Waste Heat to Power Market Assessment: Opportunities, Technologies and Barriers

Wednesday, June 24, 2015 2:00-3:00 p.m. EDT



Anne Hampson, project manager, ICF International, and lead author
Claudia Tighe, combined heat and power deployment program manager, U.S.
Department of Energy, Office of Energy Efficiency and Renewable Energy
Jessica Lubetsky, officer, clean energy, The Pew Charitable Trusts
Susan Brodie, executive director, The Heat is Power Association



Industrial Energy Efficiency

Making America's power more efficient, resilient and our manufacturing more globally competitive

pewtrusts.org

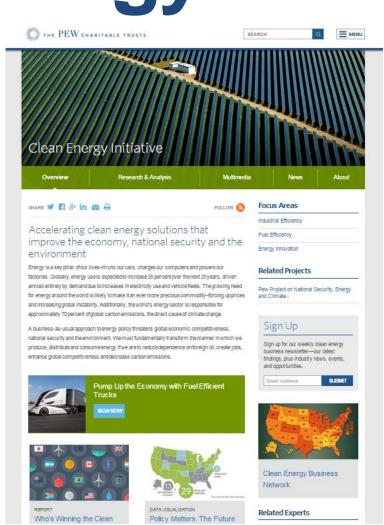
Pew clean energy initiative

The goal is to accelerate the clean energy economy for its national security, economic and environmental benefits.

The initiative promotes the adoption of key changes to U.S. energy policy in four sectors:

- Industry
- Utilities
- Transportation
- Research and Development

<u>www.pewtrusts.org/cleanenergy</u> <u>www.pewtrusts.org/businessnetwork</u>

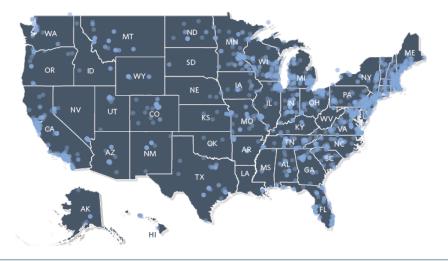




Clean Energy Business Network

Free resource to inform clean energy business leaders about Federal energy policy and share their perspectives with policymakers

Pew Clean Energy Business Network Member Locations More than 3,000 business leaders nationwide





Industrial energy efficiency in the U.S.

The Problem

Finance is needed to help energy users cover capital costs

The currently available tax credit makes it difficult for projects to qualify and is limited in the scope of eligible technologies

The Solution

The current Investment Tax Credit is in need of changes so as to ensure efficient power generating technologies like combined heat and power (CHP) and waste heat to power (WHP) have **parity** with other clean and efficient technologies in the available energy tax incentives.



Changes would make the tax credit more accessible

Current Policy	Proposed Policy
10% ITC for CHP	Expand ITC to 30% for CHP
Does not include WHP	Include WHP
Applies to the first 15MW of CHP projects which are smaller than 50MW	Apply to first 25MW, eliminate CHP project size cap
Ends Dec. 2016	Ends Dec. 2018



Senate bills in the 114th Congress

S. 1516 The Power Efficiency and Resiliency (POWER) Act

Senators Susan Collins(R-ME) and Bob Casey(D-PA) introduced in June 2015

- ✓ Expands investment tax credit to 30%
- ✓ Adds waste heat to power as a qualifying technology
- ✓ Applies to first 25MW, eliminate project size cap
- ✓ Extends ITC to December 2018

Cosponsors: Sen. Harry Reid (D-NV)

S. 913 Waste heat to power bill

Senators Dean Heller (R-NV) and Tom Carper (D-DE) introduced in February 2015:

- Included in Senate Finance Committee markup of tax bills
- Passed out of committee and is awaiting floor consideration
 - ✓ Would make WHP eligible for the existing investment tax credit (10% credit for systems up to 50 MW in size)
 - ✓ Changes to the credit would take effect on the date of enactment and would expire with the rest of the ITC December 2016.



House bills in the 114th Congress

H.R. 2657, The Power Efficiency and Resiliency (POWER) Act

Congressmen Tom Reed(R-NY) and Earl Blumenauer(D-OR) introduced in June 2015

- ✓ Expands investment tax credit to 30%
- Adds waste heat to power as a qualifying technology
- ✓ Applies to first 25MW, eliminate project size cap
- ✓ Extends ITC to December 2018

Rep. Thomas Reed (R-NY) Rep. Earl Blumenauer (D-OR) Rep. Mark E. Amodei (R-NV) Rep. Kathy Castor (D-FL) Rep. Chris Collins (R-NY) Rep. Christopher P. Gibson (R-NY)

Rep. Joseph J. Heck (R-NV) Rep. Ron Kind (D-WI) Rep. Tim Ryan (D-OH) Rep. Steve Stivers (R-OH) Rep. Dina Titus (D-NV) Rep. Peter Welch (D-VT)



Broad, bipartisan support, including:

- Manufacturers
- Large energy users
- Organized labor
- National security organizations
- Environmental organizations

	Put Am(On arto	e Mi ans		n Nor	
	Harness th	e heat	Each year, America's utilitie	-	- 18	
	to create n	ew jobs	Each year, America's utilitie chimneys to power all of Ja we can hamess that wasted make our manufacturers mo According to Call as	pan. But with existing as	igh heat up their	
	and make our	0.0	the our manufacturers one	gy, uramatically out	al and a second se	
	more com		I O Olik Hidae Mati			
4	earn man	petitive.	According to Oak Ridge Nati our industrial energy efficience rivate investment in the U.S. Y efficiency at waves	by would spur more than 1	ntly increasing	
	ball more about	industrial energ	vivate investment in the U.S. y efficiency at www.F	and create up to 1,000,00	200 billion in new 20 jobs.*	
			y at www.p	ewTrusts.org/ind	untel to the	
(Dense of the		4	75 businesses agr		astrialefficiency	
i Latina Ganaga Alas Alas Analy Prove Can	NE Company Company	da	and a set of	ee.		
Angen Line gr fange Angen Line gr fange Alfinder Coppense	Martin Californi Theorem 1 Anno Anno Californi Anno Anno Anno Anno Californi Anno Anno Anno Anno Anno Anno Anno Anno	Allen of Sections Sectors Weine Sectors Sectors Sectors	Minister Magniture West Service for Report Marine Following for West Service for Report Following for	Per Down		
Attendade Sider in For Springer Lodge	d Bale and Parent Constitution (and Constitution)	Per Per Balan	A Potters Floridan Michael Chapter of Paral Network Floridan Michael Michael Michael	Participanting Designments Design of the participanting	Derestilik, tes. Mittalange	
All same for the Annual All sa	Andweidigs Inn. DAR Advanceden d Mitcheng College Company	Breach Street	Americana A Service Can Americana A Service Can Americana A Service Can	Anders AL Land	Annual State State State	0
Andre Construction Construction, Inc. Aprilate Construction, Inc.	m Construction & Dates Construction & Dates Construction Presser (19)	Suchasella State	TP Bridanis Container Billey Alternation of America Metanis List	Robert Maddage Co. Revel Covergo Revent Covergo	Sava Canadana Sunta Prove Interference Private Interference	
Annual Corp.	Contraction Contraction	Statute in Second Second	water Lange Richards Lands	Respected Learning Development	Internation Accounting The Approximation of Data Constants The December (State Constants)	
	Service in: Separative Drivery Fue	ter Bruntereg bar nefferter Brunt Spierel	Rag, Las, MacApinel, and Don Indiffere Ramp Redeved Corps for the Second Redeved Corps for the Access	And Design Design Systems Resident States of Concession States Designed Concession	Des Card Del Artes Company Des Card Del Artes Company Des Manuel Company Des Manuel Company	
Advantum Construction Composition of the optimized Composition of Composition	any Contract Industry	Gardense Court	the local and th	Sand And American Science of C	The Lemma Report	
An article and Canada for an An article and Canada for an An article and Antonia for An article and Antonia for An article and Antonia for Antonia for an article and Antonia for an article and Antonia for an article and article Antonia for an article and article Antonia for an article and article Antonia for an article and article and Antonia for article and article and article and Antonia for article and article and article and article and Antonia for article and article and article and article and Antonia for article and article and article and article and article and Antonia for article and ar	ang Challends for it form ang Challends for demologies (County of Blance its, (Dock had form and an County of Blance its) an County of Blance its and County of Blance it	Newsy All Frances	Conception of the second			
An a circuit i a diversion a An a circuit i diversi di an a circuit di anti di anti An a circuit di forma giune An a circuit di forma giune An a circuit di forma giune An a circuit di forma giune Angina di anti di anti Angina di anti Angina di anti di anti Angina di anti Angina di anti di anti Angina di a	Ange Conservation of Area ange Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation Conservation	All Color Co. A E Folger Co.	Without Annual and Without Annual Annual Reserve to Mill Stand Charal Males Condensators West Stan Miller Condensators West Stan	Rest Conferences of Astronomy State	The Destination States The States Group, List The States of Composition The States of Composition	
A decision of informations in the second second second description of the second second description of the second second second description of the second second second second second second second description of the second seco	 Conservation (Conservation) Conservation (Conservati	Altra Jan Altra	Minimum Menungan Minimum Attachan Minimum Minimum Attachan Minimum Attacha	Rest Compressions Restance Lansing Auto- Prop Operations and Astronomics LLC Arguest Marca marks RFW Machine and Astronomics Inc. REV Machine Astronomics Inc. Rest Astronomics Astronomics Inc.	The Park Grantation Social The Social Grant (Str. The Social Grant Accession of Social Grant Accession of Social Grant Social Review Socialistics Review Socialistics Review Socialistics Review Socialistics Review Socialistics	
A densitie of definitions A definition of definitions A definition of definitions A definition of definitions A definitati	An and a second	A Card Jan A Card	Manuara Branca par F Mara, Annola San di San Manuara Mara San di San di Mana San di San di San di Bana San di San di San di Bana San di San di San di Mana San di San di San di Nataka San di San di Mana San di San di San Mana San Mana San di San Mana San Mana San di San Mana San di San Mana San Mana San di San Mana San Mana San di San Mana San Man Man Mana	Aller Experiments Analosis Landonis Ang Warrinson and Astronomics LLC Ang Warrinson and Astronomics LLC Ang Warrinson and Astronomics Inc. Mark Machinesis Mark Astronomics Ang Salary Kan and Astronomics Edit Sal. Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bally Bal	The Print Chartening Study The Unite Origin (20) The Electric Comparison of Chartening Comparison of Chartening Comparison (20) Description (20) Description (2	
An annual individual a langua (4) annual a langua (4) annual a dan annual (4) annual a dan annual (4) annual (4) dan annual (4	An	Mary R. Cali Line Record Control Control Control Market Direct Control Control Market Direct Control Market Control Control Market Contro	Marconia Marague Hana Alancia Bana Alancia B	Aller Expressions Annual Conference on Accounts 11.0 In the Account of Accounts 11.0 In the Account of Accounts 11.0 In the Account of Accounts 11.0 Account of Accounts 11.0 Accounts Accounts In the Account of Accounts 11.0 Accounts Accounts In the Account of Accounts 11.0 Accounts	The Part Directory Study The Part Directory Study The Study of Company The Study of Company T	
A manual individual a dense of the strains dense of the strains	an construction of the second	Mary 4 Cal La Bary 4 Cal La Barry Bertania Marry Bertania Cal Sever 1 Barry Bertania Cal Sever 1 Barry Barry Barry Marriel Carp 1 Barry Barry Barry Marriel Carp 1 Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry Barry	Manual Ma	Alter paperange Antibio Linkin Ask Antibio Linkin Ask Antibio Linkin Ask Antibio Linkin Alter Paperange Alter Paperange Hand Antibio Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handler Handle	All Proc. Streams Status The State Streams Status The State Streams State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State State	
An and a distance of the second of the secon	ang canadian ang ang ang ang ang ang ang ang ang a	Alexa in a second	Article Response Article Resp	All Dispanses All Dispanses All Dispanses Research and All Dispanses Research and Research Research and Re	And Deve Character Scient, The Scientific Character The Scientific Character The Scientific Character The Scientific Character The Science Character The S	
A sense of a character a sens	ang canaditational factor ang canaditational factor canaditational factor canaditational factor canaditational factor canaditational factor canaditational factor between the facto	Mary & L (eq. 14, 14, 20, 10, 10, 10, 10, 10, 10, 10, 10, 10, 1	A second	Mit Propression And State Constraints of the And State Constraints of the And State Constraints of the And State Constraints of the And Andreas Andreas Andreas Andreas	er non durante i ver no durante durante durante no durante durante durante non durante durante durante non durante durante durante non durante durante non durante durante non durante durante non durante durante non durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante durante d	
Annual de Alaman	an canada a series a	Boys	A series of the	Bill Paraman Bill Paraman In Research States States In Research States Research States	an and Auronic Yunki man and Auronic Yunki and Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Auronic Yunki Yunki Yunki Auronic Yunki Auronic Yunki Yunki Yunki Y	
An and a dischard and a second	an called an and a second and a	Nerry 4 4 201 Km / 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	An and a second	Ball Particles Ball Particles	an and Jarunia Yuak managara yang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang ang	
A read of defaults of the second seco	An and a second	 A a but, but, and a but, but, but, but, but, but, but, but,	An and a second	A A A A A A A A A A A A A A A A A A A	an and around its and the second around a second around ar	
A start of the sta		 A a but how and a second second	Area (Construction) Area (Con		An experimental and a second s	
	An and a second	An	An and a second	A second	The Control of Control	
	A CARDENAL AND A CARD	Annu A in the second se	The second secon	An experimental and a second s	The share sh	
		Annu A in the second se			An experimental and a second s	
	A DATA A		Terran bange Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannessen Hannesse	A second	and provide the second	
	a billione and a bill		Terran Annuel Terran Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel Annuel	And	an el her	
					and provide the second	
			Terran Annual An		 And Antone Take, and Antone	



Messaging for WHP

Competitiveness

- Cut costs and allow manufacturers to better compete in the global marketplace
- Create as many as 100,000 highly skilled new jobs
- Free resource produced whenever an operation is running
- Produce enough energy to power 11 million homes for a year
- No additional fuel needed, no additional combustion





Questions? Contact:

Jessica Lubetsky, Officer Pew Clean Energy Program www.pewtrusts.org/industrialefficiency

email: jlubetsky@pewtrusts.org phone: 202-540-6356

Interested in having your business endorse the POWER Act? Contact:

Lynn Abramson, Senior Associate

Pew Clean Energy Program www.pewtrusts.org/businessnetwork

email: labramson@pewtrusts.org phone: 202-540-6474



The Heat is Power Association

The industry-led advocacy organization focused exclusively on advancing waste heat to power.

Active with federal, state and regional stakeholders including business, government, agencies (DOE, EPA), industry associations and environmental groups.

Through education and advocacy, HiP seeks inclusion of WHP in federal and state legislation, regulations, and programs as an energy efficient power resource that generates electricity with no additional fuel, combustion or emissions.

The only industry association focused exclusively on reducing fuel use and emissions related to on-site power generation by increasing the U.S. market for waste heat to power.



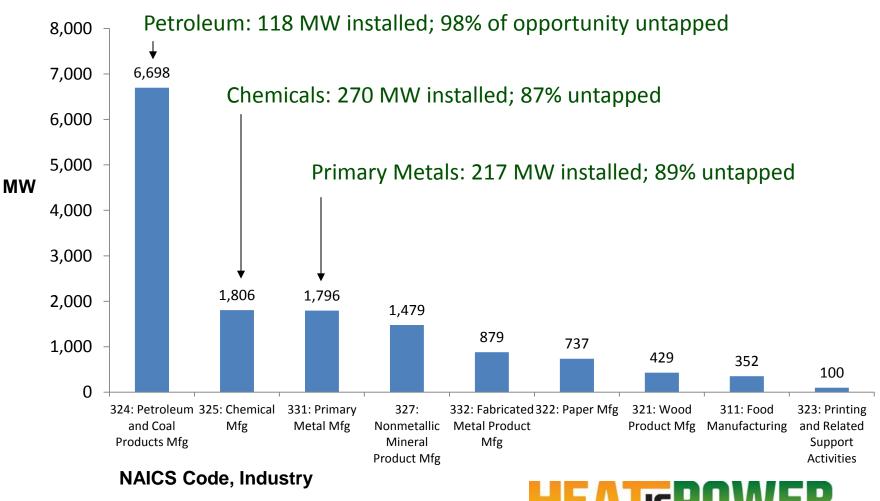
Support for WHP

- 17 states list WHP as a renewable resource in their RPSs and similar programs
- Pending federal legislation would:
 - Add WHP to the existing tax credit
 - Senate Finance Committee mark-up would make WHP eligible for the 10 % ITC
 - POWER Act would make WHP eligible for the 30% ITC
 - Add WHP to renewable energy definition for federal procurement
 - Improve interconnection procedures and tariff schedules and standards for supplemental, backup, and standby power fees for CHP and WHP (HEAT Act S 1202)
 - Advance the integration of clean distributed energy into electric grids (Clean Distributed Energy Grid Integration Act S 1201)
 - Extend the publicly traded partnership ownership structure to energy power generation projects, including WHP (Master Limited Partnership Parity Act)
- National Association of Clean Air Agencies (NACAA) "CPP: Menu of Options" highlights WHP as an option for complying with the Clean Power Plan

Since its establishment in 2011, Heat is Power has raised awareness of WHP opportunities and barriers and significantly increased support for WHP in federal and state legislation and programs.



Potential for Additional WHP Projects



Source: ICF Waste Heat to Power Market Assessment March 2015

'S CAPTURE

LET

HiP's Next Steps re: WHP Market Assessment

- The Association and its members are eager to work with industries and states that exhibit high WHP potential
- HiP members offer technologies across a wide range of temperatures, waste heat conditions, sizes, and industries
- Some members design, build, own and operate WHP projects
- HiP project fact sheets that highlight operating projects in the U.S., along with other WHP resources, are available at heatispower.org

Connecting industrial waste heat producers with solution providers. Broadening awareness of WHP as a way to address critical public policy objectives related to increasing industrial efficiency and reducing emissions of greenhouse gases and criteria pollutants.



Building Opportunities for WHP

For more information about HiP's efforts and membership, contact:

Susan Brodie, Executive Director susan@heatispower.org 630.292.1304 www.heatispower.org



WHP Market Assessment Webinar

Anne Hampson

Senior Manager, ICF International

June 24, 2015

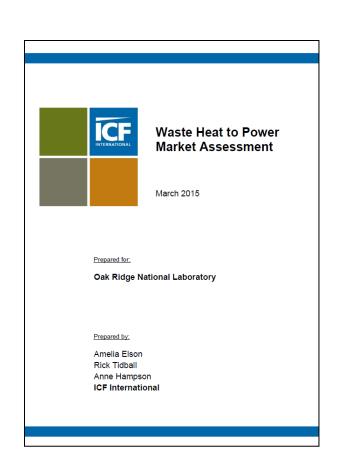
icfi.com | Passion. Expertise. Results.

Waste Heat to Power Market Assessment

- "Waste Heat to Power Market Assessment" report released in March 2015
 - ORNL Report No. ORNL/TM-2014/620
 - <u>http://info.ornl.gov/sites/publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publications/Files/Publicatio</u>

Topics covered:

- WHP Technologies and costs
- WHP Applications
- Existing WHP Installations
- Technical and Economic Potential for WHP
- Policy Drivers and Barriers





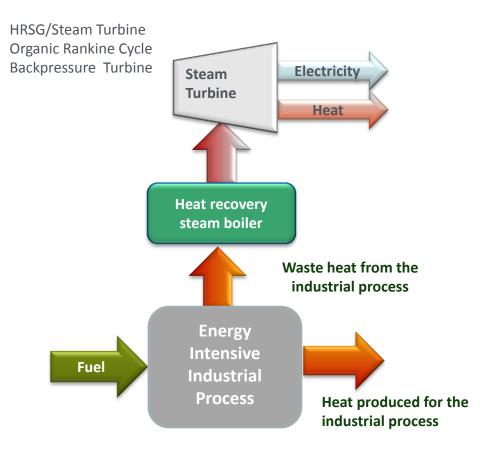
Defining Combined Heat & Power (CHP)



The on-site simultaneous generation of two forms of energy (heat and electricity) from a single fuel/energy source

Waste Heat to Power CHP

(also referred to as Bottoming Cycle CHP or Indirect Fired CHP)



- Fuel first applied to produce useful thermal energy for the process
- Waste heat is utilized to produce electricity and possibly additional thermal energy for the process
- Simultaneous generation of heat and electricity
- No additional fossil fuel combustion (no incremental emissions)
- Normally produces larger amounts electric generation (often exports electricity to the grid; base load electric power)

Types of Waste Heat Streams



Source of Waste Heat Stream	Examples (illustrations only; not all inclusive)
Thermal Process	Energy recovered from a furnace, oven, or kiln, and subsequently used in a combined heat and power (CHP) bottoming cycle, referred to as waste heat to power (WHP).
Mechanical Drive	Energy recovered from a natural gas pipeline compressor station.
Other	Waste heat recovered from industrial or other processes that generate heat as a byproduct, such as exothermic reactions, incineration, and pressure reduction.

Approach



- Objective Estimate the potential to generate electricity from industrial waste heat streams in the United States
- Type of Assessments
 - Evaluated technical potential for all temperatures including low temperature (< 450 °F) – waste heat streams using <u>top-down approach</u>
 - Conducted more detailed market penetration analysis for medium and high temperature waste heat streams (≥ 450 °F) using <u>bottom-up approach</u>
- Approach



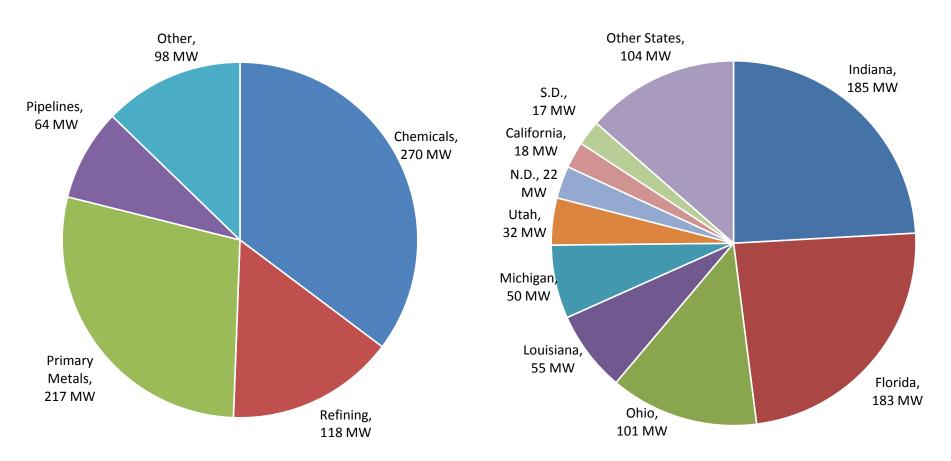
 For low temperature (<450 °F) applications, ICF did not have sufficient cost and performance data from vendors to complete a bottom-up economic analysis

Existing Waste Heat to Power (766 MW)



Existing WHP by Application

Existing WHP by State



Source: DOE/ICF CHP Installation Database (U.S. Installations as of December 31, 2013)

Technologies

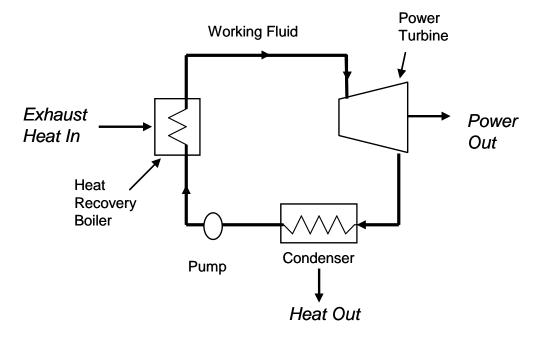


- Rankine Cycle (or variations of Rankine cycle)
 - Steam Rankine Cycle (SRC)
 - Organic Rankine Cycle (ORC)
 - Kalina Cycle
 - Supercritical CO₂

Emerging Technologies

- Thermoelectric
- Piezoelectric
- Thermionic
- Thermo-photovoltaic
- Stirling
- Steam

Rankine Cycle Heat Engine



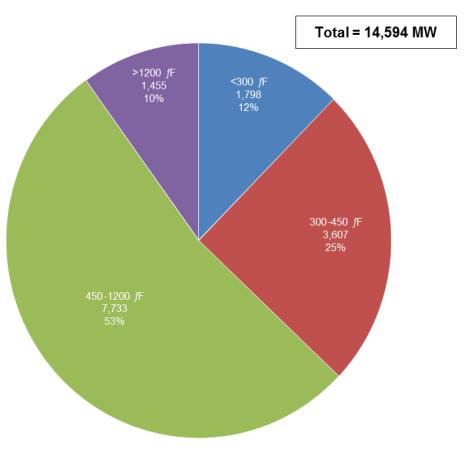
Approach for "Top-Down" Analysis of Technical Potential



- Top-down technical potential
 - Started with previously collected data on waste heat streams, including temperature and energy content from:
 - DOE, 2008. Waste Heat Recovery: Technology and Opportunities in U.S. Industry, prepared by BCS Inc.
 - ORNL, 2004. An Inventory of Industrial Waste Heat and Opportunities for Thermally Activated Technologies, prepared by United Technologies Research Center
 - Included all waste heat stream temperatures in analysis
 - Used practical efficiency based on Carnot limit to calculate WHP potential

Remaining Technical Potential for WHP in the Manufacturing Sector

(breakdown by temperature range)



Top-Down Analysis – Remaining WHP Technical Potential by NAICS Code



Industry	Electric Power (MW) by Temperature Range (°F)					
	<300	300-450	450-1200	>1200	Total	
311: Food Manufacturing	13	182	157	-	352	
312: Beverage and Tobacco Product Manufacturing	1	9	2	-	12	
313: Textile Mills	32	11	4	-	47	
314: Textile Product Mills	-	-	-	-	0	
315: Apparel Manufacturing	2	-	-	-	2	
316: Leather and Allied Product Manufacturing	-	-	-	-	0	
321: Wood Product Manufacturing	160	242	27	-	429	
322: Paper Manufacturing	129	567	42	-	737	
323: Printing and Related Support Activities	40	19	29	13	100	
324: Petroleum and Coal Products Manufacturing	320	687	5,628	64	6,698	
325: Chemical Manufacturing	331	461	739	276	1,806	
326: Plastics and Rubber Products Manufacturing	28	14	5	6	52	
327: Nonmetallic Mineral Product Manufacturing	61	288	935	196	1,479	
331: Primary Metal Manufacturing	499	337	62	899	1,796	
332: Fabricated Metal Product Manufacturing	127	671	80	-	879	
333: Machinery Manufacturing	17	34	11	-	62	
334: Computer and Electronic Product Manuf.	7	13	-	-	20	
335: Electrical Equipment Manufacturing	6	8	2	-	16	
336: Transportation Equipment Manufacturing	15	42	7	-	64	
337: Furniture and Related Product Manufacturing	5	11	4	1	21	
339: Miscellaneous Manufacturing	5	11	4	1	22	
Total	1,798	3,607	7,733	1,455	14,594	
Share of Total	12%	25%	53%	10%	100%	

Approach for "Bottom-Up" Analysis of Technical Potential



- Identified candidate facilities using existing databases
 - EPA Greenhouse Gas Reporting Program (EPA GHGRP) Database & Landfill Database
 - EIA Compressor Station Database
 - Oil and Gas Journal's Gas Processing Plants Database & Refinery Survey
 - Portland Cement Association's Cement Kilns Database
 - Association of Iron and Steel Engineer's Directory of Iron and Steel Plants

Calculated technical potential

- Started with site level assessment
- Estimated stack gas temperatures for different types of equipment
- Estimated stack gas mass flow rates
- Used practical efficiency based on Carnot limit
- Calculated site level WHP technical potential
- Rolled-up site level results to develop WHP estimates
 - By application
 - By state

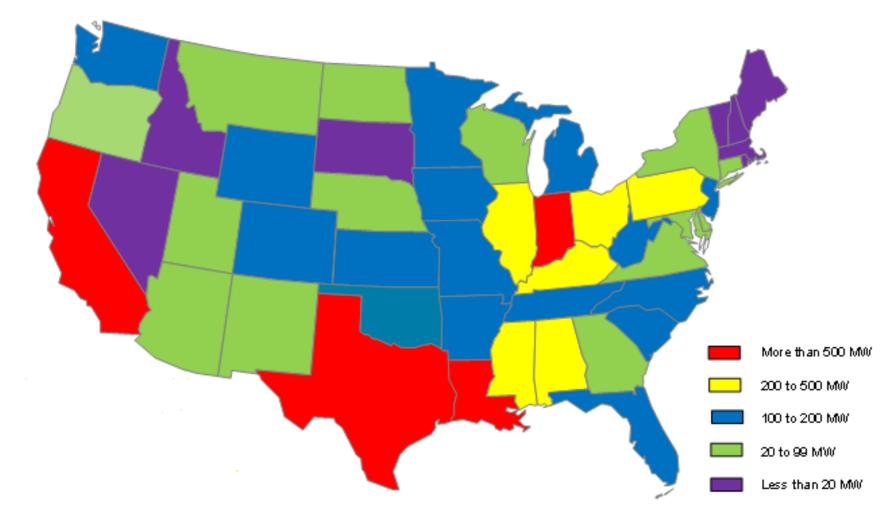
Bottom-Up Analysis – Remaining WHP Technical Potential by NAICS Code



NAICS	NAICS Description	# Sites	Capacity (MW)	Share of Total Capacity
324	Total Petroleum and Coal Products	176	3,593	40.6%
331	Total Primary Metals	116	2,186	24.7%
327	Total Non-Metallic Minerals	255	1,173	13.3%
486	Pipeline Transportation	1,363	1,102	12.5%
211	Oil and Gas Extraction	427	538	6.1%
562	Waste Management	478	113	1.3%
325	Chemical	64	92	1.0%
212	Mining, except Oil and Gas	14	23	0.3%
311	Food	19	8	0.1%
322	Paper	17	5	0.1%
333	Machinery	2	4	<0.1%
336	Transportation Equipment	1	2	<0.1%
321	Wood	2	0.5	<0.1%
312	Beverage and Tobacco	2	0.3	<0.1%
323	Printing	1	0.1	<0.1%
334	Computer and Electronic Products	4	0.1	<0.1%
611	Colleges	2	0.1	<0.1%
326	Rubber	2	<0.1	<0.1%
493	Warehousing and Storage	1	<0.1	<0.1%
-	Total	2,946	8,840	100%

WHP Technical Potential Capacity by State





*** HI and AK fall into the green category (20 to 99 MW)

Economic Potential and Market Penetration (bottom-up analysis)

- Engaged WHP community to obtain technical performance and cost characteristics
- Calculated economic potential
 - Expressed in terms of payback for each site
 - Based on cost characteristics for applicable technologies at each site
- Calculated market penetration (adoption curve as a function of payback)



Cost Assumptions for SRC and ORC



Technology	Cost	Electric Capacity for WHP Technology					
	Characteristic	50-500 kW	500 kW -1 MW	1-5 MW	5-20 MW	>20 MW	
Steam Rankine	Installed Capital Cost, \$/kW	\$3,000	\$2,500	\$1,800	\$1,500	\$1,200	
Cycle	O&M Costs, \$/kWh	\$0.013	\$0.009	\$0.008	\$0.006	\$0.005	
Organic Rankine Cycle	Installed Capital Cost, \$/kW	\$4,500	\$4,000	\$3,000	\$2,500	\$2,100	
	O&M Costs, \$/kWh	\$0.020	\$0.015	\$0.013	\$0.012	\$0.010	

WHP Technical Potential by Payback Range



		Capacity (MW) by Payback Rang			
NAICS	NAICS Description	< 2 yrs	2 to 5 yrs	> 5 yrs	Total
211	Oil and Gas Extraction	60.2	8.3	469.5	538.0
212	Mining except Oil and Gas	0.0	2.8	19.8	22.6
311	Food	0.0	3.7	4.5	8.2
312	Beverage and Tobacco	0.0	0.0	0.3	0.3
321	Wood	0.0	0.0	0.5	0.5
322	Paper	0.0	0.7	3.9	4.6
323	Printing	0.0	0.0	0.1	0.1
324	Petroleum and Coal Products	700.7	2,753.4	139.0	3,593.1
325	Chemical	0.0	45.1	47.2	92.4
326	Rubber	0.0	0.01	0.02	0.03
327	Non-Metallic Minerals	53.6	938.4	180.9	1,172.9
331	Primary Metals	77.1	2,066.4	42.3	2,185.9
333	Machinery	0.0	3.6	0.2	3.9
334	Computer and Electronics	0.0	0.1	0.0	0.1
336	Transportation Equipment	0.0	0.0	1.8	1.8
486	Pipeline Transportation	0.0	40.3	1,061.8	1,102.1
493	Warehousing and Storage	0.0	0.0	0.0	0.0
562	Waste Management	0.0	4.8	108.3	113.1
611	Colleges	0.0	0.0	0.1	0.1
Total		892	5,868	2,080	8,840

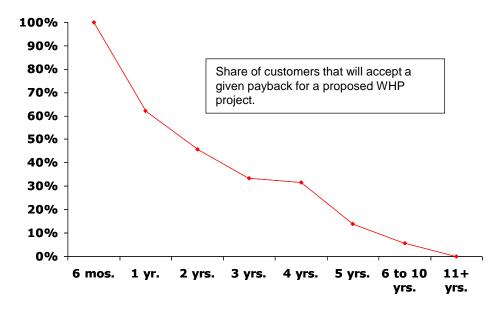
WHP Technical Potential for ORC and SRC



Technology	Payback (yrs)				Technical Potential		
	<2	2-3	3-5	>5	(MW)		
Steam Rankine Cycle (SRC)	832	3,146	2,665	421	7,064		
Organic Rankine Cycle (ORC)	60	6	51	1,659	1,776		
Total	892	3,152	2,716	2,080	8,840		

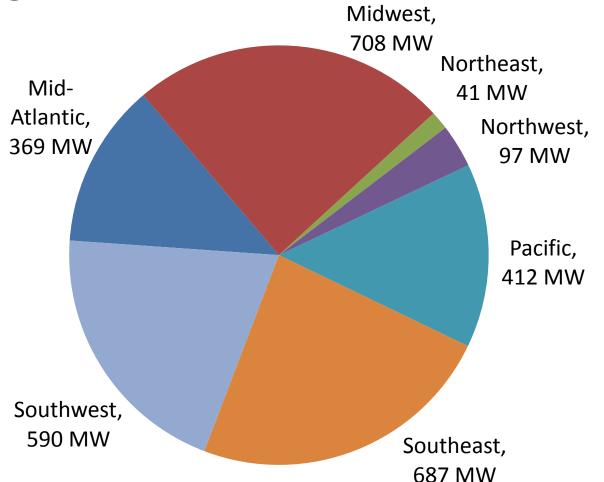
Expected Market Penetration

- Payback calculated for each site
- Market acceptance curve determines likelihood of installation based on payback
- Technical potential for each site is multiplied by market acceptance rate



Source: Primen, 2003

WHP Market Penetration Results by CHP TAP Region (2,904 MW)



Federal Policy Drivers for WHP



- FERC's "small generator" interconnection standards
- Executive Order 13624 Sets a goal of 40 GW of new, costeffective, industrial CHP installations by 2020
- Federal Memorandum on Energy Management More than doubles renewable energy targets for federal agencies, and allows renewable WHP (defined as "thermal renewable energy") to help meet targets
- Federal incentives
 - Investment Tax Credit (ITC) In February 2015, the Senate Finance Committee approved a proposal that would amend the 10% Federal ITC, allowing WHP to qualify
 - Proposed POWER Act would add WHP to the list of qualifying technologies for the 30% Federal ITC

State Policy Drivers for WHP

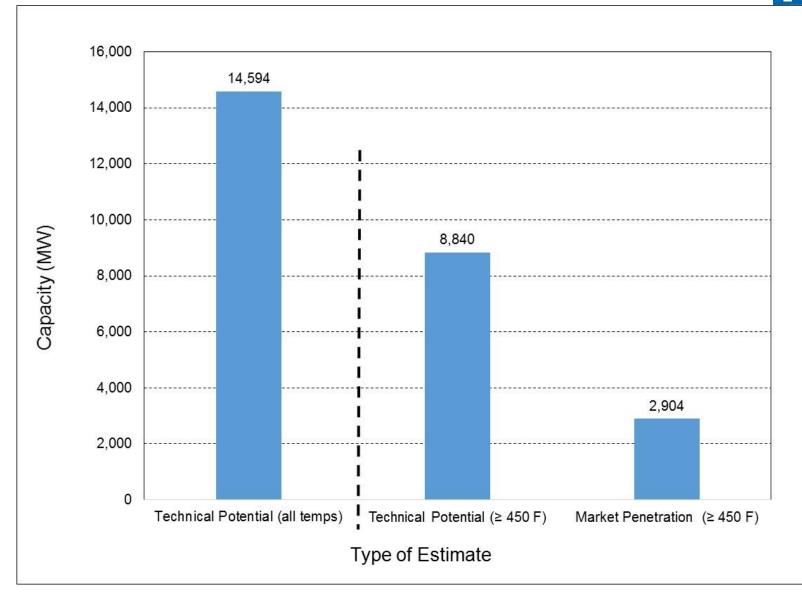


- Nine of 29 states with binding Renewable Portfolio Standards (RPS) include WHP as eligible – CO, CT, HI, MI, NV, NC, OH, PA, WV*
- Six states with nonbinding renewable energy goals include WHP in some fashion – IN, LA (pilot program)**, OK, ND, SD, UT
- Two states include WHP in stand-alone EERS targets DE, MN
- Nine states CA, CO, CT, IL, NC, NM, OR, SD, UT provide other forms of incentives for WHP, such as:
 - CA: The Self Generation Incentive Program (SGIP), a rebate program, provides an incentive of \$1.13/W for WHP projects.
 - IL: The Department of Commerce and Economic Opportunity (DCEO) CHP Pilot Program includes WHP, and provides grants for public sector projects.

Changes since report was released

- * West Virginia passed legislation in early 2015 that removes RPS requirement.
- ** The Louisiana RPS pilot program has ended.

Summary of Key Results





Questions & Contact Information

Anne Hampson

Senior Manager

ICF International AnneHampson@icfi.com +1.202.862.2982



WHP Market Assessment Webinar

The Pew Charitable Trusts and the Heat is Power Association

June 24, 2015

Claudia Tighe

U.S. Department of Energy

CHP Deployment Program Manager

Advanced Manufacturing Office

Continued DOE Support for WHP

In addition to funding WHP Market Assessment Report, DOE offers the following activities to further highlight the WHP market:

- Provide technical assistance services
- Include in the upcoming CHP Market Study with traditional CHP and District Energy with CHP
- Develop WHP handout materials (forthcoming fact sheet)
- CHP TAPs to develop WHP project profiles
- Conduct additional webinars focused on specific markets for WHP

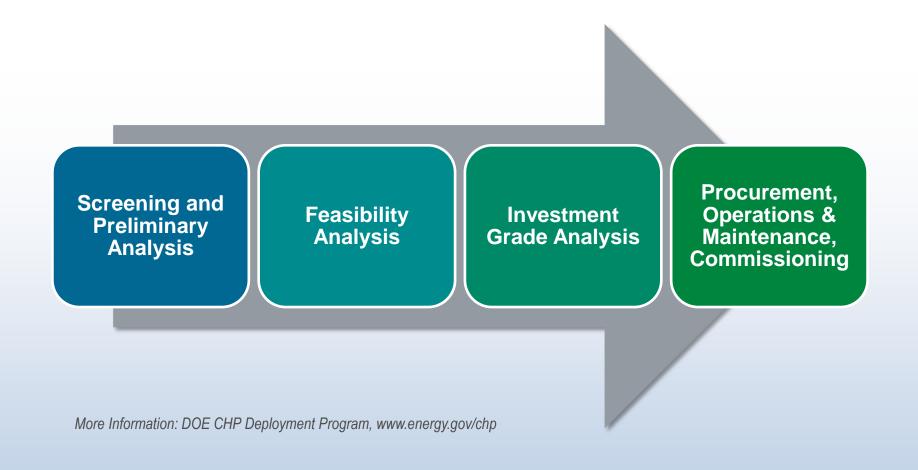
DOE's CHP TAPs promote and assist in transforming the market for CHP, waste heat to power, and district energy or microgrid with CHP throughout the United States. Key services include:

- Market Opportunity Analysis Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors
- Education and Outreach Providing information on the energy and non-energy benefits and applications of CHP to state and local policy makers, regulators, end users, trade associations, and others.
- Providing technical Assistance Providing technical assistance to endusers and stakeholders to help them consider CHP, waste heat to power, and/or district energy or microgrid with CHP in their facility and to help them through the development process from initial CHP screening to installation.

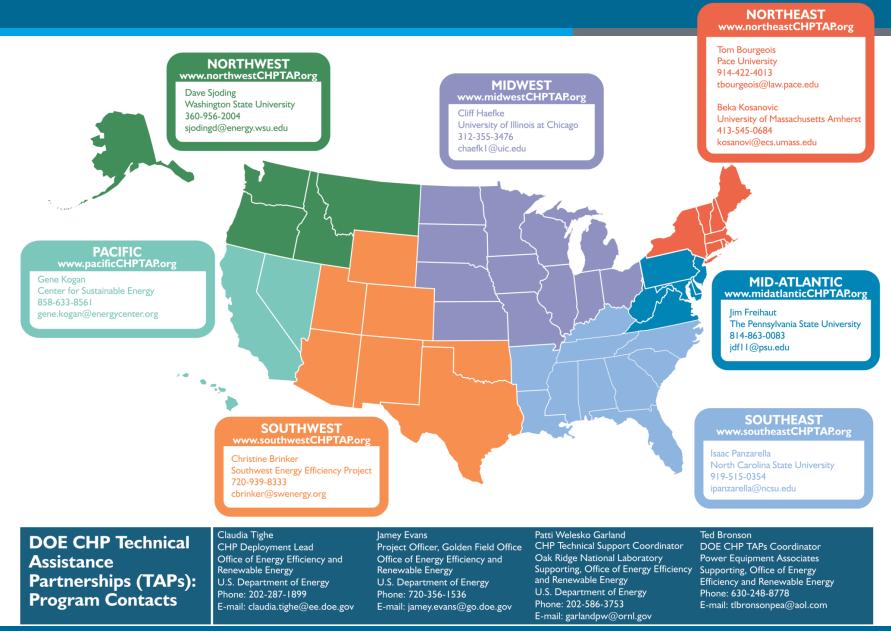


www.energy.gov/chp

CHP TAP Technical Assistance Project Support



DOE CHP Technical Assistance Partnerships (CHP TAPs)



42 | Energy Efficiency and Renewable Energy

More Information: Contact Us

www.energy.gov/chp

Waste Heat to Power Market Assessment: Opportunities, Technologies and Barriers



Jessica Lubetsky JFrohmanLubetsky@pewtrusts.org



Susan Brodie Susan@heatispower.org



Anne Hampson Anne.Hampson@icfi.com



Energy Efficiency & Renewable Energy Claudia Tighe <u>Claudia.Tighe@ee.doe.gov</u>