Thermally Activated Technologies

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Thermally Activated Technologies - Uses

Customer value of heat recovery – Delivering a new function or displacing a higher cost alternative

Increasing value generally requires increasing heat quality and system complexity/cost

Low Value	Medium Value	High Value
Driveway heating	Radiant floor space heating	Space Cooling
Pool heating	Baseboard heating	Heat to electricity (ORC, Pyroelectrics)
	Spa heating	
	Domestic hot water	
	Latent heat removal	

Key to economics is delivering high customer value with very low system complexity!

Source: IEEE 1547

Thermally Activated Technologies - Challenges

Lifecycle system complexity

Source of complexity	Potential mitigation
OEM design	Minimize moving parts Choose simplicity over elegance Design for XX from day one
Maintenance	Design for low maintenance (oil free, ten year components) Build in diagnostics and prognostics
Interfaces (grid, other systems)	Hermetically sealed, minimize interfaces, factory integration of components
Installation: Factory Cost to installed cost ratio can be 3:1 or higher	Must be as close to plug and play as possible eliminate application engineering
Matching sources and uses	Add active controls or decouple using storage

Thermally Activated Technologies – What Makes a Good Joule?

	Current Heat Sources	Current Heat Use	GENSETS (Small Residential/Commercial)
Clean	Depends		
Continuous			
Close	Depends	Depends	
Consistent (Time, Quality, Quantity)			
Compact/Scalable		Heating  Cooling 	Prime mover addressed by Gensets
Customer (Same)	Often	Often	
Cost	Challenging depending on scale and duty cycle	Challenging for cooling	Prime mover addressed by Gensets
COP/Efficiency	Generally Too low for good value w/o heat recovery	Heating  Cooling 	Prime mover addressed by Gensets

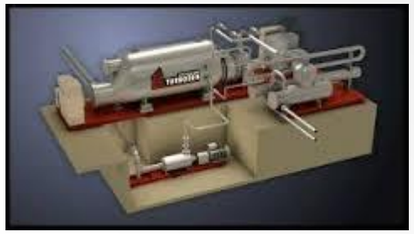
Thermally Activated Technologies – Scalability of ORC Technology

50kW to 5MW+…

- Commercial solutions available
- Low to High grade heat sources

- ✓ Solar thermal
- ✓ Biomass
- ✓ Geothermal
- ✓ Engine Waste Heat
- ✓ Industrial Waste Heat
- ✓ CHP

Source: siemens.com



Source: turboden.com

Source: electratherm.com

Source: calnetix.com

<10kW…

- No commercial solutions
- Design & cost challenges
- Installation and maintenance
- Air versus water cooling drives
- Low cycle thermal efficiency
- Customer acceptance
- Lack of prime movers

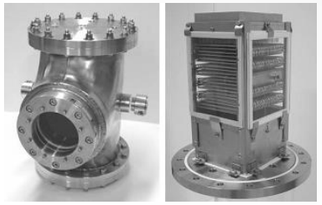
Thermally Activated Technologies – Scalability Cooling Technologies

Current Landscape…

- Commercial solutions available
- Low to High grade heat sources
- Economic challenges

Absorption

Source: energy.gov

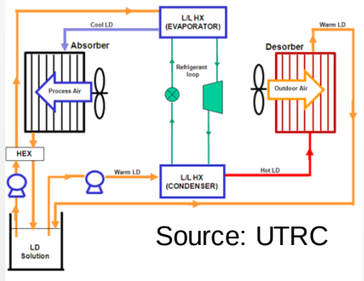


Source: stsl.gatech.edu

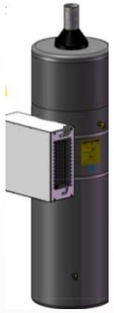
Georgia Tech

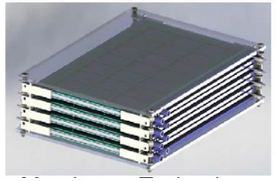
Dehumidification

Source: pall.com



Source: UTRC





Source: energy.gov

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<Residential Scale…

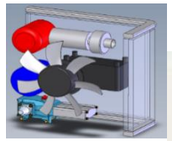
- No commercial solutions
- Design & cost challenges
- Installation and maintenance
- Low efficiency (air versus Water Cooling)
- Supply/Demand mismatch
- Low overall energy cost
- Customer Acceptance
- Lack of prime movers

Combined Heat and Power - Concepts

Can achieve remarkable results by treating the home as an integrated system

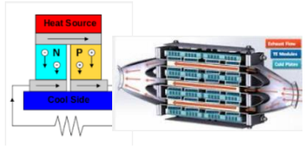
Waste Heat to Power

- Organic Rankine Cycle
- Supercritical CO2

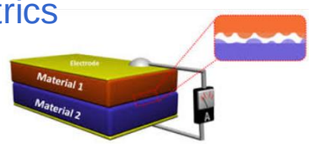


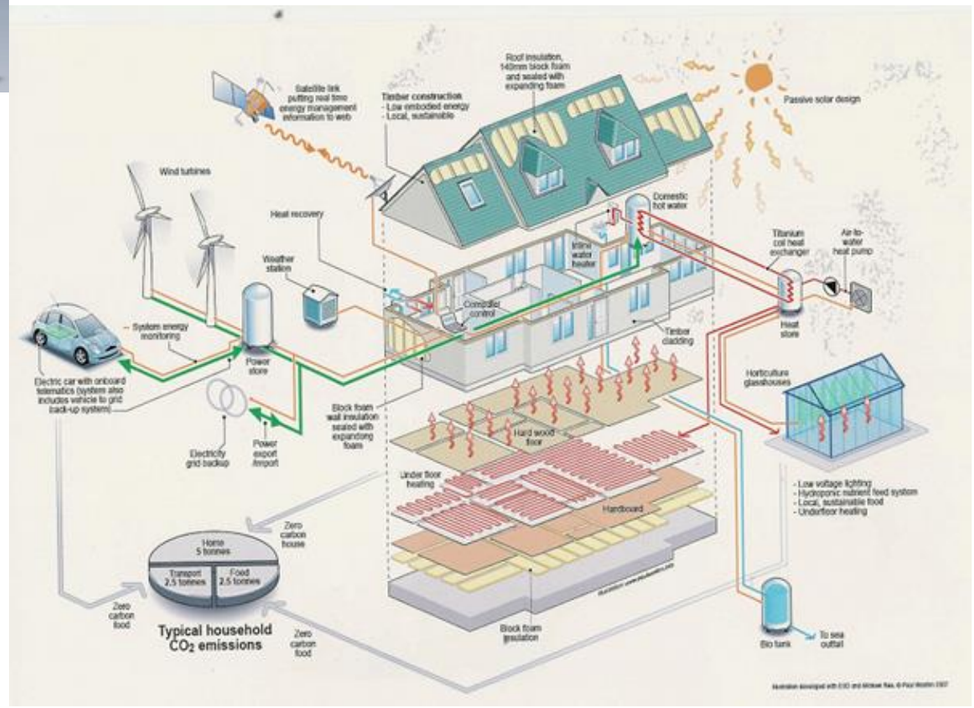
Scavenging

Thermo-electrics



Pyroelectrics





Storage: Passive or active thermal or electrical

Waste Heat to Process Heat

- Space heating
- Water heating (driveways, Pools, DHW etc.)
- Cooking
- Drying

Waste Heat to Cooling

- Absorption
- Adsorption
- Desiccant Dehumidification
- others

Efficiency of Base-load Power

2.5kW Natural Gas Generator

arpa·e
GENSETS

arpa·e
REBELS

arpa·e
BEETIT