Engineering A Clean Energy Policy

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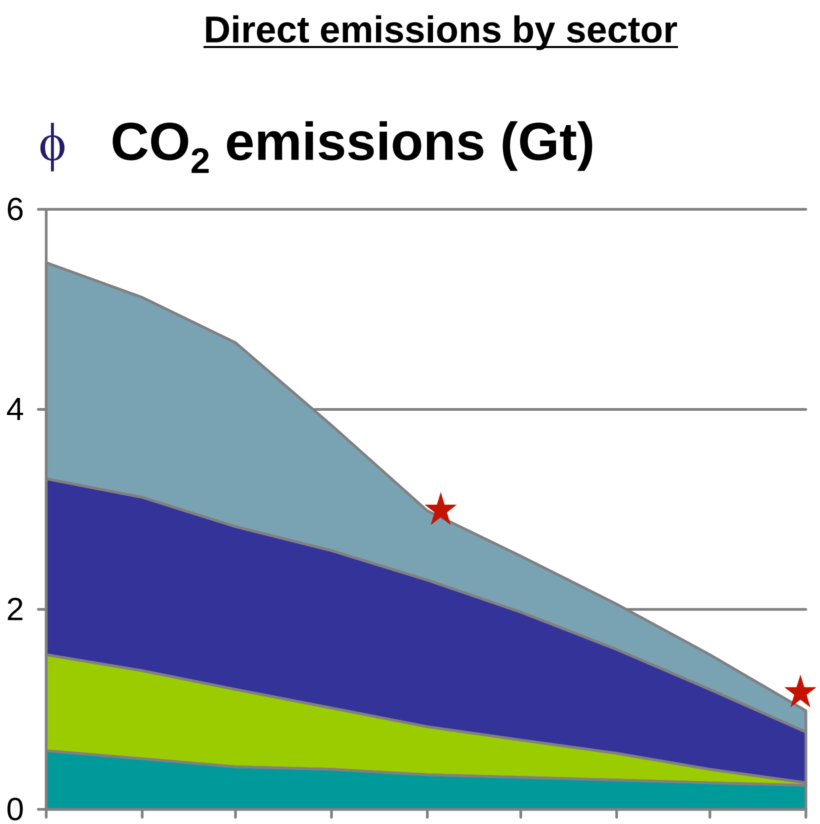
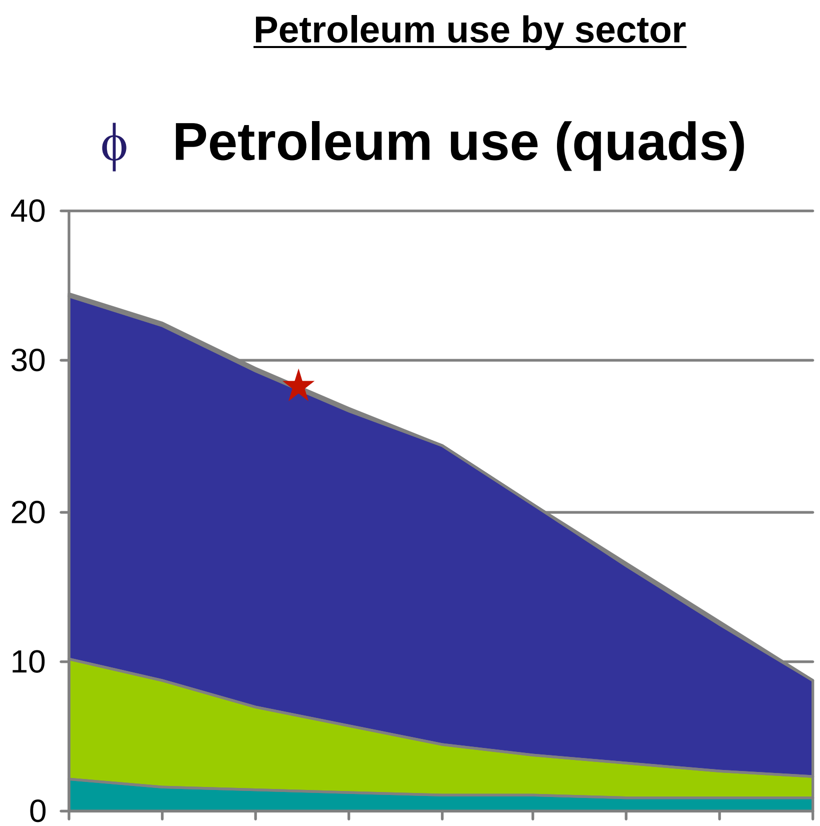
ENDURING HYDRO™

Aspirational Goals: Cut CO_2 Emissions 80% and Petroleum-based Energy Use 75% by 2050





2010-2050

Elec Gen.
Transport.
Industry
Buildings

★ Administration's goals

Strategic Technology Energy Plan (STEP) Objective:

Describe a technical path to meet US energy & environment goals

STEP engineered with several design criteria in mind:

- A portfolio approach
- Focus on known technologies – Low Risk
- Long-term view
- No economic or carbon sink offsets

Evaluate the direct costs and benefits relative to BAU

Costs and benefits "in-scope":

- Direct capital, operating and fuel expense between 2010 and 2050
- The "residual value" of newer assets and lower ongoing costs after 2050
- All calculated on "societal" basis
  - No intent to describe how costs and benefits could be split between sectors

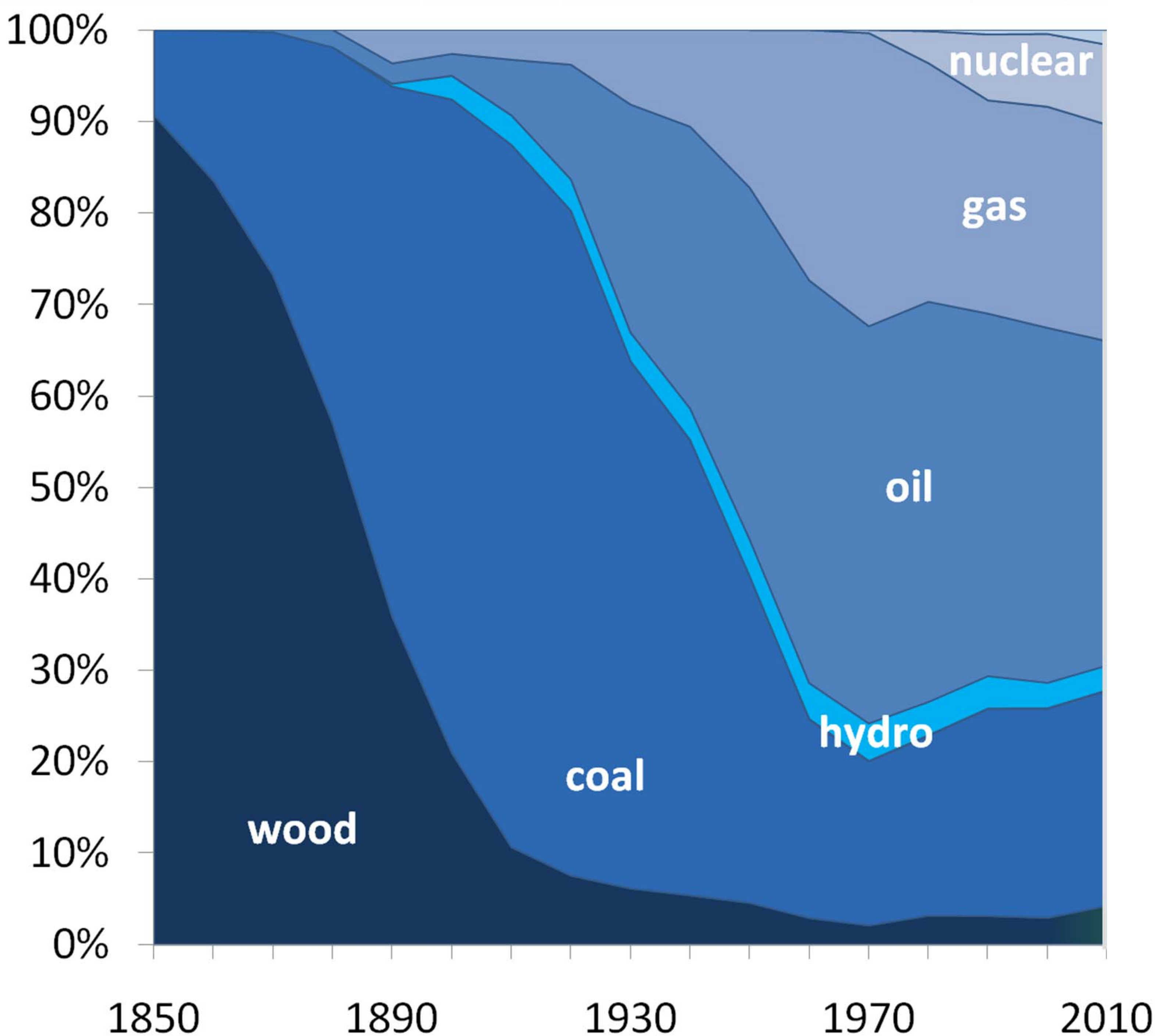
Costs and benefits "out-of-scope":

- Benefits to national security
- Domestic job creation and global trade
- Impact on health

STEP developed by DOE program offices – BCG worked with Under Secretary's team to refine plan, evaluate cost and edit report

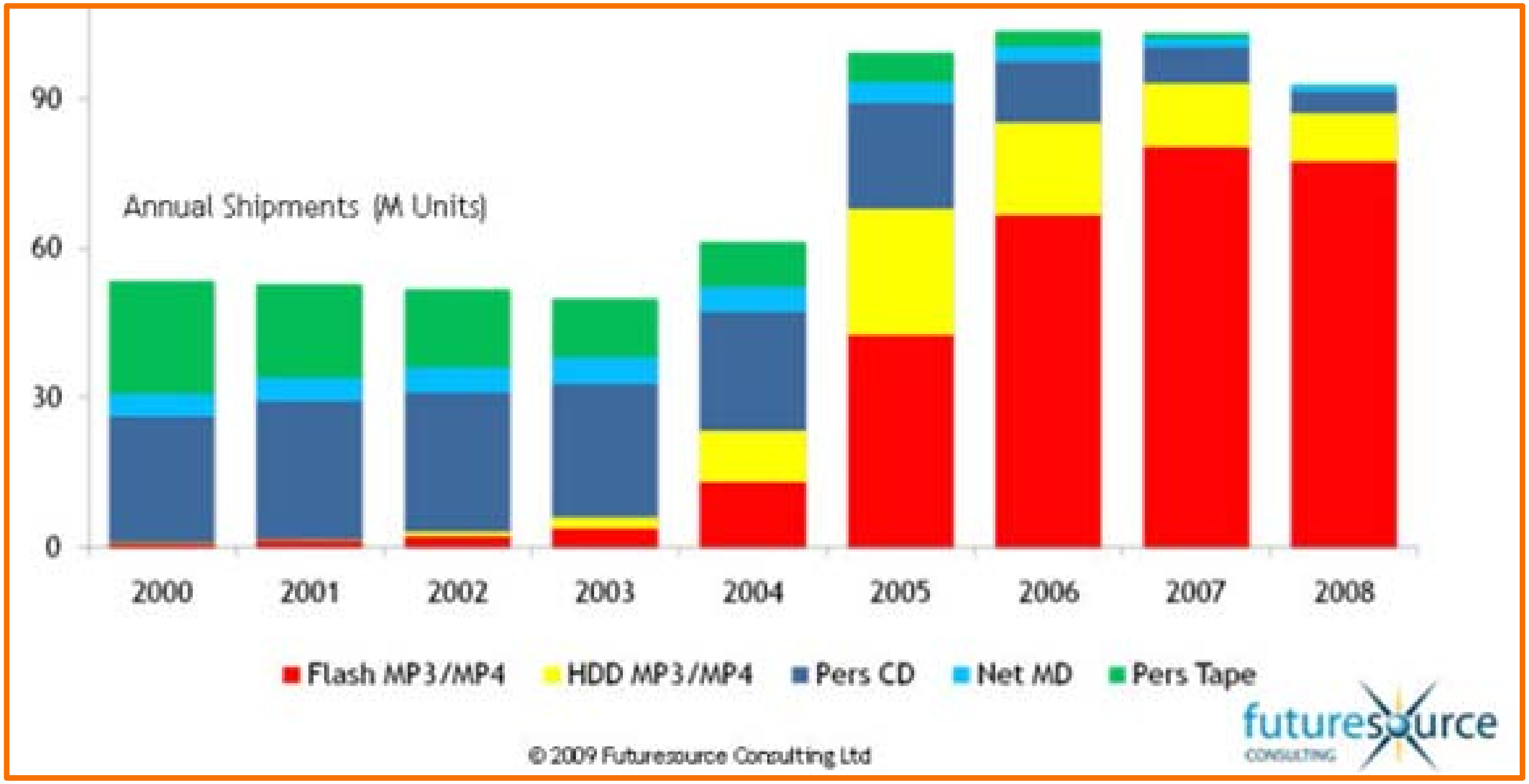
STEP built around five key levers

Five key levers	Description
1. Decarbonize electrical generation	1. Balance of Renewable, Fossil and Nuclear Energy.
2. Switch from fossil fuels to electricity for heating and personal transportation.	2. Electrify LDV transport 50% penetration by 2035.
3. Increase energy efficiency and conservation.	3. 23 Quad reduction by 2050.
4. Modernize transmission and distribution.	4. Supply and demand side mgt.
5. Substituting biofuels for petroleum in freight transportation.	5. Focus biomass resources on HDV and air transportation for freight.

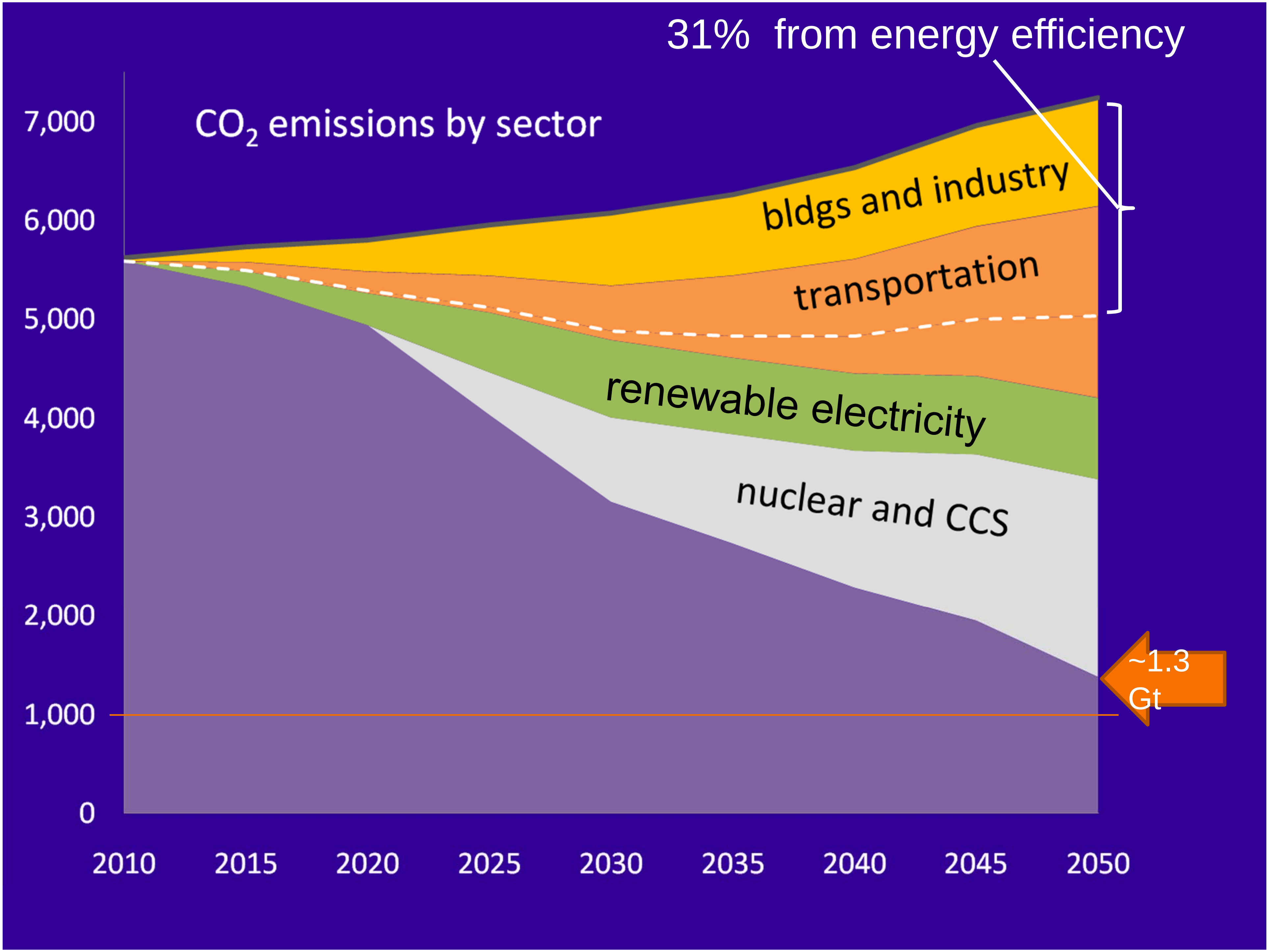

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1850
1890
1930
1970
2010
nuclear
gas
oil
hydro
coal
wood

IT Innovation Scales Much Faster Than Energy

SALES OF PERSONAL AUDIO/VIDEO MEMORY SINCE 2000



U.S. DEPARTMENT OF ENERGY



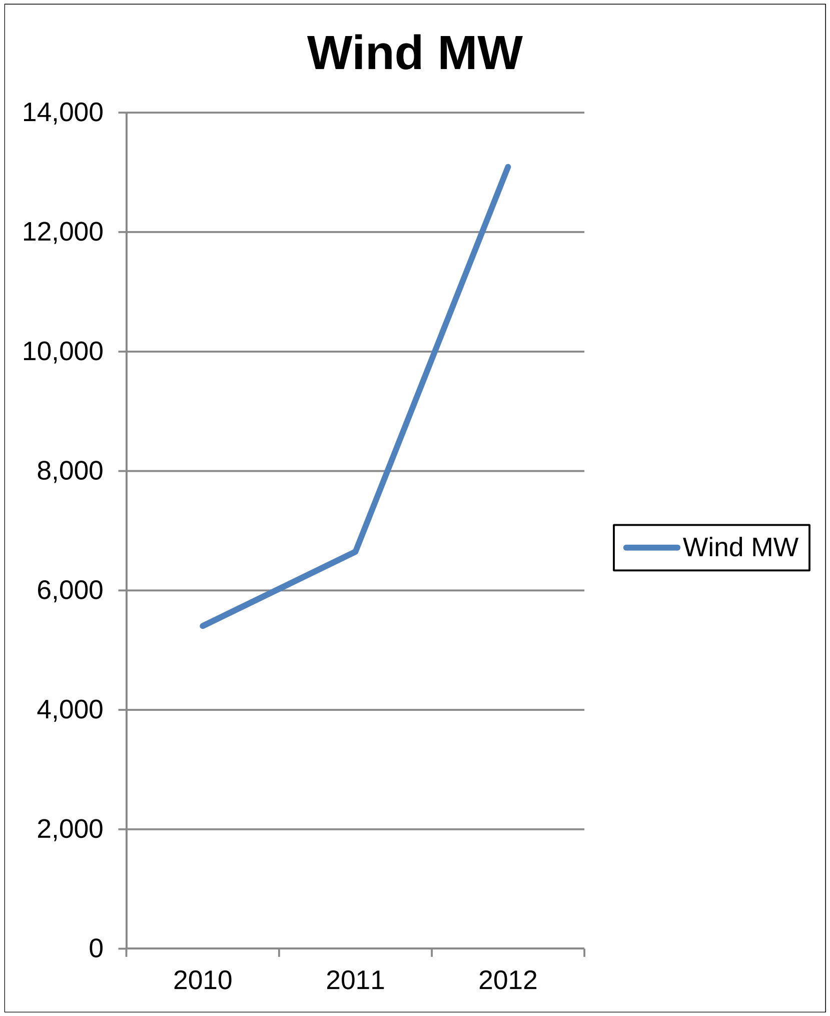
31% from energy efficiency
CO2 emissions by sector
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2010
2015
2020
2025
2030
2035
2040
2045
2050
bldgs and industry
transportation
renewable electricity
nuclear and CCS
~1.3 Gt


AMSCO
WINDOWS

Collective Action Is Crucial

Wind power installed capacity grew 49% from 2010 to 2012

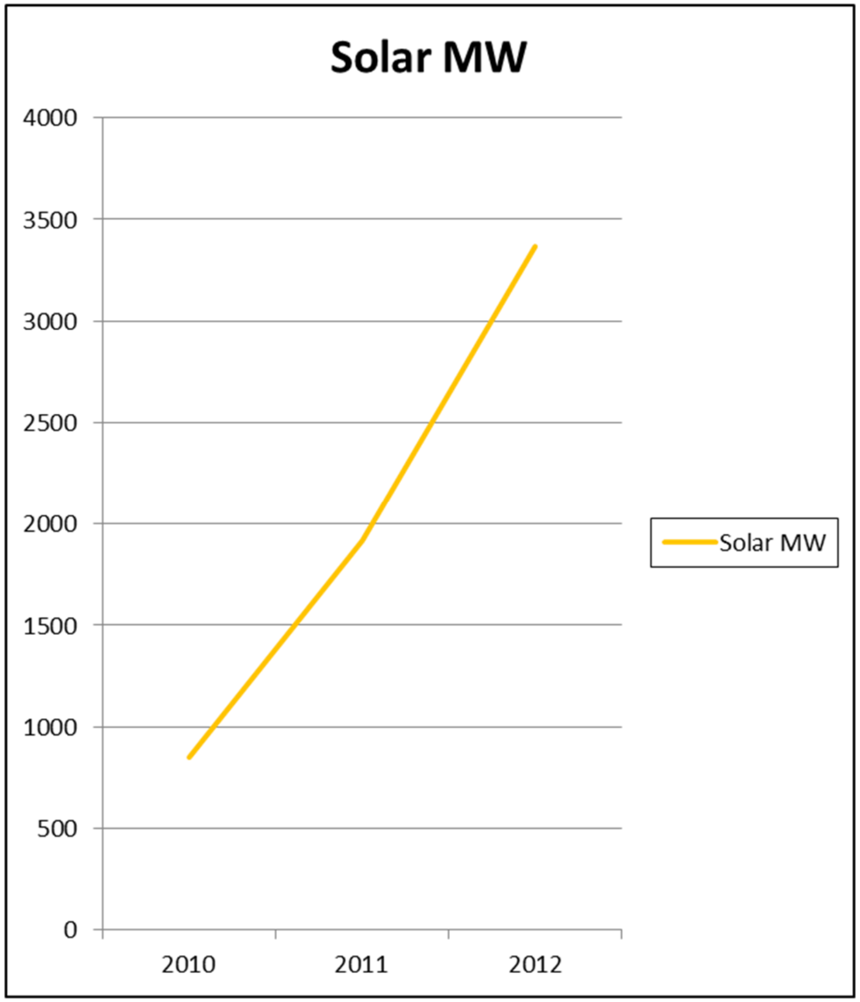
Year	MW	Total
2010	5,404	40,267
2011	6,649	46,916
2012	13,091	60,007
2013*	2,398	62,405



*Projected from projects 2,327 MW under construction and 71 MW installed by the end of Q3 Source: National Renewable Energy Laboratory 2010-2013; AWEA U.S. Wind Industry Third Quarter 2013 Market Report

US Photovoltaic installed capacity grew 208% from 2010 to 2012

Year	Additional MW	Total
2010	850	2,534
2011	1,915	4,449
2012	3,364	7,813
2013*	4,400	12,219



*4,400MW is projected by years end – there is currently 1,557 MW installed as of 2013Q2 Source:
Solar Energy Industries Association 2010-2013; SEIA/GTM Research" US Solar Market Insight" 2013

MW Installed Capacity Growth in the US Compared to Electricity Usage

	2010	2011	2012	Change	% Growth
Wind (in MW)	40,267	46,916	60,007	19,740	49%
Solar (in MW)	2,534	4,449	7,813	5,279	208%
Hydro (in MW)*	78,825	78,652	*78,652	~ -.2%	*0%

Electricity Usage (in pwh - 10^{15})	3.886 pwh	3.883 pwh	3.823 pwh	.063pwh	-1.60%

*2012 Hydro Capacity data not available
Source: US Energy Information Administration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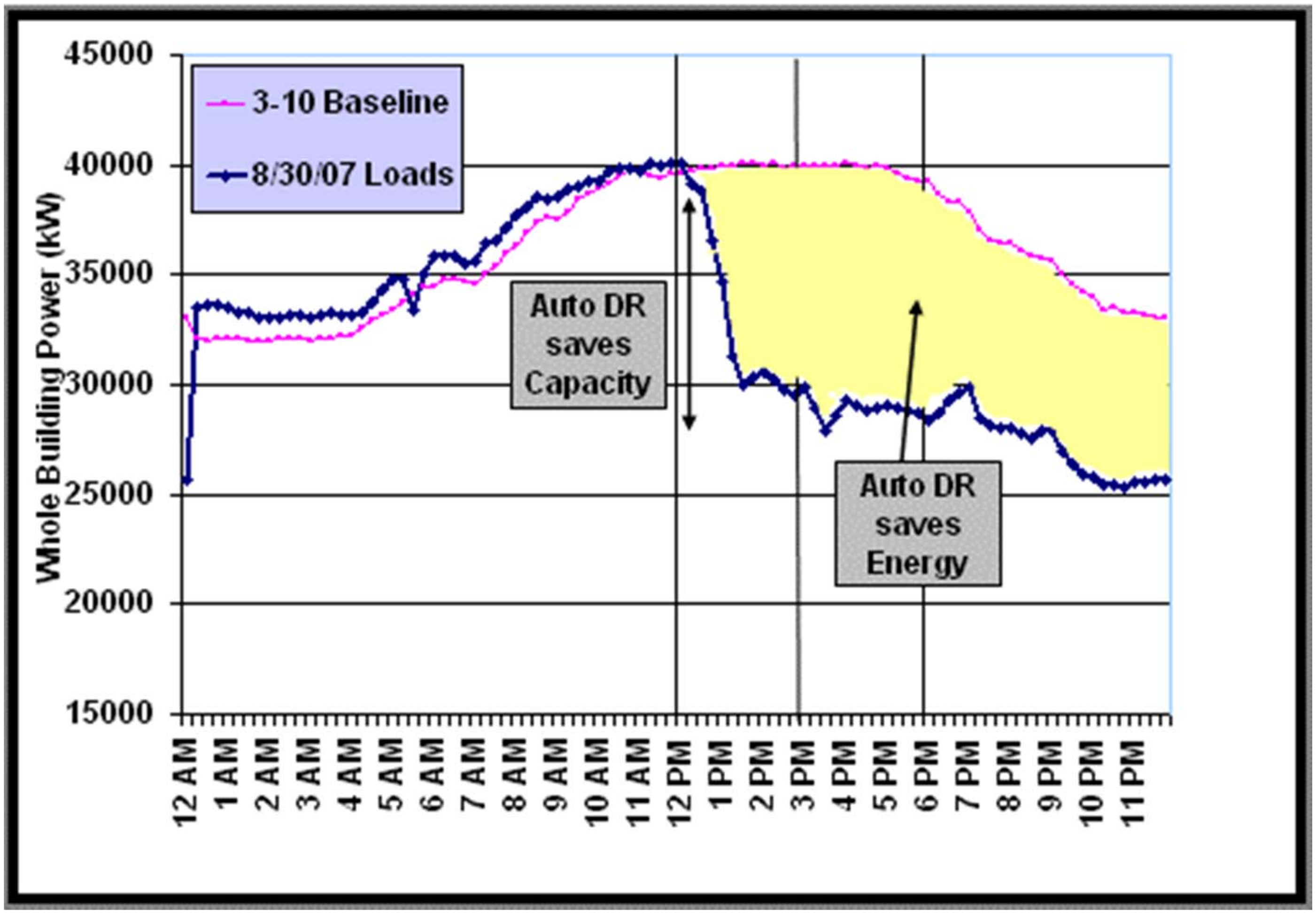
The first 10 miles of the McNary-John Day Transmission Line
Highway 14 in Washingtgon
Bonneville Power Administration

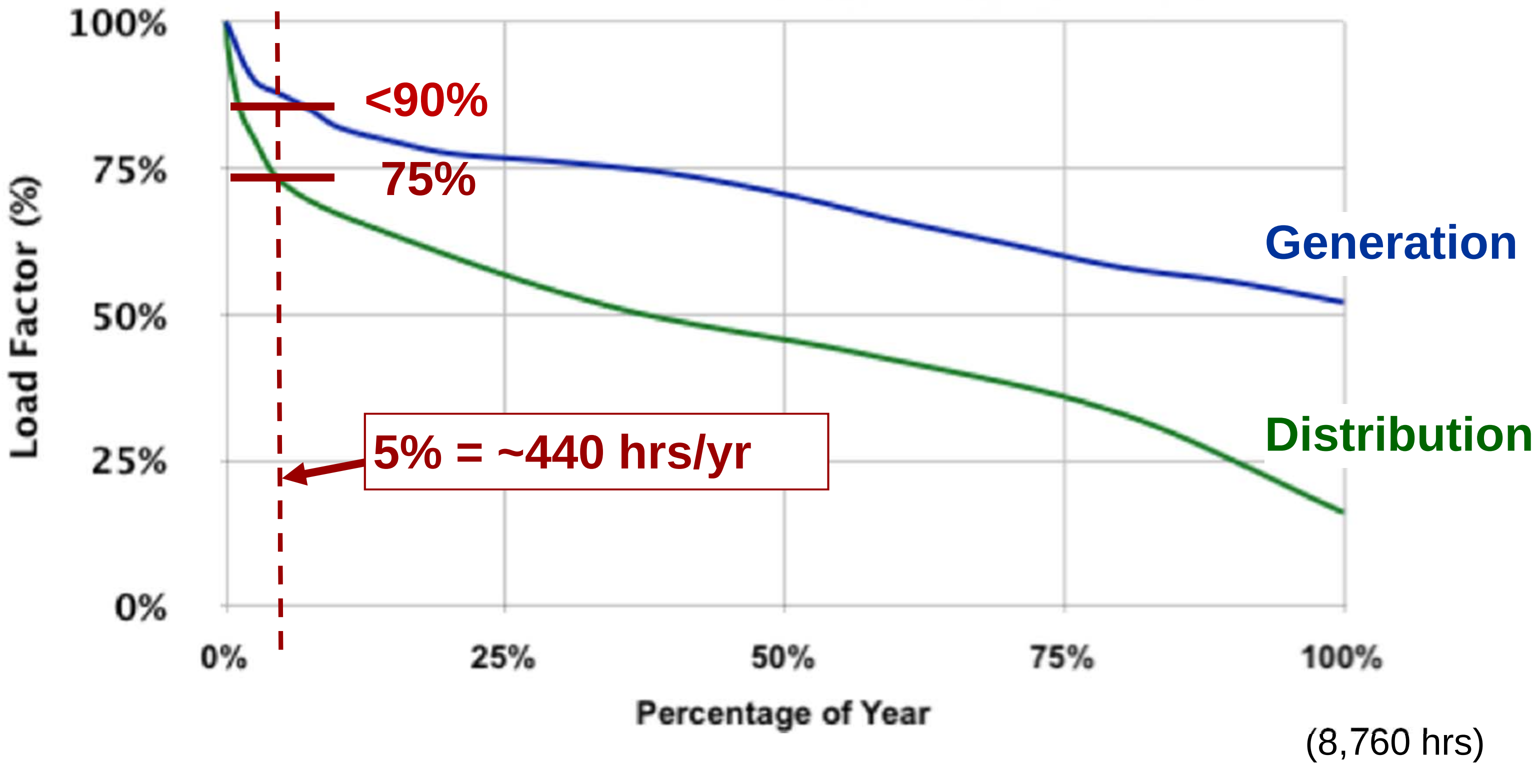
Automated Demand Response

Electric load profile for PG&E participants on 8/30/2007



Peak Reduction is Paramount

Hourly Loads as Fraction of Peak, Sorted from Highest to Lowest



- **25% of distribution and > 10% of generation assets are needed less than 5% of the time**
- **($100's of bns of investments)**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Key findings of STEP

Technical feasibility

1. **STEP is technologically feasible, but requires pulling ALL available levers.**

2. **Biomass for liquid fuel the critical area where STEP requires a "stretch“.**
   - Biomass-based fuel required to carbonize heavy duty vehicle fleet (e.g., work trucks, planes)
   - Biomass not used in passenger vehicle fleet – must be electrified

3. **Long-term focus makes some short term options less attractive**
   - Most significantly, replacing coal with natural gas for power generation
   - Sufficient to meet 2030 target, but requires CCS retrofit to achieve 2050 target

4. **Decarbonization a more "concrete" emissions solution than efficiency**

Evaluation of costs

1. **STEP is roughly breakeven on a present value basis versus BAU over 2010-2050.**
   - However, upfront investment drives ~$1T trough and takes ~25 years to reach cash flow breakeven

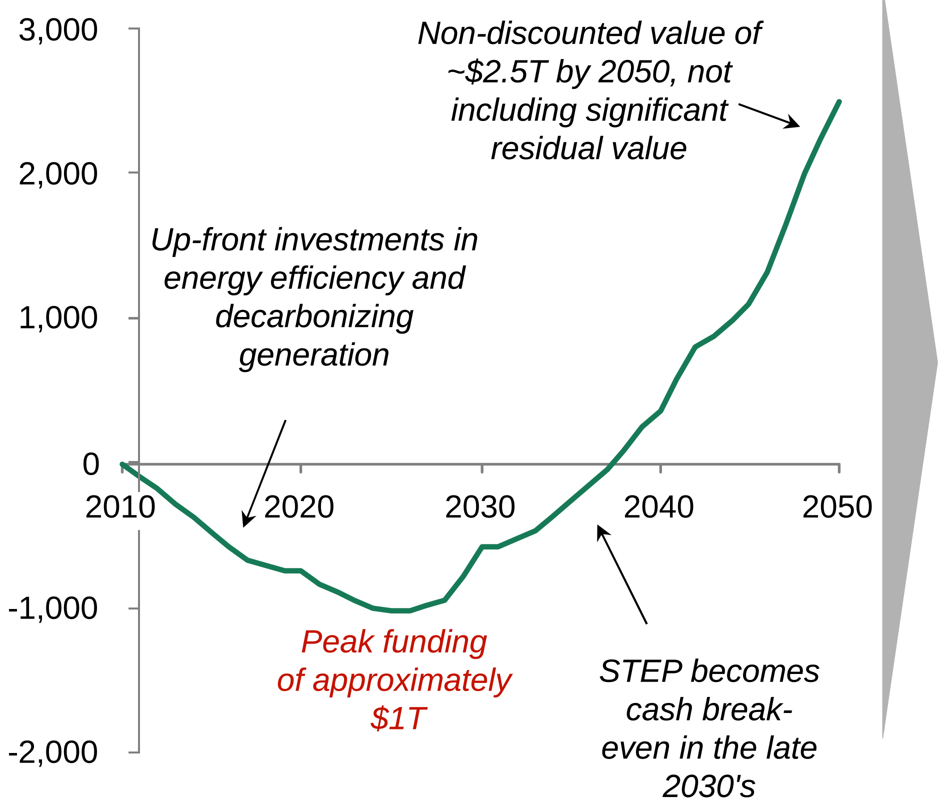
2. **STEP puts the country in a much better position looking forward from 2050 than does BAU.**
   - STEP "residual value" is very significant (>$600B) even in present value terms

3. **Costs and benefits do not accrue evenly across sectors.**
   - Critical to have a cohesive plan across sectors to address imbalances
   - Must execute across all sectors to achieve goal

STEP total cost minus BAU, in aggregate

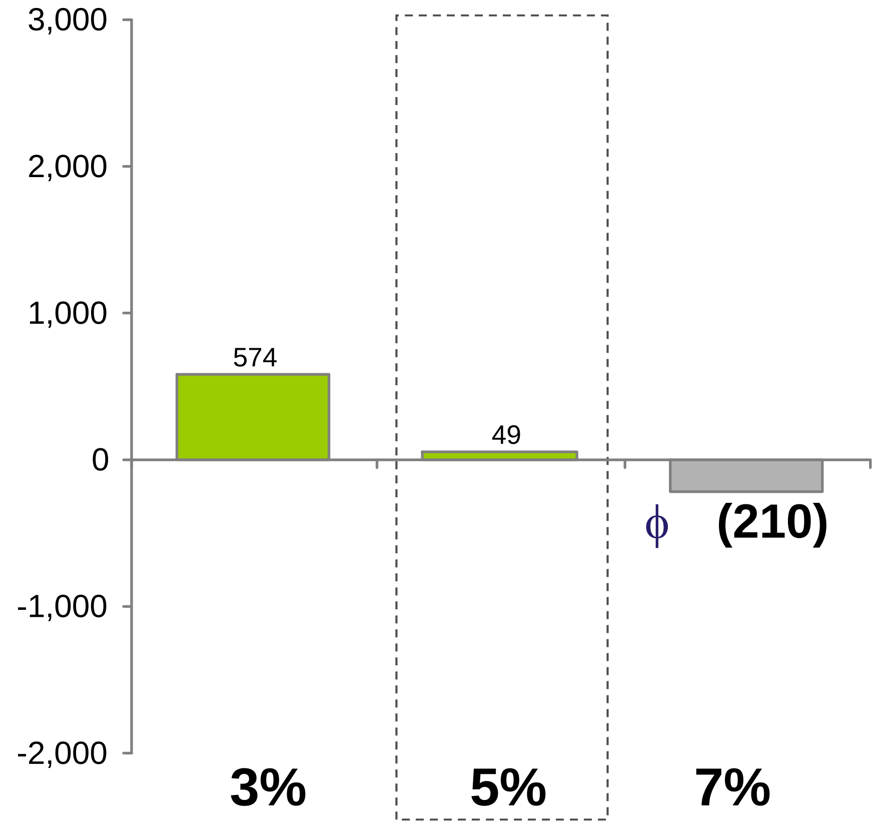
Cash flow savings of STEP compared to BAU

- Cumulative Cash Cost ($B, 2009)



Present value of STEP savings compared to BAU

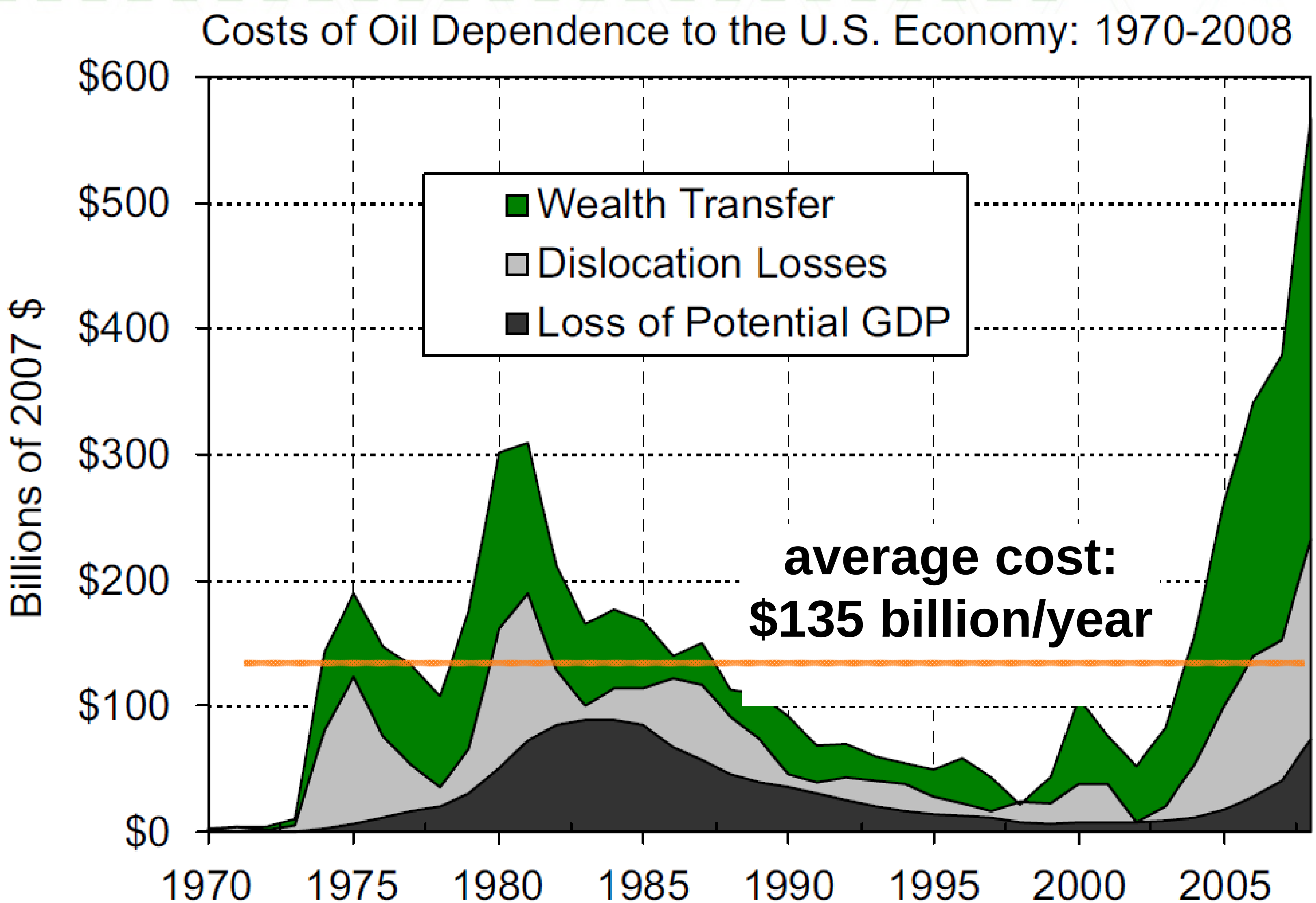
- Discounted Cost ($B, 2009)



- Real discount rate

Note: Present value discounted to 2010 using a 3, 5, or 7% real discount rate, as shown

Or, We Could Keep Doing This:



Greene, David L., "Measuring energy security: Can the United States achieve oil independence?" Energy Policy **38,** 1614-1621 (2010)

HYDROPOWER DEVELOPMENT STATISTICS

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Overview of US Hydropower Fleet

Analysis of Federal Hydro Power Fleet			
Organization	Total Capacity (MW)	Percentage of Federal Fleet	Percentage of US Fleet
USACE	20,500	50%	22%
USBR	14,800	36%	16%
TVA	5,500	13%	6%
Total Federal	***40,800***	***100%***	***43%***
Total US	***95,100***		

Federal Government:
Potential Hydropower Increases

Hydropower Potential at Federal Facilities					
Type	Capacity (MW)	Generation (MWh)	Potential Capacity Increase to Current Federal Hydro Fleet	Potential Generation Increase to Current Federal Hydro Fleet	US Homes Powered Annually by Improvements
USACE Improvements	12,998	45,944,463	32%	38%	4,073,091
USBR Improvements	268	1,168,248	1%	1%	103,568
Total Improvements	***13,266***	***47,112,711***	***33%***	***39%***	***4,176,659***
Total Current Federal Hydropower Fleet	40,800	121,200,000			10,744,681
Current Federal Fleet + Improvements	***54,066***	***168,312,711***			***14,921,340***

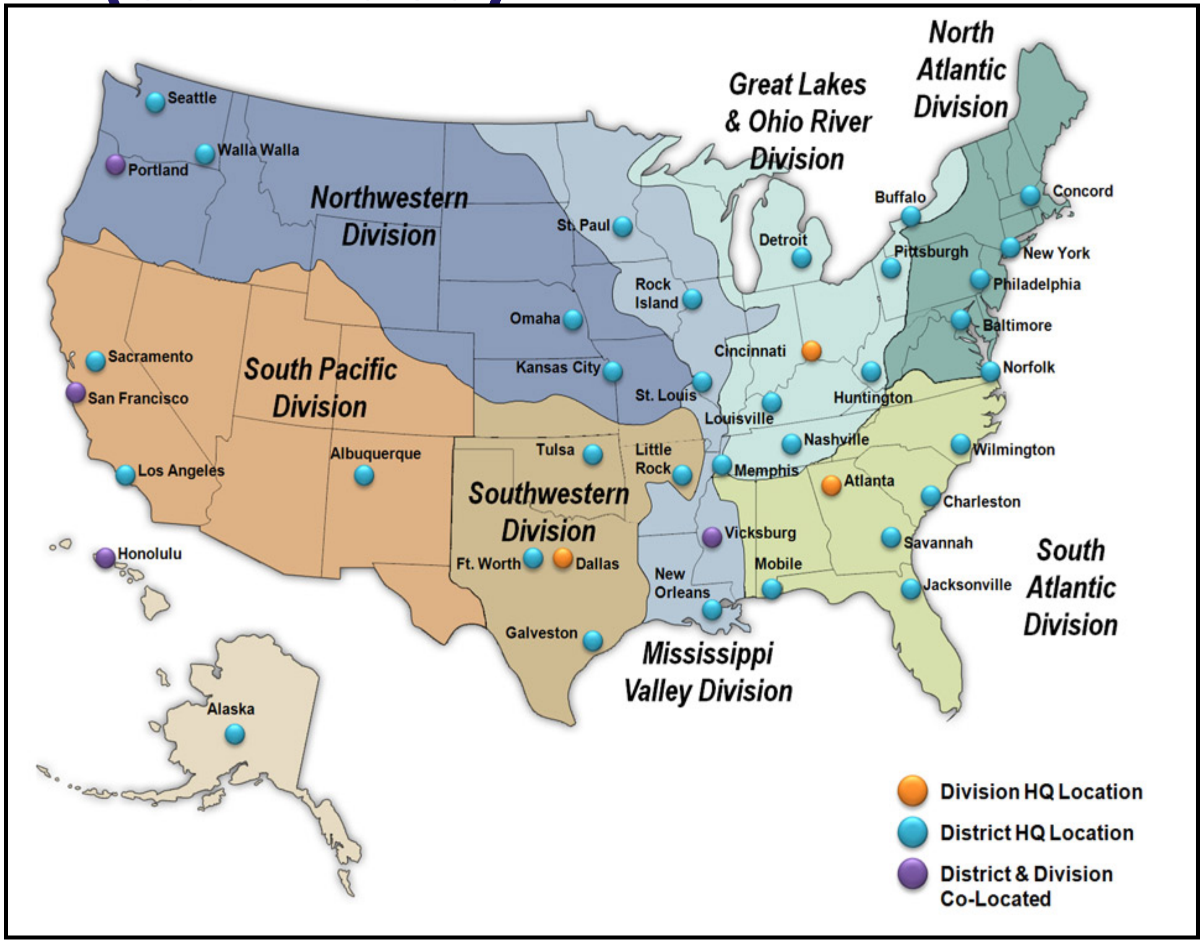
Overview of Federal Hydro Fleet

Quantity and Size of Federal and Private Hydropower Fleets

Organization	Number of Projects	Number of Units	Total Capacity (MW)	Average Project Size (MW)	Average Units per Project	Average Unit Size (MW)
USACE	75	353	20,500	276	5	58
USBR	58	194	14,800	255	3	76
TVA	30	113	5,500	183	4	49
Total Federal	***163***	***660***	***40,800***	***251***	***4***	***62***
FERC Licenses	1012	-	53,500	53	-	-
FERC Exemptions	595	-	800	1	-	-
Total Private	***1607***	***-***	***54,300***	***34***	***-***	***-***

USACE Overview (continued)

		# of Plants	Capacity (MW)
NW 15,714 MW	Portland	12	5,531
	Walla Walla	6	4,424
	Seattle	3	3,023
	Omaha	6	2,530
	Kansas City	2	207
SA 2,864 MW	Mobile	8	1,148
	Savannah	3	1,410
	Wilmington	2	222
	Charleston	1	84
	Atlanta		
	Jacksonville		
SW 1,763 MW	Little Rock	7	1,089
	Tulsa	8	584
	Ft. Worth	3	90
	Dallas		
	Galveston		
GL&O 945 MW	Nashville	8	927
	Detroit	1	18
	Buffalo		
	Cincinnati		
	Huntington		
	Louisville		
	Pittsburgh		
MVa 227 MW	Vicksburg	3	169
	St. Louis	1	58
	Memphis		
	St. Paul		
	New Orleans		
	Rock Island		



*No hydropower plants located in the South Pacific and North Atlantic divisions
*Additional opportunity - USACE unpowered dams

U.S. Army Corps of Engineers: Potential Hydropower Increases

Hydropower Potential at USACE Facilities					
Improvement Type	Capacity (MW)	Generation (MWh)	Capacity Increase to Current USACE Hydro Fleet	Generation Increase to Current USACE Hydro Fleet	US Homes Powered Annually by Improvements**
Capacity Expansion at Existing Hydro Facilities*	3,503	10,543,477	17%	17%	934,705
Development of New Hydro at Existing Dams	8,353	31,963,845	41%	52%	2,833,674
Rehabilitation of Existing Hydro Facilities*	1,142	3,437,141	6%	6%	304,711
Total Improvements	***12,998***	***45,944,463***	***63%***	***74%***	***4,073,091***

*Assumes capacity factor of 34.358%, based on most recent USACE data obtained

**EIA 2011 average annual electricity consumption for a U.S. residential utility customer is 11.28 MWh

Sources

- Bureau of Reclamation. U.S. Department of the Interior. *Hydropower Resource Assessment at Existing Reclamation Facilities*. Power Resources Office, 2011.
- Office of Energy Efficiency and Renewable Energy. U.S. Department of Energy. *An Assessment of Energy Potential at Non-Powered Dams in the United States.* Idaho Operations Office, 2012.
- U.S. Army Corps of Engineers. U.S. Department of the Army. *Outlook for the U.S. Army Corps of Engineers Hydropower Program*. Institute for Water Resources, 2011
- U.S. Department of the Interior, U.S. Department of the Army, U.S. Department of Energy. *Potential Hydroelectric Development at Existing Federal Facilities*. 2007.

Mahoning Creek Hydroelectric Project: 6.5 MW and 22,000 MWh Western PA

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Draft tubes (Discharge) set in place in powerhouse end of May

Spiral cases welded to conical draft tube. Small Turbine Shutoff Valve installed on concrete support.

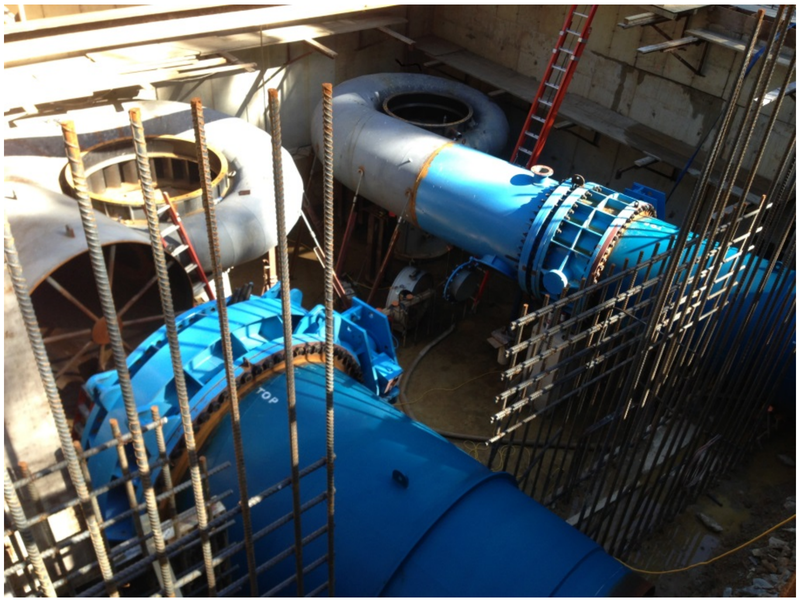
Uncovering the conduit in Monolith 15 on the downstream face of the dam.

Valve vault base slab pour on 07/31/2013

By the end of September there were 15 pieces of penstock pipe installed.

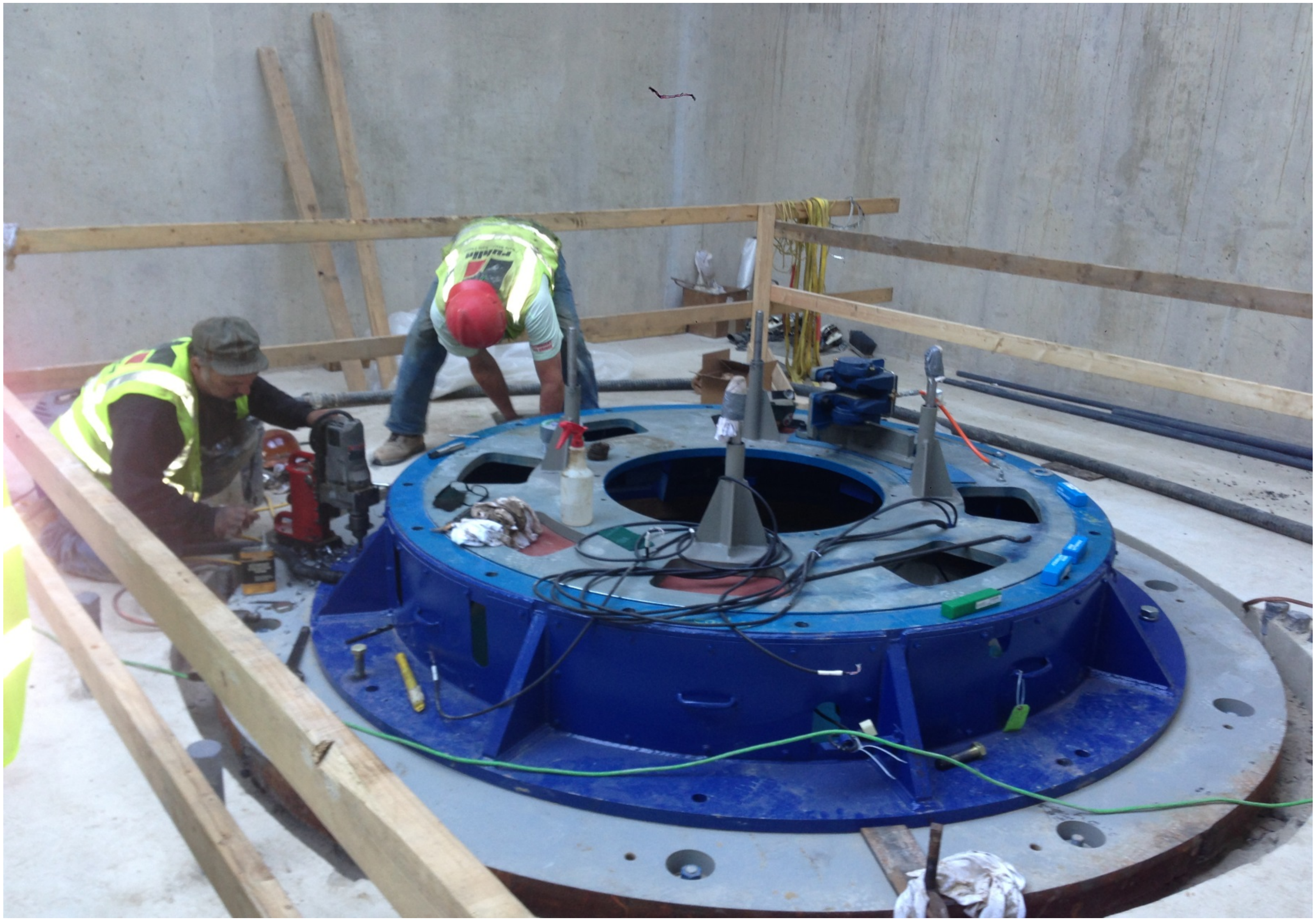
Photos of MCHC progress

Installation of both spiral cases and TSV's in powerhouse



Pouring Valve Vault Base Slab

Installation of concrete lagging for soldier pile wall



Sole plate and lower bracket installed in powerhouse last week of September. Generator installation in October. Dry commissioning November 2013

Major Q4 Milestones

Finance

Convert construction loan to permanent loan. PPA in place.

Technical

Installation of Roller Gate and intake sub-frame on August 15, 2013

Complete walls of powerhouse on September 9, 2013

Finish turbine and generator installation on October 11, 2013

Complete build of penstock and TSV's on October 12, 2013

Install interconnections on October 15, 2013

Commission turbine and generator on December 4, 2013

Impact

Equivalent to planting 1,000,000 fully grown trees or
taking 4,000 cars off the road.
30X more efficient than "Cash for Clunkers"






Its all our responsibility