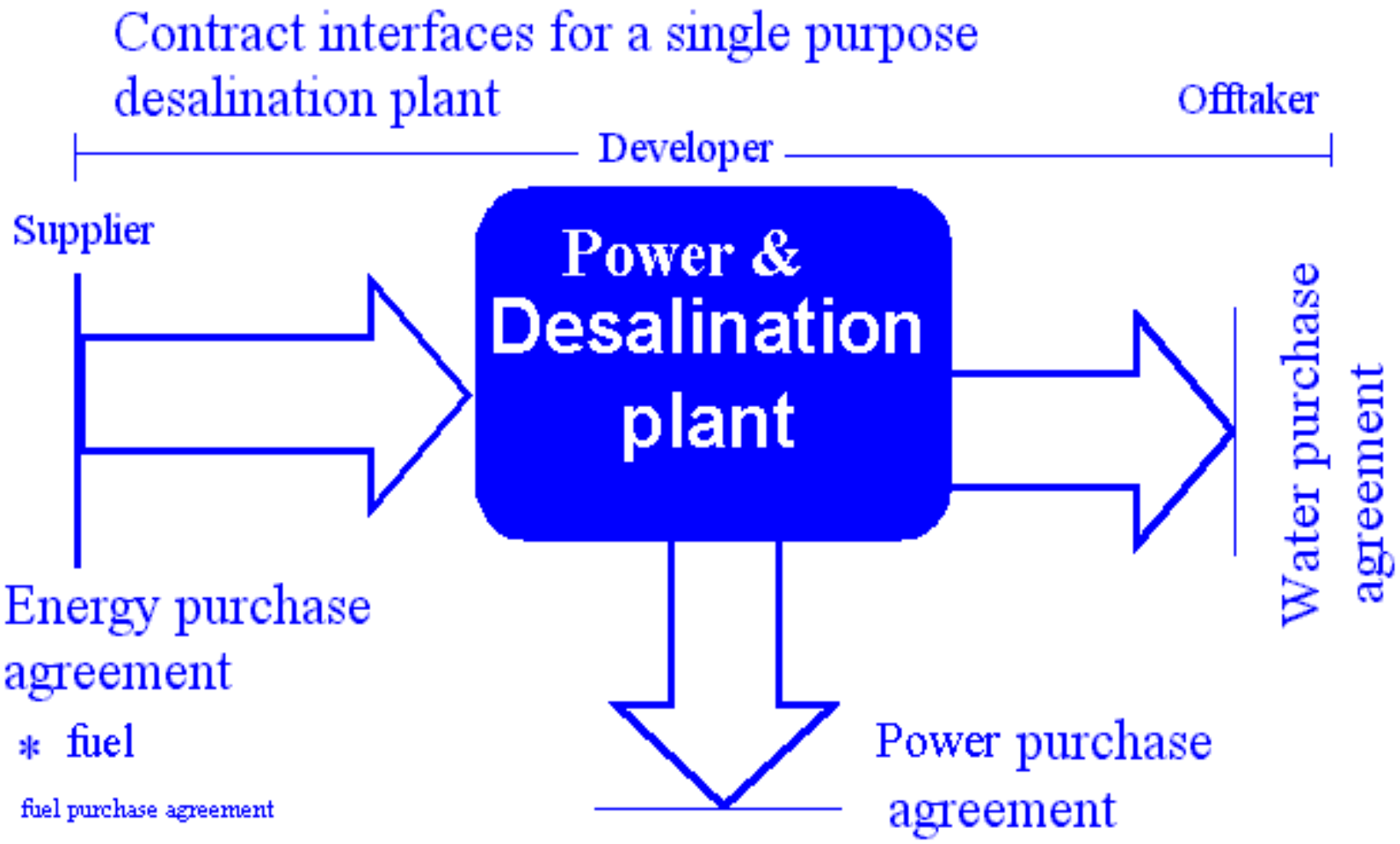
· Electricity input. The reverse osmosis process depends on a reliable electricity supply, through some resilience to supply interruptions can be gained through use of buffer storage of product water

Private projects



* thermal
* power

Private projects



Private projects

No immediate funds required

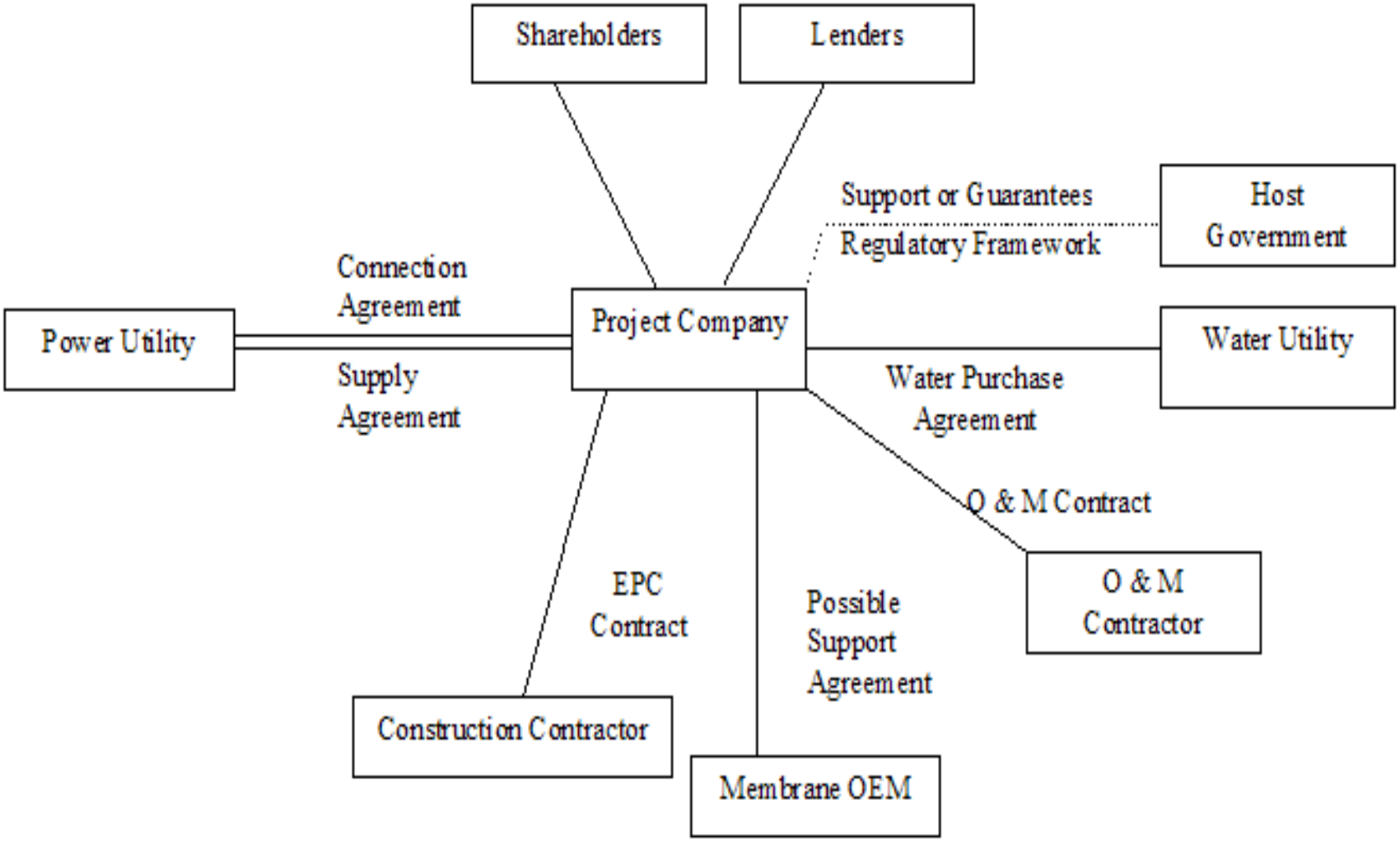
Performance risk with the Developer

-Time

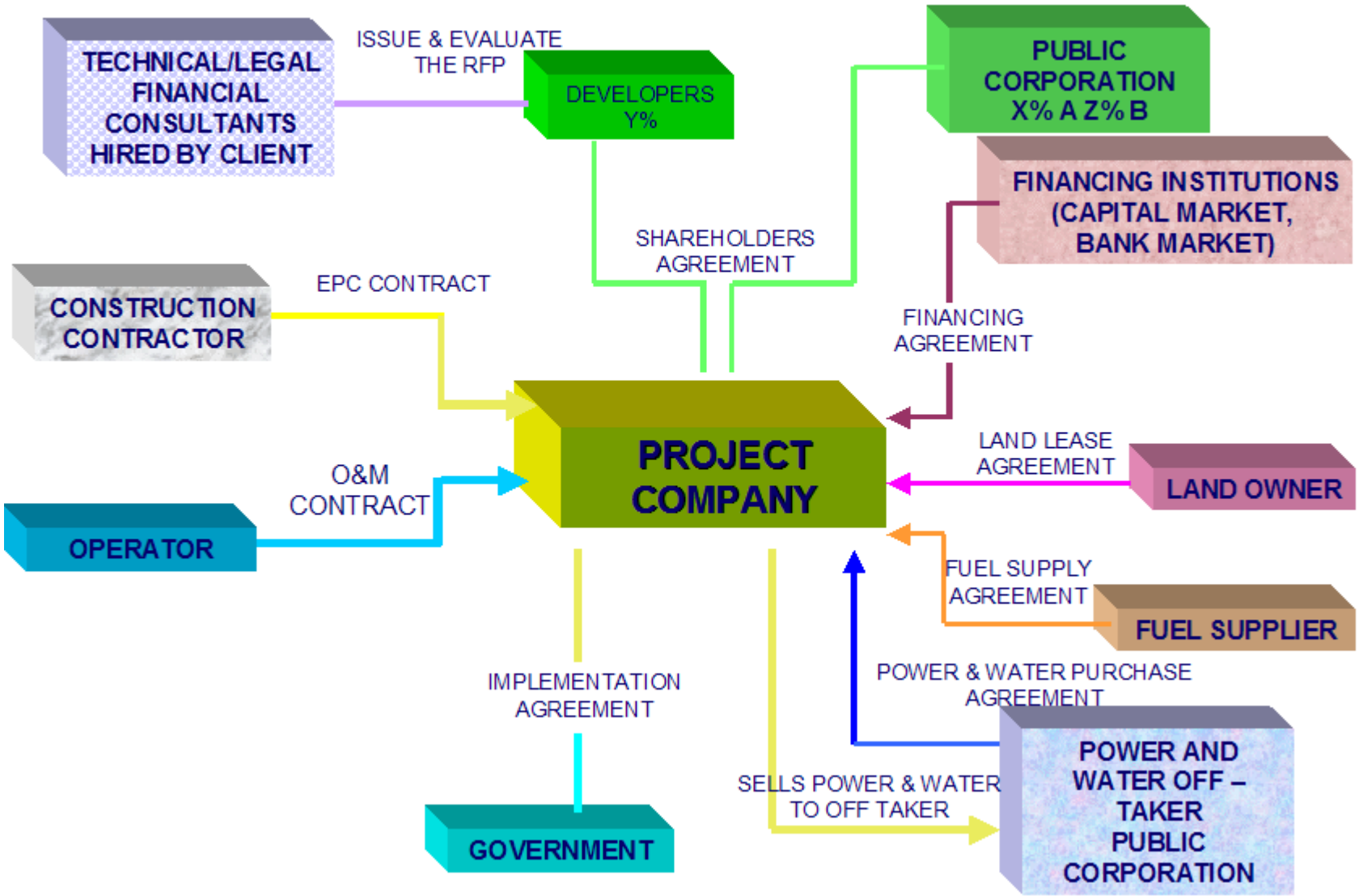
- cost overrun

-Performance

- Typical project structure single purpose



- Typical project structure double purpose



Key agreements:

- The Joint Venture Agreement: Between the shareholders of the project company: the sponsor(s) and, often, the off-taker or another state-owned entity.

- The off-take agreement(s): Between the project company and the water and, if any, electricity off-takers for the sale of the water and electricity produced by the project.

- The turnkey contract: Between the project company and an industrial contractor for the construction of the plant.

- The O&M contract: Between the project company and an industrial operator for the operation and maintenance of the plant.

- The lease agreement: Between the project company and the lesser of the land on which the plant shall be erected. The lesser is often a state-controlled entity.

- The financing agreements: Between the project company and the lenders for the financing of the project including loan agreement and security documentation.

WHERE DOES PERFORMANCE RISK STAY ?