GE Hitachi
Nuclear Energy

Life Extension and Power Uprates

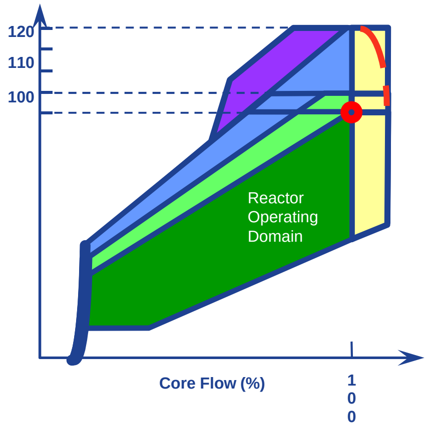
James Carneal
Program Manager -
New Product Introduction

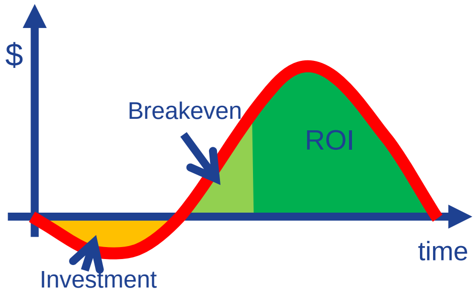
HITACHI

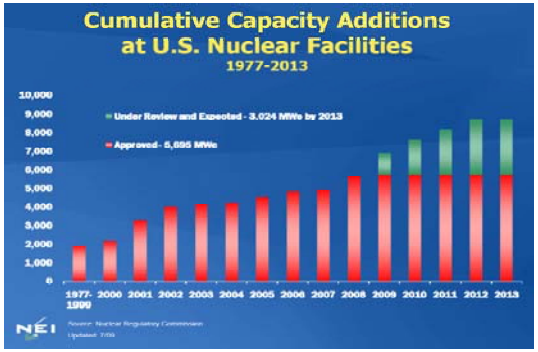
2011 LB60 Workshop
February 22-24, 2011
Washington, D.C.

Outline

- EPU Fundamentals and Economics
  - How do you achieve EPU
  - EPU: higher steam quality, FW, Steam flows.
  - Economics
- Primary concerns with EPU
  - Impact on Reliability, Design, Materials
  - Typical EPU Mods/Pinchpoints
- Impact of EPU on Plant Life Extension
  - Current EPU Experience
  - Survey of Literature
  - What are primary concerns







HITACHI

EPU Fundamentals

EPU Fundamentals

How EPU is achieved:

- EPU reclaims the margins available in the original plant design configuration
  - more realistic state-of-the art analysis methodologies.

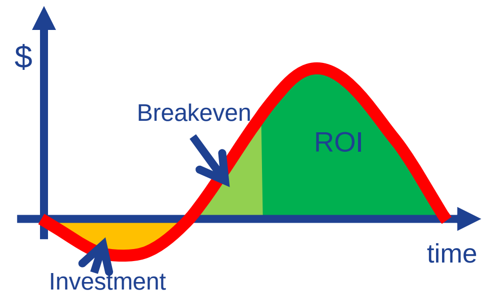
- Higher performance equipment is installed to maintain safe plant operation.
  - The majority are in the Balance-of-Plant & Turbine/Generator areas.

HITACHI

EPU Fundamentals

Economics:

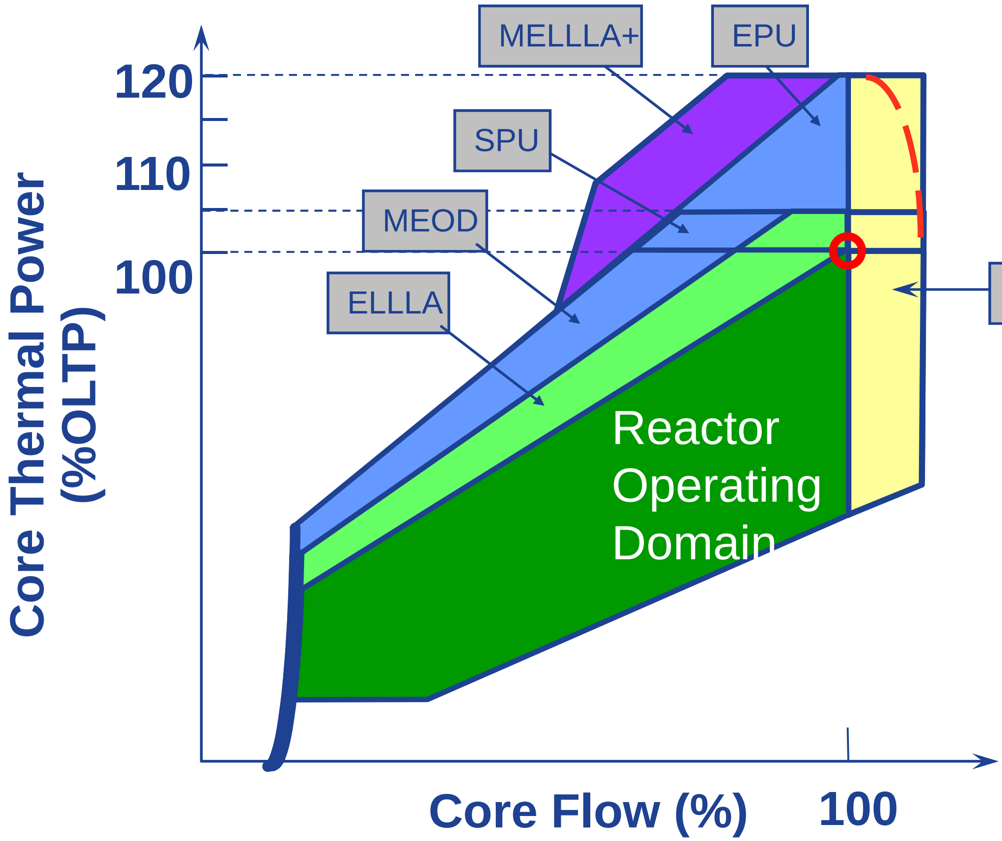
- The utility's decision on power uprate is based on a cost/benefit evaluation
  - must meet the financial metrics & long-term asset management plan.



- Regulatory approval to operate an additional 20 years
  - a large positive factor in the cost/benefit evaluation.


Generic Aging Lessons Learned
(GALL) Report

EPU: Operational Domain



MELLLA+ = MELLLA Plus

EPU = Extended Power Uprate

SPU = Stretch Power Uprate

MEOD = Max. Ext. Op. Domain

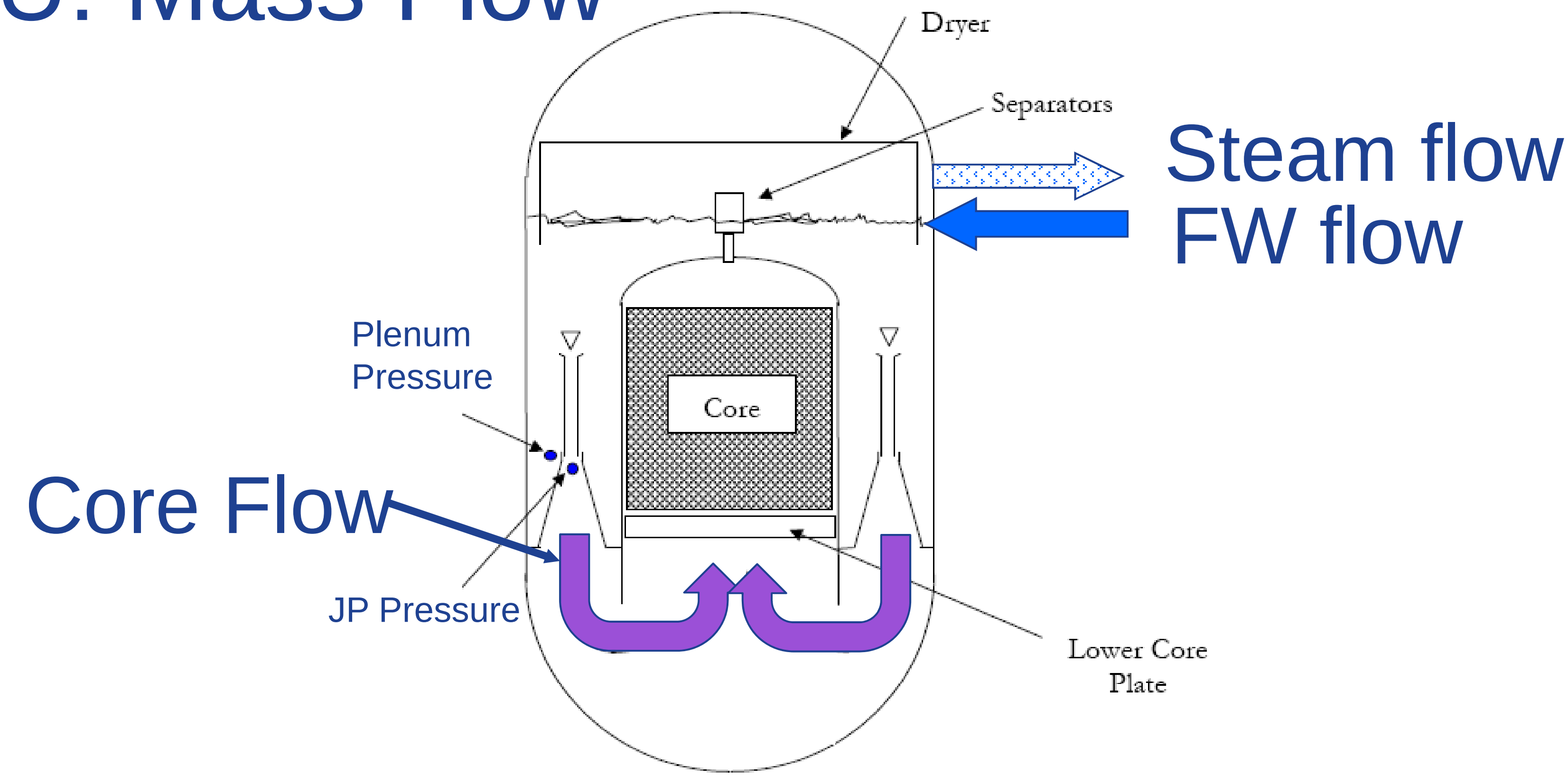
ICF = Increased Core Flow

ELLLA = Extended Load Line Limit Analysis

OLTP = Original Licensed Thermal Power

- EPU will reduce both ends of the core window at rated power conditions.
  - Min core flow state point will "increase"
  - Max core flow state point will be reduced

EPU: Mass Flow



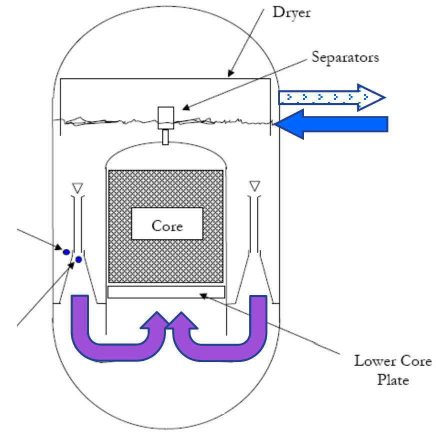
- EPU results in increased Feedwater flow/Steam flow:
  - Core flow: small effect since Recirc flow.
- EPU effect: 1-2% increase in core dP
  - <1% increase in JP SJ dP
  - Reduction in maximum core flow capability

HITACHI

JP/EPU: EPU without Core flow increase?

Example #'s from BWR/5-251, CLTP 105%

	CLTP and ICF (105% CF)	EPU (120% OLTP, 104% CF)
Steam Flow / FW Flow (Mlb /hr)	15.1	17.7
Core Flow (Mlb /hr)	114 (7.5*steam)	112.7 (6.3*steam)
Steam Quality @ core exit	13.2%	16.2% (+3%)

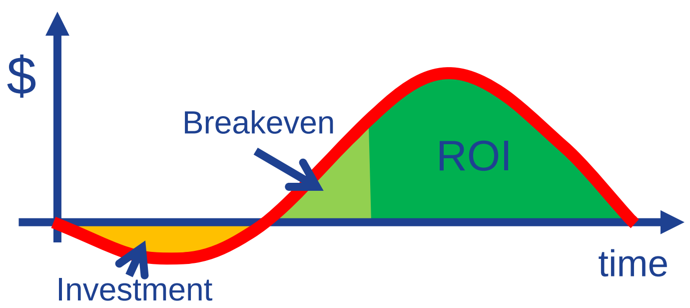


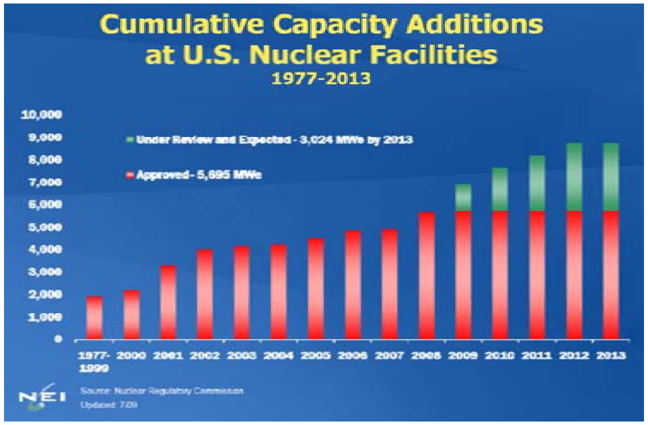
- Example calculation:
  - Core flow is 6.3 times more than steam/FW flow.
- Steam quality is +3% more than OLTP.
  - 112.7/ 17.7 * 3%=19.0% more steam for same core flow.
- EPU achieved by increasing quality at core exit
  - multiplied by (recirc flow/steam flow) ratio.

HITACHI

EPU Economics

- Typical 120% power uprate :
  - cost approximately $250MM to $500MM.
- Plant economic and plant safety:
  - better reliability/availability performance
  - more robust and advanced designs of equipment upgrades/ replacements.
- 7 plants at 150MWe uprate = 1 new 1100 Mwe plant
  - Cost: $1.75B to 3.5 B versus $10+B

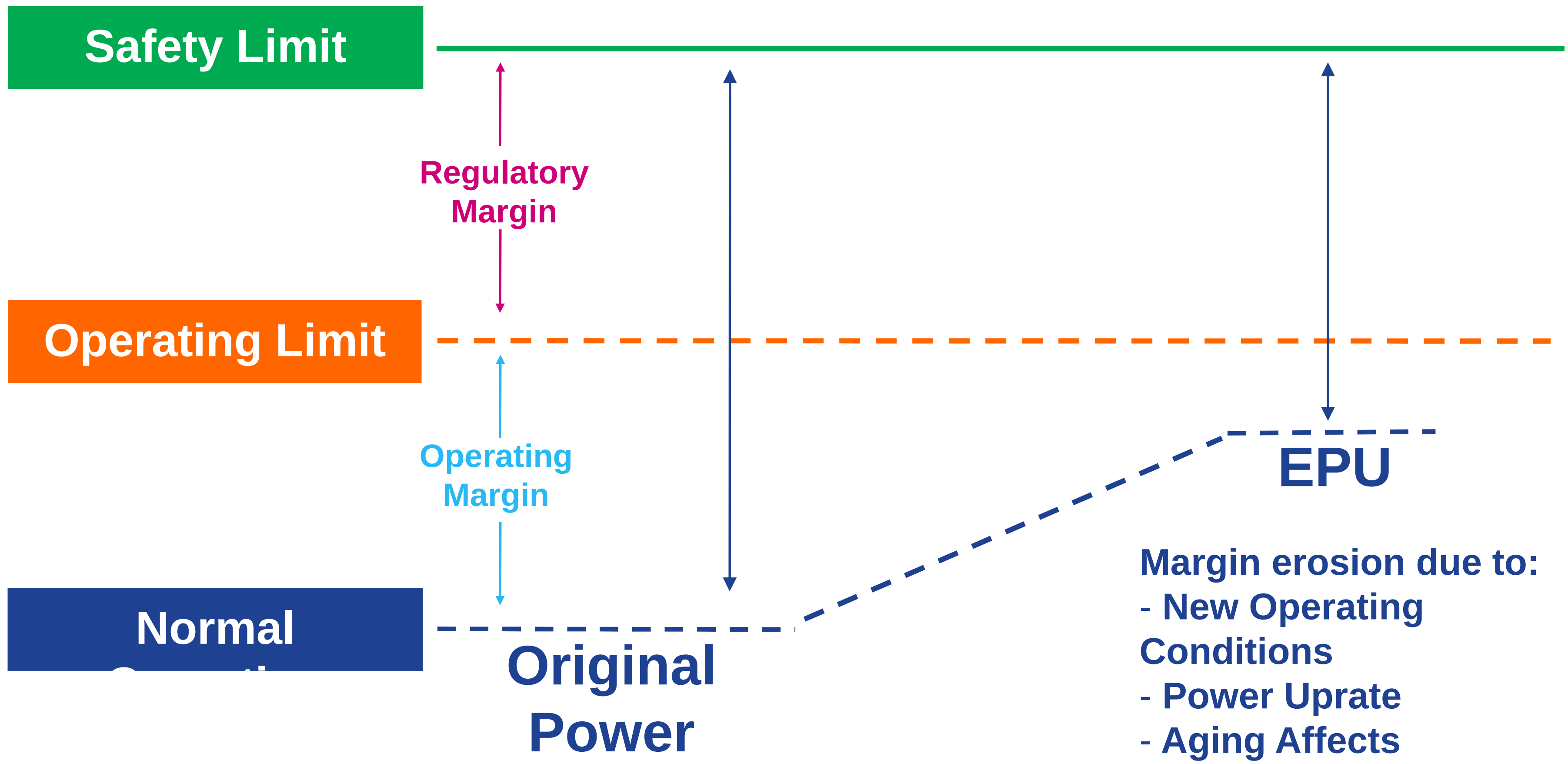




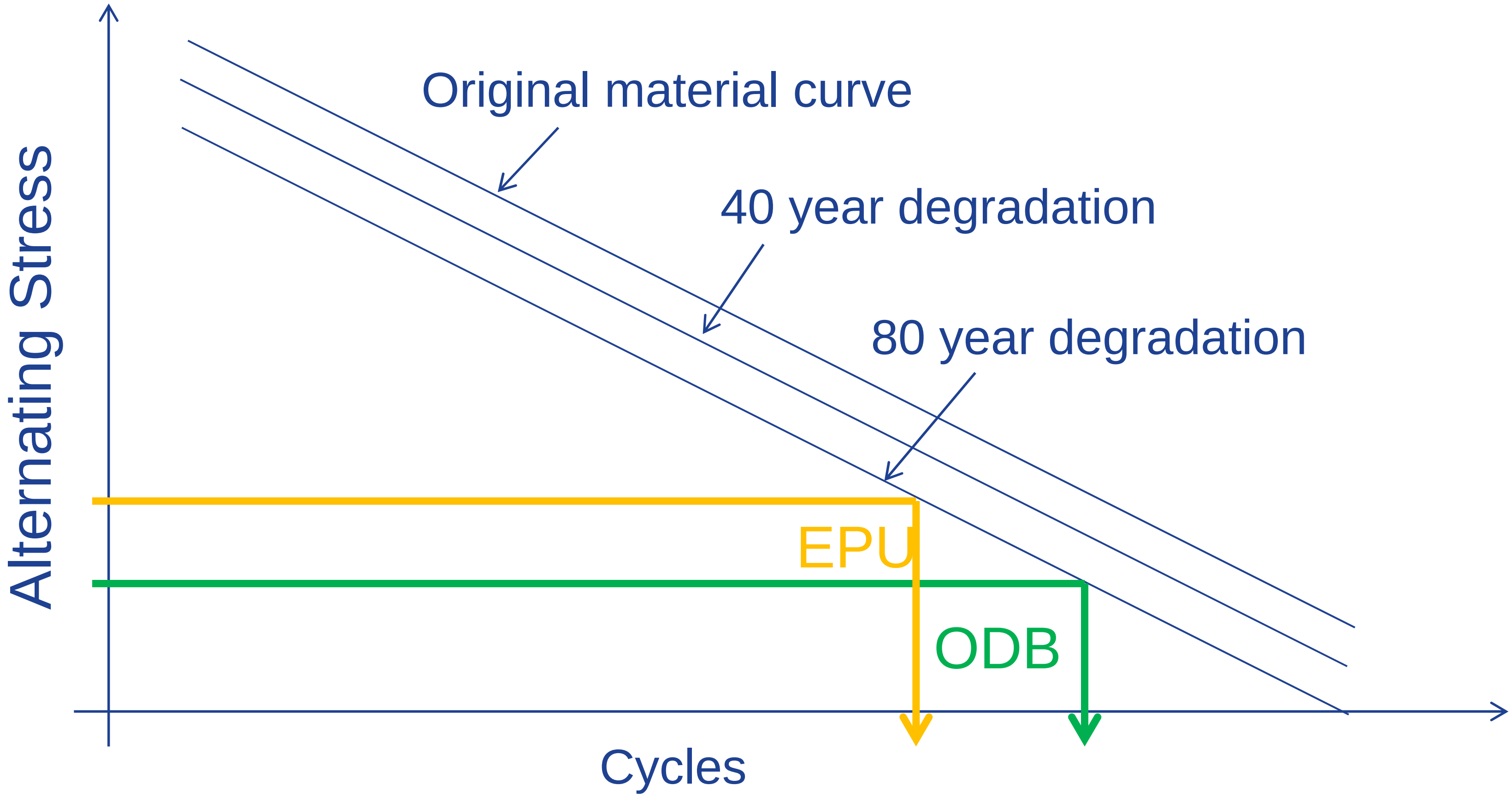
HITACHI

Primary Concerns

Impact on Reliability & Design Limits



Impact on materials



- Need to gage material life.

Summary of Typical EPU Mods

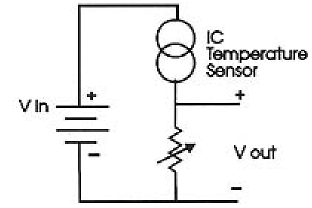
1) NSSS
- Steam dryer replacement/modifications
- Power Range Neutron Monitoring system

2) BOP upgrade/replacement
- Feedwater heaters
- Condenser tube staking
- Condensate pump and/or motor
- Condensate demin filter
- Moisture-separator reaheater
- Feedpump motor and/or blade
- Iso-phase bus duct
- Torus attached piping
- Switchgear
- Cooling tower fan

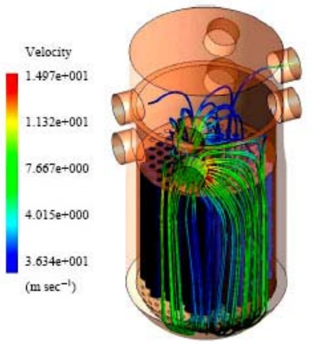
3) Turbine/Generator upgrade/replacement
- High pressure turbine replacement
- Generator rewind
- Hydrogen cooler for generator

- Most utilities will include other hardware modifications to maintain equipment reliability, availability and/or higher efficiency.
- This is important to successful long-term EPU operation.

Non Hardware-Related Pinchpoints



1) Set point changes
   - calibrate to the new 100% rated thermal power condition
2) Reactor vessel overpressure design limit
3) Core thermal-hydraulic stability
4) Containment pressure/temperature limit
5) ATWS reactor vessel overpressure and containment P/T limit
6) RPV mechanical stress limit



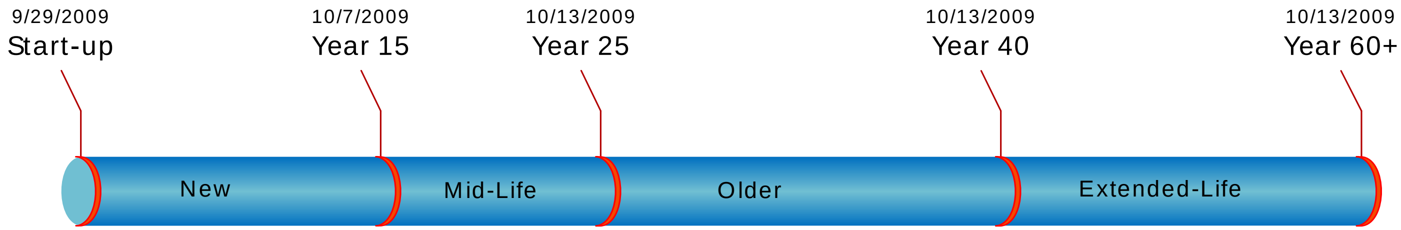
Notes:

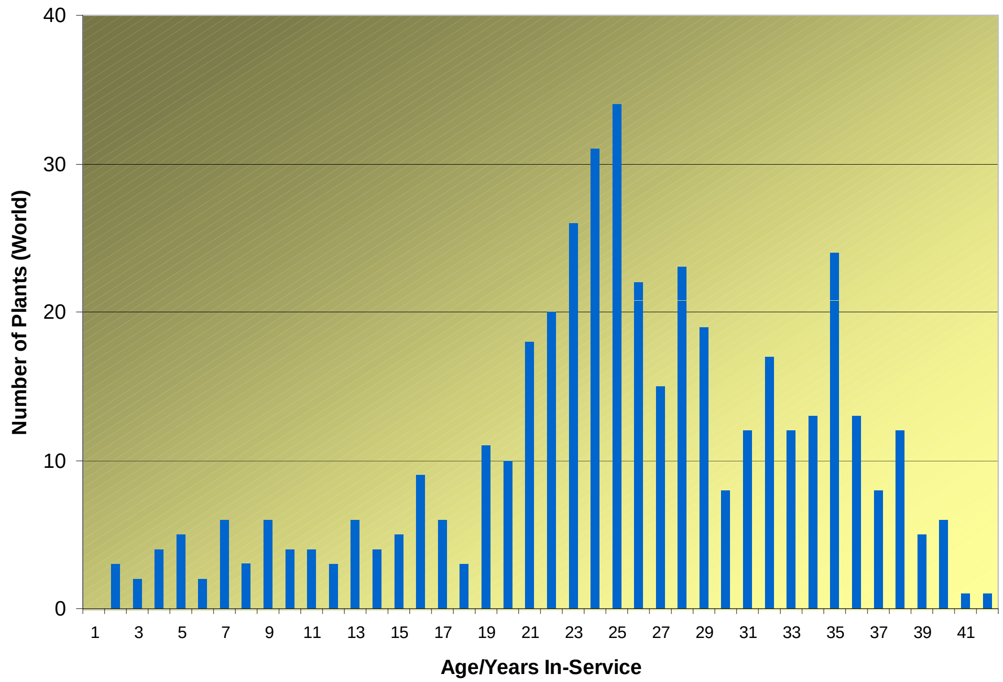
A) Except for item 1, the remaining pinch points are addressed by using refined methodologies to meet the respective safety criteria.
   - For example, use TRACG (3-D) vs. ODYN (1-D method) for items 2 and 5.

- GEH has not experienced a hardware mod/replacement resulting from the pinch points.

Impact of EPU on PLEX

World Nuclear Plant Age





Due to length of LE, plants will start as early as current regulations allow.

Source: IAEA

HITACHI

Factors Impacting EPU Planning

EPU Pinch Points

- Licensing safety margins requirements
- Hardware capabilities

Control System Capabilities

- Data Rates / Data Quality / Data Availability
- Digital upgrades improve Safety Margin

Design Basis Documentations

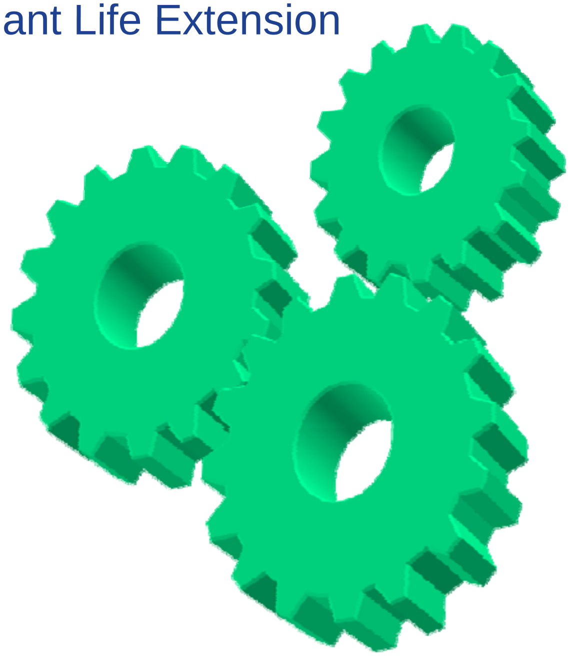
- Completeness/Quality
- Retrievability

Other Planned Initiatives

- Technical rework
- Licensing constraint

Operational Margins

- Equipment reliability/availability
- Plant Life Extension

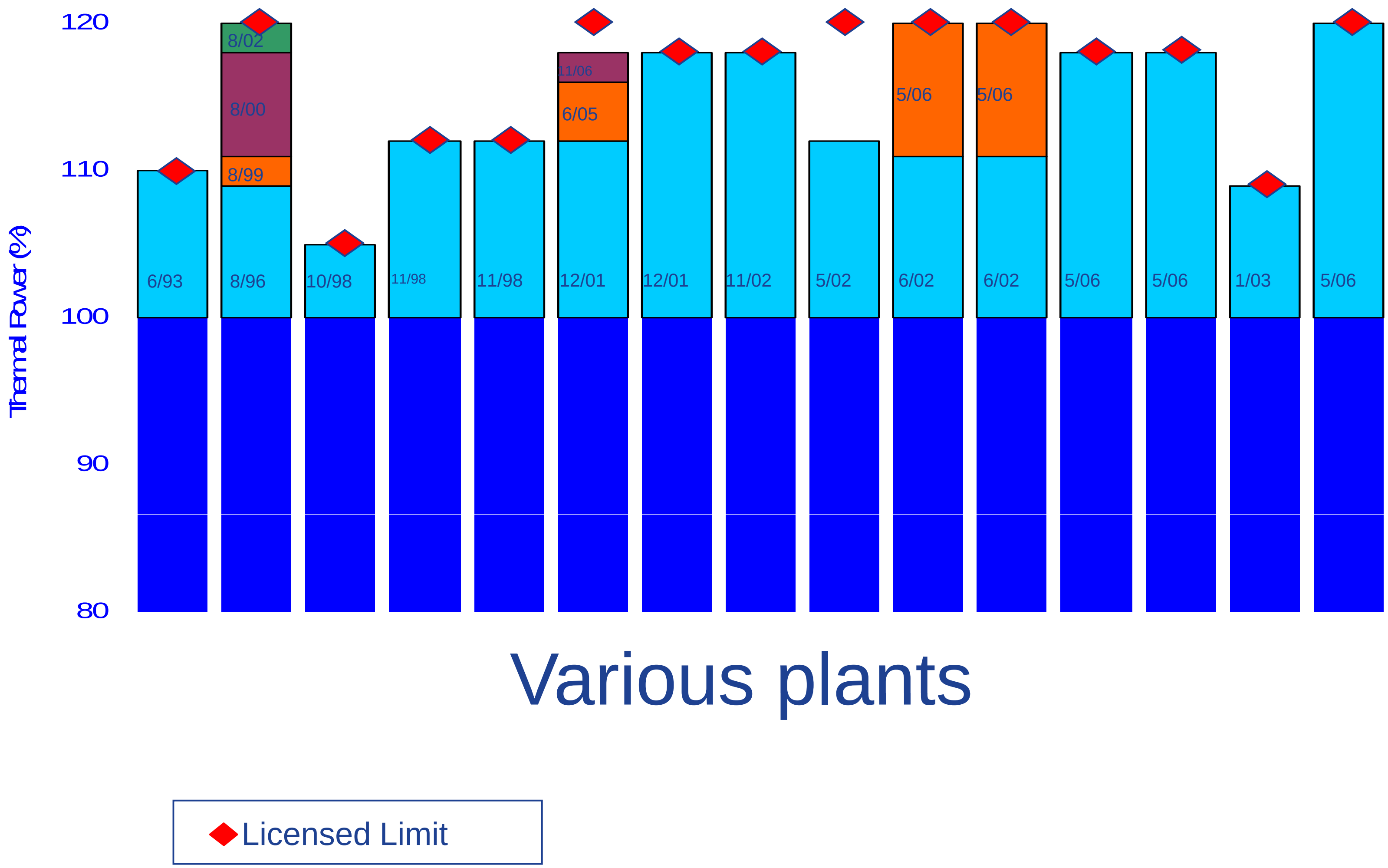


Project Management

- Utility/Vendors interface
- Resources

HITACHI

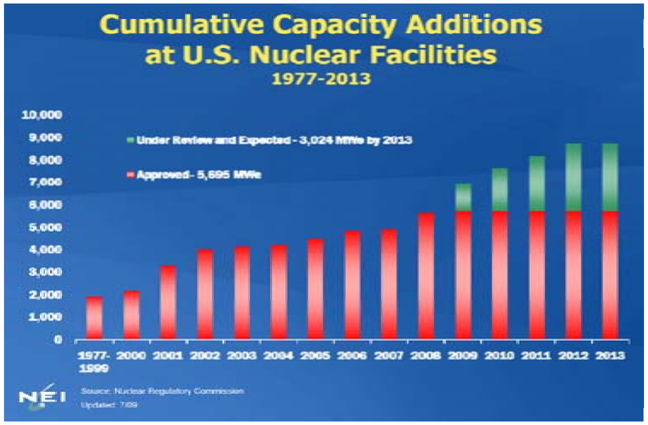
Extended Power Uprate Experience



HITACHI

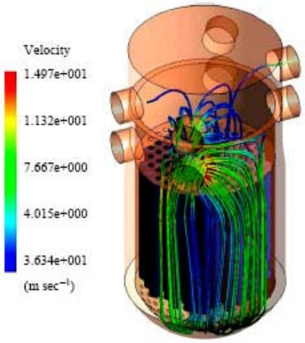
Current EPU Experience

- Several EPU projects were performed with 60-year plant life assumptions
- No resulting plant modifications linked to the 60 year assumption have been experienced
- Safety licensing criteria (such as CUF<1.0) are met with current or improved methodologies
    - Some plants are very close to operational limit, and additional actions may be necessary
- Is the trend going to be the same for +60 plant life condition?



HITACHI

Literature Survey- Potential EPU Impacts



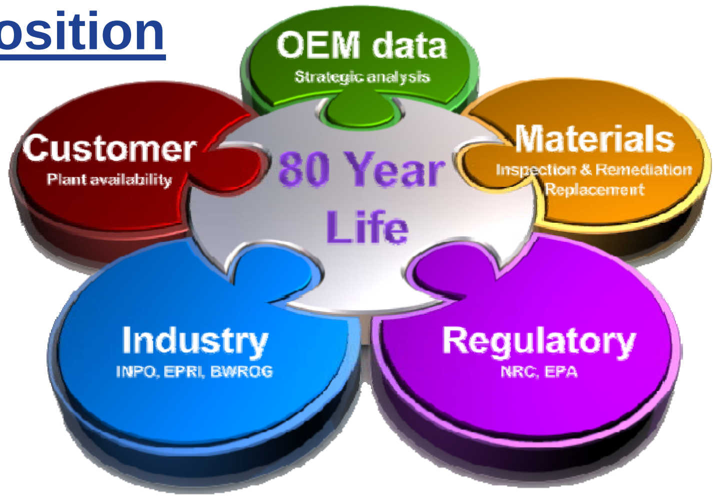
- RPV and Internals embrittlement
  - Increased fluence
  - Potential regulatory changes
- Water availability/conservation
- Cable Aging
  - Impact varies with plant specific application
- Concrete exposed to high temperature and radiation
- Weld Techniques – Repair of irradiated materials
- Other Non-technical:
  - Lack of cohesive domestic Research Infrastructure.
  - Shortfall in trained workers at all levels.
  - Public Opinion and Policy.

and the list goes on…

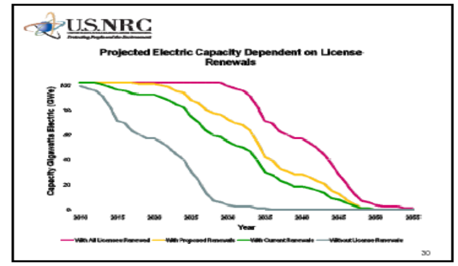
HITACHI

GEH PLEX Effort

Strategic Position



Opportunity



- Clear Utility cost-benefit… ↑life versus NPP.
- Increased Federal regulation (NRC and EPA).
- GEH will be engaged with industry, regulatory and customers for PLEX.

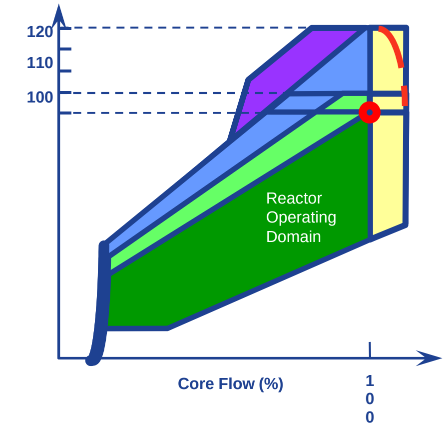
Timeline

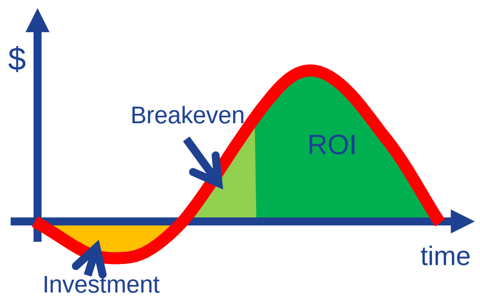
Initial Goal: *80 Year Life Asset Management Strategy and White Paper*

- Clear strategic direction based on data analysis
- Clear cost/benefit analysis of future potential markets
- Multi-Generational Product Plan from short-term to long-term

What will be Life Limiting?

- Currently no known generic issue that will limit plant life to less than 80 years
- Industry must develop technical bases for high risk life limiting issues
- Individual plants must assess their risk and
  - Maintain mitigation/contingency plans for high risk issues, and
  - Maintain life cycle and aging management to avoid obsolescence





HITACHI

QUESTIONS ?

Thank you!