Recycled Energy: An Untapped Resource

April 19, 2002

Thomas R. Casten **Martin J. Collins**

Private Power LLC
Recycling Energy

Recycled Energy: An Untapped Resource

Executive Summary

Recycled energy uses the energy content of flared gases, wasted exhaust heat and unused gas pressure drop to generate electricity. Both in terms of the economic value of otherwise wasted energy and the environmental consequences resulting from such wasted energy, recycled energy represents a significant untapped resource.

The benefits of recycled energy are clear. There is a potential to generate between 9% and 13% of the current fossil fueled electrical power by simply recycling waste energy streams. In addition, because the waste energy streams are produced on-site, the recycled electricity would be consumed locally, minimizing line losses and avoiding transmission and distribution system upgrades. And yet, barriers have prevented the development of recycled energy projects.

Overcoming the barriers to recycling energy could be achieved through the inclusion of recycling energy within the scope of the *Renewable Portfolio Standard* (RPS). Senate Energy Bill S. 517 contains an RPS provision that requires US electric providers to purchase credits from a rising percentage of RPS-defined sources. The purposes of the RPS are to reduce our country's dependence on fossil fuel and at the same time reduce the emissions of harmful pollutants and greenhouse gases. Adding recycled energy to the list of RPS-defined sources would accomplish both purposes. Recycled energy production, like renewable power, displaces fossil generation. In addition, recycled energy, by displacing fuel, will significantly reduce emissions of sulfur dioxide, nitrous oxide and carbon dioxide associated with electricity production.

The US can either build more T&D or encourage decentralized generation.

Finally, inclusion of recycled energy within the scope of the RPS will provide needed revenue to our nation's industrial plants. At a time when our nation's various industries are struggling to compete with their respective competitors abroad, the mandated support for recycled energy through the RPS would improve the competitive positions of industrial facilities in world markets.

The Value of Recycled Energy

The clear benefit of recycled energy is that it is fuel-free and pollution-free, and displaces fossil generation, pollutants, and greenhouse gases. In this manner, recycled energy will reduce emissions of NOx, SOx, particulate matter, mercury and hazardous air products and will reduce greenhouse gases.

Recycled energy, like other decentralized energy sources, also provides an alternative to expensive, and often controversial, transmission expansion. The need for such an alternative has become especially clear over the past few years. A spate of recent power failures and electricity generation shortages has pointed to the need for both increased generation and transmission upgrades and expansions. While there is no question that some upgrades may be required, it is a mistake to conclude that the only solution to the existing problems is to build central station generation facilities and transmission upgrades. Instead, decentralized generation offers an alternative, and a relatively less costly one at that.

Decentralized generation needs no new transmission or distribution as it is produced on-site. And while 9% of centrally generated power is lost in transmission, decentralized generation has neither transformer nor line losses because it is also consumed on-site. Even power generated on-site in excess of use will flow to the nearest user, regardless of power sales contract, thereby freeing the T&D system and allowing the existing wires to serve other loads. The overtaxed transmission system will cause more power failures unless 1) more transmission lines are constructed, 2) decentralized generation is built near users, or 3) a combination of both is pursued. Clearly, U.S. policy should encourage the development of more decentralized generation.

Recycled Energy Potential

Potential recycled energy, using only available data, could displace 9% of current US fossil generation. However, such an estimate could reach 13% of fossil-fueled electrical generation by tapping other waste sources not considered or missing data.

Much energy is vented from industrial processes or is lost in the pressure drop of any gas, but little is currently recycled – converted to electricity. The three major sources of recyclable energy are 1) exhaust heat from industrial processes including electric generation, 2) industrial process fugitive tail gas that is flared without energy recovery and 3) gas and steam pressure drop that could provide nearly fuel-free electricity. We list below the identified sources of currently wasted energy. These sources could produce 240,000 to 360,000 gigawatt hours per year of recycled electricity – 9% to 13% of US fossil-fuel based generation.[1]

Exhaust Heat: Exhaust from many industrial processes – steel mills, glass producers, refineries and chemical processes – is vented at 800 to 3,000 degree F. Exhaust from the reciprocating engines and combustion turbines driving gas pipeline compressors is vented at roughly 1,000 degree F. Condensing steam turbine generators can convert 25% of the energy in each of these sources to electricity without burning any added fossil fuel or emitting any added pollution. For installations with low-grade thermal energy needs nearby, the spent steam from backpressure turbine generators can displace boiler fuel and increase recycling to 90% of the exhaust energy.

Backpressure turbine generator can be used instead to lower gas pressure and produce fuel-free electricity

New electric generation also has energy recycling potential. The US DOE and EPA both have programs to double the percentage of power produced in combined heat and power installations, known as CHP plants, by 2010. By producing steam at higher pressures, these new plants can convert some exhaust energy to electricity at 80% plus efficiency. The extra electricity is essentially fuel-free and pollution-free. This source has not been counted in this analysis.

Industrial Tail Gas: Many industrial processes emit fugitive gas that is flared to reduce hazardous air products. The US EPA aerometric survey identifies 2800 separate point sources of tail gas, with several states not fully reporting.[2] These fugitive gases come from carbon black plants, refineries, chemical factories, automobile and appliance painting operations and ethanol plants. Converting the existing fugitive gas flares to the burners needed for heat recovery will improve combustion and lower stack pollution. Recycled electricity displaces central generation, further lowering pollution. Based on this logic, EPA's MACT guidance for carbon black flare gas states that equipment for recovering heat as described above is a pollution control device.

Recycled tail gas could support 148,000 GWh/year of new fuel-free electrical generation.

Gas Pressure Drop: Many processes compress gas or steam to pack more gas or energy into a pipe. Transcontinental natural gas pipelines compress gas to 40 to 110 times atmospheric pressure. Every 50 miles or so, another compressor station boosts the gas pressure for travel to the next station. When the pressurized gas reaches distribution points, pressure is reduced with valves to as low as two times atmospheric pressure. This wastes the energy recovery potential of the pressure drop. Expansion turbine generator sets can lower gas pressure and produce fuel-free electricity.

Similarly, steam systems serving multiple buildings generate steam at ten times atmospheric pressure or higher, to pack more steam in relatively small pipes, and then reduce the pressure at point of use to twice atmospheric pressure with a valve. Backpressure steam turbine generators can convert the pressure drop to fuel-free electricity.

We estimate wasted gas or steam pressure drop could support 78,000 GWh/year of fuel-free generation.

Total Potential for Recycled Energy: Total recycled energy from published data would support 240,000 gigawatt hours per year of fuel-free electrical generation, equivalent in annual output to one third of US nuclear generation in 1999.[3]

State by State Data

The attached table shows the potential for recycled energy by state and the retail value of each state's recycled energy potential. The table limits results to published data and shows the annual kWh per capita of recycled energy potential for each state as well as the current renewable energy production in kWh/capita. Each state and the District of Columbia is ranked from 1 (highest kWh/capita) to 51 for both recycled energy potential and for renewable energy production. Some

states with low renewable kWh/capita rankings have high rankings on recycled energy potential. For example, Texas is 44th in renewable but 5th in recycled energy potential. Louisiana is 51st on renewable energy today, but, in spite of under reporting, 23rd on recycled energy.

Recycled energy will be easy to measure, as it will largely come from discreet, non-fueled generators. In some cases, recycling will require a small amount of fossil fuel to stabilize the combustion or to add heat. If that fossil fuel were burned in a conventional electric plant, one third of the energy would be converted to electricity. Thus, an RPS definition of recycled energy should exclude an amount of electricity equal to 33% of the energy content of any incremental fossil fuel burned. The proposed amendment assumes advances in fossil efficiency and deducts 40% supplemental fuel energy content from the RPS definition.

Why Is So Little Energy Recycled Today?

In regulated markets, electrical generation and distribution were natural monopolies and the incumbent utilities had little incentive to capture waste energy. As a result, unintended (and sometimes-intended) barriers were enacted that block the deployment of recycled energy facilities.[4]

Unfortunately, while electricity markets are evolving, many of the barriers to recycling energy remain. Few institutions have been able to develop energy recycling in spite of numerous attempts because of the following regulatory barriers and common practices:

- *Regulated local utilities have little incentive to build recycled energy projects. Fuel savings would simply lower user electricity prices while utility management would have to deal with many small projects.*
- *Producers of tail gas, exhaust heat and pressure drop are not in the energy business and tend to "stick to their knitting," or in current management speak, focus resources on core competencies.*
- *Independent power developers, whose core competency is energy, face high capital costs, high standby and interconnection charges for small recycled energy projects, and then receive discounted prices for the power because the below 50 megawatt blocks do not fit the current power market.*
- *Regulated local utilities, to avoid losing sales and profits, use many techniques to block all decentralized generation.*

Although the societal benefits of recycled energy are clear, few recycled energy projects have been developed. The barriers to recycling energy will continue to impede successful deployment unless certain actions are taken.

Why Recycled Energy Should be Included Within the Scope of the Renewable Portfolio Standard

As explained above, a number of barriers have served to limit the deployment of recycled energy facilities. Nevertheless, the value of such facilities from both an economic and environmental standpoint is clear. A national RPS standard mandating support for recycled energy would serve as an elegant wedge to force modernization of the rules that currently act as barriers to such efficiency. And the inclusion of recycled energy within the scope of the RPS would result in a program that is more cost-effective, more broadly shares the benefits across states, and will be more beneficial for the nation's economic well-being.

Broadening the Scope of the RPS to Include Recycled Energy Should Lower the Overall Cost of the RPS

The RPS in the Senate's recently passed energy bill contains a requirement that all retail electric suppliers purchase credits from eligible renewable facilities, rising to 10% of the supplier's retail sales by 2020. In addition, the RPS language in the Senate bill imposes a credit cap of 3 cents per kilowatt-hour. The rising mandate for credits from renewable sources should force the price of the credit up to the cap as more expensive RPS sources are brought on line. Recycled energy, on the other hand, would be able to overcome its barriers to deployment with credits smaller than the 3 cent cap. In fact, recycled energy facilities could overcome barriers to deployment with a much smaller credit, making recycled energy a very cost-effective RPS source of power that will lower the overall cost of the program.

Including Recycled Energy within the Scope of the RPS Would Result in an RPS that is More National in Scope

The RPS definition currently in the Senate energy bill would primarily benefit certain regions in the country, with ratepayers in other regions of the country paying for that support. If existing renewable generation is taken as an indicator of RPS induced renewables, then states like California, Montana, the Dakotas and Washington will be major beneficiaries, while states like Indiana, Ohio and Texas stand to lose revenue to other states. But these low renewable states have high-recycled energy potential and could satisfy the expanded RPS requirement. Accordingly, adding recycled energy to the RPS definition of eligible sources would extend the benefits of the RPS to many more States. (See page 5 for current renewable energy per capita and state rankings).

Including recycled energy within the Scope of the RPS would Benefit US Industry

Including recycled energy within the scope of the RPS will provide US industrial plants with payment for their presently wasted energy. In addition, recycled electricity generation with exhaust heat and tail gas will produce spent steam that can offset fossil fuel for industrial and institutional thermal needs, further reducing heating costs. Such value from recycled energy would lower costs of production, thereby improving the competitive position of US industries in world markets.

In addition to the benefits to the on-site facility, mandating support for recycled energy will push several technologies up the learning curve, improving their value position. American exports of clean energy products will thus increase.

Including Recycled Energy within the Scope of the RPS Would Educate the Industry on the Benefits of Decentralized Generation

Public education would be an important value of RPS-mandated support for energy recycling. Worldwide production of heat and power is less than optimal. Barriers prevent the optimal deployment of decentralized generation. A national RPS mandate to support renewable and recycled energy will result in the deployment of clean, localized energy generation in every community, at most factories and on many rooftops. The public will learn that decentralized electric power will reduce the need for central station generation facilities or upgraded transmission wires. The RPS mandate will force the industry to recognize the locational value of decentralized energy. It will also give regulators experience with decentralized technologies, providing them with the necessary information to eliminate the barriers to the deployment of such technologies.

Proposed Inclusion of Recycled Energy in RPS Definition

The following amendment would add recycled energy to the RPS definition:

Amend Section 606 of the Senate energy bill by adding ", recycled energy" after "generation offset," in subsection (l)(3) and subsection (l)(10) and by adding the following after subsection (l)(13):

"(14) RECYCLED **ENERGY**. The term 'recycled energy' means (1) exhaust heat resulting from any industrial process; (2) industrial tail gas that would otherwise be flared, incinerated, or vented; or (3) energy extracted from a pressure drop in any gas, excluding any pressure drop from a condenser that subsequently vents the resulting heat. If the process used to recycle energy incorporates supplemental use of a fossil fuel, the amount of the recycled energy that qualifies as a renewable eligible resource shall be reduced by 40% of the net heating value of the incremental fossil fuel used in the process."

---- End ----

---

[1]Internal analysis of Private Power based on US EPA data cited below, individual industry data and pipeline compressor databases.

[2]US EPA Envirofacts database, July 2001. http://www.epa.gov/enrivo/index_java.html

[3]Energy Information Administration, Form EIA-759, "Monthly Power Plant Report," and Form EIA-900, "Monthly Nonutility Power Plant Report, and Form EIA-860B, "Annual Electric Generator Report – Nonutility".

[4]See chapter 8, Barriers to Efficiency, in "Turning Off The Heat," by Thomas R. Casten, Prometheus Press, 1998.

	Potential Recycled Generation - GWh/yr				Potential Recycled Generation Benefits				Existing Renewable Generation (1999)		
	Pipeline Compressor Station Heat	Flared Tail & Stack Gas	Steam and Gas pressure Drop	Total Recycled Potential	Recycled Energy as % of Fossil Fuel Generation	Retail Value of Recycled Energy (millions)	Potential Recycled kWh per Capita / yr	*State Ranking per Capita*	Existing Renewable Generation (Gwh)	Renewable kWh per Capita / yr	*State Ranking per Capita*
Alabama	438	4,362	1119	5,907	8%	331	1,328	***11***	11,673	2625	***9***
Alaska	0	104	887	984	20%	98	1,569	***6***	817	1303	***18***
Arizona	540	949	655	2,132	5%	153	416	***40***	9,863	1922	***14***
Arkansas	308	1,894	805	3,002	10%	174	1,123	***15***	4,008	1499	***15***
California	284	5,167	6019	11,347	12%	965	335	***49***	65,454	1932	***13***
Colorado	159	2,750	1206	4,103	11%	246	954	***19***	1,594	371	***37***
Connecticut	34	3,776	1009	4,813	35%	457	1,413	***10***	2,583	758	***22***
D. of Columbia	0	152	296	445	193%	33	778	***27***	0	0	***49***
Delaware	0	1,015	187	1,200	17%	82	1,531	***8***	0	0	***50***
Florida	140	3,068	1275	4,459	3%	308	279	***50***	5,683	356	***39***
Georgia	164	5,811	1399	7,353	9%	456	898	***24***	5,795	708	***24***
Hawaii	0	366	61	427	4%	60	353	***46***	910	751	***23***
Idaho	193	295	350	834	213%	35	645	***30***	13,930	10765	***4***
Illinois	602	6,189	3917	10,641	13%	702	857	***25***	1,312	106	***45***
Indiana	472	11,212	2063	13,717	11%	700	2,256	***4***	530	87	***47***
Iowa	352	810	1120	2,269	7%	134	775	***28***	1,363	466	***34***
Kansas	1,012	1,075	919	2,992	9%	188	1,113	***16***	12	5	***48***
Kentucky	708	8,028	1008	9,731	11%	399	2,408	***3***	2,569	636	***26***
Louisiana	1,667	150	2293	4,062	6%	268	909	***23***	0	0	***51***
Maine	14	1,103	429	1,546	29%	153	1,212	***12***	6,834	5360	***6***
Maryland	48	0	1250	1,283	4%	86	242	***51***	1,965	371	***36***
Massachusetts	19	745	1767	2,509	7%	238	395	***43***	3,066	483	***33***
Michigan	443	5,064	3715	9,165	11%	651	922	***22***	4,283	431	***35***
Minnesota	540	90	1764	2,369	7%	137	482	***39***	2,953	600	***28***
Mississippi	1,200	808	628	2,625	10%	155	923	***21***	1,456	512	***31***
Missouri	222	669	1359	2,228	4%	134	398	***42***	1,914	342	***40***
Montana	130	2,097	266	2,490	14%	124	2,760	***2***	13,874	15378	***2***
Nebraska	130	184	551	857	5%	45	501	***35***	1,731	1011	***19***
Nevada	67	163	484	704	2%	43	353	***47***	4,253	2128	***11***
New Hampshire	0	422	291	712	14%	83	576	***32***	2,554	2067	***12***
New Jersey	82	103	3308	3,449	13%	314	410	***41***	1,409	167	***41***
New Mexico	564	19	562	1,137	4%	75	625	***31***	254	139	***42***
New York	217	1,620	8212	9,956	12%	1,115	525	***34***	27,476	1448	***17***
North Carolina	145	3,122	1204	4,456	6%	290	554	***33***	5,262	654	***25***
North Dakota	265	150	334	746	3%	41	1,162	***14***	2,615	4072	***7***
Ohio	352	5,136	3854	9,283	7%	603	818	***26***	1,060	93	***46***
Oklahoma	241	4,040	1059	5,320	10%	319	1,542	***7***	3,344	969	***20***
Oregon	173	1,555	712	2,429	23%	117	710	***29***	46,177	13497	***3***
Pennsylvania	949	10,060	3539	14,503	12%	957	1,181	***13***	4,515	368	***38***
Rhode Island	19	14	346	374	6%	38	357	***45***	120	115	***43***
South Carolina	53	725	755	1,524	4%	84	380	***44***	3,235	806	***21***
South Dakota	96	73	206	373	10%	23	494	***36***	6,677	8846	***5***
Tennessee	703	3,834	1238	5,759	10%	322	1,012	***17***	8,458	1487	***16***
Texas	1,310	35,424	7149	43,747	14%	2,844	2,098	***5***	2,219	106	***44***
Utah	63	0	714	767	2%	37	343	***48***	1,419	635	***27***
Vermont	0	154	144	297	690%	30	488	***38***	1,607	2639	***8***
Virginia	198	5,255	1628	7,062	16%	424	998	***18***	3,474	491	***32***
Washington	212	1,544	1159	2,898	23%	130	492	***37***	98,336	16684	***1***
West Virginia	304	1,750	648	2,696	3%	137	1,491	***9***	930	514	***30***
Wisconsin	82	3,154	1870	5,078	12%	289	947	***20***	3,129	583	***29***
Wyoming	251	1,575	334	2,156	5%	95	4,366	***1***	1,181	2393	***10***
U.S. Total	16,164	147,827	78,069	240,914	9.3%	15,924	856		395,874	1407	

States that under / do not report are in red

Note: Exhaust heat from steel and glass furnaces and other industrial processes could support 35,000 to 70,000 more GWh of annual fuel-free generation, but have been omitted due to lack of state data.

	Emissions from Fossil Fuel-based Electricity Production - 1999 (thousand metric tonnes)			Potential to Reduce Emissions w/ Recycled Energy (thousand metric tonnes)			
	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	Sulfur Dioxide	Nitrogen Oxides	Carbon Dioxide	% Reduction
Alabama	435	230	70,181	36	19	5822	8%
Alaska	5	21	4,766	1	4	1023	21%
Arizona	58	119	39,111	3	6	2089	5%
Arkansas	64	85	27,326	7	10	3065	11%
California	0	26	19,057	0	3	2479	13%
Colorado	78	122	33,493	9	14	3949	12%
Connecticut	21	5	4,872	8	2	1883	39%
D. of Columbia	1	0	235	2	0	495	211%
Delaware	24	11	4,825	5	2	918	19%
Florida	585	289	103,856	19	10	3413	3%
Georgia	437	191	70,128	44	19	6987	10%
Hawaii	15	8	5,304	1	0	258	5%
Idaho	0	0	5	0	0	11	233%
Illinois	559	307	73,002	80	44	10507	14%
Indiana	736	422	111,323	91	52	13748	12%
Iowa	131	138	33,165	10	10	2423	7%
Kansas	81	124	33,017	8	12	3273	10%
Kentucky	722	305	86,740	85	36	10161	12%
Louisiana	116	116	39,385	7	7	2426	6%
Maine	5	1	770	1	0	242	31%
Maryland	278	80	30,632	11	3	1184	4%
Massachusetts	103	37	20,049	8	3	1592	8%
Michigan	364	255	68,666	43	30	8032	12%
Minnesota	77	113	29,988	6	9	2395	8%
Mississippi	99	64	20,304	11	7	2323	11%
Missouri	225	258	62,940	9	10	2409	4%
Montana	15	54	16,970	2	8	2615	15%
Nebraska	53	83	18,535	3	4	948	5%
Nevada	45	65	20,782	1	2	559	3%
New Hampshire	44	8	4,388	7	1	684	16%
New Jersey	44	27	8,485	6	4	1192	14%
New Mexico	51	114	29,140	2	4	1117	4%
New York	146	50	30,675	20	7	4100	13%
North Carolina	389	161	61,695	25	11	4021	7%
North Dakota	138	104	31,266	4	3	883	3%
Ohio	1,111	425	114,933	90	34	9318	8%
Oklahoma	83	135	40,887	9	15	4579	11%
Oregon	13	18	4,889	3	5	1229	25%
Pennsylvania	786	205	84,141	103	27	11072	13%
Rhode Island	0	0	8	0	0	1	6%
South Carolina	225	85	32,563	10	4	1451	4%
South Dakota	21	17	3,816	2	2	399	10%
Tennessee	354	151	50,366	38	16	5426	11%
Texas	468	551	201,235	70	82	30007	15%
Utah	25	93	31,453	1	2	743	2%
Vermont	0	0	39	0	0	294	752%
Virginia	194	85	32,823	34	15	5792	18%
Washington	66	40	8,933	16	10	2218	25%
West Virginia	1,113	262	82,772	35	8	2591	3%
Wisconsin	179	169	41,102	23	21	5193	13%
Wyoming	77	166	43,152	4	9	2393	6%
U.S. Total	10,857	6,396	1,988,190	1013	609	191,933	10%

Private Power LLC
Recycling Energy

About Private Power

Private Power recycles normally wasted energy into heat and power to achieve double bottom line benefits -- lower energy costs and lower pollution.

To accomplish this mission, the company develops, manufacturers and owns combined heat and power (CHP) plants that convert normally wasted exhaust heat to power and thermal energy. We extract both heat and power from streams of currently wasted tail gas, exhaust and pressure drop in industrial and institutional processes.

1. We provide the capital and knowledge to generate heat and power on site.
2. We align our interests with customer interests through gain sharing.
   - *We provide heat and power under long-term contracts, freeing customer capital for core activities.*
   - *We meter extensively.*
   - *We help customers lower energy use per unit of production by over 20%.*
3. We demand each project have both cost and pollution benefits, constantly staying ahead of pollution limitations and earning pollution credits.
4. We are a knowledge based company, relying on the deep and varied experience of our managers to achieve double bottom line results.

Private Power LLC – 2000 York Road, Suite 129, Oak Brook IL 60523, Phone: 630-371-0505.

About the Authors

Thomas R. Casten has spent 25 years developing decentralized heat and power as founding President and CEO of Trigen Energy Corporation and its predecessors from 1977 through 2000 and currently as founding Chairman and CEO of Private Power LLC, an Illinois based firm specializing in recycling energy. These organizations have deployed over $1.0 billion in decentralized heat and power plants that all achieve at least twice the efficiency of the US average electric generation. Tom currently serves as the Chairman of the World Alliance for Decentralized Energy or WADE, an alliance of national and regional combined heat and power associations, wind, photovoltaic and biomass organizations and various foundations and government agencies seeking to mitigate climate change by increasing the fossil efficiency of heat and power generation. Tom holds a BA in Economics from Colorado University and an MBA from Columbia University. Tom's book, "Turning Off The Heat," published by Prometheus Press in 1998, explains how the US can save money and pollution.

E-mail: tcasten@privatepower.net

Martin J. Collins is a Development Engineer at Private Power LLC working on energy projects that utilize waste heat and waste fuel. He earned his Bachelor of Engineering, Mechanical, from Marquette University in 1990, and a MBA degree from the Kellogg Graduate School of Management, Northwestern University. Mr. Collins joined LTV Steel Corporation in 1990, where he served in various positions of increasing responsibility in operations and technical support. He gained operations experience in the energy arena as Area Manager of the Boiler House, Co-Gen Facility, and By Products Recovery areas in LTV's Chicago facility. He also went on to manage the development, integration, and implementation of capital and maintenance projects into the Chicago plant as Area Manager Technical Systems.

E-mail: mcollins@privatepower.net