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Managing Water in the West

Mt. Elbert Start/Stop Costs and Ongoing Integration Cost Studies

U.S. Department of the Interior
Bureau of Reclamation

Reclamation Overview

- 58 Powerplants
- 194 Units
- 14,876 MW Installed Capacity
- 2nd Largest Hydropower Producer in United States
- 40 Million MWH Annual Average Net Generation
- Approximately 10 Percent of Power in West
- Power distributed by Power Marketing Agencies
- Annual Carbon Offset – 27 Million Tons

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Bureau Of Reclamation
Mt. Elbert Pump/Generating Plant
Fryingpan-Arkansas Project
Colorado

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Mt Elbert Pump/Generating Plant

- 2 – 105 MVA Pump/Generators
- 170,000 HP Pump Mode
- Constructed – 1981/1984
- No Major Rehabilitations
- Approx. 10,000 ft elevation

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Drivers

- 1997-2001 Increased Starts and Stops
- 1999-2001 Increased Outages
- Reclamation and Customer Concerns over Availability and O&M Cost

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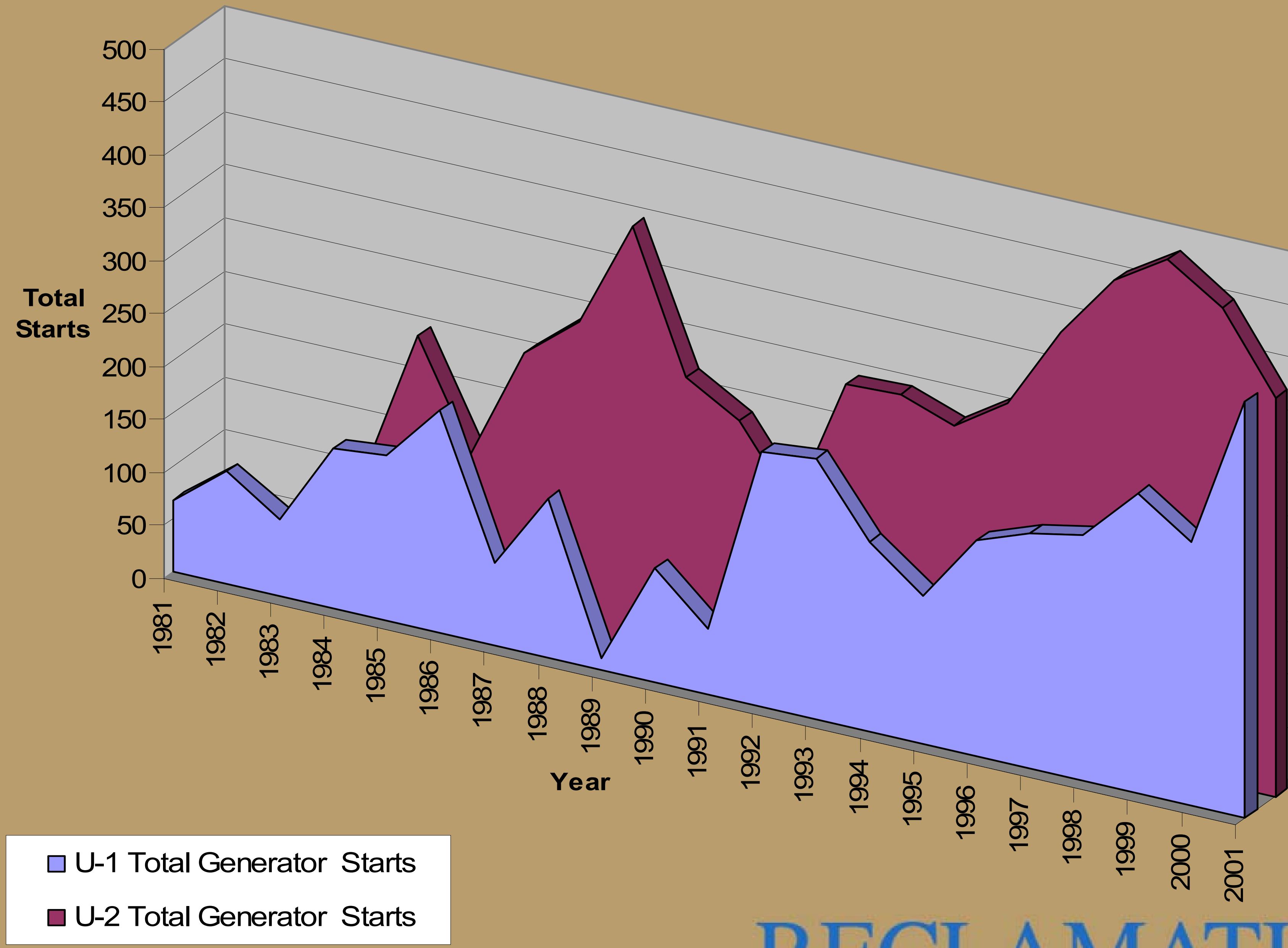
Unit 1 & 2 Generator Starts



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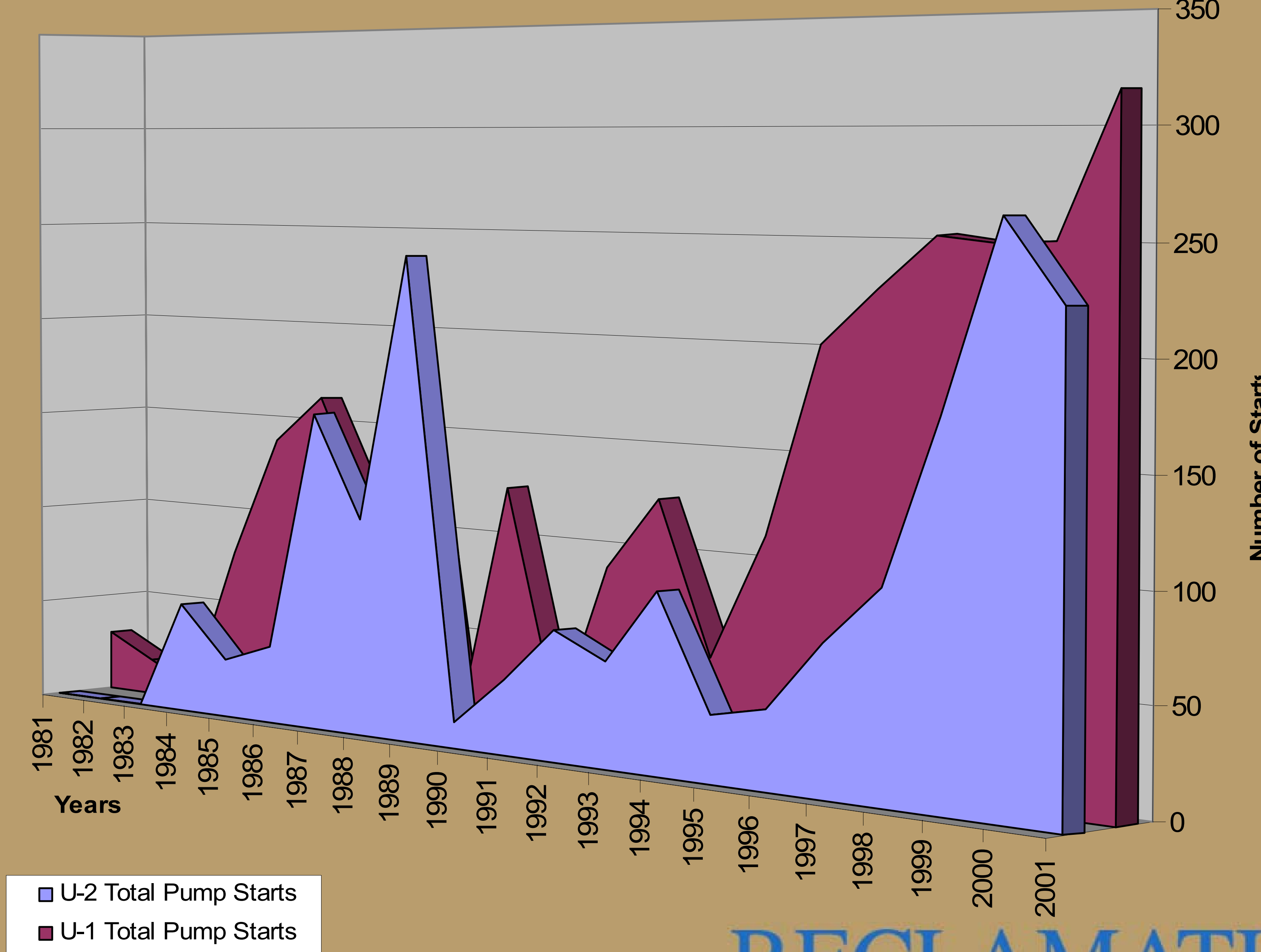
Unit 1 & 2 Total Pump Starts



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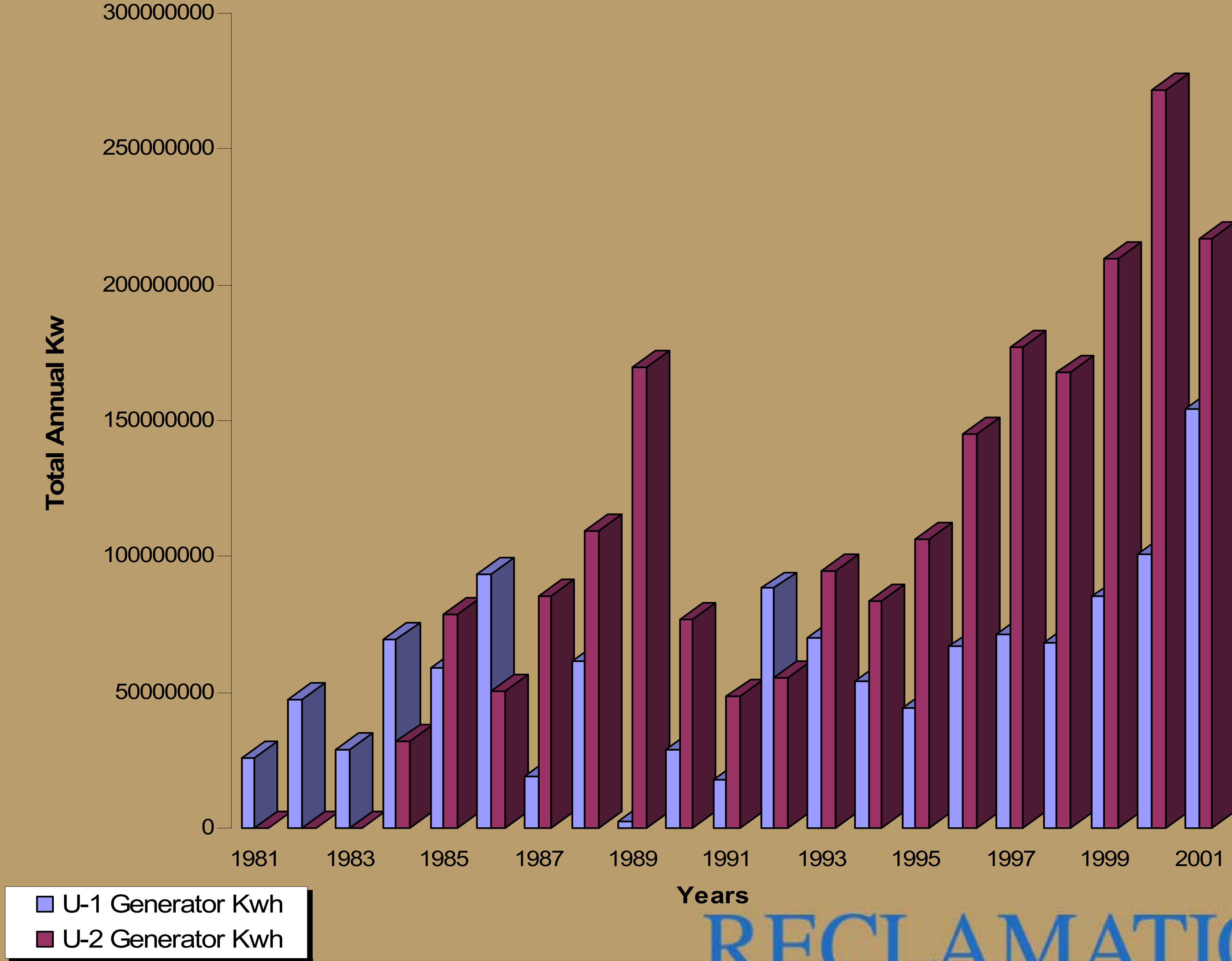
Unit 1 & 2 Generator Kwh



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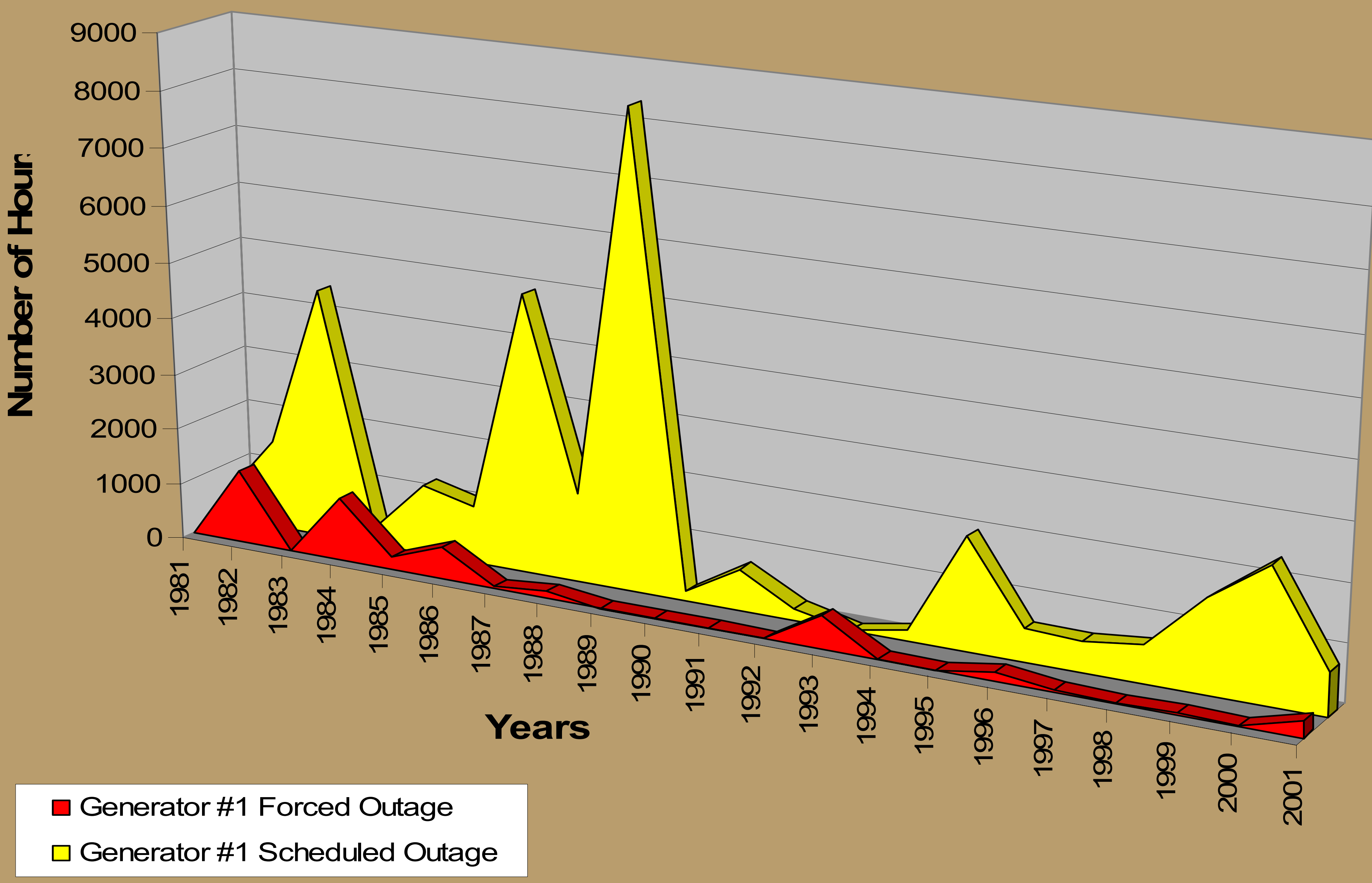
Unit 1 Generator Outages CY-1981 to CY-2001



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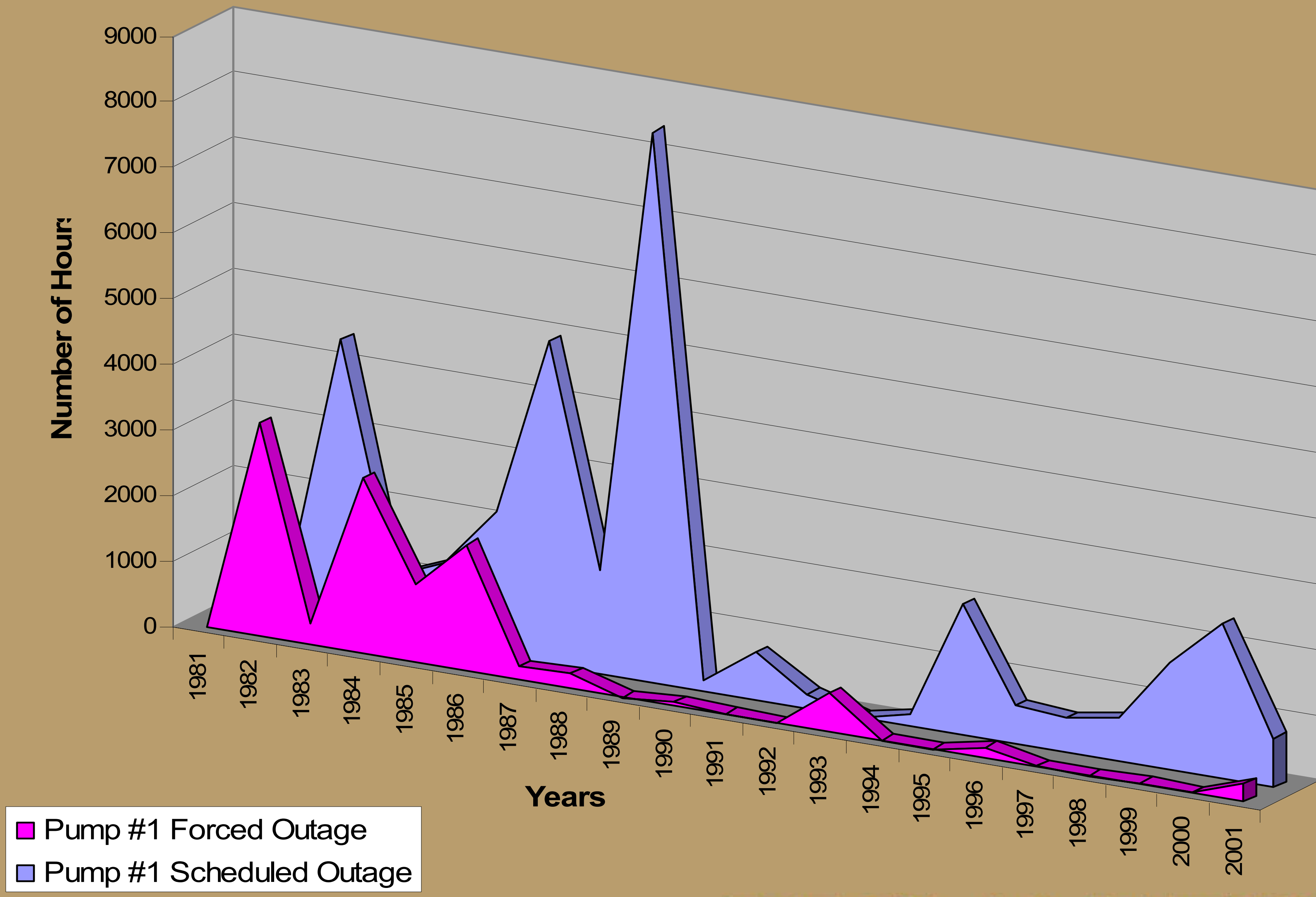
Unit 1 Pump Outages CY-1981 to CY-2001



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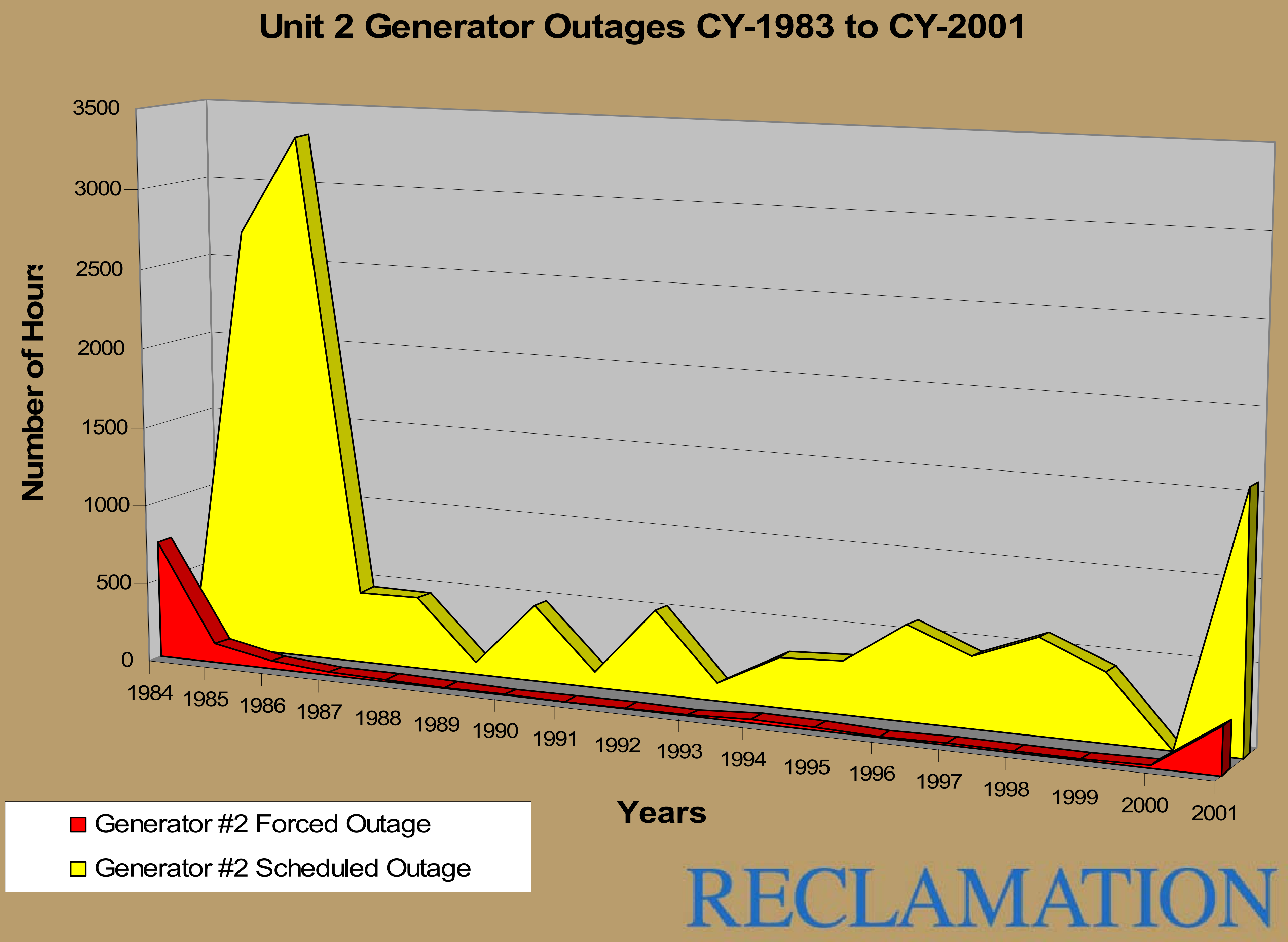
Unit 2 Generator Outages CY-1983 to CY-2001
Number of Hours
3500
3000
2500
2000
1500
1000
500
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Years
Generator #2 Forced Outage
Generator #2 Scheduled Outage
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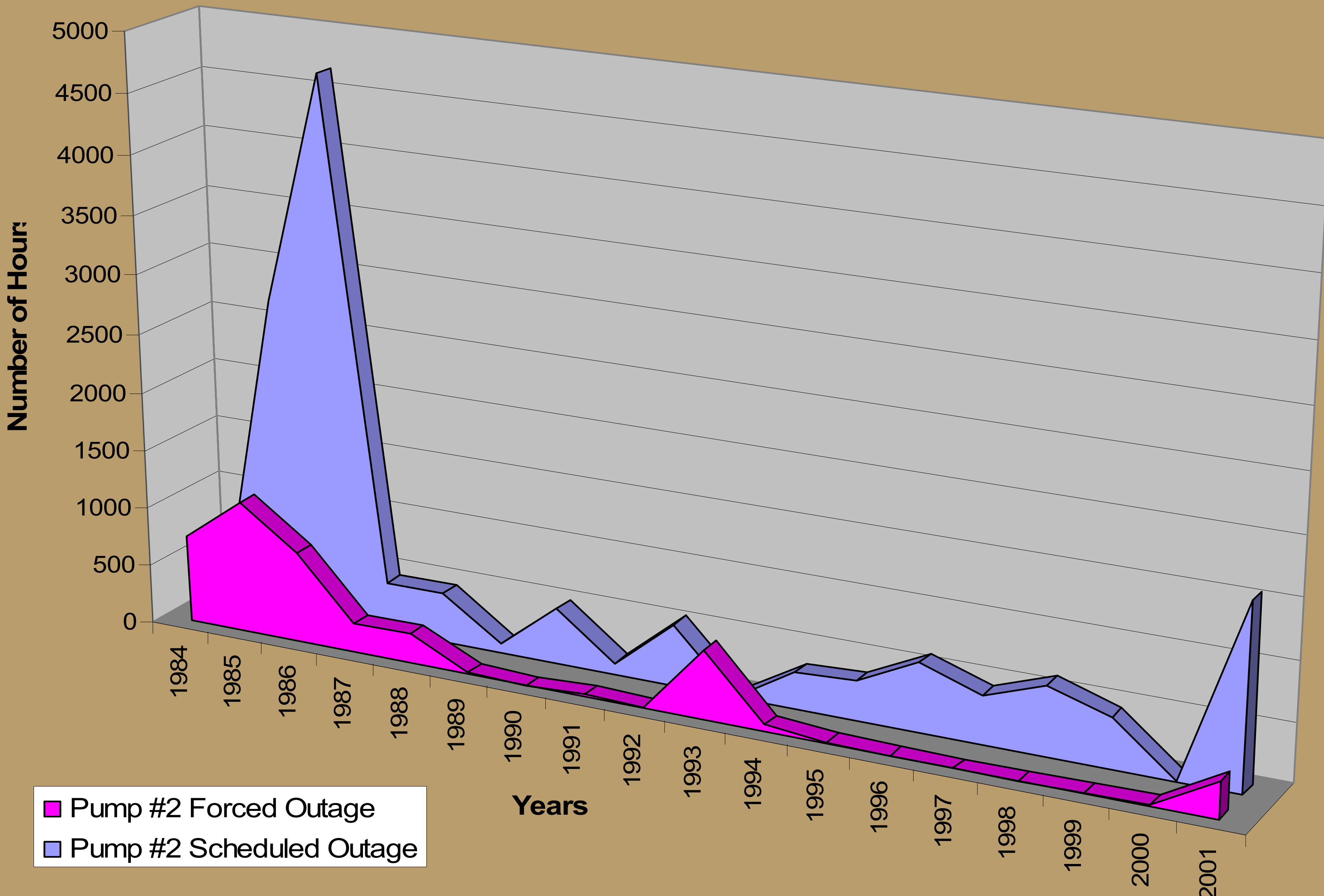
Unit 2 Pump Outages CY-1983 to CY-2001



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EPRI

Hydropower Technology Roundup Report: Accommodating Wear and Tear Effects on Hydroelectric Facilities Operating to Provide Ancillary Services

TR-113584-V4

LICENSED MATERIAL

Technical Report

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Strategy

- Generator Component Wear and Tear
  - Generator Components Affected by Starts/Stops
  - Normal Life
  - Replacement Cost
  - Component cost per hour
  - Failure Mechanism
  - Loss of Life per Start/Stop (Hrs)
  - Component Cost per Start/Stop (Total $80.78)

Strategy

- Other Costs
  - Increased Maintenance
  - Efficiency Loss
  - Indirect Labor Costs (Operator, Dispatcher)
  - Lost Opportunity Cost
  - Water Cost
  - Total Other Costs ($437.32)

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Results

- Mt. Elbert Cost per Start/Stop
- $518.10/Start
- In Comparison
  - Similar Pump/Generator Plant
  - $375/Start

Conclusions

- **Lots of Assumptions**
- **Not So Much the Actual Cost as it was the Realization that there was a Cost**
- **Dispatcher Awareness**
- **Reduced Start/Stop Cycling**

Some Major Past U.S. Studies on the Cost of Wind Integration

- **Wind Power Impacts on Electric Power System Operating Costs, Summary and Perspective on Work Done to Date" presented at the Global WindPower Conference and Exhibition, March 29-31, 2004**
- **Wind Integration Study for Public Service Company of Colorado, May 2006**
- **Minnesota Public Utilities Commission Statewide Wind Integration Study, November 2006**
- **Idaho Power Wind Integration Study, February 2007**
- **Avista Corporation Wind Integration Study, March 2007**

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Some Major Past U.S. Studies on the Cost of Wind Integration cont'd

- Arizona Public Service Wind Integration Cost Impact Study, September 2007
- CAISO Study in Integration of Renewable Resources (IRRP), 2007
- NW Wind Integration Action Plan, 2007
- Analysis of Wind Generation Impact on ERCOT Ancillary Services Requirements; GE Energy, March, 2008
- WAPA Wind and Hydropower Feasibility Study, Dec. 2008

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Some Current Activities

- 2009 NW Wind Integration Plan Phase II Study
- WECC Variable Generation Task Force
- NERC Variable Generation Task Force
- Bonneville Power Administration 2010 Rate Case
- PNNL study in conjunction with BPA and CAISO on Wide Area Energy Storage and Management System to balance intermittent resources
- NREL/WestConnect/GE study of large scale wind integration in WestConnect footprint and the impacts of combined BA operations

What is typically included in these cost studies

- The opportunity costs associated with the operational or marketing changes required to carry additional operating reserves are the chief source of wind integration costs. There may also be additional wear and tear on hydro and other units, as well as efficiency losses resulting from the additional cycling. Together, these direct and opportunity costs are the underlying drivers of wind integration typically reported in utility wind integration studies.

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Common Results

- No technical obstacles preventing wind integration of up to 20-30%, but there are costs to transmission and generation operators
- Costs rise as the ratio of wind generation increases relative to the peak load of the balancing area
- For the penetration levels considered in most studies (generally less than 20 percent) the integration costs per MWh of wind energy are around $2 to 12/MWH
- As penetration levels begin to approach 20 percent, the costs begin to rise in a non-linear fashion
- When wind turbines (or wind farms) are dispersed over large areas/regions the variability of electrical output from wind generation decreases

Northwest Wind Integration Action Plan Study Results, 2007

Table 1: Wind integration costs, at various levels of penetration, from investor owned utility studies[1,2,2A] ($/MWh of wind generation)

Utility	Peak Load (MW)	5%	10%	20%	30%
Avista	2,200	$2.75	$6.99	$6.65	$8.84
Idaho Power	3,100	Not run	$9.75	$11.72	$16.16
Puget Sound	4,650	$3.73	$4.06	Not run	Not run
PacifiCorp	9,400	$1.86	$3.19	$5.94	Not run

Table 2: Wind integration costs, at various levels of penetration, from BPA study[1,2A]($/MWh of wind)

Utility	Peak Load (MW)	5%	10%	20%	30%
BPA (Within-Hour Impacts Only)	9,090	$1.90	$2.40	$3.70	$4.60

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What's Needed in Future Studies?

- Greater granularity of cost analysis
  - Increased unit cycling (stops and starts).
  - Increased range and variation in the output of generators.
  - Increased wear on electrical and mechanical equipment.
  - More frequent replacement of capital equipment and attendant costs.
  - Increased plant operation and maintenance (O&M) costs
- Assess real-time reserve requirements
- Determine realistic existing flexibility

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What’s Next?

- Benefits of storage technologies
- Market Based Solutions/Sub-hourly Markets vs. Balancing Authority Consolidation
- Costs/benefits of integration of wind forecasting technologies into the control room

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