Challenges and Opportunities facing the International Supply Chain for Nuclear Components



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About WNA

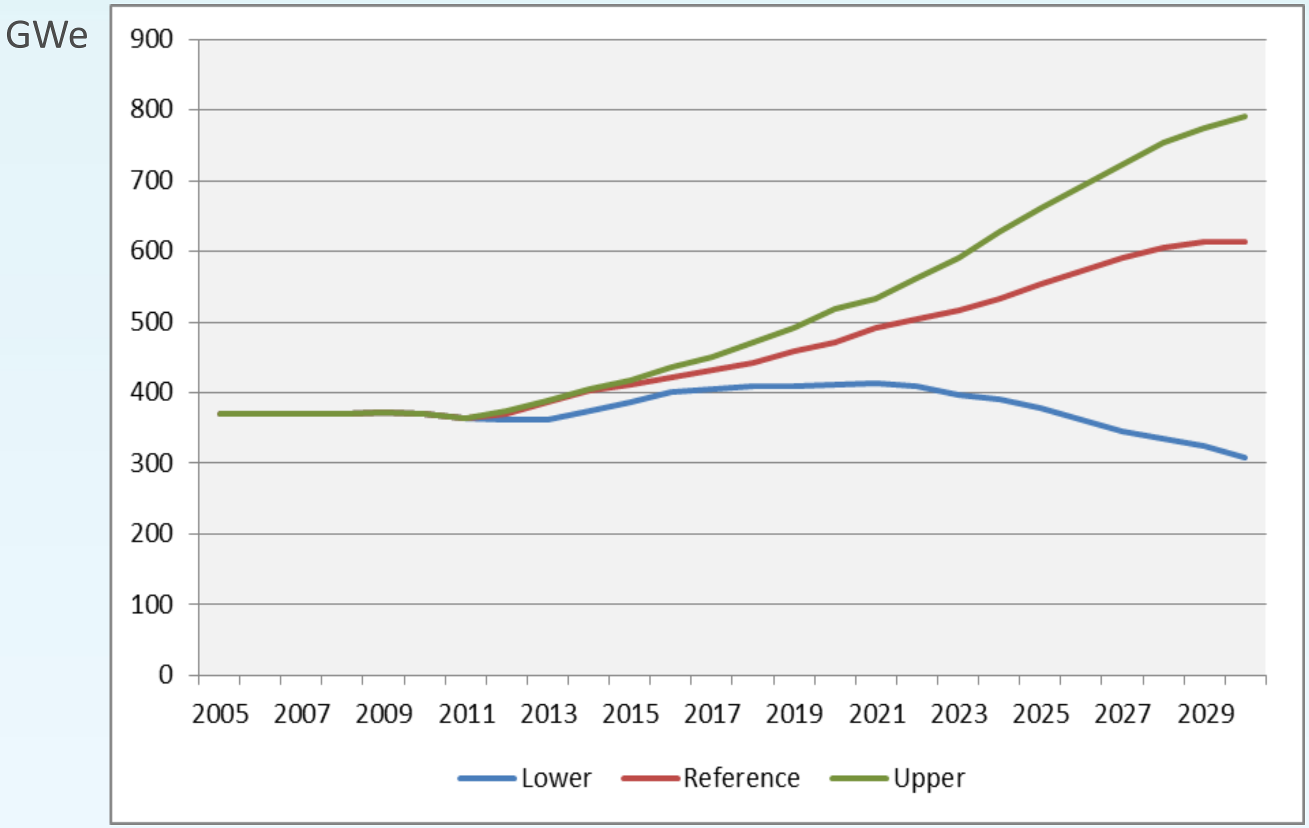

Providing Public Information and News
Nuclear Fuel Market and Supply Chain
Enabling Industry Contacts and Cooperation
Representation in Key International Forums

Challenges & Opportunities facing the international nuclear supply chain

- **Potential market size up to 2030: WNA Scenarios**
- **The Challenges:**
  - For the industry: How can nuclear power stay competitive?
    - Economics of nuclear energy;
    - Ensuring conformity and reliability in the supply chain.
  - For policy-makers: What makes nuclear power an attractive option?
    - Localization of component production;
    - Role of energy market regulators;
    - Options for financing the construction of nuclear power plants.
- **The Opportunity:**
  - To build a global industry with reliable and competitive international supply chains.

WNA Scenarios

Significant growth expected in nuclear power but Low Case remains possible



Nuclear Generating Capacity to 2030

Size of the Market

Output & Turnover from Nuclear Power Plants, 2000-2009

		2000	2005	2006	2007	2008	2009
OECD	Output from NPPs (TWh)	2249	2346	2356	2273	2279	2243
	Turnover (US$ billion)	164.2	220.3	237.4	246.2	277.6	271.8
Non-OECD	Output from NPPs (TWh)	346	422	436	447	458	454
	Turnover (US$ billion)	:	28.1	27.0	35.7	39.4	:
World	Output from NPPs (TWh)	2595	2768	2792	2720	2737	2697
	Turnover (US$ billion)	:	248.4	264.4	281.9	317.0	:

Sources: IEA, 2011, *Electricity Information 2011*: Tables 1.2, 2.6, 2.14, 3.5, 3.7 and previous editions; US Energy Information Administration, 2010, Electricity Prices for Households; WNA estimates.

- **Nuclear power plants generate a turnover worth around US$ 320 billion a year**
  - 85 % of turnover generated in OECD countries;
  - Non-OECD turnover has grown from 11 to 12.5 % since 2005.

Size of Market - Projected

Output & Turnover from Nuclear Power Plants, 2008-2030

		2008	2015	2020	2025	2030
OECD	Output from NPPs (TWh)	2 279	2 267	2 384	2 521	2 638
	Turnover (US$ billion)	277.6	311.9	379.8	403.4	441.1
Non-OECD	Output from NPPs (TWh)	458	733	1 147	1 683	2 029
	Turnover (US$ billion)	39.4	53.5	86.5	125.4	153.0
World	Output from NPPs (TWh)	2 737	3 000	3 531	4 204	4 667
	Turnover (US$ billion)	317.0	365.4	466.3	528.9	594.1

Sources: WNA estimates.

- **3 % growth per annum – depends on price assumptions:**
  - Electricity prices rise in line with IEA assumption for steam coal (main fuel for base load);
  - If prices rise faster then gross revenues could rise 4% pa to US$733 billion by 2030.
- Non-OECD share of turnover rises from 12.5% to 26% by 2030.

Value of New Construction to 2030

- **298 new NPPs planned**
- 94 in OECD countries
- 106 in China
- 40 in FSU
- 33 in India

Total Value of Planned New Build US$ 1.5 trillion

Minimum Value of International Procurement US$ 530 billion

- **Investment in new NPPs to grow 4-5% pa between 2012 and 2030**:
  - International procurement worth US$ 30 billion a year;
  - Nuclear investment is a small proportion of the US$ 14-17 trillion needed for clean power (Goldman Sachs estimate) to stabilize CO_2 emissions
  - How can this level of investment be sustained in the current climate of economic uncertainty?

Nuclear New Build Scenarios

IEA and WNA Scenarios compared for 2030

IEA 2011	**Low Nuclear Case**		**WNA 2011**	**Lower case**	
	• Nuclear capacity (GWe)	390		• Nuclear capacity (GWe)	307
	• Nuclear generation (TWh)	3 175		• Nuclear generation (TWh)	2 321
	New Policies			**Reference case**	
	• Nuclear capacity (GWe)	591		• Nuclear capacity (GWe)	614
	• Nuclear generation (TWh)	4 337		• Nuclear generation (TWh)	4 667
	450 (CO_2 stabilization)			**Upper case**	
	• Nuclear capacity (GWe)	758		• Nuclear capacity (GWe)	790
	• Nuclear generation (TWh)	5 582		• Nuclear generation (TWh)	5 991

Source: IEA, 2011, *World Energy Outlook 2011*: pp. 458-459, 620-621.

- **WNA Scenarios are relatively consistent with IEA Scenarios, but**:
  - WNA Scenarios are 'bottom up';
  - IEA Scenarios are driven by an economic model, but this may underestimate electricity consumption from poor people (very price sensitive to demand).
  - IEA model apparently estimates the nuclear component in the energy mix as a residual and does not give sufficient weight to the competitiveness of nuclear power vs. renewables.
- **Little attention has been paid to the cost of a high renewables element in electricity systems.**

Industry Challenges

How can nuclear power stay competitive?

- Ensuring that the economics of nuclear power are competitive with other generating sources
- Developing reliable international supply chains

Nuclear Economics

Capital Cost Estimates for a new NPP, US$/kWe

Country	Technology	Overnight cost[1] 1998	Overnight cost[1] 2009	Investment cost[2] 1998	Investment cost[2] 2009
Europe					
Belgium	PWR (EPR)		5 383		7 117
Finland	BWR	2 256	:	2 672	:
France	PWR	1 636	:	2 280	:
	PWR (EPR)	:	3 860	:	5 219
Germany	PWR	:	4 102	:	5 022
Netherlands	PWR	:	5 105	:	6 383
Spain	PWR	2 169	:	2 957	:
Switzerland	PWR	:	4 043	:	5 612
Asia					
Japan	BWR	2 521	:	3 146	:
	ABWR	:	3 009	:	3 940
South Korea	PWR	1 637	1 876	2 260	2 340
North America					
Canada	PHWR (Candu)	1 697	:	2 384	:
USA	APWR	1 441	3 382	2 065	4 296
OECD Average		**1 908**	**3 845**	**2 538**	**4 991**

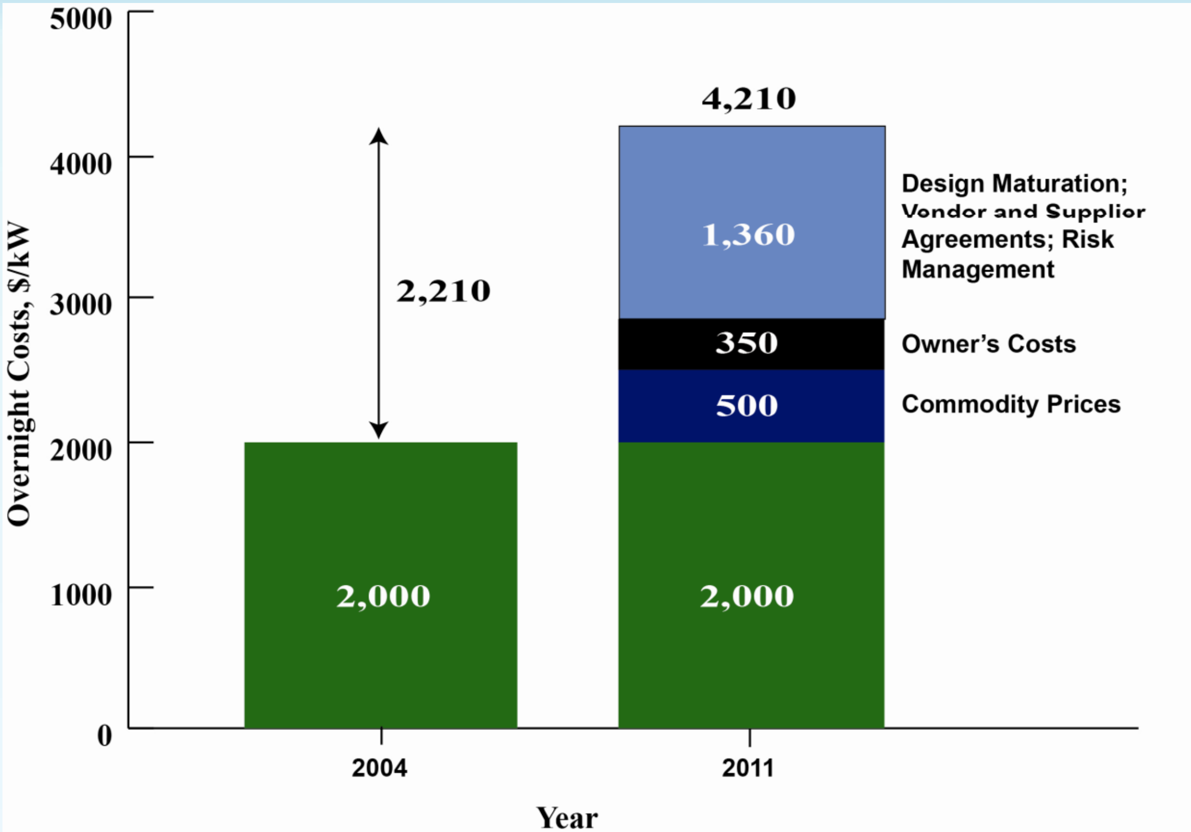
1. Overnight cost includes owner's costs pre-construction and during construction and EPC cost.
2. Overnight cost plus imputed interest charges during construction at 10 percent a year.

Source: IEA, 2001, *Nuclear Power in the OECD*, Paris: OECD: table 15, p. 131; IEA-NEA, 2010, *Projected Costs of Generating Electricity*, Paris: OECD: Table 3.7a, p. 59.

Nuclear power is one of the most cost-effective low carbon energy technologies

(Nuclear lifecycle emissions: 28 tonnes of CO_2 equivalent per GWh; Wind: 26; Gas: 599; Coal: 888)

Why have EPC costs risen?



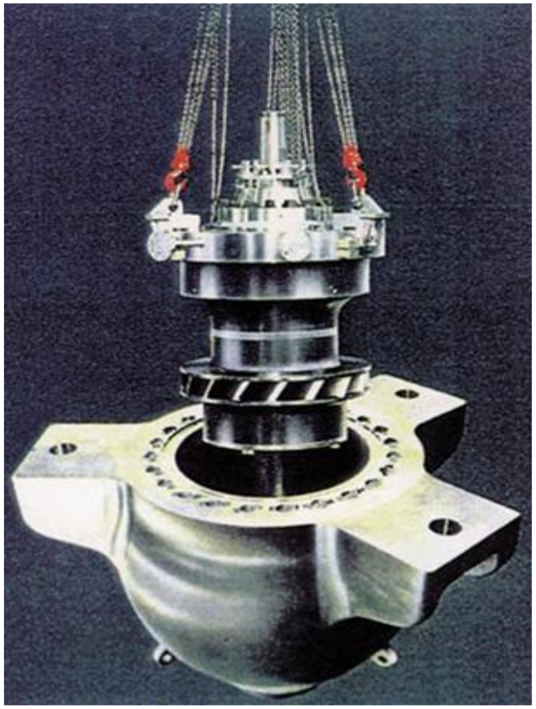
University of Chicago Study, 2011

- **Cost in 2004 may have been underestimated**
  - Reliance of estimates on Asian costs that reflected standardised design (Nth of a Kind, not First of a Kind, FOAK);
  - Inflation in commodity prices (including steel);
  - Price pressure from full order books and "pinch points" on capital costs

First-of-a-kind Premium

- **The extra cost of a First-of-a-kind (FOAK) plant arises from the following factors**:
  - Low economies of scale; with multiple orders manufacturers can offer bulk discounts;
  - Additional construction costs reflecting the 'learning curve';
  - A risk premium, reflecting the contingency element built into component and plant prices;
  - A profit element that takes account that there may not be any follow-up orders.
- **The FOAK premium may account for 10-40 % of the price of the first plant built:**
  - Mott MacDonald for the UK Government (2010);
  - University of Chicago Study (2004 and 2011);
  - Cours des Comptes (French national auditor, 2012)
- **Conclusion: Build a series of standard plants that can take advantage of global supply capacity.**

Components: What is needed



- **Typical amount for a Generation III Nuclear Power Plant:**
  - Pumps (~ 200)
  - Valves (5000+)
  - Piping (~210 km)
  - Cabling (2000 km+)
- **Non-NSSS equipment: 30-40% of cost**
- **Split between nuclear-grade and industrial grade equipment**
- **Engineering: civil, mechanical, electrical, software**

Challenges along the supply chain

- **Conformity to specification**:
  - Lack of orders has led to an erosion of capability to achieve exceptional performance.
  - Defects need to be picked by the QA system and rectified.
  - Human performance improvement programmes to reduce human error.
  - Manufacturing quality systems like Six Sigma (6σ) to minimize defects.
  - Factory environment to assemble modules at the construction site.
- **Economies of scale:**
  - The lists of safety significant components and of components to which export controls apply differ between regulatory jurisdictions creating uncertainty for equipment vendors.
  - Lack of predictability in orders for new NPPs means that suppliers cannot spread the cost of an enhanced QA system for nuclear grade components over a long production run.
- **Enhancing the role of the Technology Vendors:**
  - There exists a split of authority for NPP fleet oversight between operators, the design authority and the Tier 1 technology vendors providing the Nuclear Steam Supply System (i.e. the nuclear reactor). This means that:
    - the control of modifications is dispersed and cooperation is informal (through owners groups); and
    - barriers may be created that prevent lesson learning from operations and decommissioning from feeding into the design of the model.

  The nuclear industry could become more like the aircraft industry.

Policy Challenges

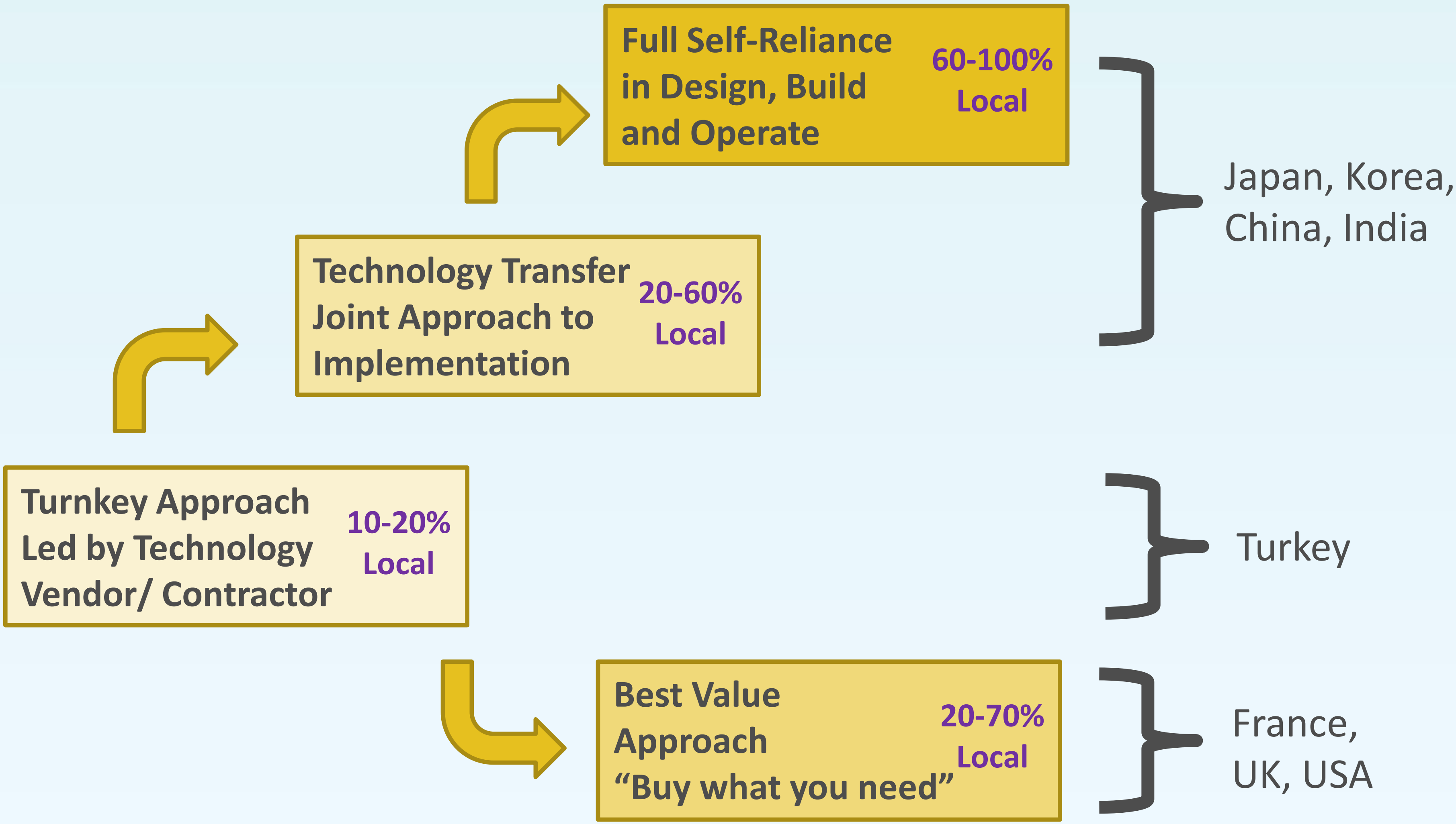
What makes nuclear power an attractive option?

- Developing the economy through localization of the supply chain
- Achieving energy security through market regulation
- Obtaining the appropriate finance

Localization

- **Encouraging high local content in investment projects is one tool for economic development:**
  - To transfer and embed technology and raise productivity;
  - To create employment;
  - To facilitate further foreign direct investment and indigenous economic development by upgrading the capacity among local suppliers.
  - To move the country's industrial sectors up the value chain.
- **But ….**
  - The strategy for localization has to be sustainable, so there must be a viable business case for each venture.
  - Each venture must be planned and evaluated on its merits. A local content policy founded on the premise that 'one size fits all' may be prohibited under the WTO Agreement on Trade-Related Investment Measures (TRIMs) and/or introduce programme delays.
  - Indirect employment gains may arise from cheap and reliable electricity.
- **Localization is desirable but not crucial to the success of a nuclear investment programme.**

Stages in Localization



Energy Market Regulation

Energy policies must reflect the differences between two types of energy market:

- **Price regulated energy markets**:
  - Regulator permits power producers to pass on the costs of current investment to electricity consumers (e.g. some US States including Georgia and South Carolina).
  - Market risk is borne by the consumers but they can influence the electricity prices they pay through the political process.
- **Liberalized energy markets:**
  - Regulator encourages competition among power producers (e.g. some US States).
  - Regulator encourages competition among power utilities for customers (e.g. some EU States).
  - Market risk is borne by the companies.

Energy Market Coordination

Energy polices should be coherent but not over-prescriptive:

- **Long-term energy planning:**
  - Who is responsible for security and continuity of power supply: the government, the regulator or the utilities?
  - Price signals must accompany policy objectives. Companies need to convince their shareholders and bankers and they will not act without an economic incentive.
- **Choice of technology:**
  - Who decides the technology for power generation: the government, the regulator, the utilities or the consumers?
  - Cost effectiveness must accompany public preferences. Consumers need to be engaged on the merits of energy technologies.
  - A mechanism is needed to set a floor to the price of power from low carbon sources to encourage investment (e.g. UK and possibly the EU in the future).

Financing Nuclear Power Plants

Options for finance are affected by the regulatory model:

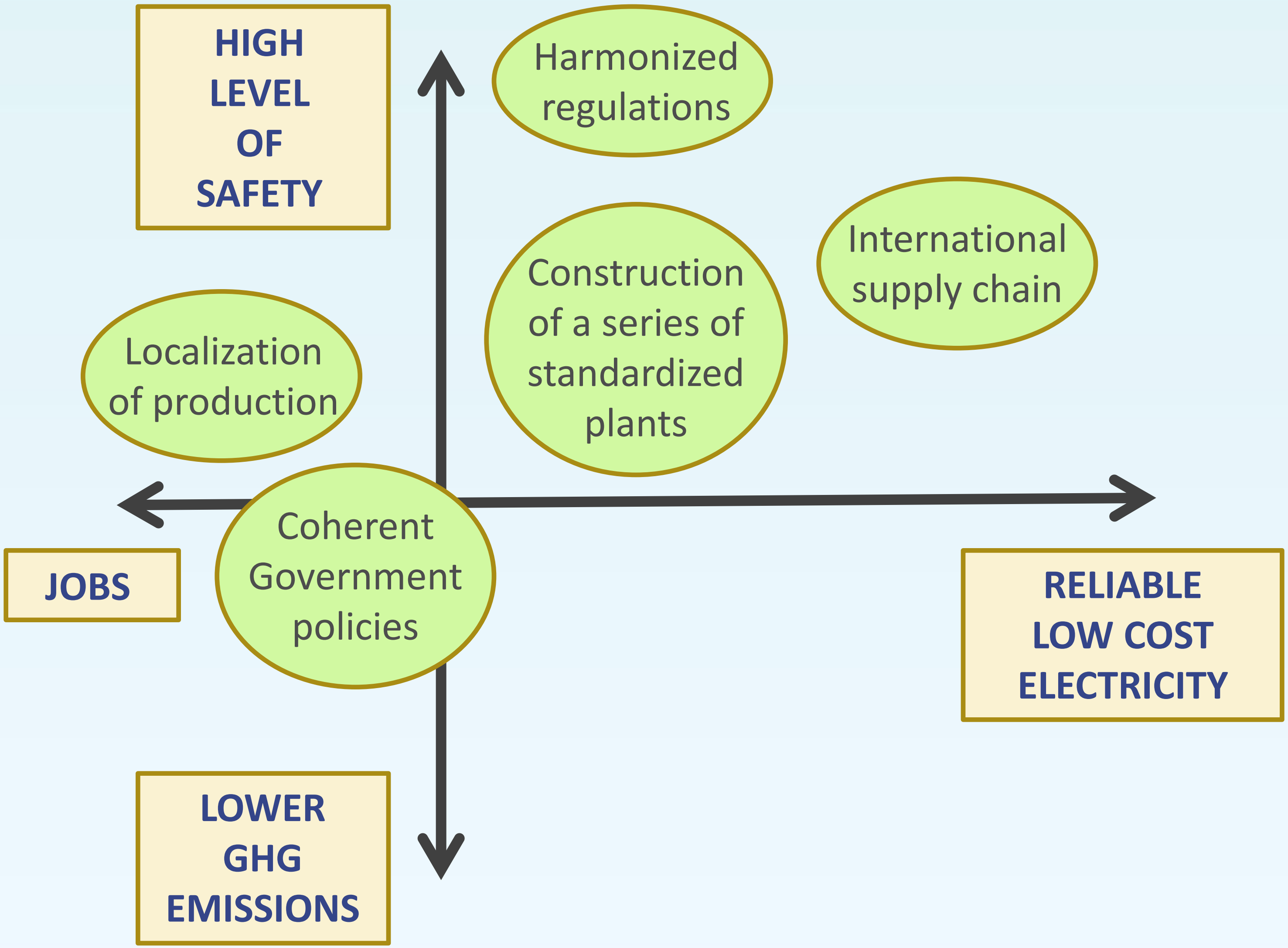
- **Corporate finance**:
  - Energy utility issues bonds to raise the investment and records this in its accounts;
  - A nuclear power plant is a major investment and may ‘crowd out’ other investment opportunities;
  - Difficult to attract strategic (minority) partners to share the risks (technical, regulatory, commercial, societal/political).
- **Project finance:**
  - Energy utility establishes a special purpose vehicle with strategic partners;
  - Higher financing and transaction costs;
  - Hampered by uncertainties (technical, regulatory, commercial & societal/political risks);
  - Unsuitable for financing a series of NPPs unless supported by government loan guarantees.
- **Development finance:**
  - Largely unavailable but would enable the financing of a series of NPPs to meet rising electricity demand;
  - Possible finance partners are the European Bank for Reconstruction & Development, European Investment Bank, Asian Development Bank, Development Bank of Japan, Japan Bank for International Cooperation, Islamic Development Bank, World Bank, etc.

Governments need to provide a stable long-term framework to encourage low carbon capacity for the electricity system.

Some key issues facing the nuclear industry

- **Standardization of safety requirements:** e.g. Unified list of safety-related components that is accepted by regulators.
- **Harmonization of Third Party Conformity Assessment:** A global supply chain calls for 'one-stop' supplier certification and monitoring of nuclear grade component manufacturers for their QA program. Some **vendor and client coordination** would be required on an industry-wide basis.
- **Technology Vendors to be awarded recognition for their control of their supply chains in delivering exceptional performance:** A more **cooperative regulatory regime** between national regulatory bodies for nuclear safety and with technology vendors would encourage innovation and improve safety and competitiveness.
- **Localization:** Local content policy should be part of national economic development policy. **Direct employment** is created from the 'backward linkages' in the value chain through the processing and manufacture of basic materials and intermediate products and services. Transfer of **experience and learning** are critical for sustainability.
- **Long-term planning of the energy system:** Utilities need to be able to plan for long-term energy security within a regulatory framework that promotes environmental responsibility but is **neutral on the choice of technology**.

Optimizing for results



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