Job Creation Opportunities in Hydropower

Executive Summary

Presented to
National Hydropower Association

Final

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Content of Report

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This study focused on estimating the direct and indirect jobs creation potential for the U.S. Hydropower Industry.

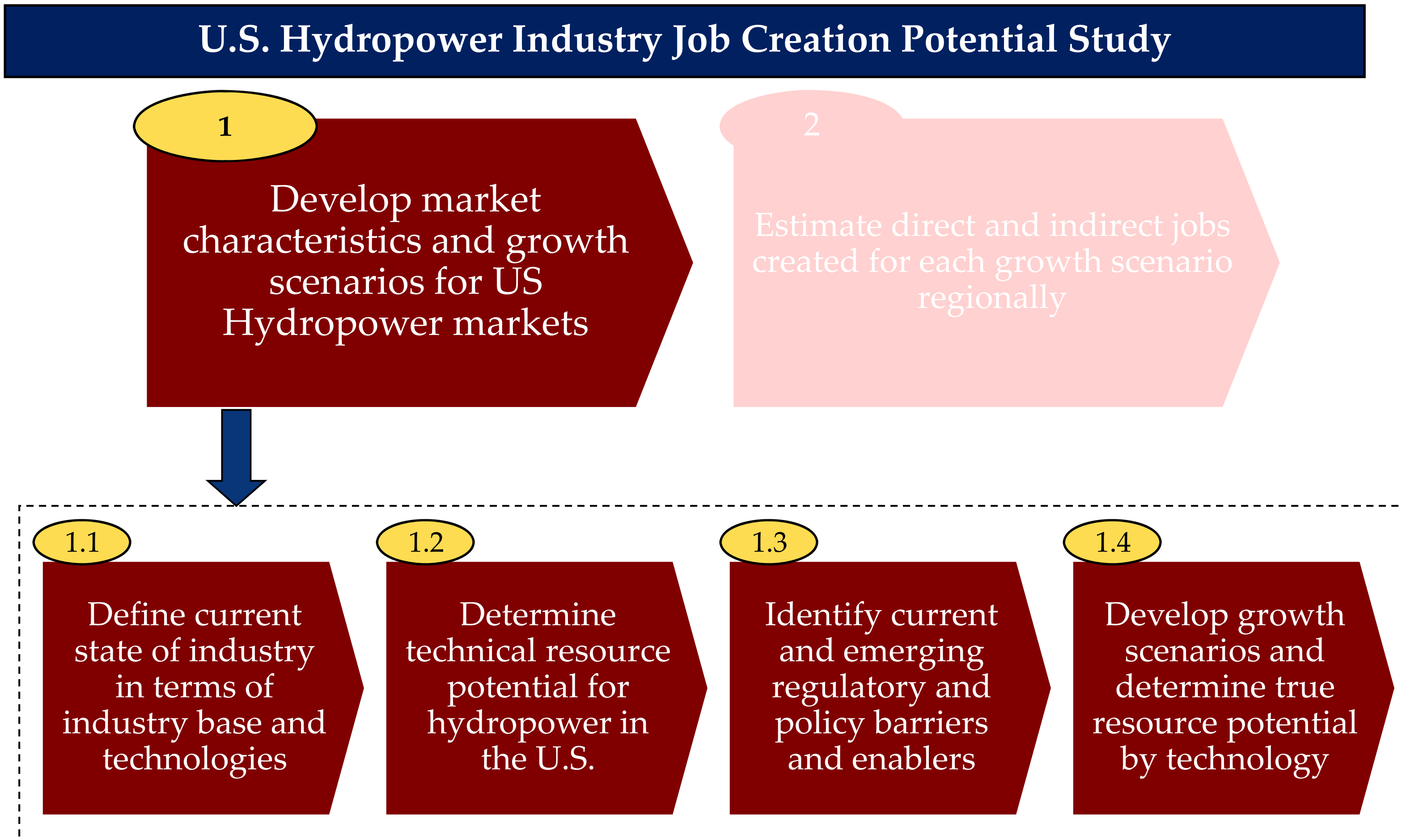
U.S. Hydropower Market Job Creation Potential Study

1. Develop market characteristics and growth scenarios for US Hydropower markets
2. Estimate direct and indirect jobs created for each growth scenario regionally

Key Deliverables

- **Task 1:** Technical and true resource potential (under two growth scenarios) for various hydropower technologies in the US by region and state through 2025
- **Task 2:** Direct jobs in each part of the market value chain and indirect jobs created, by region for each for growth scenario

Task 1 focused on identifying the technical resource potential for various hydropower technologies in the U.S. by state and region.



Key U.S. hydropower industry characteristics have been summarized below.

Key U.S. Industry Characteristics
• The U.S. hydropower industry currently accounts for approximately 200,000 – 300,000* jobs. – The jobs span four specific value chain elements: 1) Project Development, 2) Manufacturing, 3) Project Deployment and 4) Operations and Maintenance. • The U.S. has the second largest installed capacity of hydropower in the world at ~100 GW (including pumped storage). • Hydropower accounts for approximately 7% of overall domestic electricity production in the U.S. and ranks 10^{th} worldwide in electricity production. • Over 400+ GW of untapped hydropower resource potential (inland and ocean) exists within the U.S. • Developing these untapped hydropower resources could contribute significantly to the emerging green jobs market in the U.S.

* Assumes an average of 2-3 FTE/MW needed to operate, maintain and license compliance of existing 100,000 MW fleet

Despite recently published reports and new studies that are underway, there is need for continued study of the U.S. hydro potential.

Research on U.S. Hydroelectric Potential	
Streams	DOE's 2006 and 2003 Idaho National Laboratory reports, as well as other studies, have been conducted in this area.
Constructed Waterways	DOE is currently examining the potential for developing hydro in constructed waterways in the U.S.
Tidal	• EPRI has estimated technical potential in 5 states and a more theoretical potential for Alaska. • Georgia Tech is working on an assessment of both available and effective tidal power densities in the U.S.
Wave	EPRI has estimated the theoretical potential for wave power in the U.S.
Ocean Current	An assessment of potential off the coast of the U.S. has not been undertaken. Potential off the coast of Florida has been estimated at 4 - 10 GW.
Ocean Thermal	No assessment of U.S. potential has been undertaken or is under way.
Ocean Salinity Gradient	No assessment of U.S. potential has been undertaken or is under way.

Key:		
Existing research on U.S. potential, fairly comprehensive.	**New research is underway/research exists, but further work is needed**	**No existing reports on U.S. potential.**

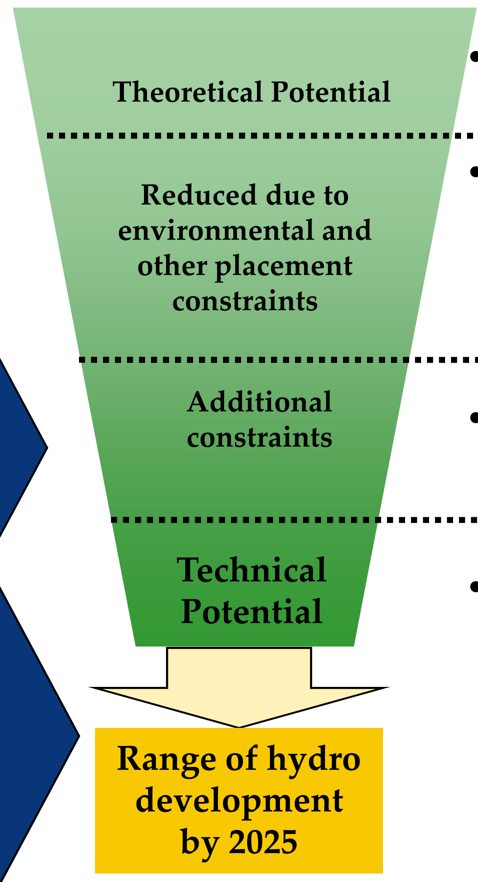
A range of hydro development by 2025 based on *technical potential* was estimated based on the methodology summarized below.

NCI Methodology for Estimating Technical Potential

Key
Hydro potential reported in this study.

This study reports an estimated Technical Potential for Inland and Ocean hydro.

Based on the Technical Potential, NCI derived a range of hydro development by 2025. This range was then used in calculations of job creation potential.



- Represents total energy available for capture, regardless of competing uses or protected areas.
- Exclusions for areas that would likely not be developable due to sensitive environmental habitats or other constraints (i.e. competing land use, load/transmission proximity, site access). Does not include economic constraints.
- Any additional constraints which affect the ultimate feasibility of development. Does not include economic constraints.
- Represents the portion of the theoretical potential which could technically be developed. It does not take economic issues into consideration.

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Navigant's upper limit for the 2025 technical potential was based on DOE inland reports, supplemented with information from other sources.

Comparison of Findings

	Navigant (NCI) Report	DOE Report
Theoretical Potential	• Not assessed in this report	• 600 GW
Reduced due to environmental and other placement constraints	• Not assessed in this report	• 300 GW (after removal of already developed potential and protected areas)
Additional constraints	• Not assessed in this report	• 200 GW (after site feasibility taken into account)
Technical Potential	• 60 GW (plants<30MW at existing dams without hydro and green field) • 15 GW (plants>30MW at existing dams without hydro and green field) • ~9 GW (capacity+efficiency upgrades) • See note: Pumped storage • 95 GW (Ocean – largely theoretical potential)	• 60 GW (plants<30MW) (after development criteria, i.e.working flow, taken into account) • Additional hydro potential examined by NCI was not assessed in the DOE report.

1. DOE numbers have been converted from MWa to MW based on a 50% capacity factor.
2. NCI did not estimate a pumped storage tech. potential, but did determined a range of possible development by 2025 later in the report.
3. *Feasibility Assessment of the Water Energy Resources of the US for New Low Power and Small Hydro Classes of Hydroelectric Plants* 2006, DOE-ID-11263 produced by Idaho National Labs for the U.S. Department of Energy.

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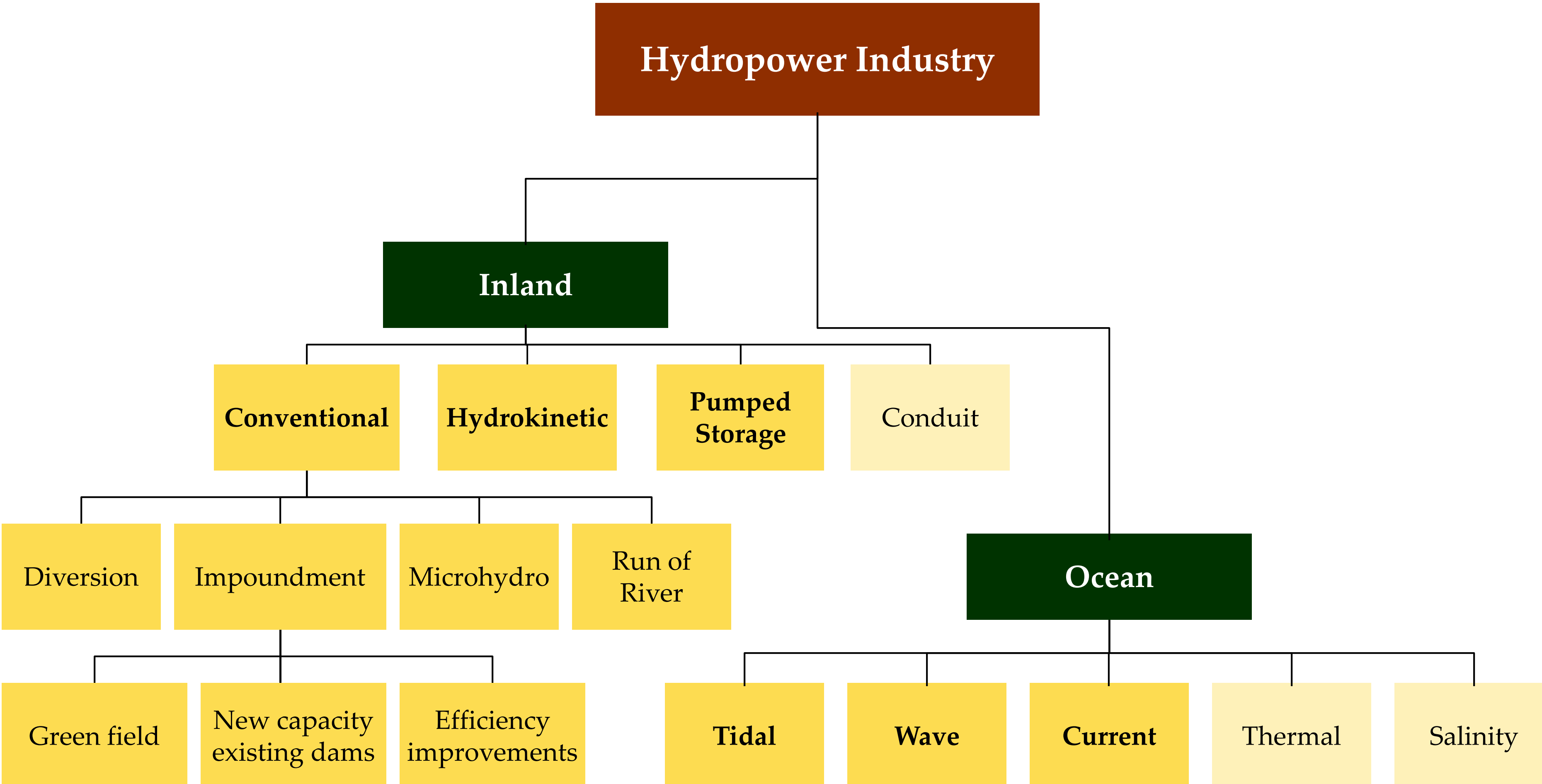
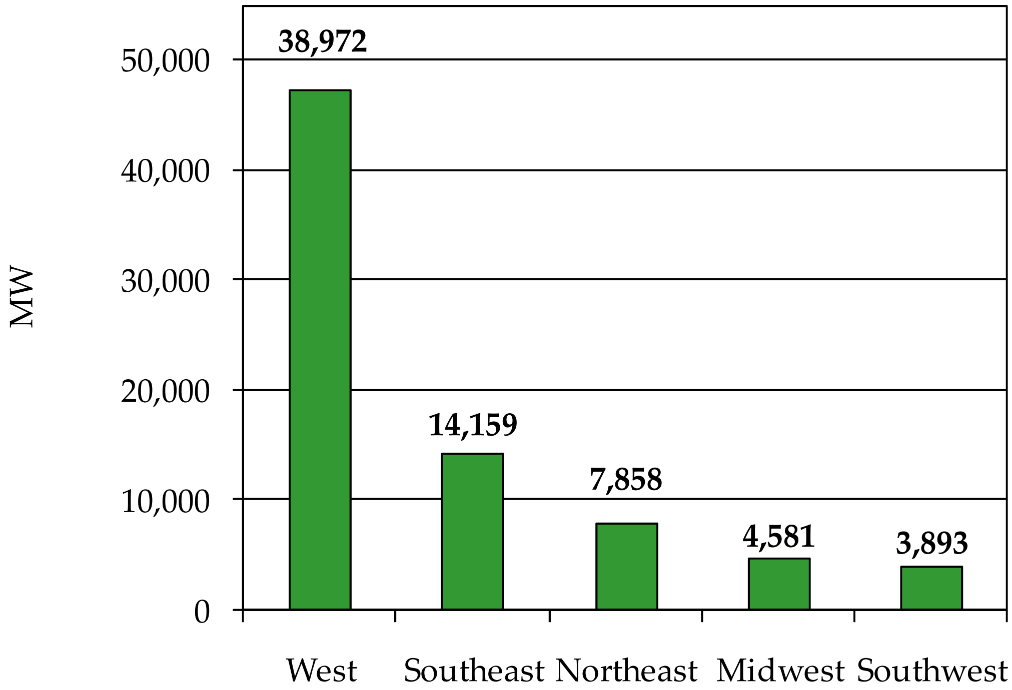
Navigant Consulting has classified the hydropower industry into two categories and several subcategories shown below.

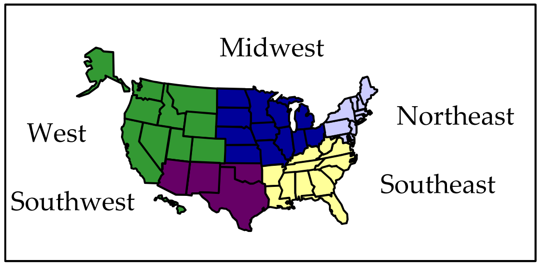


Note : Lighter colors indicate less mature technology not considered in this study

The West has the largest installed base of conventional inland hydro.

U.S. Developed Inland Hydro Nameplate Power by Region (MW)



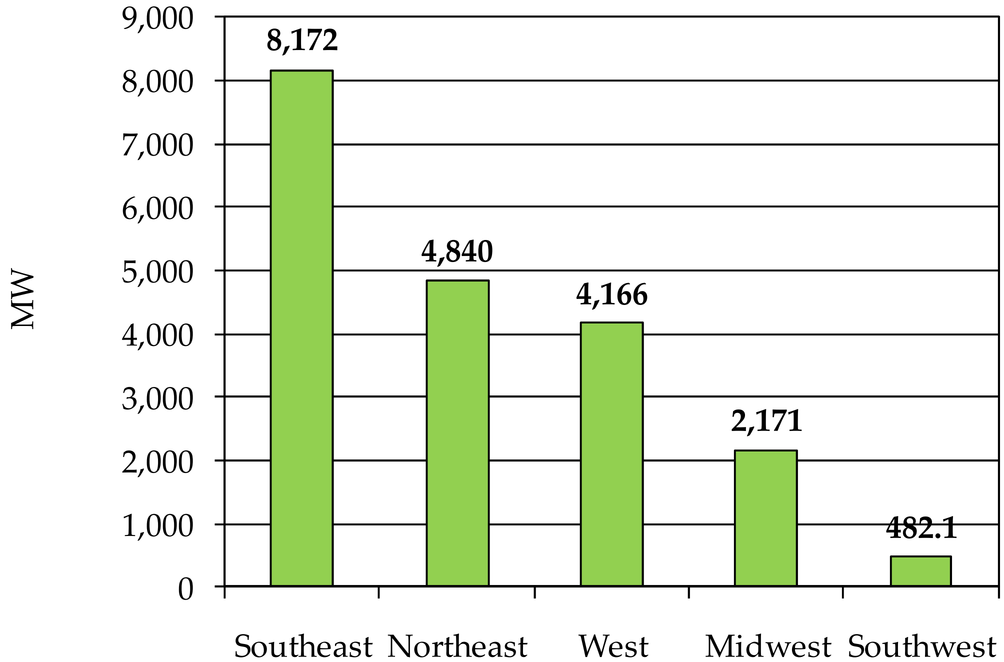


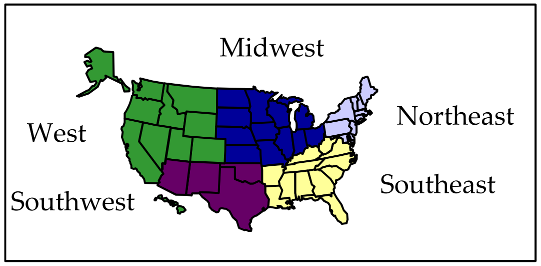
Total: ~78,000 MW

Source: Energy Velocity, 2009 data, Idaho National Lab, January 2006 data. Excludes pumped storage
Micro power: <100 kW; Low: >=100kW, <1MW; Small: >=1MW, <30MW; Medium: >=30MW, <100MW; Large: >=100MW

The Southeast has the largest installed base of pumped storage.

U.S. Developed Pumped Storage Nameplate Power by Region (MW)





Total: ~20,000 MW

Source: Energy Velocity, 2009 data.

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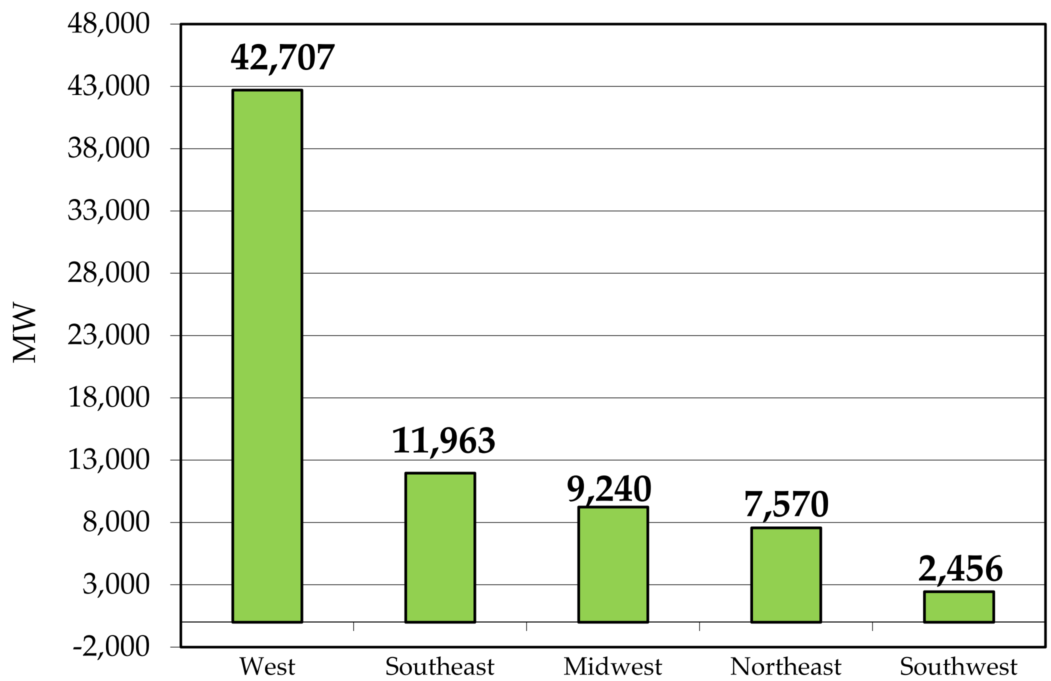
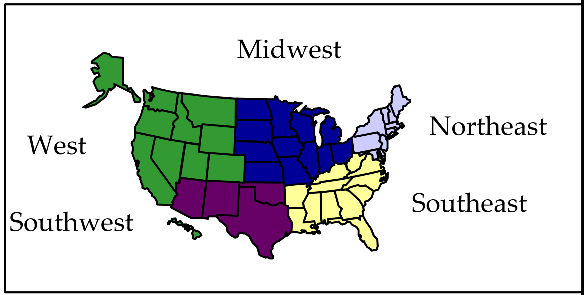
The West has the greatest untapped inland technical potential in the U.S.

U.S. Inland Technical Potential Nameplate Hydropower by Region (MW)





Total: ~74,000 MW
(excludes capacity additions and efficiency upgrades)

Source: INL *Feasibility Assessment of the Water Energy Resources of the US for New Low Power and Small Hydro Classes of Hydroelectric Plants* 2006 and *Estimation of Economic Parameters of U.S. Hydropower Resources* 2003: Excludes Capacity Additions and Efficiency Upgrades

Some studies exist that have examined the technical resource potential for wave and tidal energy technologies.

U.S. Ocean Hydropower Technical Potential by Technology	
Technology	**Technical Potential**
Wave	• 90 GW nameplate capacity (~30 GWa) as estimated by EPRI.[1]
Ocean Current	• Major U.S. ocean currents include the Florida Straits, Gulf Stream and California Current. The Florida Straits current is the largest U.S. ocean current resource.[2] • Off the coast of Florida, approximately 750 MW of technical potential may be developable by the year 2020, which represents a small fraction of estimated 4 to 10 GW of theoretical potential available in that region.[3]
Tidal In-Stream Energy Conversion (TISEC)	• An assessment of technical potential has not been undertaken. EPRI has conducted a TISEC study of 5 states, finding 300 MW of feasible technical potential, and an estimated 3,800 MW of theoretical potential in Alaska.

Sources:

1: *Assessment of Waterpower Potential and Development Needs. EPRI, Palo Alto, CA: 2007*. 1014762.

2: MMS, Technology White Paper on Ocean Current Energy Potential on the Outer Continental Shelf, 2006

3: Florida Atlantic University, Center for Ocean Technology estimates 25 GW total ocean current energy off the FL coast, which , when constrained by capture efficiency of technology and areas excluded due to slow flow, results in 4 – 10 GW of theoretical installed potential, uncontrained by technical considerations such as siting, transmission, cost, or environmental exclusion. 750 MW estimate installable capacity by 2020 based on discussions with FAU ocean energy experts and ocean current developers.

4: Bedard, R., et al. North America Tidal In-Stream Energy Conversion Technology Feasibility Study, EPRI TP 009 – NA, June 11, 2006. Estimate of MW potential in Alaska was calculated based on estimated generation as reported by EPRI.

Below are four main policy and/or legislative efforts led by the Federal government that support hydropower development.

Incentive/ Legislation	Description	Eligible Hydro
Production Tax Credit (PTC) **[OR - Optional ITC/Grant]**	» 2.1 ¢/kWh (2008 tax year) for first 10 years of operation. PTC is indexed to inflation and is good through 12/31/2012 for wind, 12/31/2013 for others. » Credit value is 1.1 ¢/kWh for hydro technologies » Taxpayers eligible to take the PTC may instead opt to accept the Federal Investment Tax Credit (ITC) or a US Department of Treasury Grant, both typically equal to 30% of eligible costs.	Incremental and qualified conventional, ocean & hydrokinetic (>=150 kW)
Renewable Energy Production Incentive (REPI)	» Rough equivalent to the PTC but for public power entities » 2.1¢/kWh (2008 $) adjusted for inflation for the first 10 years of operation. The REPI is subject to annual appropriations such that it may not be fully funded from year to year. » EPAct 2005 reauthorized this program through 2026 (i.e., for projects installed through 2016)	Tidal, wave, ocean thermal
Clean Renewable Energy Bonds (CREBs)	» Tailored for not-for-profit utilities; generally has the same applicability as the PTC. » The federal government grants the bondholder a tax credit in lieu of the issuer paying interest to the bondholder » $800 MM in CREBs are authorized through December 31, 2009 under *The Energy Improvement and Extension Act of 2008*. H.R. 1 allocated an additional $1.6 B.	Qualified conventional hydro, hydrokinetic, tidal, wave, ocean thermal
Minerals Management Services (MMS)	» Issued a final rulemaking in 2008 regarding guidelines for development and use of resources in the outer continental shelf (OCS) of the U.S. This rulemaking may help address some barriers which have hindered development of this region.	Any development on the outer continental shelf.

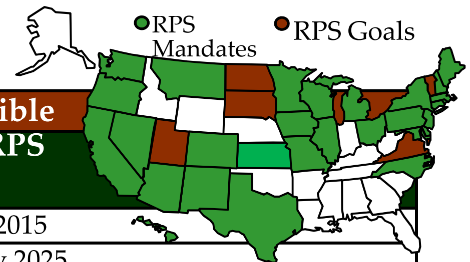
Note: Hydro is not eligible for the Federal Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation.

Many states have incentives or policies that could enhance adoption of hydroelectric, hydrokinetic, and ocean energy technology.

Existing Hydro Incentives		
Enabler	**Description**	**Relevant States**
MA ocean energy development plan	MA's ocean plan may include pre-approved sites for renewable energy projects	MA
Property Tax Credit	Property tax exemption or credit for the value added by hydropower	AZ, CO, CT, IN, KA, KS, KY, MA, MT, NC, NJ, NV, VT
Loan Programs	Low-interest loans for hydropower development	HI, IA, ID, MA, MS, MT, NE, NC, OR, PA, RI, WI
Public Benefits Fund	Funding for investment or R&D support for renewable energy technology	CA, CO, CT, DC,DE, FL, IL, IA, ME, MA, MN, NJ, NM, NY, OH, OR, PA, RI, WI
Production tax Credit	A tax credit for every kWh generated from a renewable resource, provided by the state	FL, MD, OK
Production Based Incentive	A production-based incentive paid for every kWh generated from a renewable resource, provided by the state.	CA, MN
Industry Recruitment Support	Grants, loans and other financial incentives to attract manufacturers of renewable energy to the state.	HI, CO, MT, OR
Investment Tax Credit	Income Tax Credit for alternative energy investments, with hydro eligible	MT, OR, UT
Net Metering	State law requiring net metering, with hydro eligible	AZ, CO, HI, IA, MN, MO, MT, ND, NE, NV, OK, OR, UT, WA, WY
State Rebate Program	Dollar per Watt rebates for renewables, including hydro.	NV

Source: March 2009, Database of State Incentives for Renewable Energy (DSIRE)

29 states and DC have RPS and 5 have goals. Hydro technologies qualify in all of these states.



State Renewable Portfolio Standards (RPS) for which Hydro is Eligible

State	Hydro Techs	Total RPS Target	State	Hydro Techs	Total RPS Target
AZ	CH^{10},CH^{EI}	15% by 2025	ND	CH, CH^{EI}	10% by 2015
CA	CH^{30}, CH^{EI},O	20% by 2010	NH	CH^{EI},CH^{*5}	23.8% by 2025
CO	$CH^{E,30}$,CH^{10}	20% by 2020 (IOUs), 10% munis and co-ops	NJ	CH^{*30}, O	22.5% by 2021
CT	ROR^{5} ,$ROR^{*E,5}$, O	27% by 2020	NM	CH	20% (IOUs), 10% (co-ops) by 2020
DC	CH*, O	11% by 2022	NV	PH, CH^{30}	20% by 2015
DE	$CH^{30,ENV}$	20% by 2019	NY	CH, ROR, O	24% by 2013
HI	CH, O, OC	20% by 2020	OH	CH^{ENV}	12.5% by 2025
IA	CH	105 MW (2% by 1999)	OR	O, CH^{EI}	25% (large utilities), 5%-10% (small utilities) by 2025
IL	CH^{EI}	25% by 2025	PA	CH^{ENV}, CH^{EI}, CH*	18% in 2020
KS	$CH^{10,}$ CH^{E}	20% peak demand by 2020	RI	CH^{30}, O	16% by 2020
MA	$CH^{ENV,EI}$,CH^{*5}, O	4% by 2009 (+1%/yr after) (tier 1); 3.6% tier 2	SD	CH	10% by 2015 goal
MD	CH^{30},CH^{*30},O, OC	20% by 2022	TX	O, CH^{O}	5,880 MW by 2015
ME	CH^{ENV},$CH^{100,E}$, O	10% add'l by 2017 class 1	UT	O, $CH^{EI,}$ $CH^{E,}$ CH	20% by 2025 goal
MI	CH^{E}, HK	10% by 2015	VA	CH, O	12% of 2007 sales by 2022
MN	CH^{100}	25% by 2025, (Xcel 30% by 2020)	VT	CH^{200}	Energy growth 2005-'12 met by RE; 20% by 2017
MO	CH^{10}	15% by 2021	WA	O, $CH^{EI,}$	15% by 2020
MT	$CH^{E,10}$	15% in 2015	WI	CH^{60}	10% by 2015
NC	CH^{10}	12.5% of 2020 sales by 2021 (IOUs), 10% of 2017 sales by 2018 (munis & co-ops)	n/a	n/a	n/a

O = Tidal Wave & Ocean Thermal, OC = Ocean Current, PH=Pumped Hydro, ROR=Run-of-river only, CH=Conventional Hydro (includes ROR) , HK=Hydrokinetic (no dams), ^{ENV}=State Environmental Standards, *Class/Tier2, ^{E}=Existing, ^{EI}=Incremental Efficiency Improvements to Existing, ^{5}=Under 5 MW, ^{10}=Under 10 MW, ^{30}=Under 30 MW, ^{60}=Under 60 MW, ^{100}=Under 100 MW, ^{200}=Under 200 MW, ^{O}=Unspecified "other hydro"

Source: July 2009, Database of State Incentives for Renewable Energy (DSIRE)

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Business as usual (BAU) represents a low RES (10% Renewable Electricity Standard) and accelerated represents a high RES (25%).

U.S. Hydropower Market Growth Scenarios – Cumulative Capacity by 2025				
Category	**Technology**	**Realizable by 2025 (BAU)**	**Realizable By 2025 (Accelerated)**	**Projected Level of Development**
Inland	Efficiency Improvements + New Capacity	5,750 MW	8,900 MW	4,400 MW is current industry consensus commercial. Add 3% improvement to 45,000 MW of federal facilities for base case and 10% improvement in accelerated
	New facilities in existing dams without hydropower	5,000 MW	10,000 MW	Consistent with EPRI projections for 2025 used in normal case, >60% of resource potential deployed in accelerated case
	Greenfield Sites	500 MW	1,000 MW	Projecting accelerated case as twice business as usual case
	Inland Hydrokinetic	500 MW	2,000 MW	Projecting 2/3rds of full resource potential achieved in accelerated case
	Pumped Storage	10,000 MW	24,000 MW	Project 1/3rd of current queue deployed in BAU case, accelerated has >80% of all in queue projects (31 GW being approved).
	Total by 2025	**21,750 MW (7%)**	**45,900 MW (15%)**	
	% of Total Resource Available	**7%**	**15%**	300,000 MW total available inland

Sources: INL and industry interviews.

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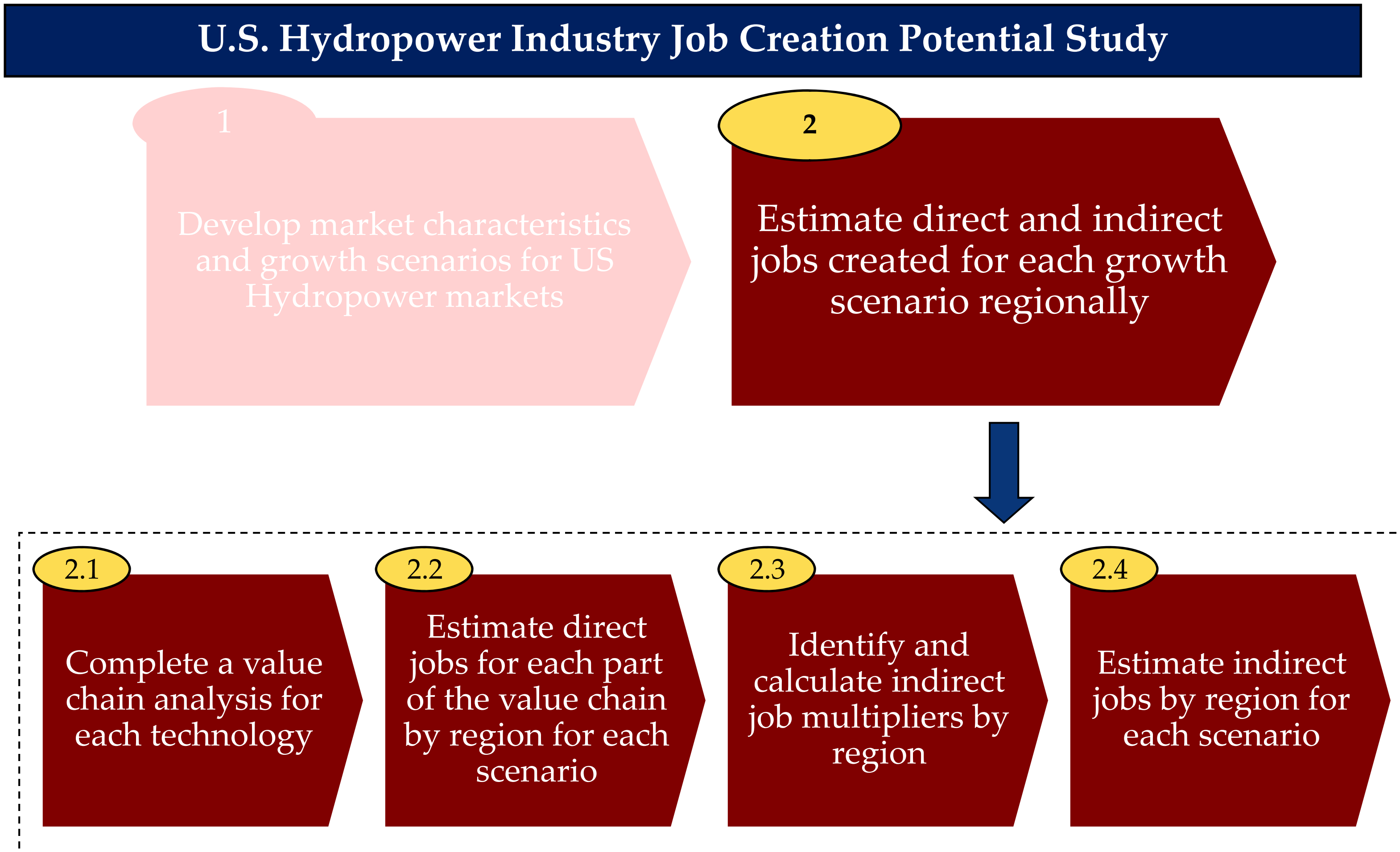
Below are ocean business as usual and accelerated potentials by 2025.

U.S. Hydropower Market Growth Scenarios – Cumulative Capacity by 2025				
Category	**Technology**	**Realizable By 2025 (BAU)**	**Realizable By 2025 (Accelerated)**	**Projected Level of Development**
Ocean	Wave	900 MW	9,000 MW	Project 1% of achievable capacity deployed after 2015 (normal) versus 10% of capacity for accelerated
	Ocean Current	250 MW	750 MW	Only assumed Florida potential with 1/3 of full potential realized in BAU and full capacity realized in accelerated
	Tidal In-Stream Energy Conversion (TISEC)	400 MW	4,000 MW	Project 10% of achievable capacity deployed after 2015 (normal)versus full capacity achieved for accelerated
	Total	**1,550 MW**	**13,750 MW**	Assumed after 2015 by 2025
Total Hydro	**Inland + Ocean**	**23,300 MW**	**59,650 MW**	
	% of Total Resource	**6%**	**15%**	300,000 MW Inland + 95,000 MW Ocean

Sources: INL and industry interviews.

Task 2 focused on estimating direct and indirect jobs created regionally for each growth scenario.



This analysis covered key parts of the value chain impacting jobs.

Hydropower Value Chain

Project Development
- Permitting
- Regulatory studies
- Licensing
- Design
- Scaled model testing
- Financing
- Insurance

Component Manufacturing
- Turbine
- Generator & Excitation
- Governor and Control System
- Other hydro mechanical components (valves, penstock etc.)
- Other electrical components (transformers, power electronics etc.)

Project Deployment
- Shoreline development
- Environmental instrumentation construction (e.g. fish bypass)
- Project Construction
- Project Commissioning
- Financing
- Insurance

Project Owner & Operator
- Routine O&M
- Minor equipment overhauls
- Major equipment overhauls

RECs & Offtakers

Note: Items in grey included in indirect jobs

In scope

Out of scope

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Navigant cross-checked cost basis job estimates with industry interviews. Below are typical full time equivalents (FTEs) per MW.

U.S. Hydropower Market Direct Jobs in FTE (Full Time Equivalents) – 2009		
Technology	**Average Project Size**	**Total FTE/MW (Average)**
Inland Hydrokinetic, Micro Hydro (<1 MW)	10 MW	6.00
Efficiency Improvements, New Capacity in existing facilities, modifications	10 MW	6.50
New Facilities in low head/low flow Existing Dams without Hydropower	10 MW	5.30
Green Field	50 MW	6.00
New Facilities in higher head / higher flow Existing Dams without Hydropower	50 MW	5.30
Green Field	100 MW	6.00
Pumped Storage	500 MW (interviews) 1,000 MW (cost basis)	5.10
Ocean – Wave, Tidal[1]	15 – 200 MW (literature) 50 MW (cost basis)	14.0

NOTE:
- FTE/MW represents typical value (non cumulative) required to execute a project of that size. Actual years taken to implement project will vary and this needs to be multiplied by years taken to get the cumulative man years estimate.
- Used interviews with 20+ industry stakeholders to arrive at a range of FTE/MW estimates
- Also used typical project costs to arrive at a cost based FTE/MW estimate that was used as the "average" value

Navigant Consulting's methodology for calculating indirect jobs is summarized below.

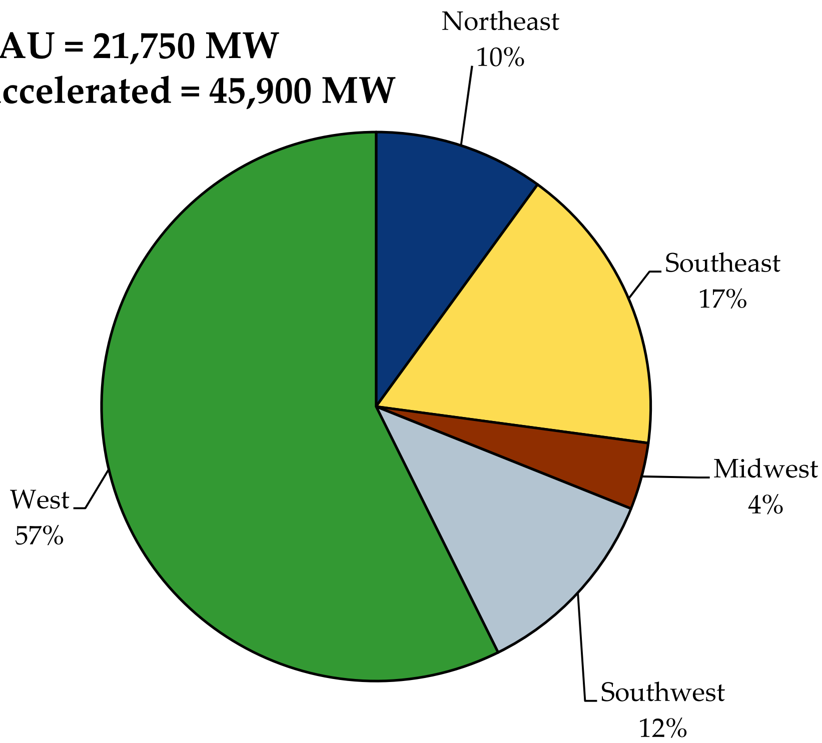
Indirect Jobs Analysis Methodology
• Used business as usual and accelerated forecasts out to 2025. • Used current distribution of technical resource potential available to estimate the MWs deployed by region.   – For example, the current resource potential suggests that 9,000 MW (~57%) of inland and ~1,200 MW (~59%) of ocean potential would be deployed in the West by 2025. • Assigned 80% of the manufacturing in the Northeast with 10% each in the Midwest and West • Assigned identical indirect (Type I) multipliers for both inland and ocean so total direct job numbers were added up by job classification (value chain, type) to calculate corresponding indirect jobs. • Obtained Type I multipliers by state from the US Bureau of Economic Analysis database.

Sources: Industry interviews, June 2009 and INL Report.

Forecasts by region were based on resource potential allocations by state.

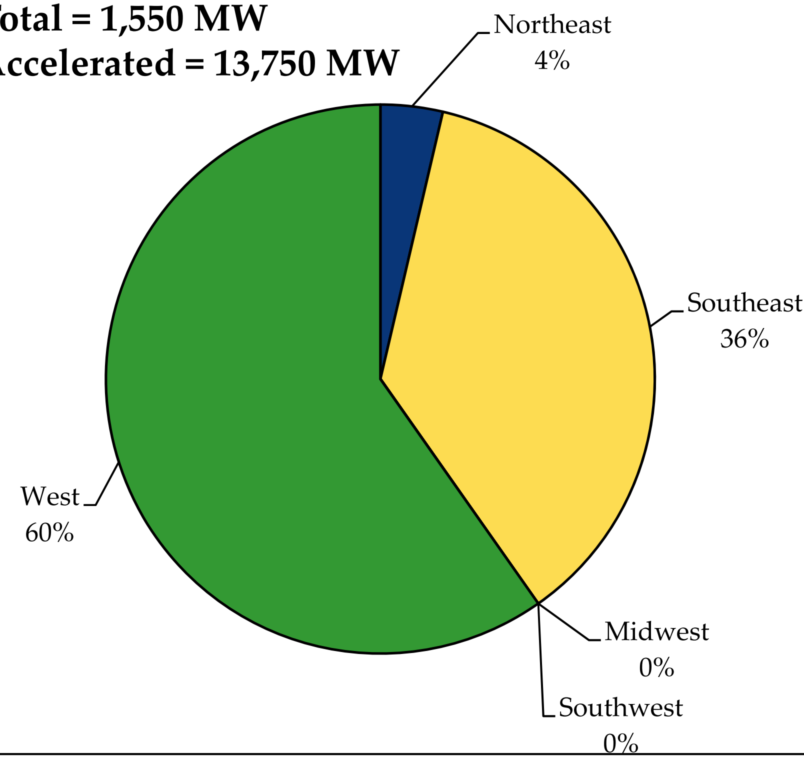
Inland Forecast Allocation
2025

BAU = 21,750 MW
Accelerated = 45,900 MW



Ocean Forecast Allocation
2025

Total = 1,550 MW
Accelerated = 13,750 MW



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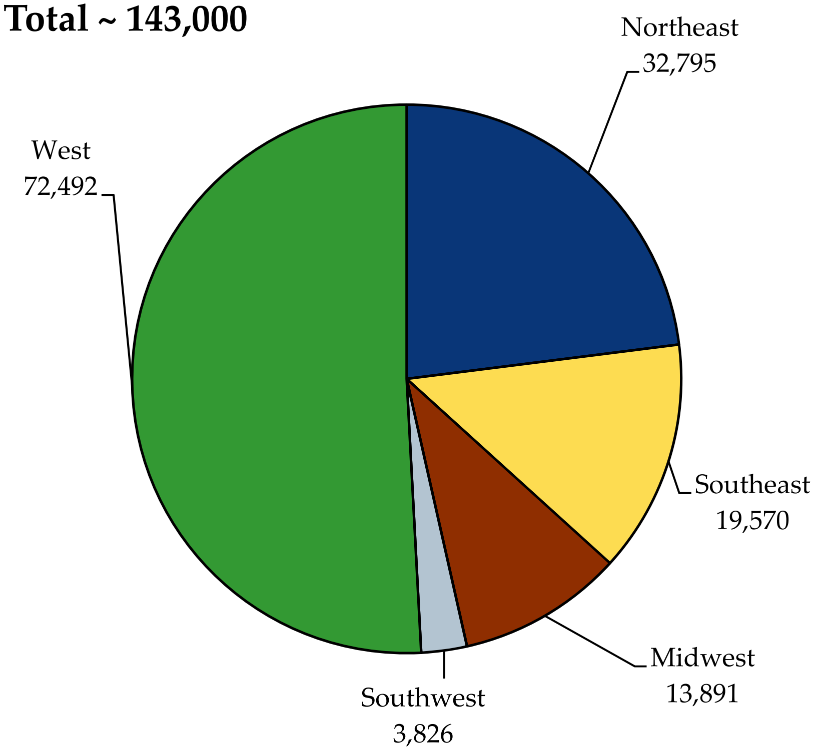
A total of ~238,000 jobs are estimated to be created in a BAU scenario with a low Renewable Energy Standard - RES (~10% by 2025).

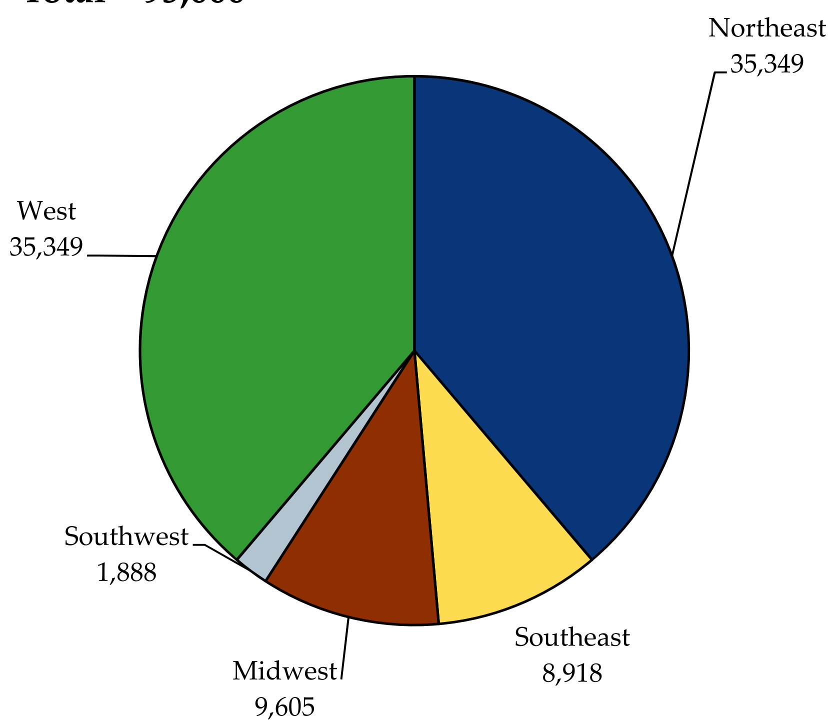
Direct Jobs Allocation (Cumulative)
BAU 2025

Total ~ 143,000



Indirect Jobs Allocation (Cumulative)
BAU 2025

Total ~ 95,000

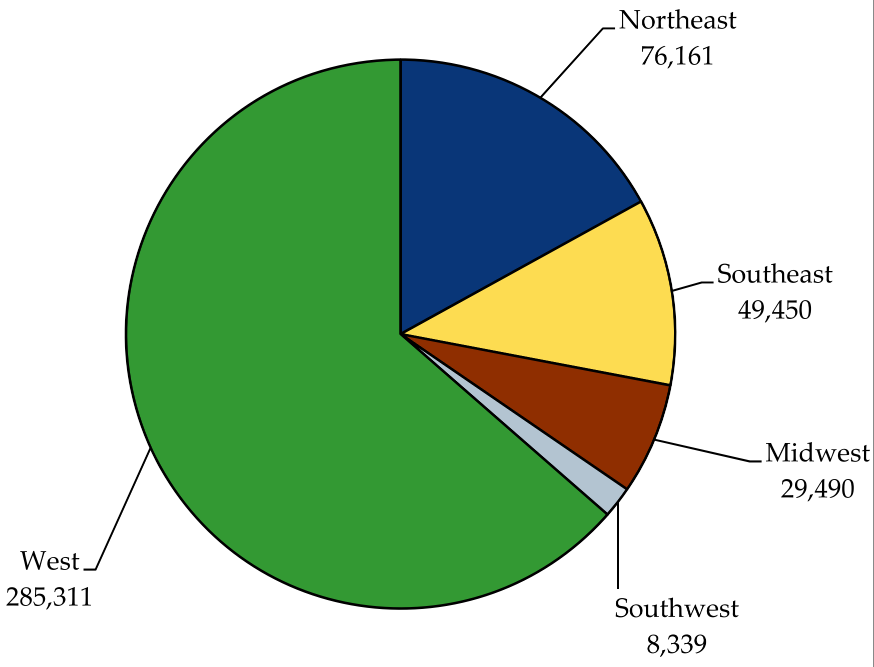


Note : Job estimates represent cumulative FTEs required over a 16 year period out to 2025

A total of ~700,000 jobs are estimated to be created in an accelerated scenario with a high RES (~25% by 2025).

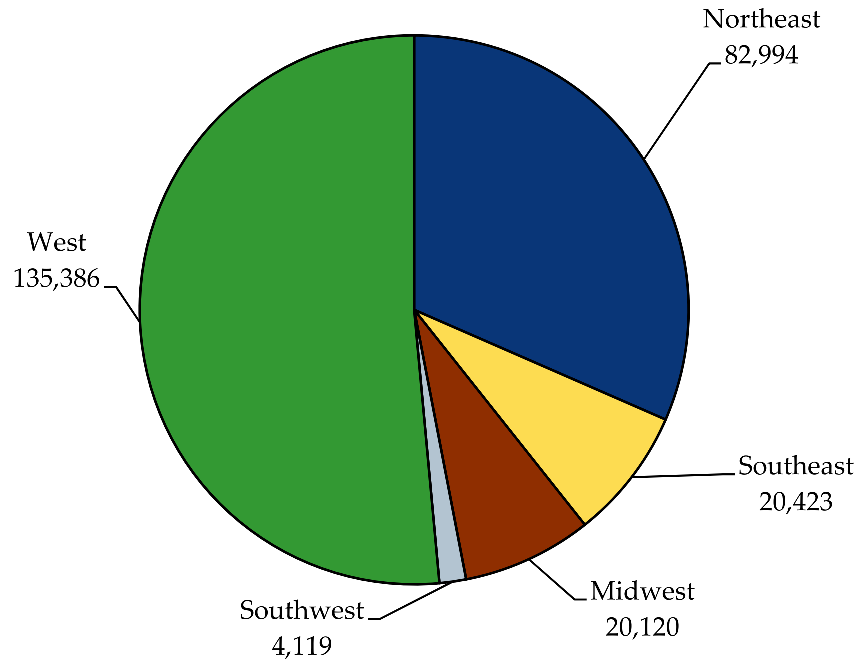
Direct Jobs Allocation (Cumulative) Accelerated 2025

Total ~ 443,000



Indirect Jobs Allocation (Cumulative) Accelerated 2025

Total ~ 265,000



Note : Job estimates represent cumulative FTEs required over a 16 year period out to 2025

The U.S. hydropower industry could install 23,000 MW – 60,000 MW of new capacity by 2025 depending upon the national RES adopted.

Conclusions
• The U.S. hydropower industry could install 23,000 MW – 60,000 MW of new capacity by 2025 depending upon the national RES adopted. – This additional capacity represents only 6% - 15% of the total untapped hydropower resource potential in the U.S. – Installing this additional capacity will require an estimated 140,000 – 440,000 cumulative direct jobs over a 16 year period. – These jobs will result in an additional estimated 95,000 – 265,000 indirect jobs over that same period. • Total jobs (direct + indirect) would therefore be in the range of 230,000 – 700,000 jobs • These total job estimates do not include induced jobs (e.g., service sector jobs such as retail, restaurants created by added dollars flowing into the market) that represent an additional upside potential from the growth of the hydropower industry.

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