

LIFE

LIFE Economics and Delivery Pathway

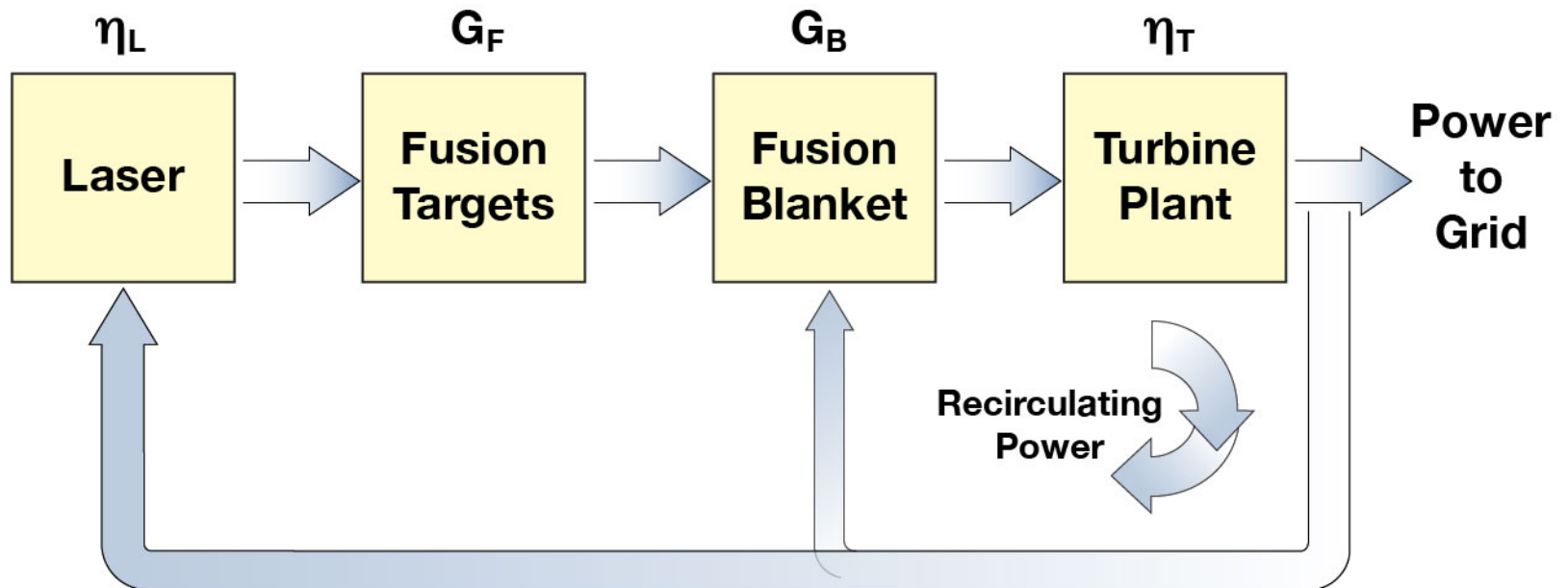
Presentation to
**National Research Council's review on
"Prospects for Inertial Confinement Fusion Energy Systems"**
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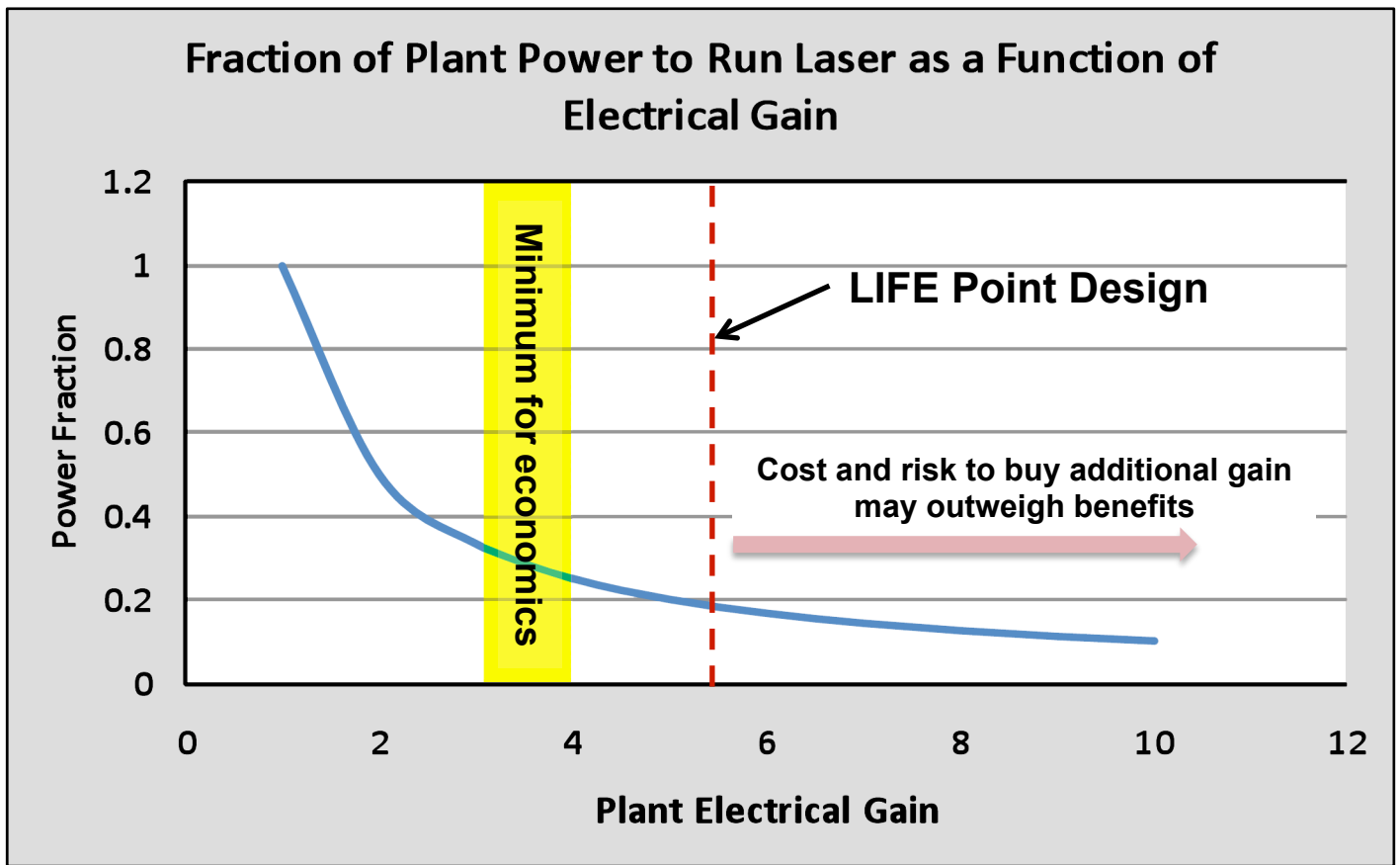
The Gain Story



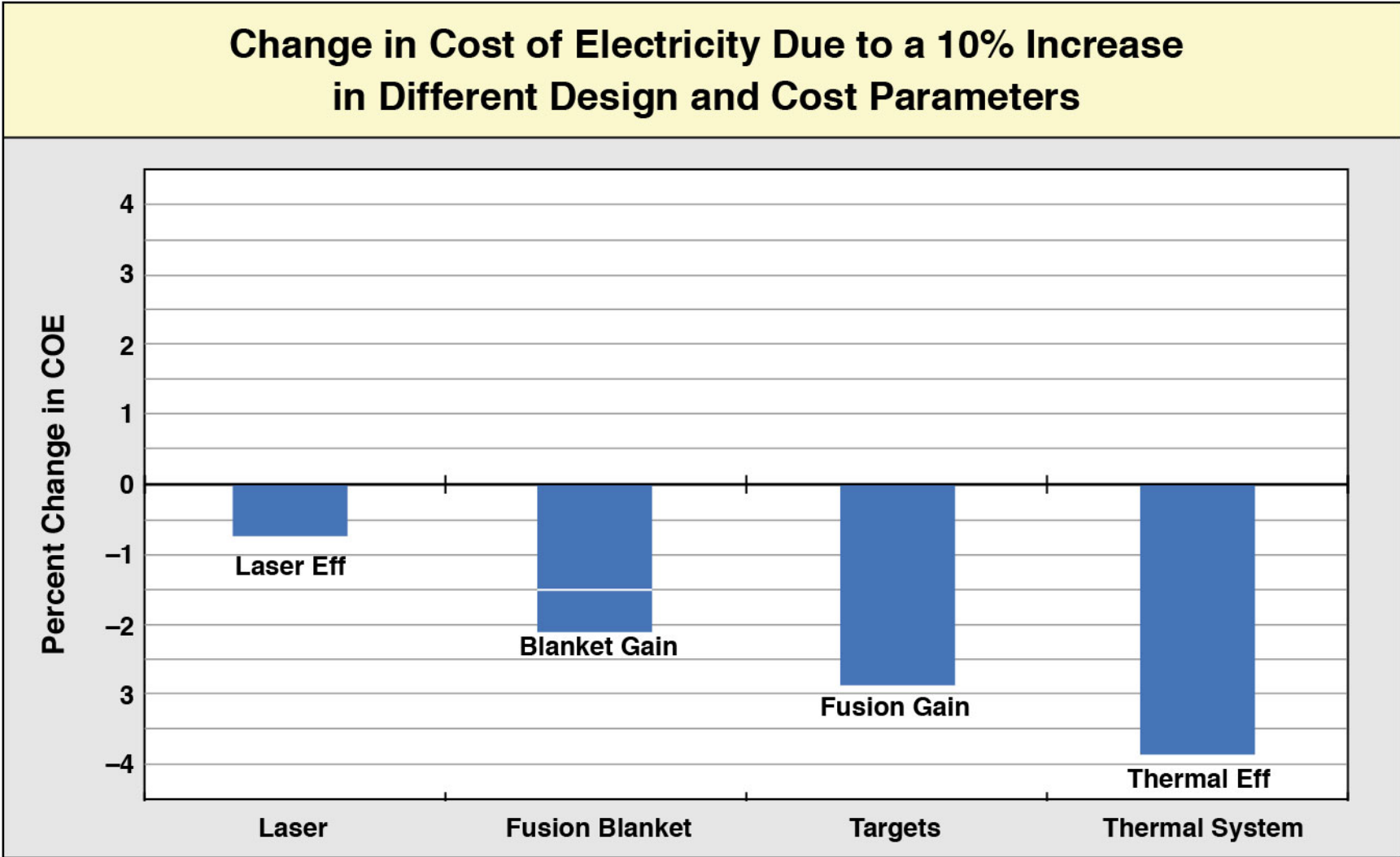
$$\text{Plant Gain} = \eta_L G_F G_B \eta_T = \frac{P_{\text{Gross}}}{P_{\text{Recirc}}}$$

$$f_{\text{Recirc}} = \frac{P_{\text{Recirc}}}{P_{\text{Gross}}} = \frac{1}{\text{Plant Gain}}$$

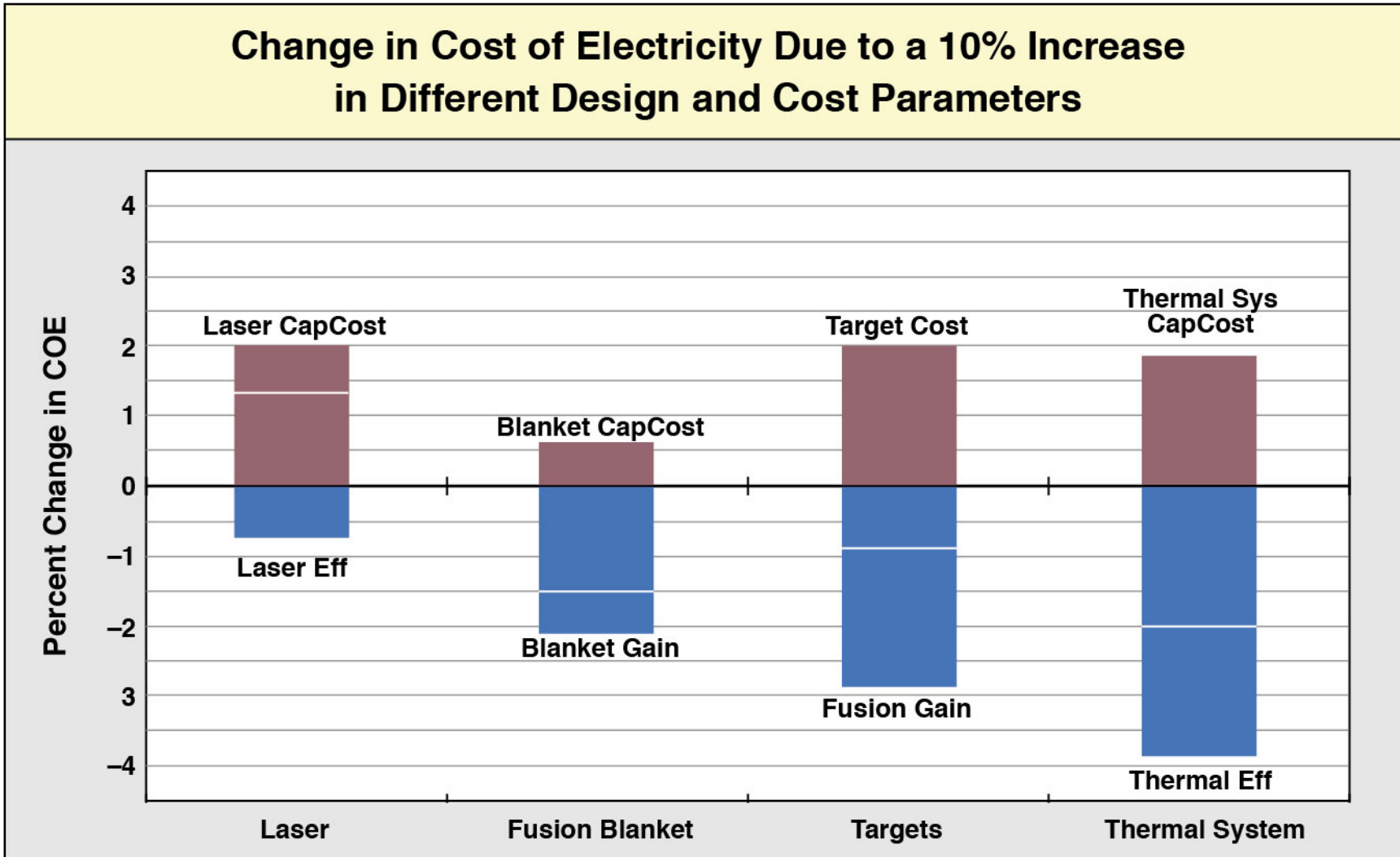
A minimum electrical gain of 3 to 4 is necessary (but not sufficient) for economic viability



Improvements to gain need to be weighed against cost impacts on affected systems

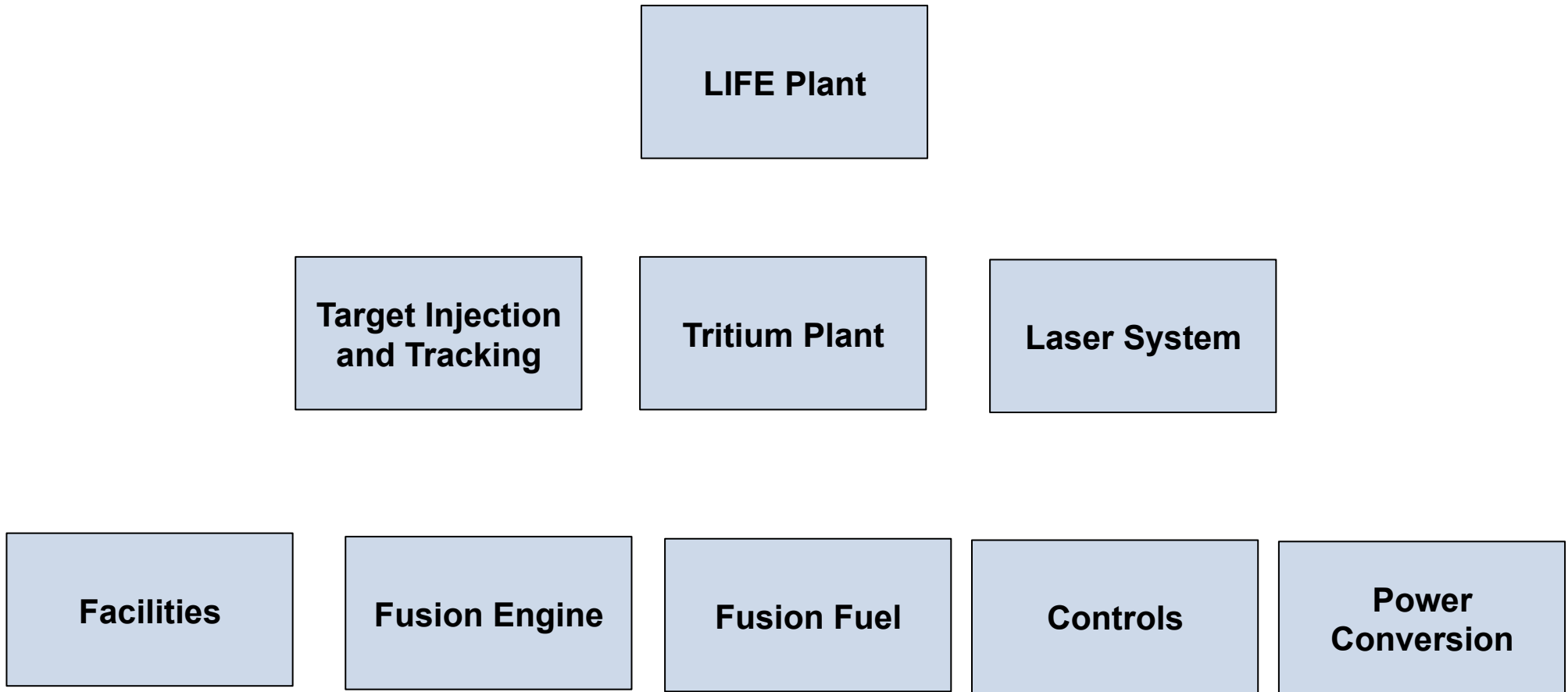


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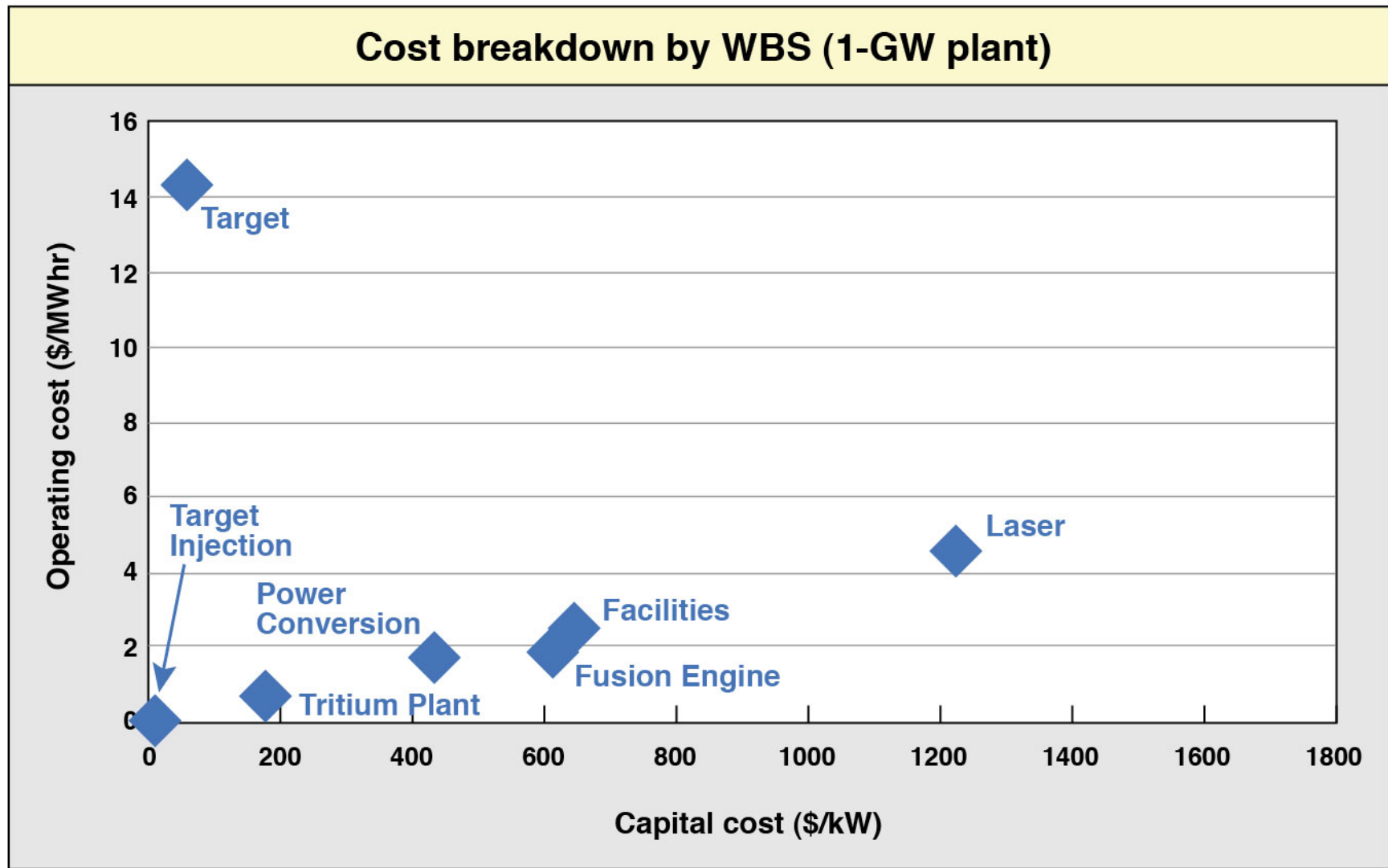
An integrated systems approach is required to develop an economically viable plant design

At the top level, LIFE plant can be grouped into 8 functional elements

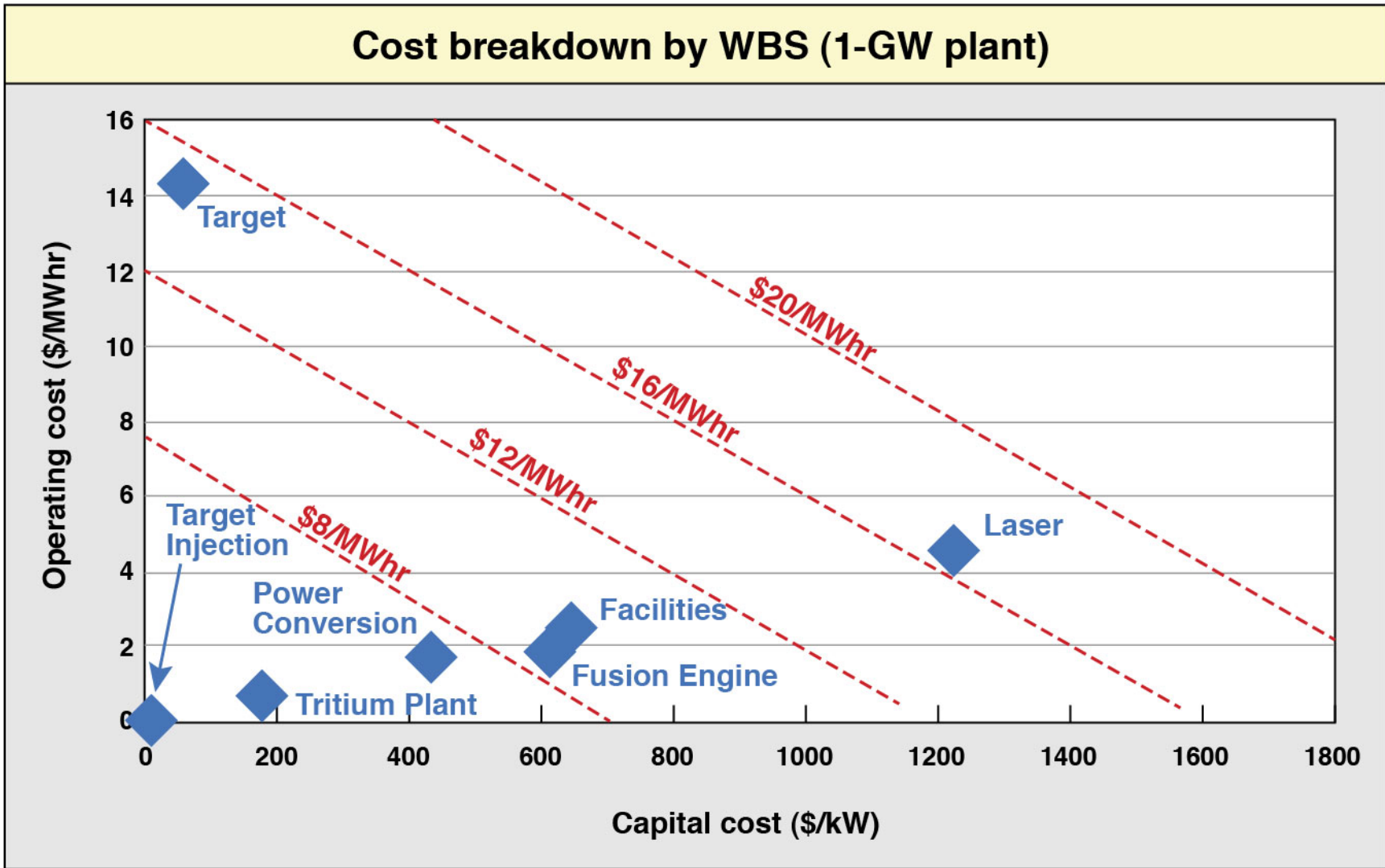


LIFE work breakdown structure extends these 8 elements to an additional 350 lower level functional elements

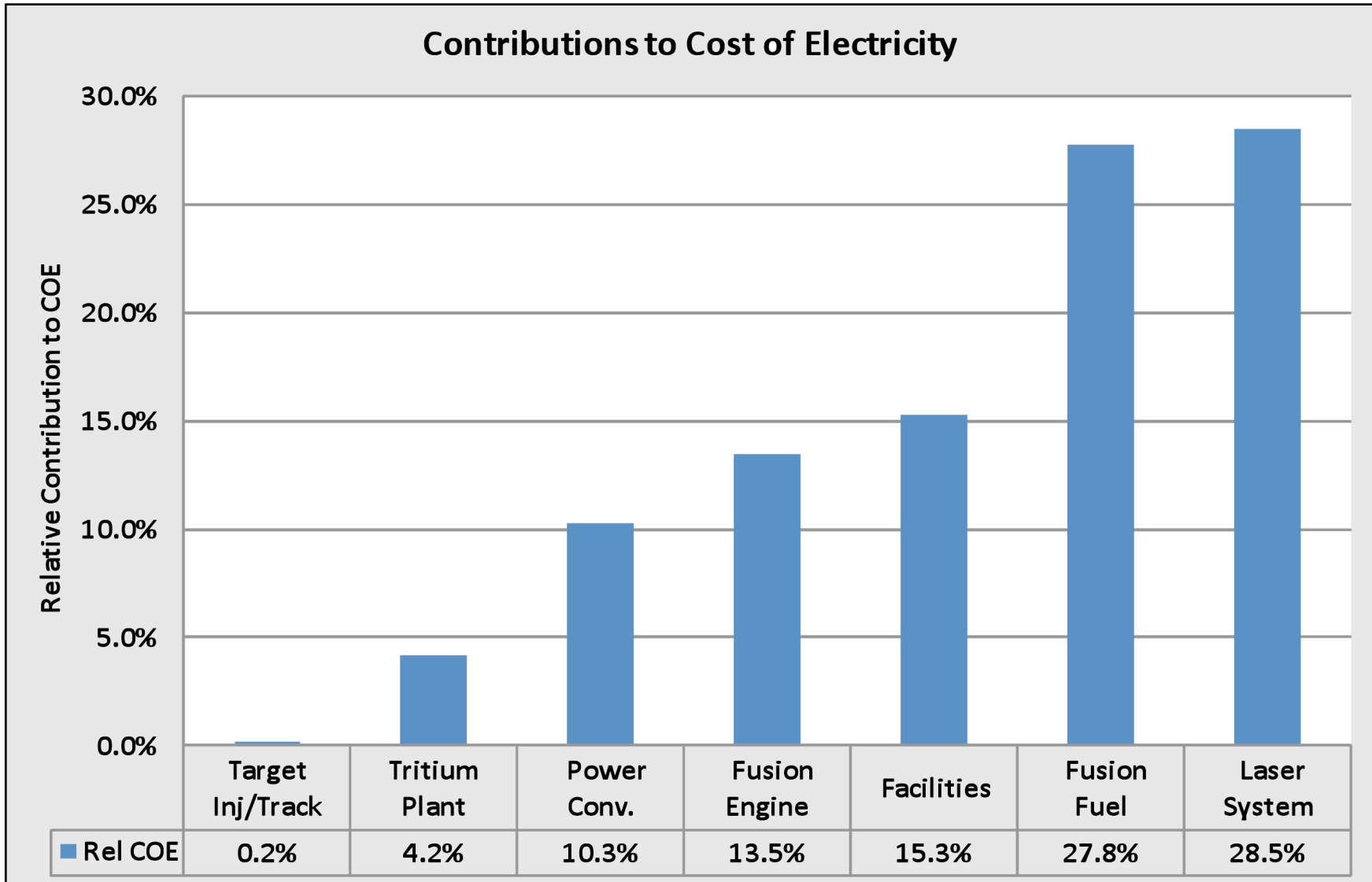
Cost of electricity can be deconstructed into capital and operating costs



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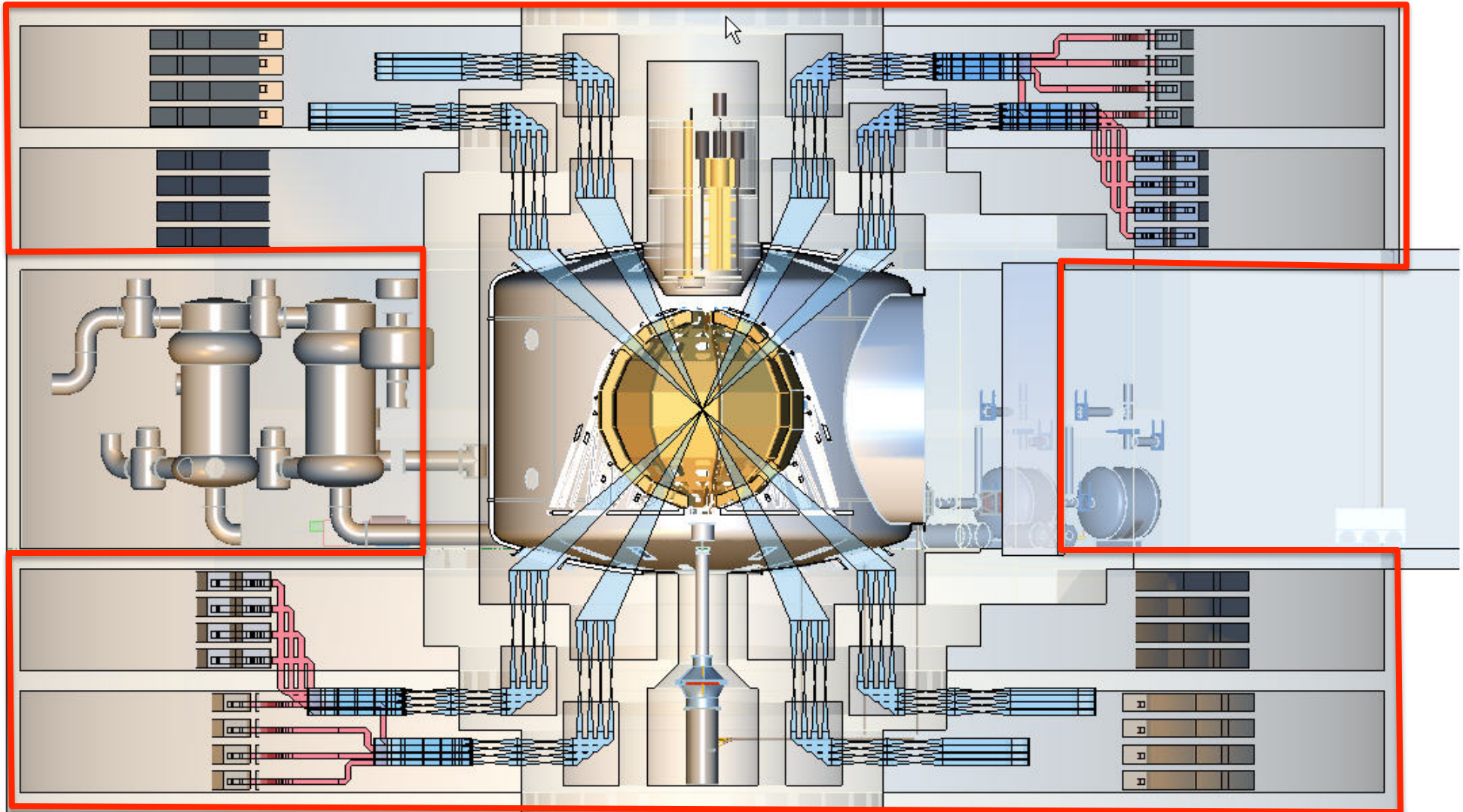


Aggregation of cost centers yields cost of electricity \$65/MWhr

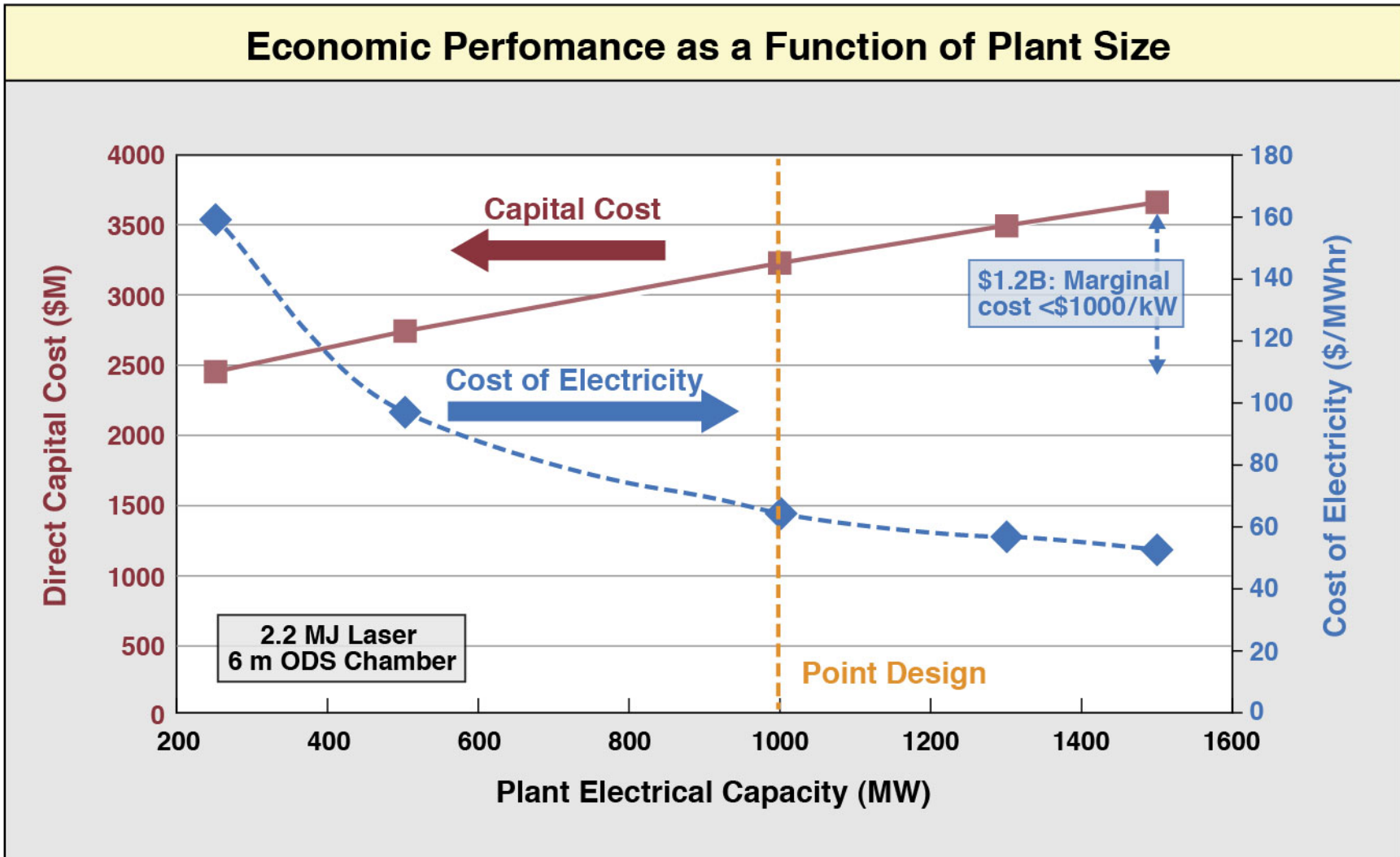


Deployment strategy revolves around demonstration of the LIFE “fusion kernel”

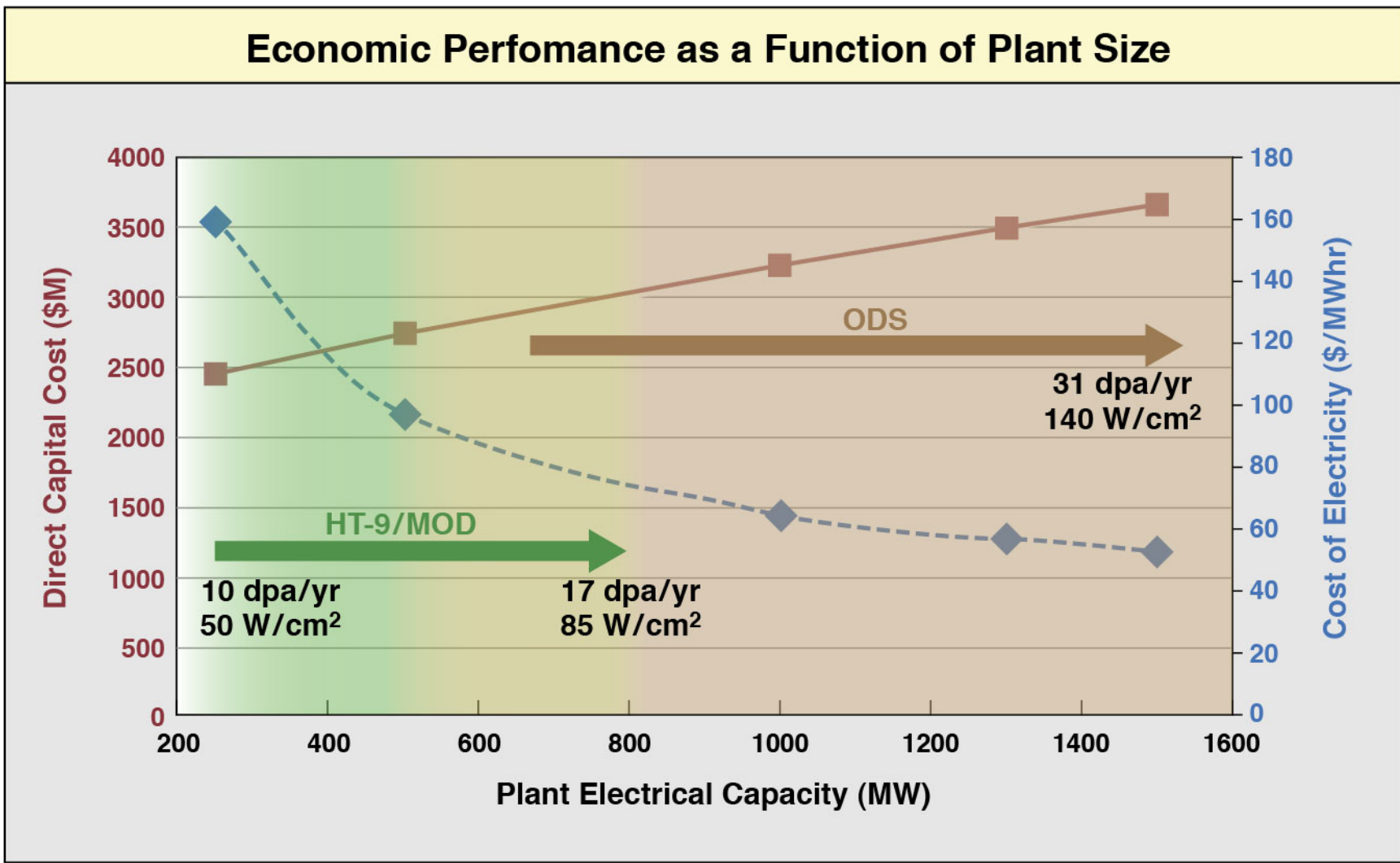
Kernel is 384 beams, 6 meter fusion chamber



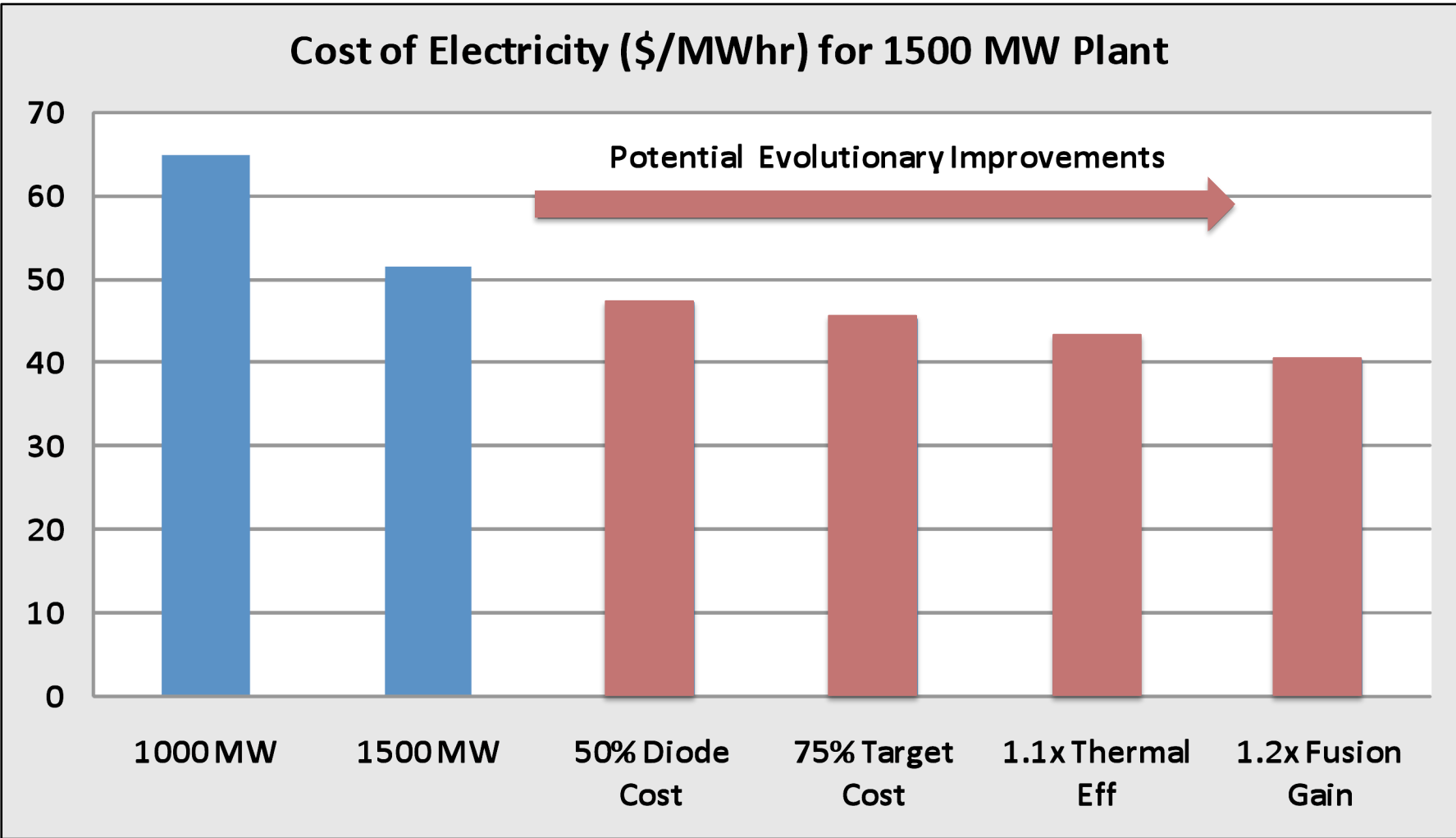
LIFE is economically viable over a range of plant sizes



Modular fusion chamber enables commercially viable plant without need for ODS or SiC



Fully mature LIFE technology would likely move toward >1000 MW plants for economy of scale



Delivery of commercial fusion energy hinges on reducing technical and financial risk to acceptable levels

- Quantified in terms of confidence level that an issue has been demonstrated as resolved X impact if it is not resolved

	Degree of Resolution	Low	Med	High
Impact		0	1	2
Low	1	0	1	2
Med	2	0	2	4
High	3	0	3	6

High Impact: Show-stopper
 Med Impact: Major impact on economics
 Low Impact: Significant but manageable impact on economics

- Commercialization is divided into four phases that roughly map to TRL levels 1 through 9
 - Modeling/Concept Level Testing: TRL's 1 to 3
 - Subsystem Level Testing/Laboratory Environment: TRL's 4 to 6
 - Integrated Fusion Environment Testing (Commissioning): TRL's 7, 8
 - Initial Commercial Operations: TRL 9

Delivery strategy is to progressively reduce risk to support continued investment and commercialization



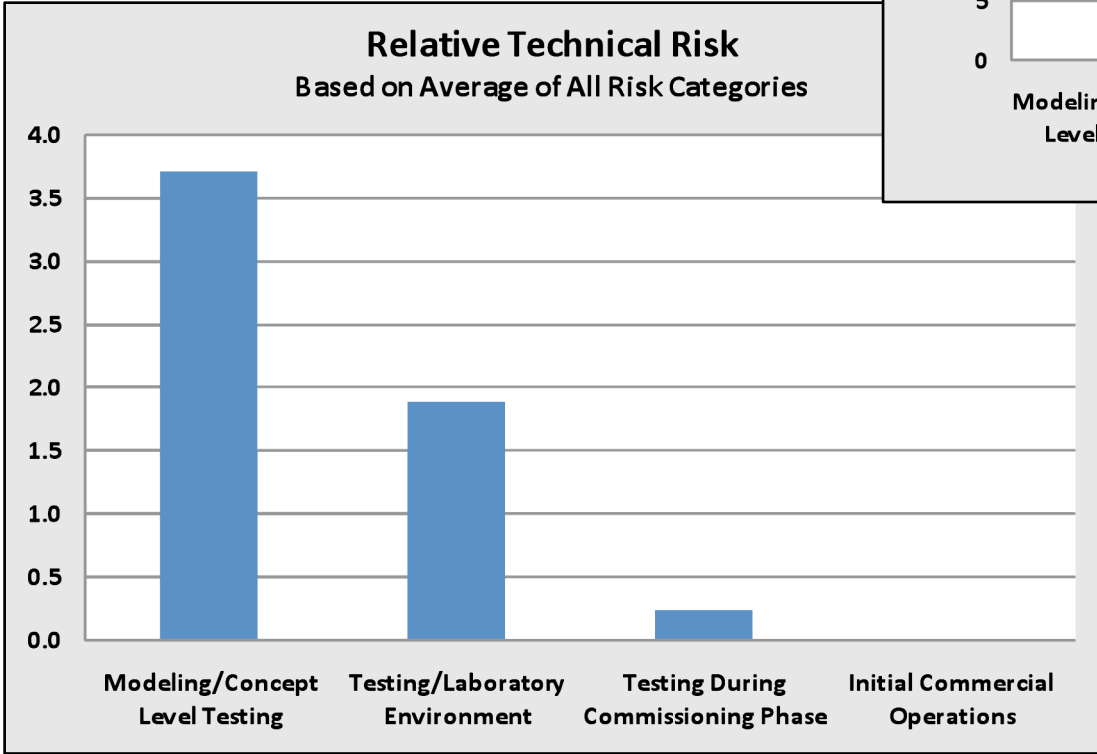
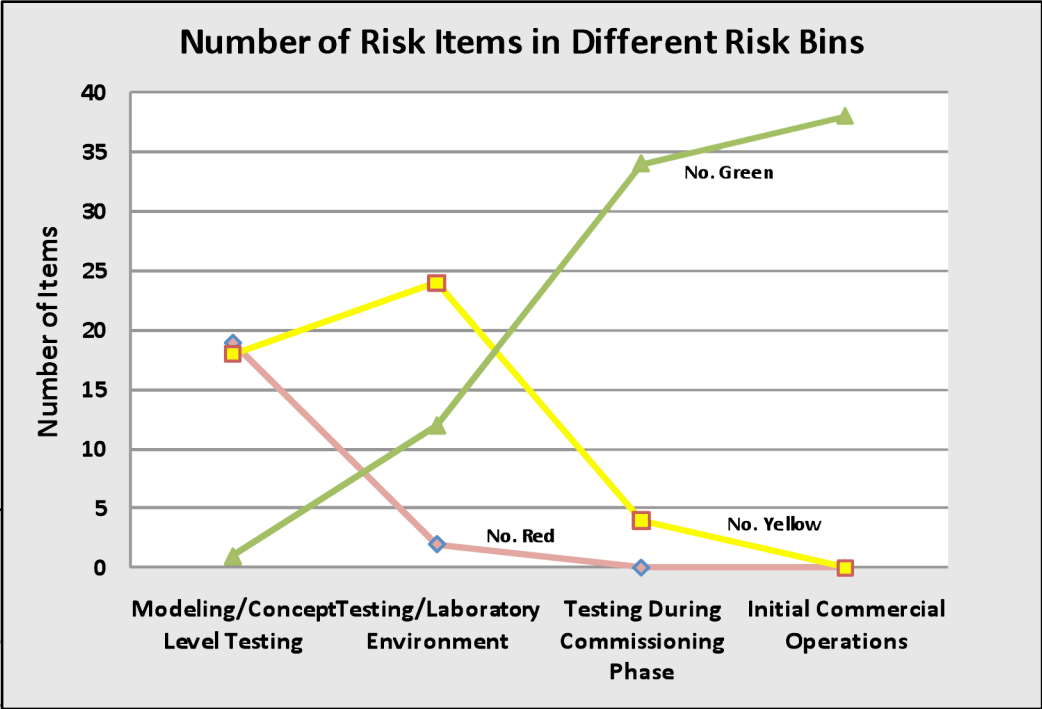
Delivery plan reduces risk to commercially acceptable levels

- Fusion delivery abstracted to 38 core technical issues

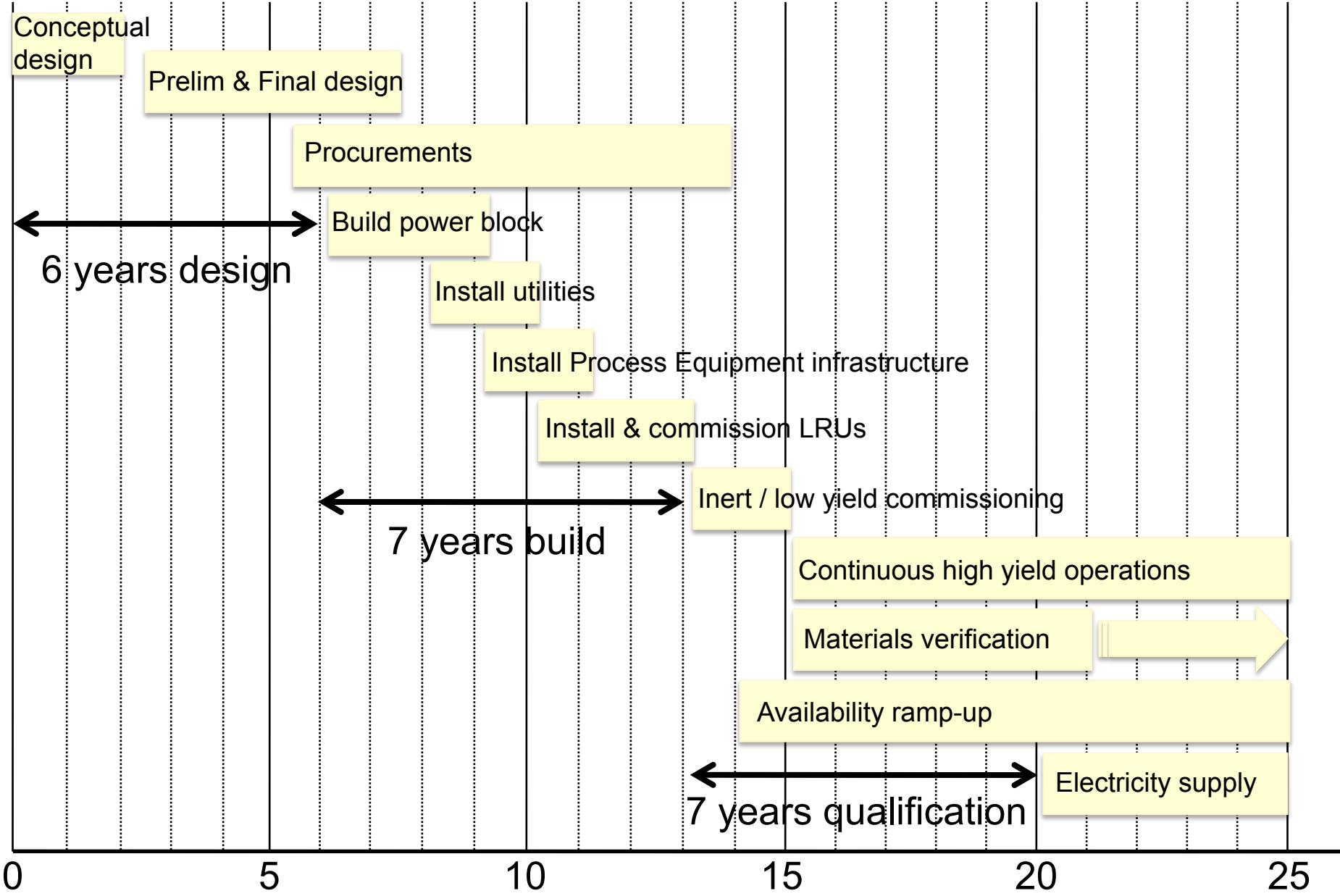
WBS	Issues	Impact	TRL 1 to 3	TRL 4-6	TRL 7-8	TRL 9
			Modeling/Concept Level Testing	Testing/Laboratory Environment	Testing During Commissioning Phase	Initial Commercial Operations
	Fusion Physics					
	Gain >60	M	2	0	0	0
	On-the-fly ignition	H	6	3	0	0
	>~99% probability of ignition	M	4	2	0	0
	Materials compatible w/Manufacturing	M	2	0	0	0
	Materials compatible w/Debris Mgmt	M	2	2	0	0
	Materials compatible w/Beam Prop	M	2	0	0	0
	LEH compatible w/focal spot, FO standoff	H	3	0	0	0
	Fusion Targets					
	DT layer in production environment	H	3	0	0	0
	Target survival: injection, flight	H	6	3	0	0
	Mass manuf: 400M/yr, <\$1	H	6	3	0	0
	Minimal Tritium Inventory	M	4	2	0	0
	Tritium Fuel Cycle					
	Tritium Breeding Ratio	H	3	3	0	0
	Recovery from Li	H	3	0	0	0
	Recovery from Xe	H	3	0	0	0
	Target Injection and Tracking					
	Accurate and repeatable in fusion env	H	6	3	0	0
	Injector reliability in fusion env	M	4	2	0	0
	Target survival in injector (fusion env)	H	6	3	0	0
	Injector availability	M	2	2	0	0
	Target tracking in fusion env	H	3	3	0	0
	Laser Fusion Driver					
	Rep-rate operation	H	3	0	0	0
	Final optic survival	H	6	3	0	0
	Electrical efficiency	M	2	0	0	0
	Target engagement	H	6	3	0	0
	Focal spot consistent with LEH	H	0	0	0	0
	Laser system availability	M	2	2	0	0
	Fusion Engine					
	First wall radiation damage survival (HT-9)	H	3	3	0	0
	First wall radiation damage survival (ODS)	H	6	6	3	0
	Chamber clearing	H	6	3	0	0
	Debris management	H	6	3	0	0
	Heat removal	M	2	0	0	0
	Thermal and mechanical insults	H	3	3	0	0
	Corrosion	M	4	2	0	0
	Fabrication (ODS)	M	2	0	0	0
	Tritium containment	H	6	3	0	0
	Availability	M	4	4	2	0
	Concept of maintenance	M	4	2	0	0
	Production capability for ODS	M	4	2	2	0
	Power Conversion Systems					
	Rankine integrated with fusion source	M	2	2	2	0

Most technical risk is retired by completion of commissioning phase

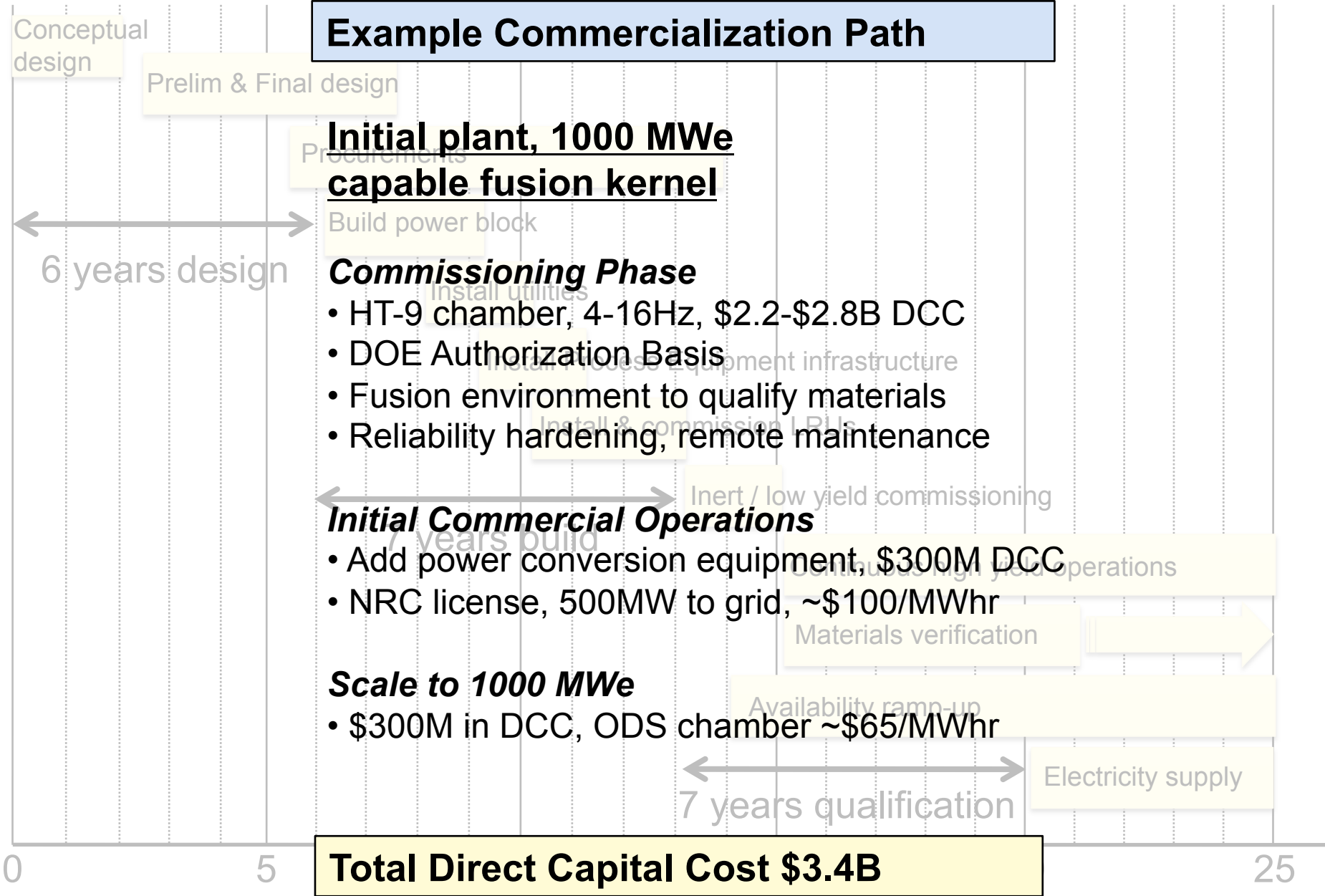
Commissioning phase provides the fusion environment needed to qualify materials and processes needed for commercial operations



LIFE schedule, consistent with RD&D, Construction and Licensing timescales is being developed

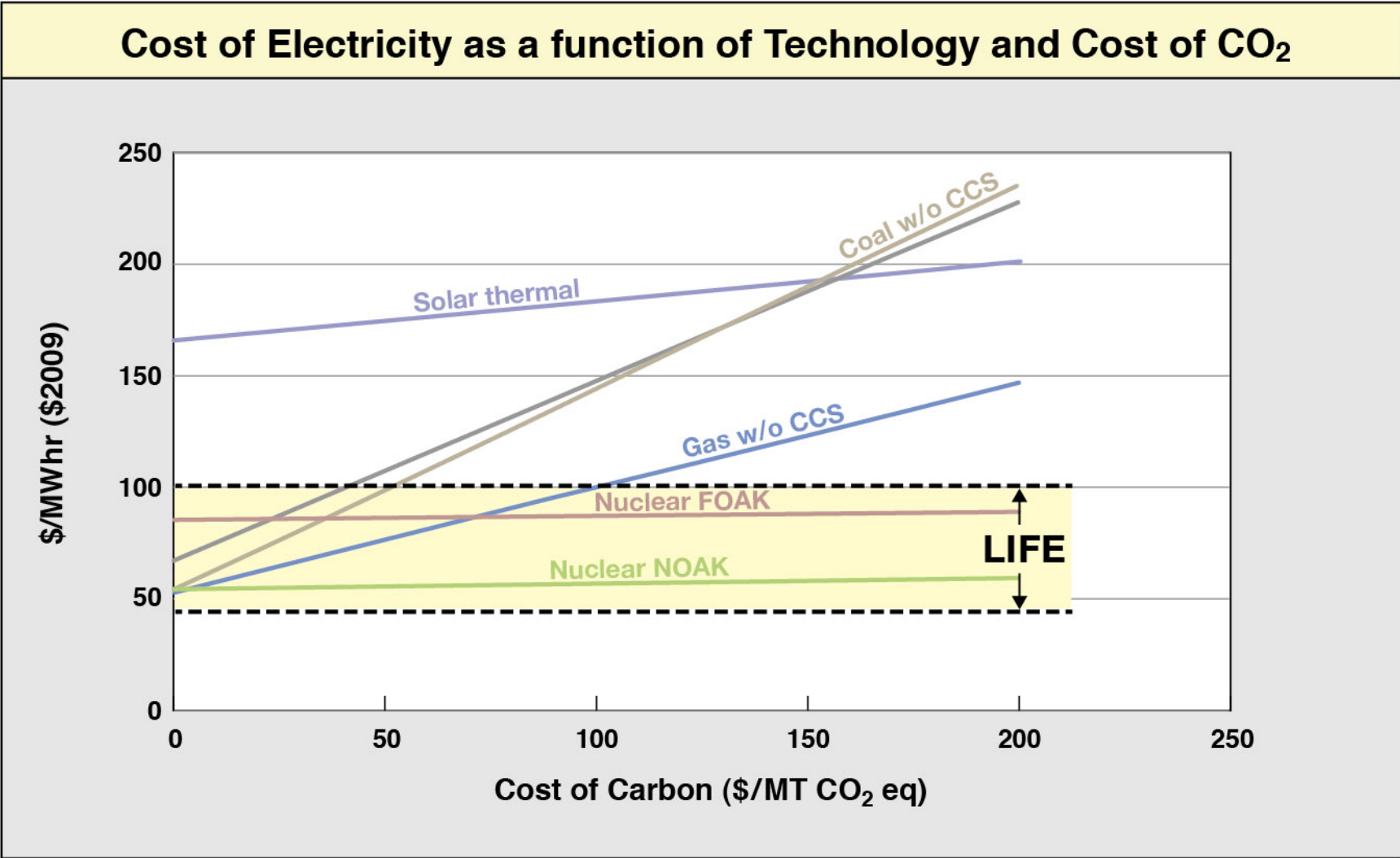


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LIFE can be an economically attractive source of low carbon electricity

Nicholson et al, Energy (2010)



LIFE

