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# Scope and Options for Refurbishing Existing Facilities

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# HYDRO POWER PLANT MODERNIZATION SCOPE DEFINITIONS (I)

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**Modernization (beyond maintenance) consists of:**

- **Plant Rehabilitation to restore it to its original design performance. Improves plant reliability and extends service life**
- **Plant Upgrading is based on advances in technology, design and materials since the plant was commissioned or its last rehabilitation. Improves plant efficiency, output and reliability, extends service life and reduces losses**
- **Plant Automation is the replacement of obsolete and unreliable control systems with up-to-date technology. Enables an older power plant to be operated with the same degree of reliability/performance as a new plant**

# HYDRO POWER PLANT MODERNIZATION SCOPE DEFINITIONS (II)

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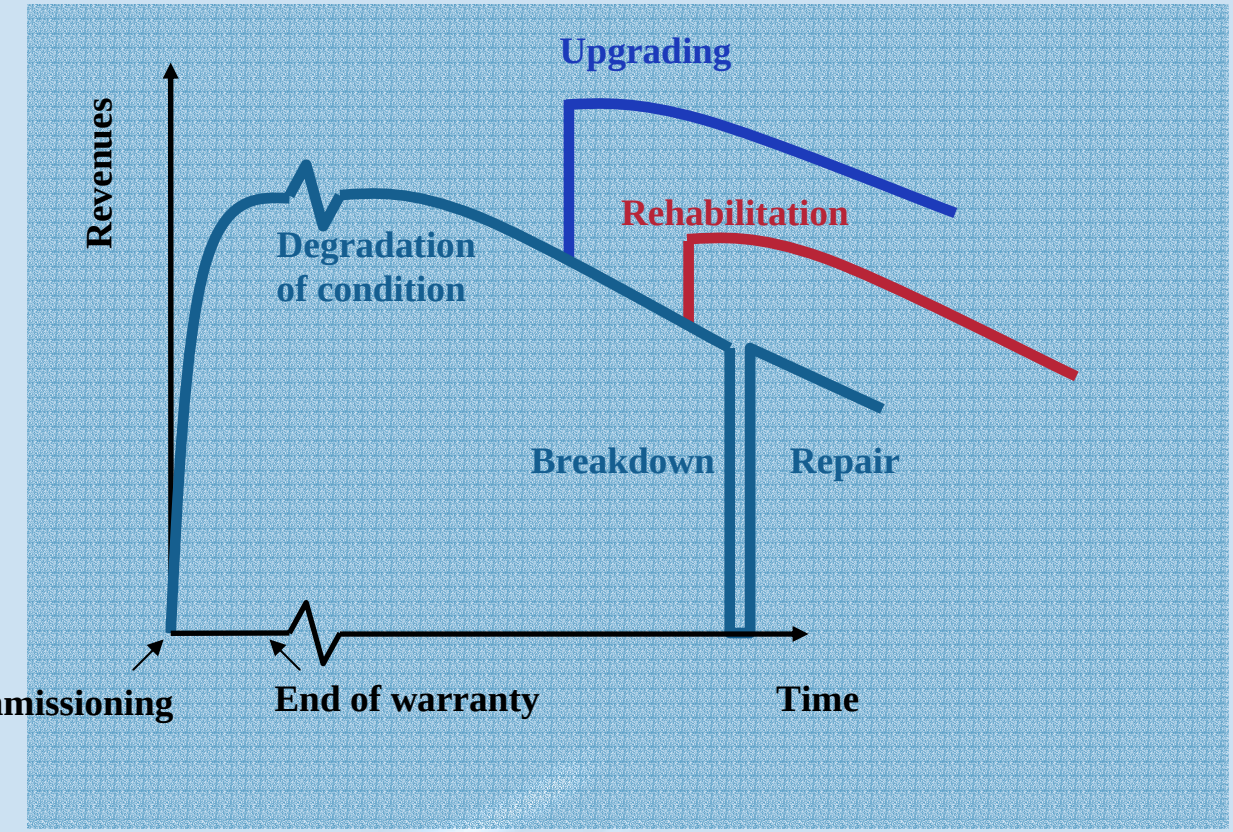

# ITEMS* IN HYDRO PLANTS THAT CAN BE MODERNIZED

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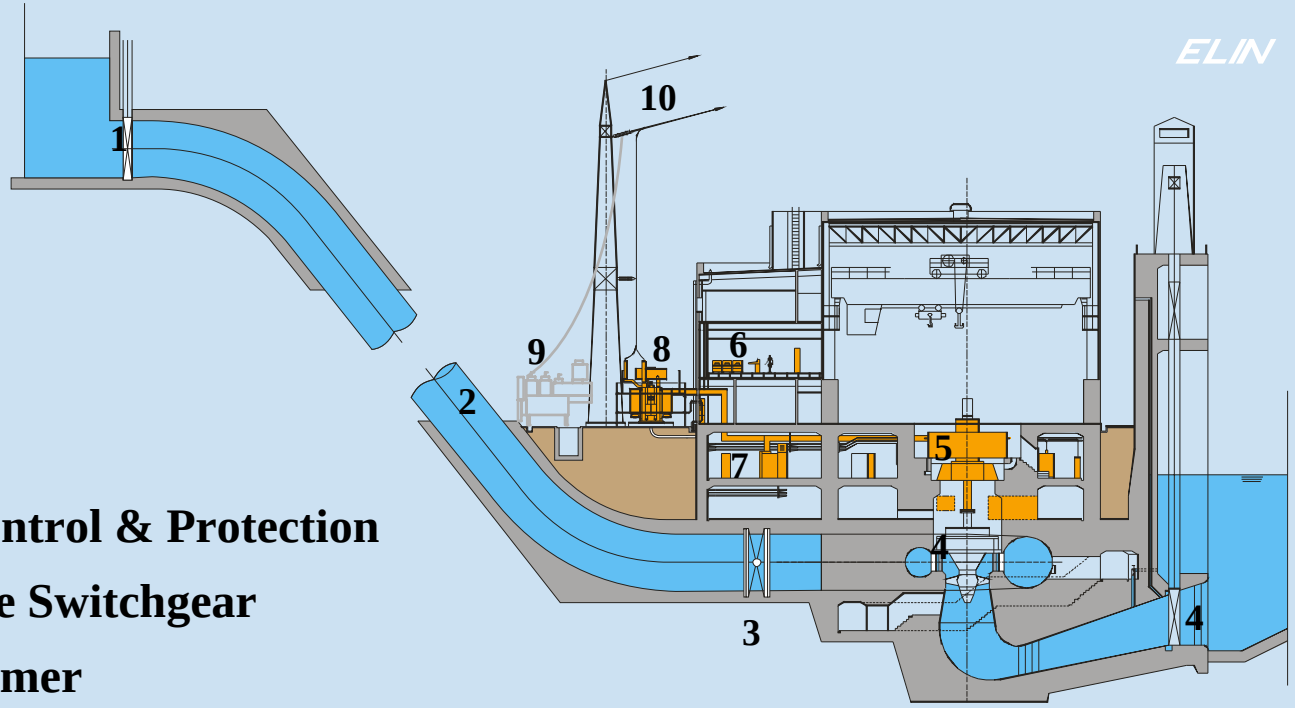
1. Gates
2. Penstocks
3. Inlet valve
4. Turbine
5. Generator
6. Automation, Control & Protection
7. Medium Voltage Switchgear
8. Power Transformer
9. High Voltage Switchgear (GIS)
10. Transmission Line




*Other than civil works

# TECHNICAL INNOVATIONS

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**Applicable new technologies in modernizing Hydropower Plants:**

- **VPI High Voltage Generator Insulation**
- **New Hydraulic Shapes to improve output and efficiency**
- **Use of surface coatings extend the Service Intervals and slow down efficiency decline**
- **Oil-free and Fish-friendly turbines**

# Paldang, Korea, 4 X 30 MW Bulb
# Head Increase of 2.2 m

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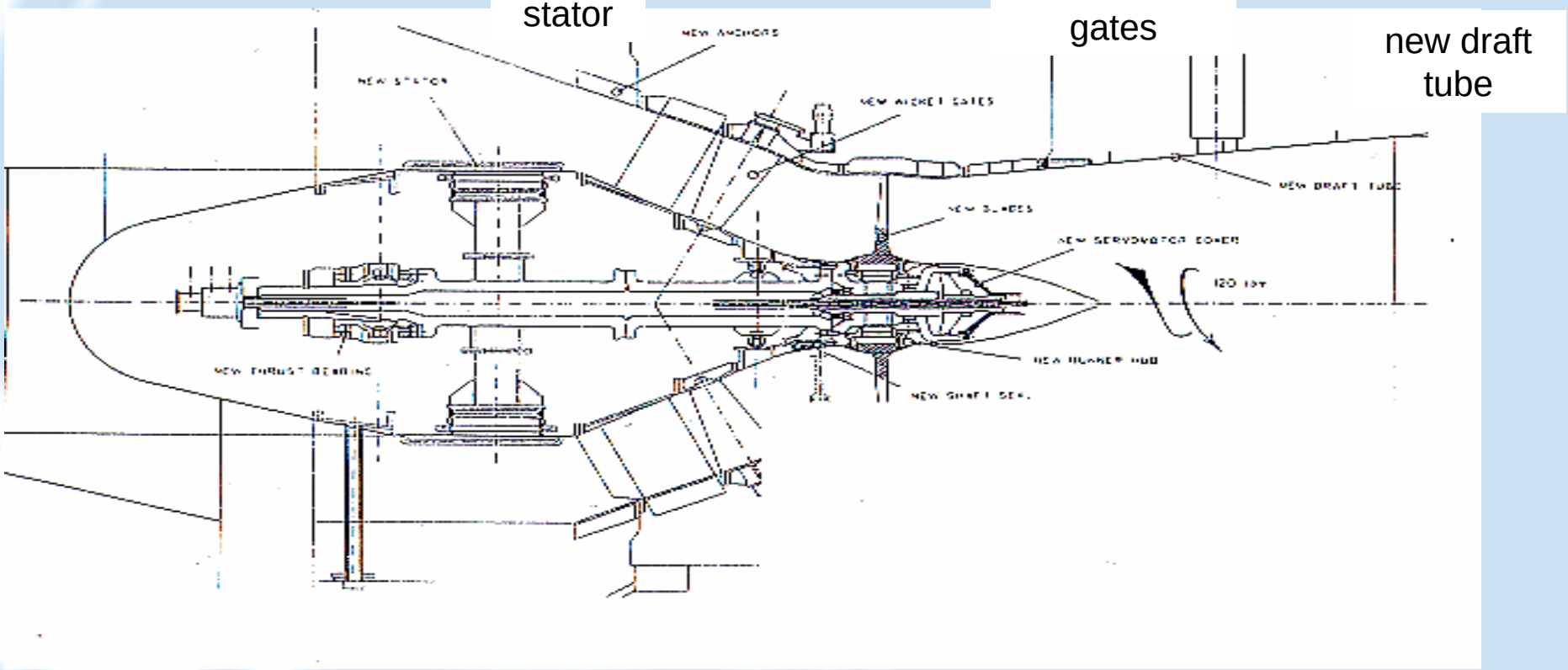
**Comprehensive Refurbishment with actual increases of 38% in energy generation and 50% in installed capacity (Source: Alstom)**

new stator

new anchors

new wicket gates

new draft tube



# CASE STUDIES:
# TENNESSEE VALLEY AUTHORITY (USA)

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**Upgrading of the Raccoon Mountain**
**1900 MVA pumped storage plant (built 1979),**
**Source: Voith Siemens Hydro**

**Project objectives:**
**increase plant capacity as well as plant reliability**

| Key Project Data | Pump Turbines | Generators-Motors |
|---|---|---|
| → Contract Award | → January 1998 | → December 1998 |
| → Unit Output Increase | → 422 MW→481 MW | → 425 MVA→476 MVA |
| → Efficiency Increase | → 1.62% - points (T)<br>→ 1.55% - points (P) | → 12% |
| → Others | → New/revised spherical valves | → Excessive vibrations eliminated |

# Why is Modernization favourable?

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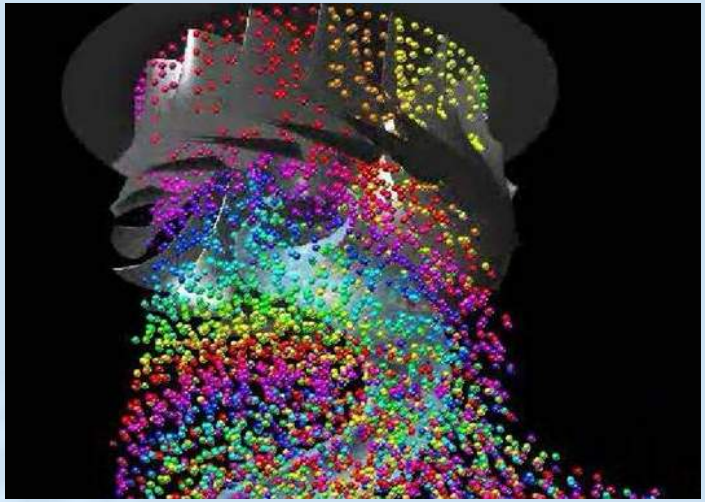
**Almost half of the total installed hydro capacity worldwide is older than 30 years.** And i**t pays to modernize existing hydro systems:**

- **Investments with short amortization times**
- **Efficiency improvement / output improvement**
- **Reduction of the maintenance costs**
- **Avoiding $CO_2$ emissions**
  **(Kyoto approach – European / intl. emission trading - JI/CDM)**
- **<u>NO</u> additional impact on the environment**



# Market Scope
# Global Annually Installed Capacity

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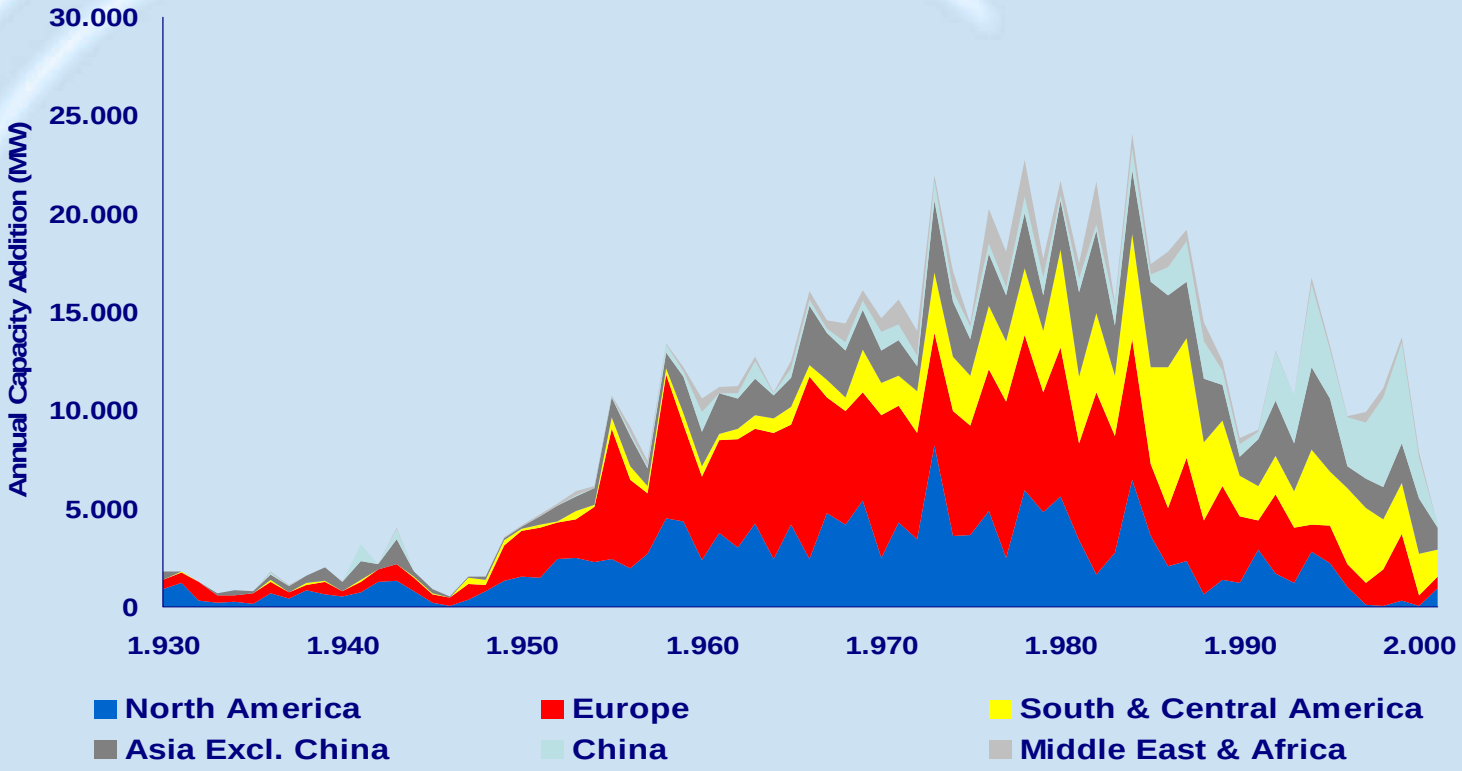


**The ageing of the existing installed base generates a strong underlying growth trend for modernisation**

# Hydro Modernization
# Market Scope

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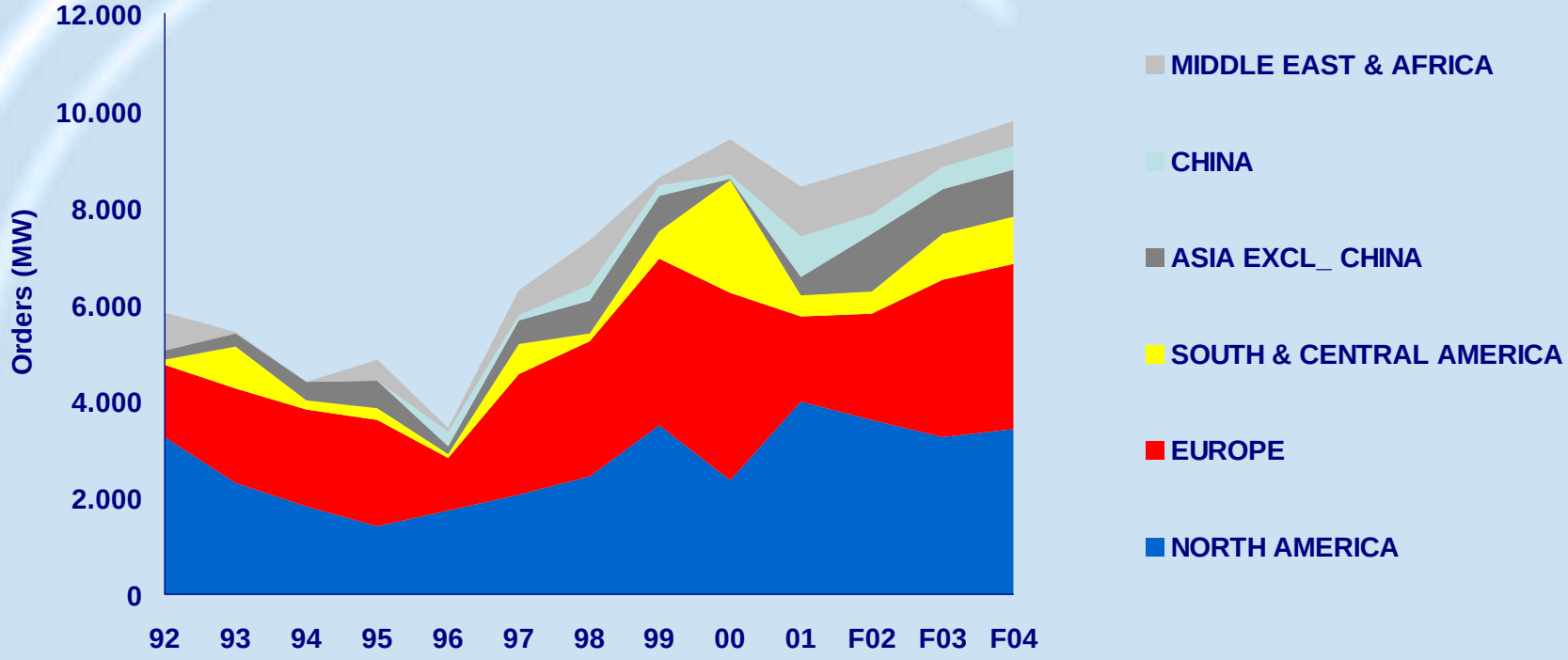


**Total Orders for Refurbishment Close to 10 GW p.a.**
**With 100 US$/kW this requires 1000 mUS$!**
**NAM and Europe Remain the Main Markets (70% of Total)**

# Certificate Subsidies Increase Market Scope (Source: VA Tech)

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## Refurbishment: Renewable Obligation Certificates

### Output Improvement of Hydropower Plants in the UK

- Legal initiation through ROC's (=Renewable Obligation Certificates) in 2001. Increasing the share of renewable energies up to 2010 is subsidized.
- Investments in the refurbishment of existing small hydropower plants.

| Cruachan | Gaur | Aigas | Kilmorack |
|---|---|---|---|
| Output improvement: +30% | Output improvement: +12% | Output improvement: +5% | Output improvement: +5% |
| **$CO_2$ reduction: 130,000 t/year** | **$CO_2$ reduction: 4,000 t/year** | **$CO_2$ reduction: 4,800 t/year** | **$CO_2$ reduction: 4,800 t/year** |




# BENEFITS AND COSTS OF HYDROPOWER PLANT MODERNIZATION

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- **Plant modernization can extend plant capacity at a fraction of the cost of greenfield plant capacity. For example, the USBR has undertaken a major program of upgrading its hydro power electrical systems at an average cost of US$ 69/KW**

- **Example: Rehabilitating a Hydro Power Plant of 100 MW, producing 500 GWh per year, will cost about 8 - 15 m$ capital cost (80-150 US$/kW), generate a revenue of 15 m$ per year for an operating cost as low as 2,5 m$ per year (no fuel cost)**

**Low capital cost MW - Low operating cost MWh**

# SIMPLE EXAMPLE OF OPTIMIZATION ANALYSIS FOR UPRATE

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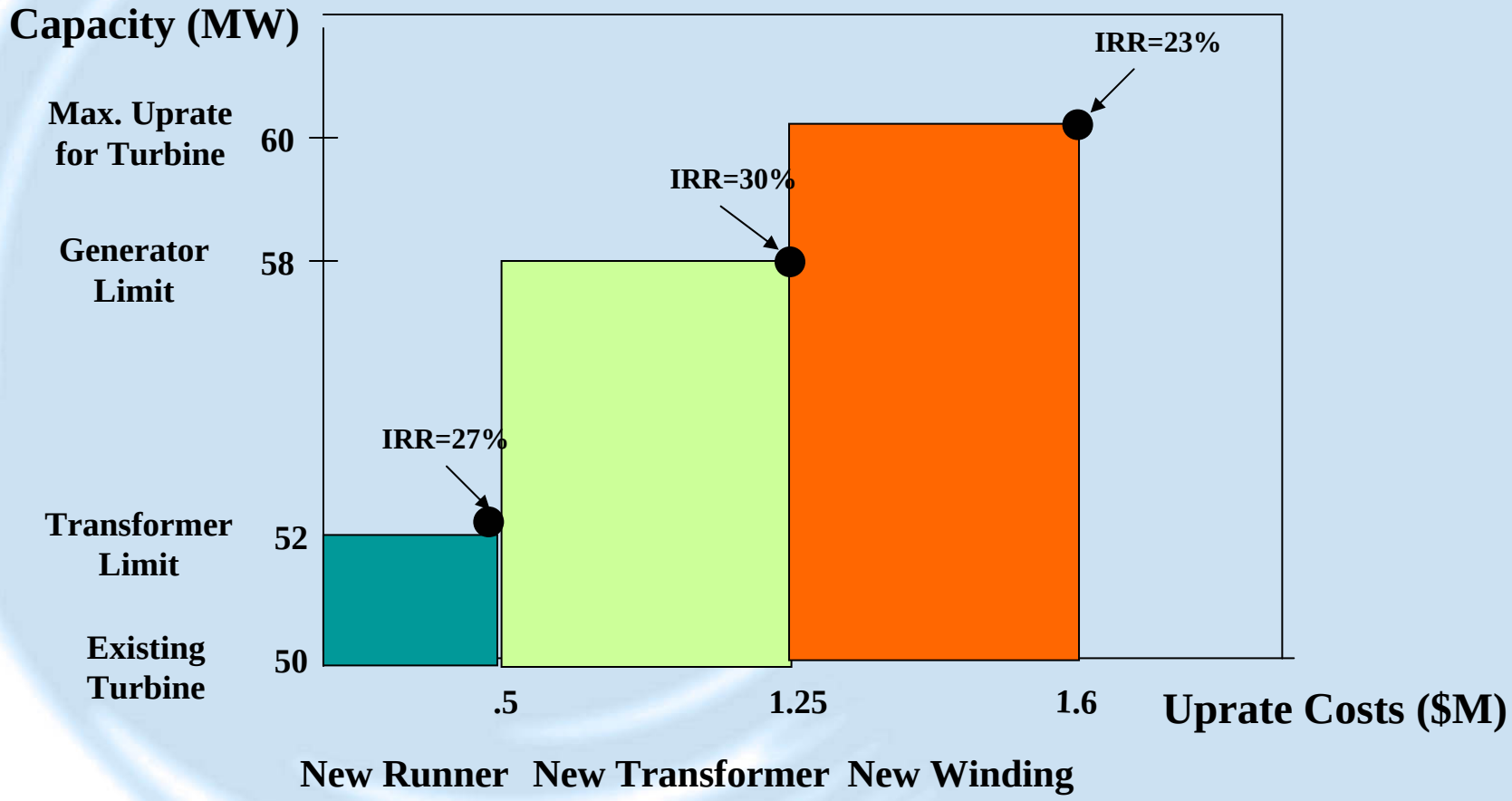


Source: VOITH SIEMENS HYDRO POWER GENERATION

# COST ALLOCATION TO SPECIFIC ENERGY INCREASES

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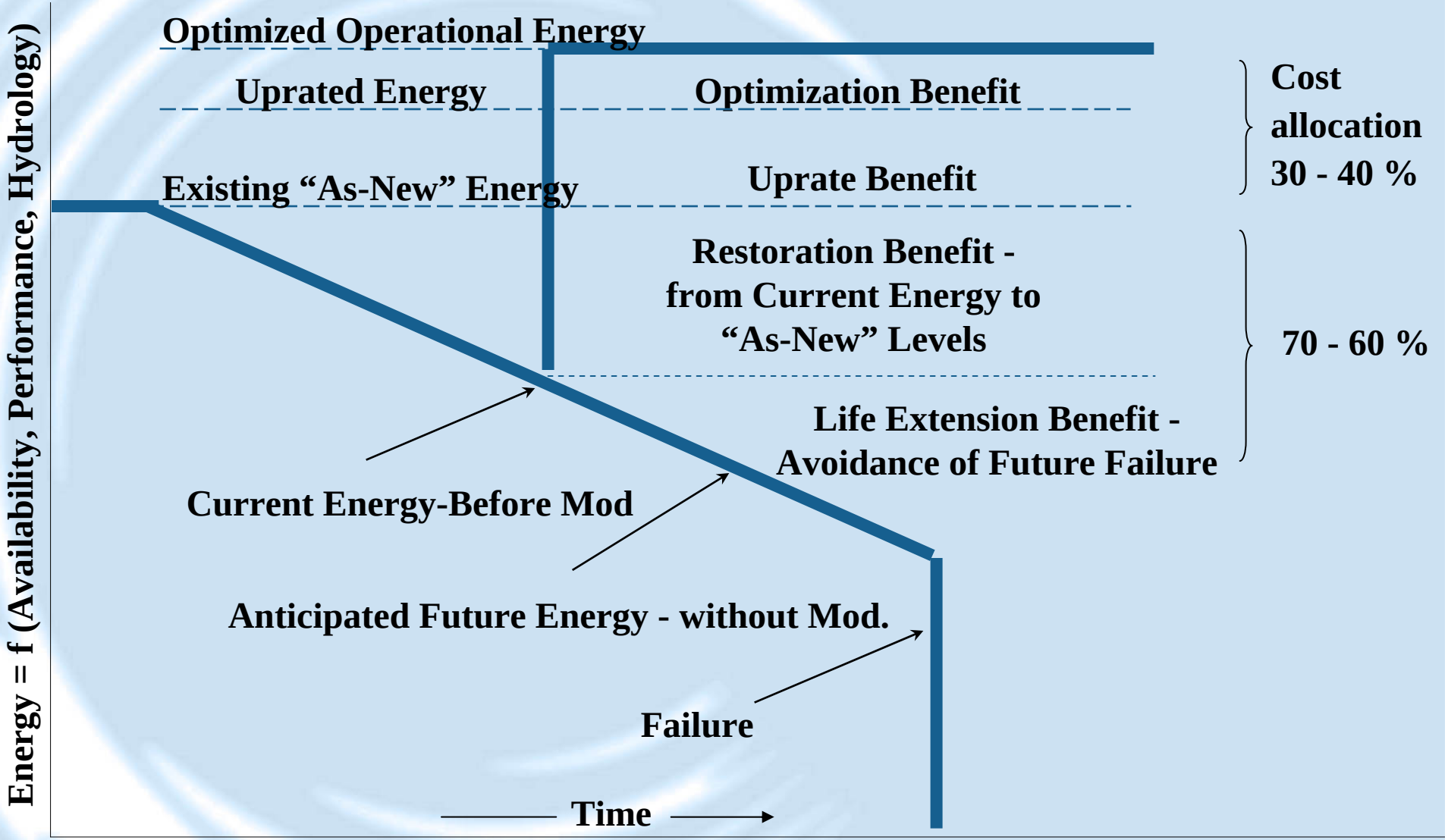


Source: VOITH SIEMENS HYDRO POWER GENERATION

# OPTIONS TO PROCEED

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- **Assessment of a number of preselected plants for prioritizing the plants to be modernized according to the highest IRR**
  - **a) either through a Consultant**
  - **b) or in direct cooperation with one or more potential supplier(s)**
- **Result of the assessment phase:**
  - **scope and cost of modernization**
  - **power output,revenues,operating cost**
  - **schedule**
  - **IRR**

# EVALUATION OF ALTERNATIVES (I)

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**Alternative a): Consultant**

- ⊕ **independance of supply interests**
- ⊕ **standard procedure of development banks**
- ⊕ **integrated approach for all plant elements**

- ⊖ **supplier´s special modernization know how introduced only indirectly**
- ⊖ **scope/specification does not reflect special supplier technologies**
- ⊖ **contract wording and performance inherently based on diverging interests of customer,consultant and supplier**

# EVALUATION OF ALTERNATIVES (II)

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**Alternative b): Supplier**

⊕ **special supplier´s know how and technologies lead to optimized scope and most precise cost information**

⊕ **performance based contract with bonus/malus system leads to common interests of customer and supplier during contract execution in achieving highest IRR**

⊕ **shortening of time to re-commissioning by approx. one year increases return**

⊖ **corresponds to „+“ of alternative a)**

# EXAMPLE OF SAVINGS FOR BEING ONE YEAR EARLIER ON LINE

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- **Assumptions**
  - **20 MW Plant**
  - **50% Capacity Factor**
  - **Average Value of Incremental Generation = $30/MW-HR**
  - **Total Project Value = $4M (Life Extension & Uprate)**
- **Calculations**

| | Capacity Increase | | |
|---|---|---|---|
| | 10% | 15% | 20% |
| ΔMW | 2 | 3 | 4 |
| ΔMW-HRS | 8,760 | 13,140 | 17,520 |
| ΔRevenue | $263K | $394K | $525,600 |
| % of Total Contract (Life Extension & Uprate) | 7% | 10% | 13% |

# EVALUATION OF ALTERNATIVES (III)

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**Possible solution for combining advantages of a) and b):**

- → **consultant responsible for the overall project management integrating the environmental and regulatory tasks,the civil construction tasks and the equipment tasks**

- → **equipment tasks (starting with the assessment) performed on the basis of „performance based contracting“**

- → **different suppliers work on different projects**

- → **competitive benchmark of results (IRR´s) before approval of project execution**