CMC RESEARCH INSTITUTES

Regional Waste Energy Mapping Alberta Industrial Heartland

OUTLINE

- What is energy mapping?
- Why do energy mapping
- Alberta Industrial Heartland project
- Technology Applications and Priorities
- Waste Energy Mapping Across Canada

WHAT IS ENERGY MAPPING?

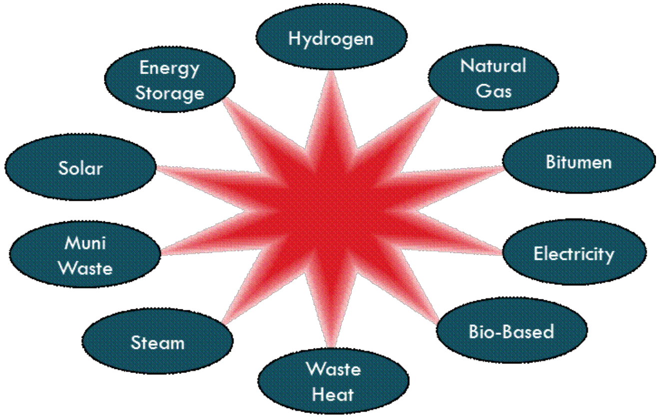
WHAT IS ENERGY MAPPING?

- Determine energy used and released in terms of:
  - **Type** – heat, electricity, petroleum, biomass, solar, wind, etc.
  - **Quantity** - how much in terms of MJ, MW, BTU
  - **Quality** – temperature, pressure, pollutant levels
  - **Variability** – over typical day, seasonally
- Group waste energies and energy needed by type, quality, and geographic location.
- Identify potential uses for “waste” heat including integrated energy options.

WHY DO ENERGY MAPPING?

WHY DO ENERGY MAPPING?

- Identify and quantify waste energies so potential new uses can be found



- Develop viable integrated energy solutions

- Provide information needed to prioritize efficiency investment decisions
  - Technologies (e.g., energy conversion, storage, & sources)
  - Assess economic viability of possible integrated energy solutions
  - Evaluate regulation and policy implications

WHY DO ENERGY MAPPING?

- Help facilitate cultural changes - how we think about energy
  - Removes information barriers between business units
  - Enables holistic approach to energy systems
  - Supports regional energy planning

- Understand the wider sustainability implications for:
  - Water conservation
  - Waste reduction
  - Capacity building

ENERGY MAPPING IN ALBERTA'S INDUSTRIAL HEARTLAND

SUPPORTED PROPOSAL TO NRCAN

Agrium

Air Liquide

Keyera

Suncor

Western Hydrogen

Rio Tinto Alcan

ADDED ADDITIONAL COMPANIES

Agrium
where the future is growing™

ALBERTA ENVIROfuels INC.

ATCO Energy Solutions

AIR LIQUIDE

AltaSteel

SULZER
Sulzer Metco (Canada) Inc.

KEYERA

NWR
NORTH WEST REDWATER PARTNERSHIP

PLAINS MIDSTREAM CANADA

SUNCOR ENERGY

sherritt

umicore

WesternHydrogen

AIR PRODUCTS

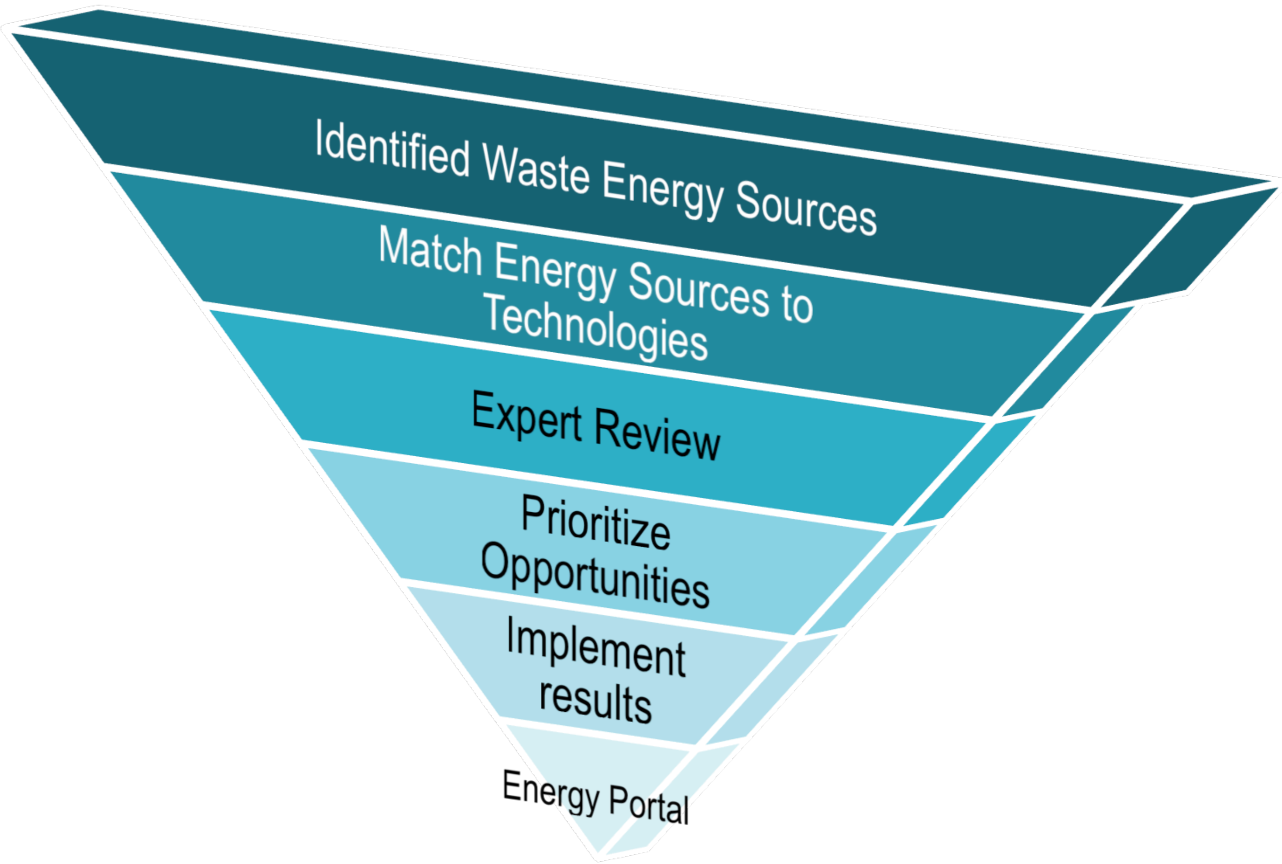
Shell

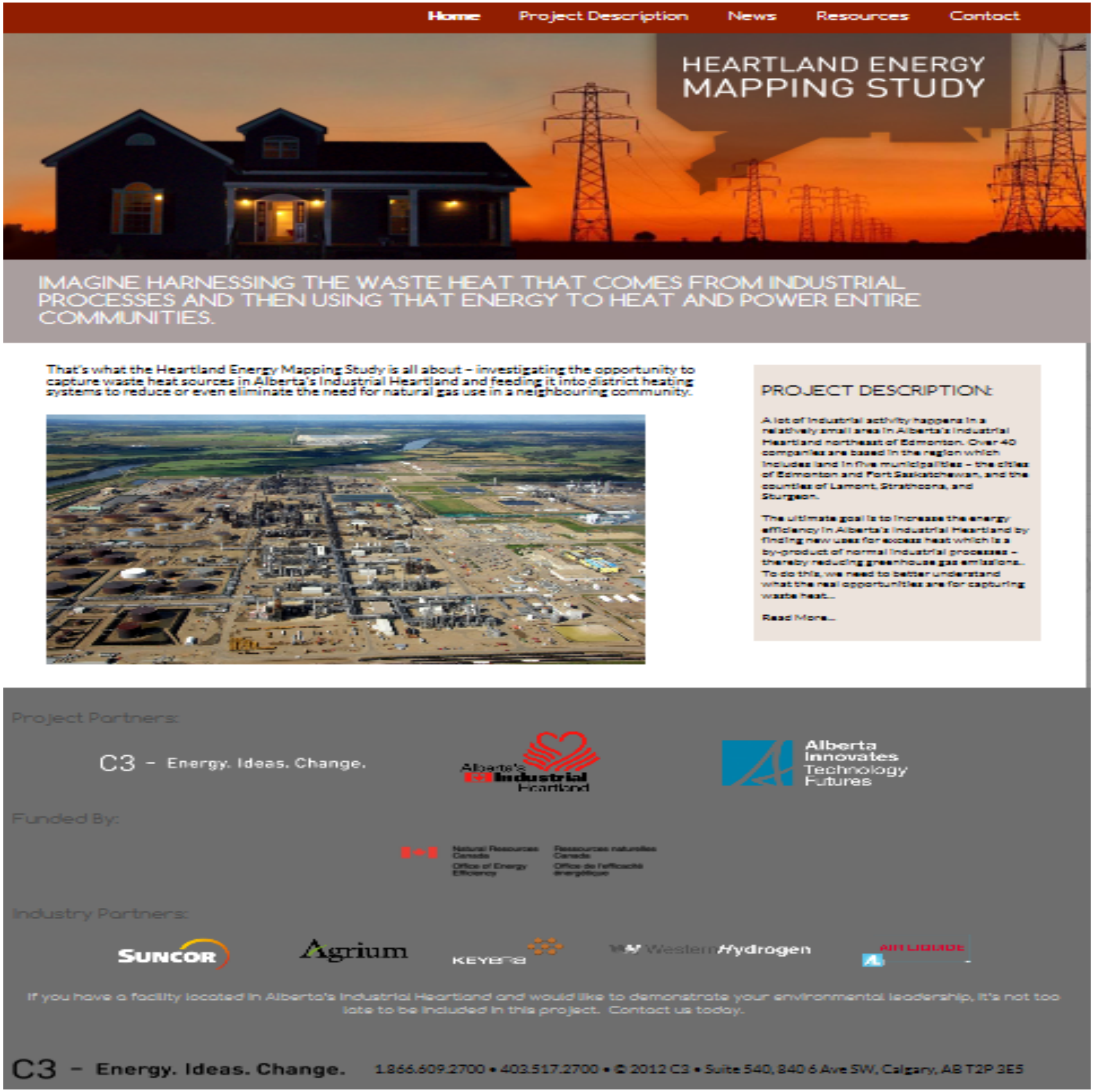
RioTintoAlcan

VERESEN

LONG-TERM GOAL

Achieve greater energy efficiency in the Heartland by identifying viable waste energy sources, matching them to recovery technologies to prioritize future regional integration projects





http://heartlandenergymapping.c-3.ca/

RESULTS

ENERGY IDENTIFICATION BY SITE

- Assumed sites are internally optimized with no economically viable opportunities to use waste energy on site

- Asked experts to tell us about energies on site
  - 80-20 Rule - focus on “big” energy streams, no energy audit or process-level info on energy or mass flows
  - Energy inputs & wastes
  - Experts emailed info back to us
  - Phone-call to clarify

SITE-LEVEL WASTE ENERGY SOURCES

- Exhaust Stacks (Heaters & Boilers, Turbines, Petcoke)
  - Description of source, fuel type, rate of exhaust gas, temperature, qualitative description of contaminants & temporal variability
- Coolers & Compressors
  - Description or source, source temperature, temperature drop, flow rate of liquid, specific heat capacity
- Letdown of Pressurized Streams
  - Identified by a few participants

DATA SYNTHESIS: EXHAUST STACKS

- Classified each stream by:
- Pollutant level
  - Low
  - High or other risk
- Temperature:
  - 120-230 Deg C
  - 230-650 Deg C
  - 650-1100 Deg C
- Size (MW)
  - Based on cooling stream from actual temperature to 120 Deg C (sensible heat)
    - Also computed sensible & latent heat when cooled to 40 Deg C,

DATA SYNTHESIS: EXHAUST GASES

- Moisture content and composition of exhaust gases unknown in most cases, but knew fuel type so computed heat content using Aspen Plus® assuming:

- Heaters or Gas Fired Boilers
  - Natural gas feed, 10% excess air, complete combustion of methane

- Gas Turbine
  - Natural gas feed, 200% excess air, complete combustion of methane

- Petcoke Pyrolysis
  - 20% excess air, complete combustion of carbon to CO_2, added additional water to reach reported moisture content.
  - Latent heat based on lowering to 175 C (not 120 C).

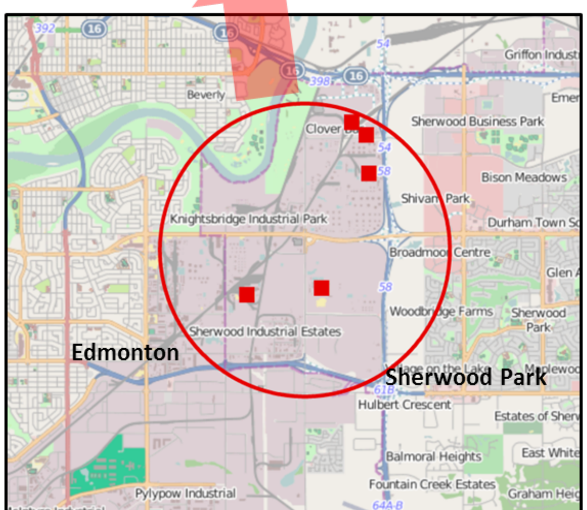
HIGH LEVEL FINDINGS

- The study revealed a significant amount of waste heat exists in the Strathcona and Heartland industrial areas.

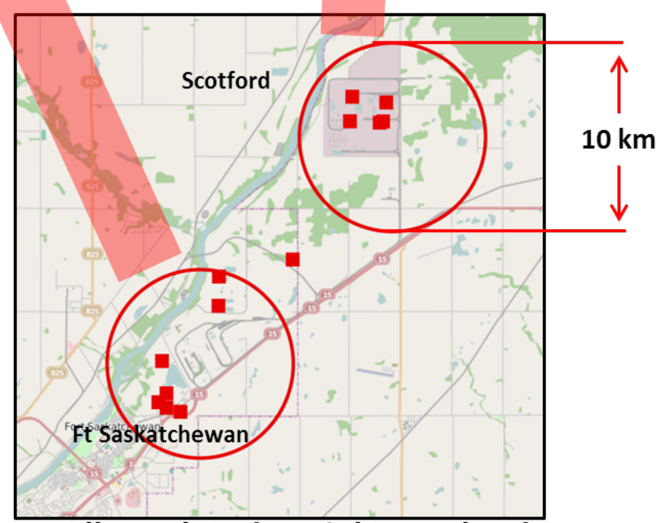
- Geographically, the waste heat was clustered into three heat islands (see Figure 1) across the two industrial areas.

GEOGRAPHIC LOCATIONS

	Waste Heat (MW)	# Households Heated	Power Generation (MW)	# Houses Supplied Electricity	Reduction CO2e (t)	Waste Heat (MW)	# Households Heated	Power Generation (MW)	# Houses Supplied Electricity	Reduction CO2e (t)	Waste Heat (MW)	# Households Heated	Power Generation (MW)	# Houses Supplied Electricity	Reduction CO2e (t)
Exhaust Stacks															
120 to 230 C	23	4,500			41,100	13	2,500			23,100	49	9,600			87,000
230 to 1100 C	39		9	10,000	26,000	25		5	5,600	14,600					
Coolers & Compressors															
80 to 230 C	136	26,400			239,500	10	2,000			18,000	5	1,000			9,000
Total 100% Capture	198	30,900	9	10,000	307,000	48	4,500	5	5,600	56,000	54	10,600			96,000
Total (33% Capture)	65	10,200	3	3,300	101,000	16	1,500	2	1,800	18,000	18	3,500			31,700



Strathcona Industrial Area



Alberta's Industrial Heartland

HIGH LEVEL FINDINGS

- 300 MW of sensible waste energy was identified, of which:
  - 64 MW comes from low pollutant exhaust stacks with temperatures between 230 and 1100 °C;
  - 85 MW comes from low pollutant exhaust stacks with temperatures between 120 to 230 °C;
  - 151 MW comes from coolers and compressors with temperatures between 80 and 230 °C.

HIGH LEVEL FINDINGS

- These results are only for the 17 participating sites. Other companies known to have significant amounts of waste heat did not participate in the study.
- Further, not all participating companies reported on all of their major waste heat streams (e.g., a few only reported on exhaust stacks, but not cooling towers).
- Finally, lower temperature cooling streams between 20 and 80 °C have been excluded due to the inherent challenges of repurposing such low temperature heat.

HIGH LEVEL FINDINGS

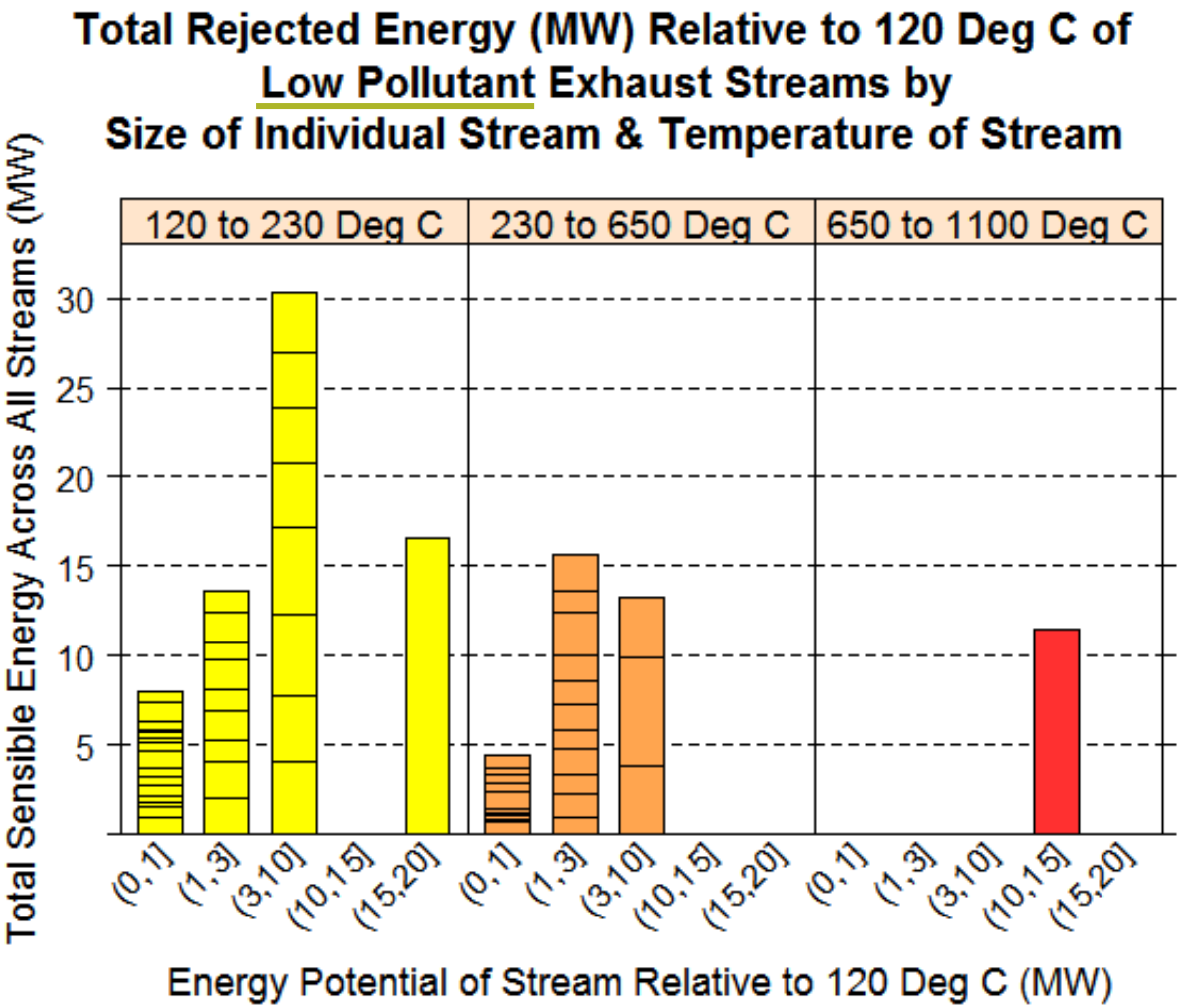
- For each heat island, assuming that 33% of this total available waste energy could be captured and repurposed, the resulting 99 MW of waste energy could theoretically be used to:
- Heat 15,200 average homes;
- Generate 5 MW of power - enough to power 5,100 homes;
- Reduce CO_2e emissions in the region by ~151,000 tonnes.

Based on NRCAN emission reduction factors

That 20-30% of the waste energy (depending on temperature) could be converted to power, and that a house requires 7,800 kWh of power a year.

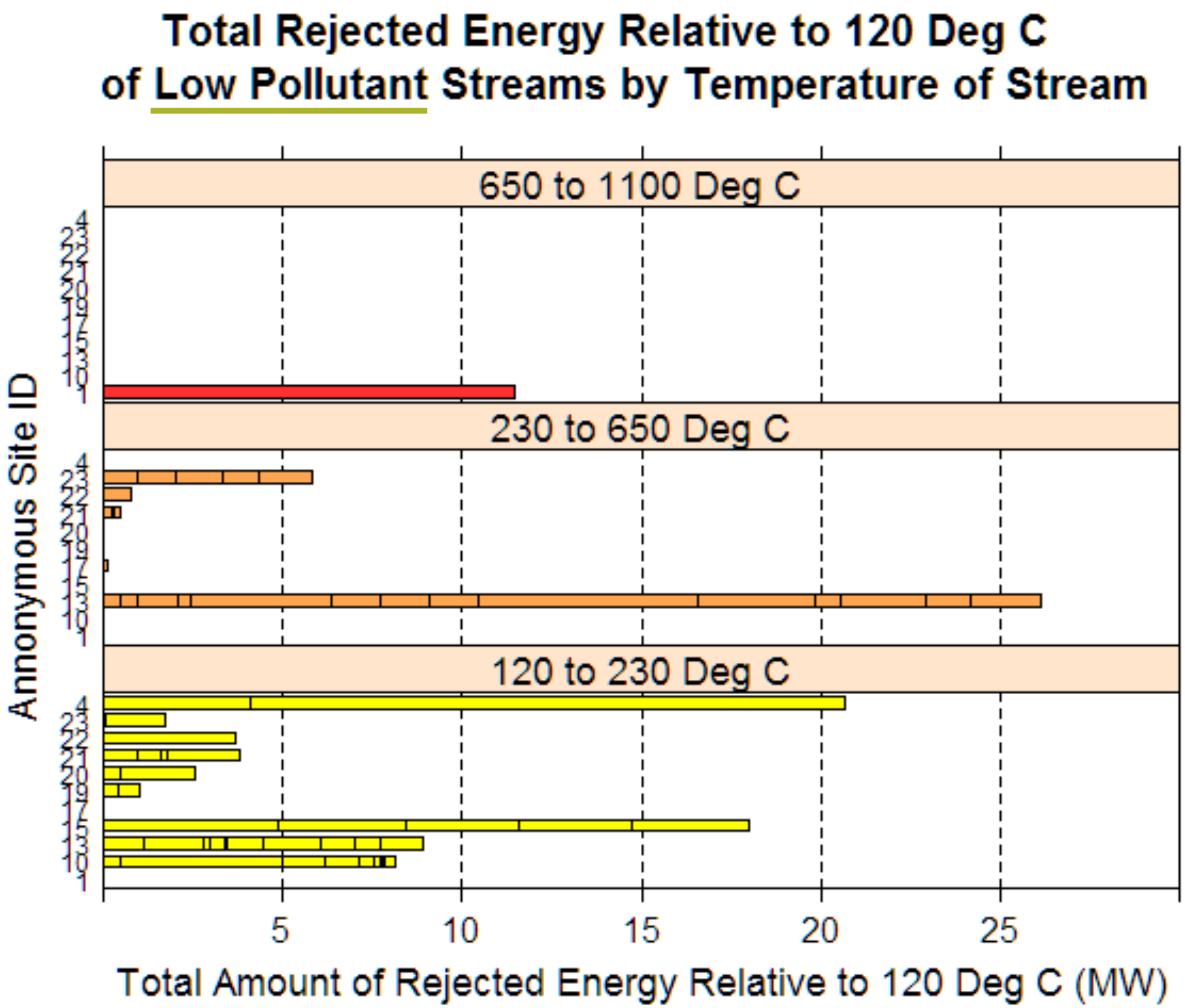
(http://www.nrcan.gc.ca/energy/efficiency/industry/technical-info/benchmarking/canadian-steel-industry/5193)

RESULTS: EXHAUST STACKS



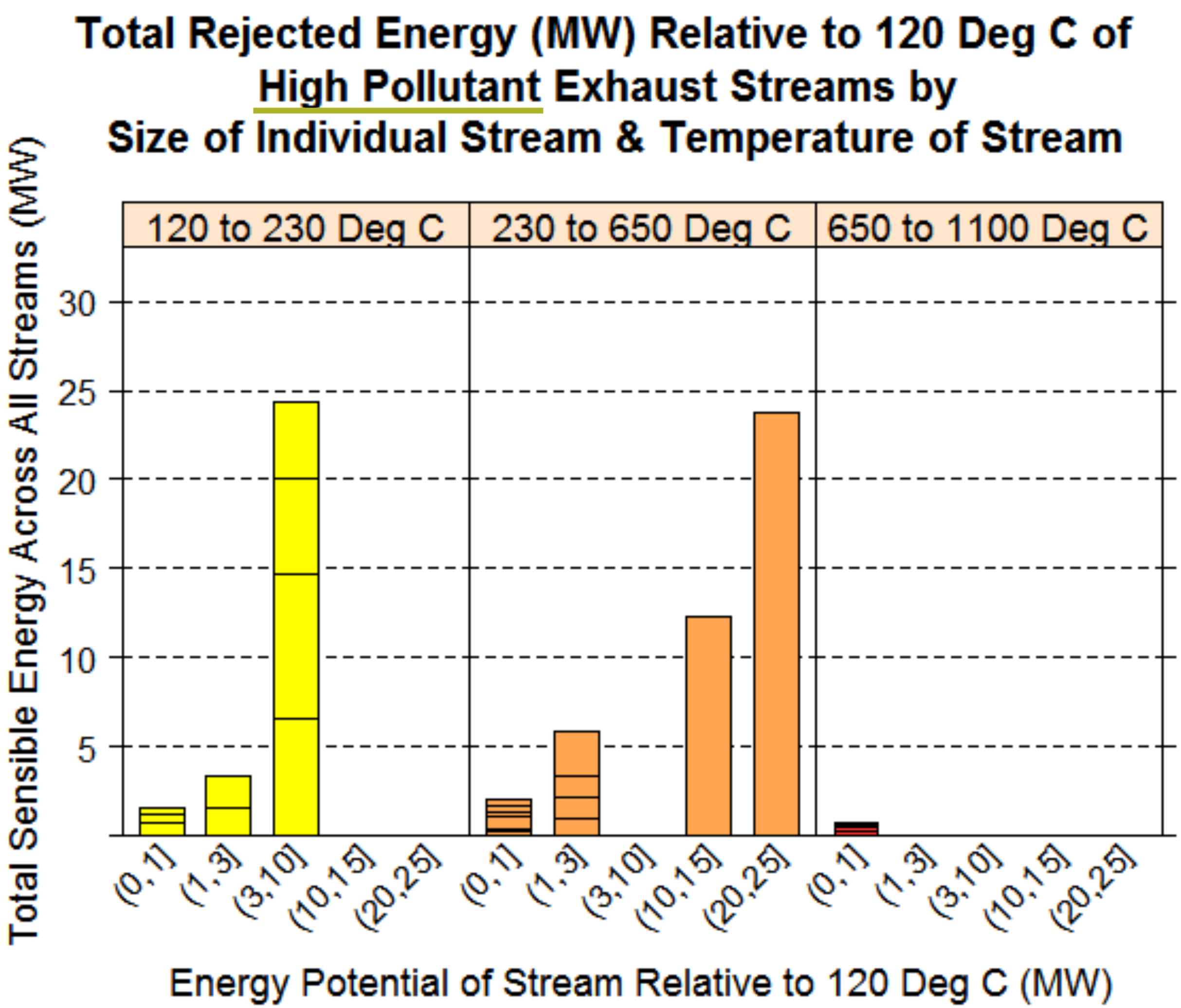
Significant amount of higher temperature waste energy streams

RESULTS: EXHAUST STACKS BY SITES



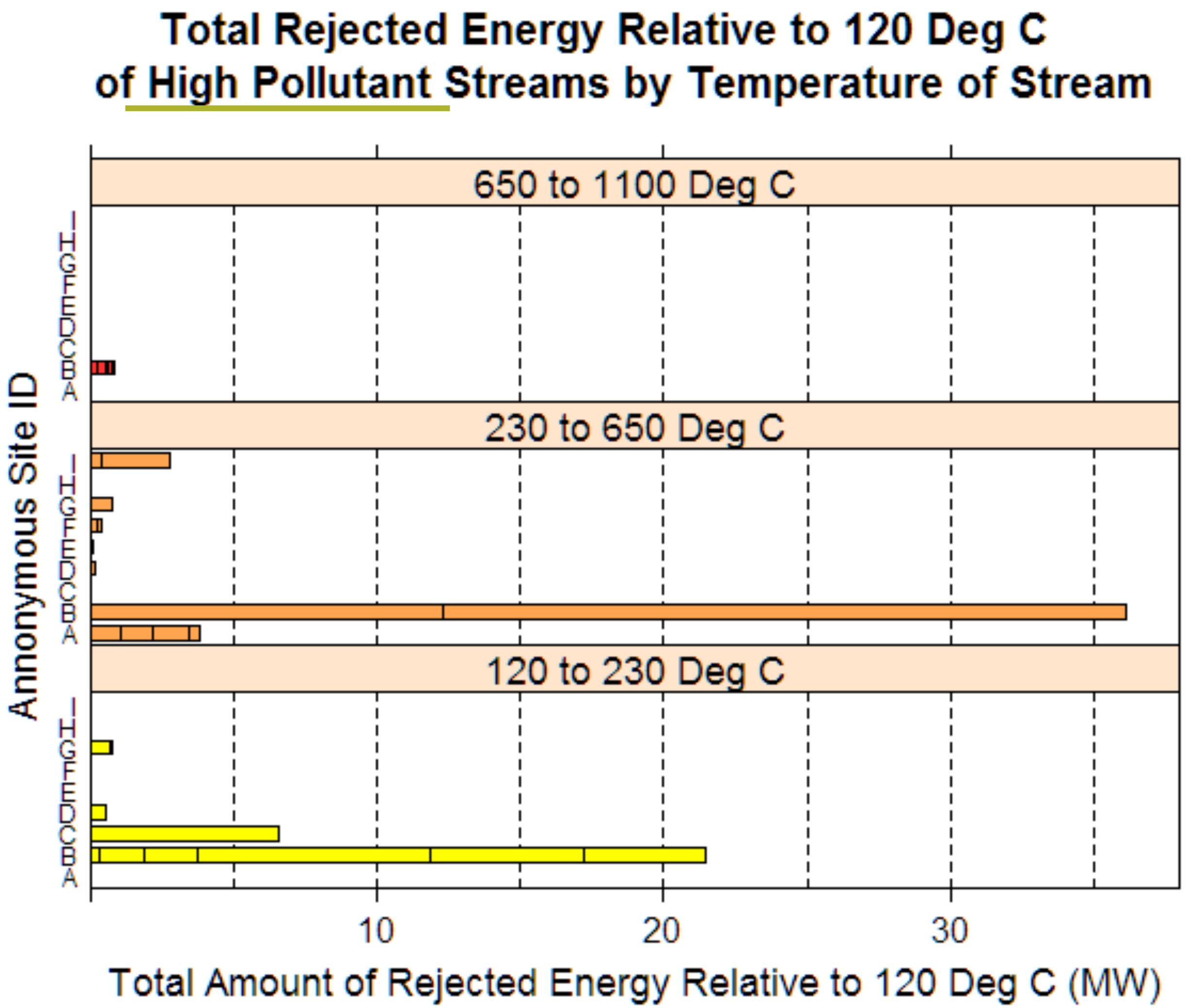
Higher temp waste energies concentrated on a few sites

RESULTS: EXHAUST STACK



Fair amount of mid-temperature energy if could deal with pollutant issues

RESULTS: EXHAUST STACK BY SITES



A single site has most mid and lower temperature energy with high pollutants

SUMMARY FINDINGS – EXHAUST STACKS

Low Pollutant Streams:

- ~64 MW of mid and high temp waste energy which needs further investigation to assess feasibility of re-use.
- Waste Energy clustered across a few sites

High Pollutant Streams:

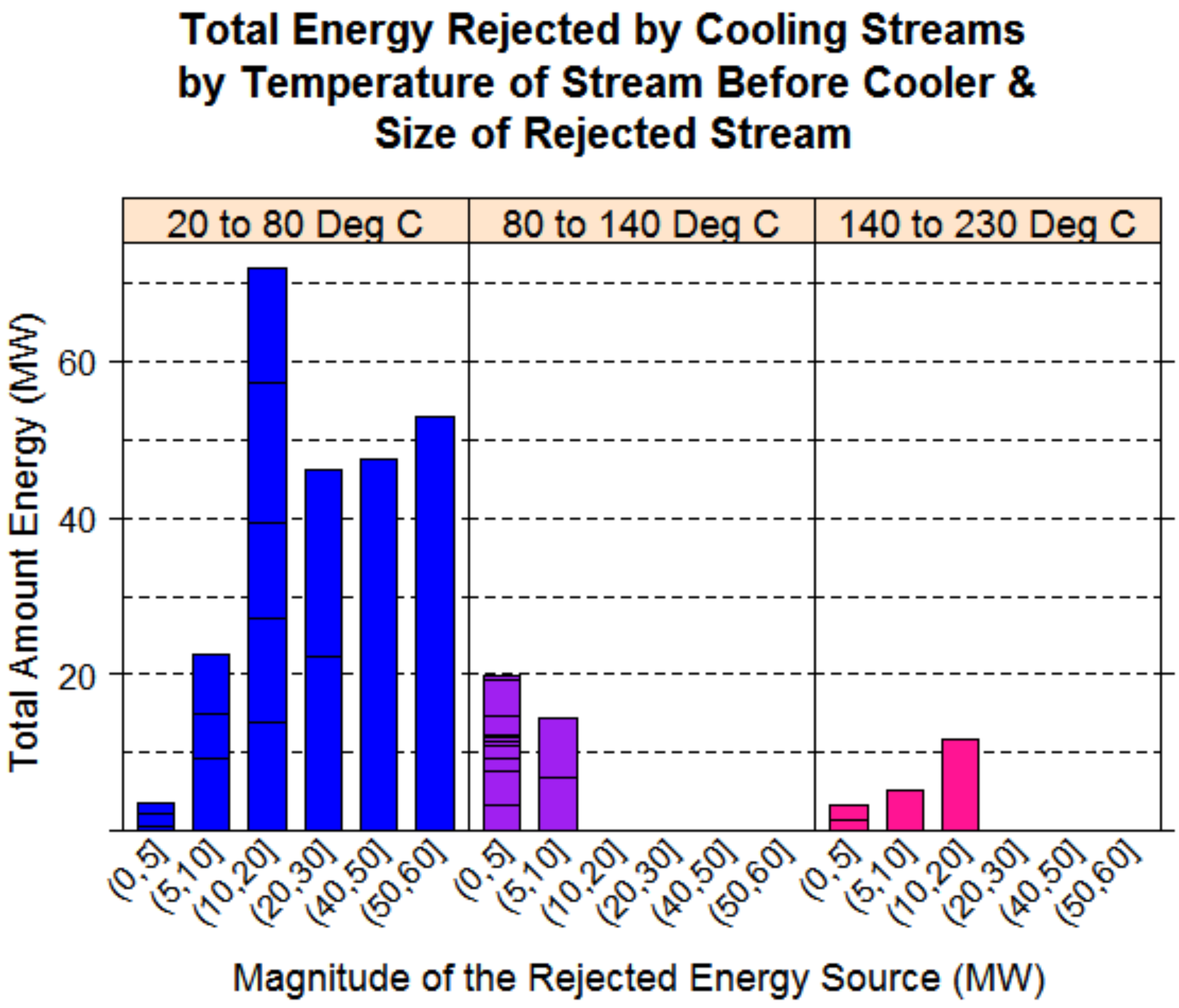
- >85 MW of mid temperature waste heat
- Unclear how much recoverable with advance technologies

DATA SYNTHESIS: COOLERS

- Computed rejected energy based on temperature drop, rate of mass flow, & specific heat capacity of liquid

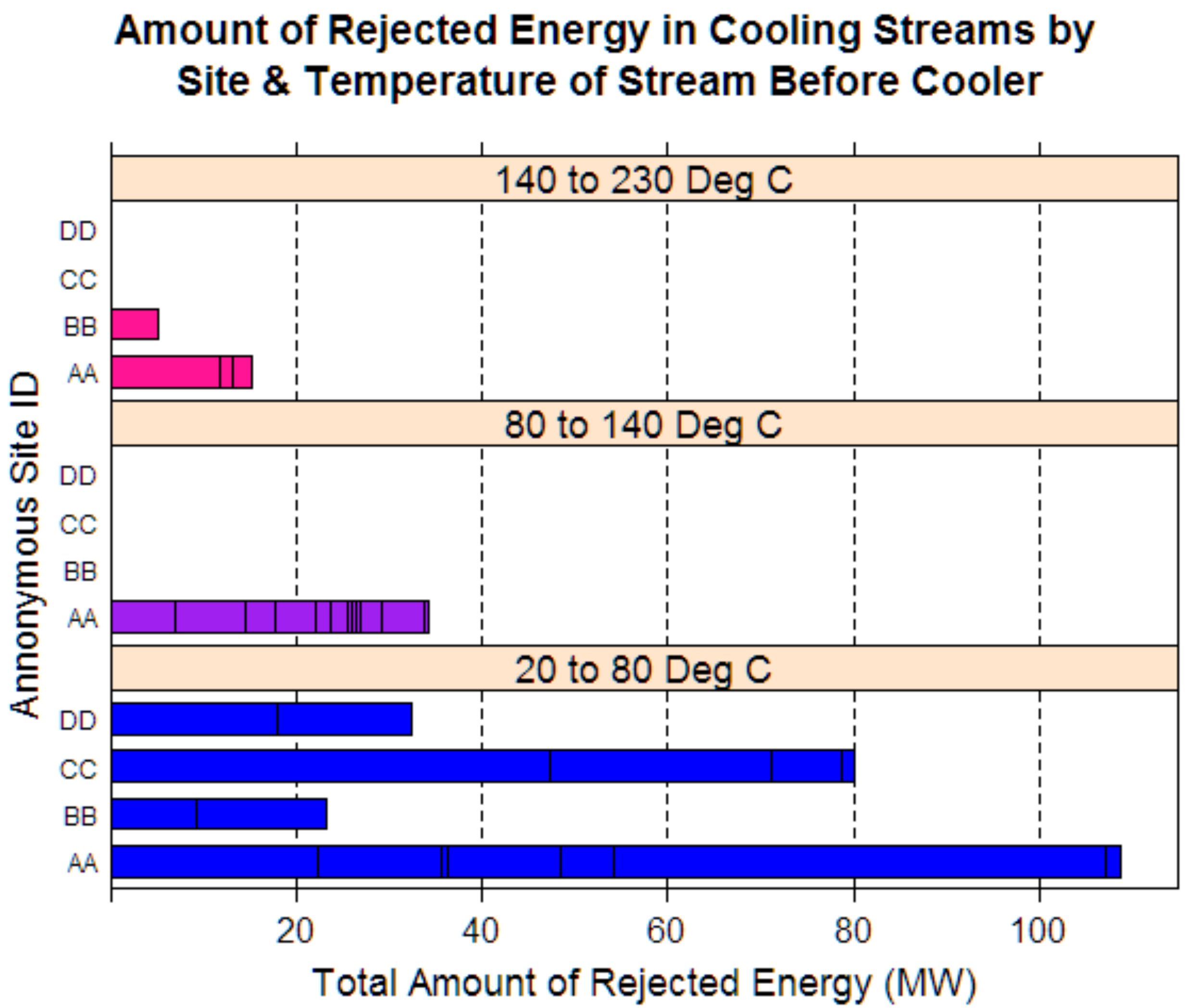
- Classified streams by:
- Stream source temperature
  - 20-80 Deg C
  - 80-140 Deg C
  - 140-230 Deg C

RESULTS: COOLERS



A few "higher temp" cooling streams with fairly large energy amounts

RESULTS: COOLERS



"Higher" temp Cooling Streams on just 2 sites

SUMMARY FINDINGS – COOLERS

- 20 MW of heat between 140-230 Deg C
- 32 MW of heat between 80-140 Deg C
- 244 MW of heat between 20-80 Deg C
  - 96 MW between 60-80 Deg C

TECHNOLOGY APPLICATIONS AND PRIORITIES

EXPERT REVIEW PANEL

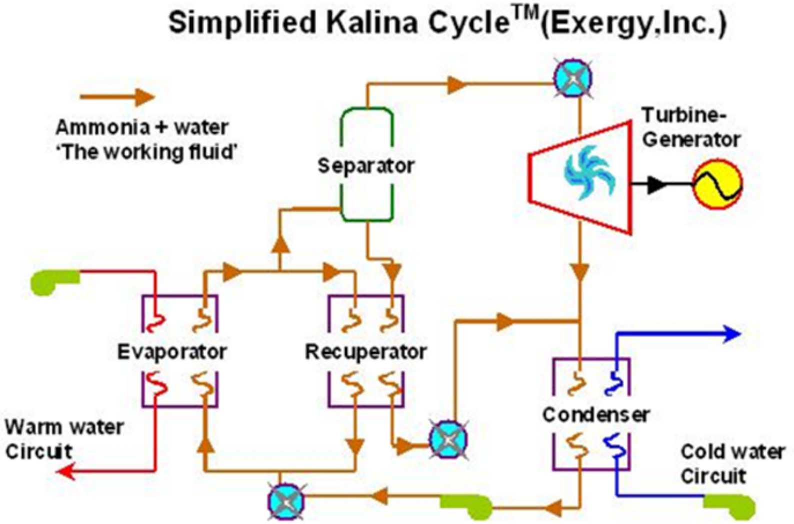
- **Neil Camarta**
  - CEO and President – Western Hydrogen
- **Bob Mitchell**
  - Manager, Climate Change, Business Development and Strategic Planning, Conoco Phillips Canada
- **Pat Bohan**
  - Director, District Energy Generation & Wholesale Energy, ENMAX
- **Jim Seaba**
  - Manager, Facilities Technology and Integration, Conoco Phillips Canada
- **Alan Chambers**
  - Alberta Innovates Technology Futures
- **Frank Vagi**
  - Senior Process Advisor, Bantrel
- **Warren Frost**
  - Director, Consulting Services, Genalta Power

TECHNOLOGY

- Natural Gas Pressure Reducing Turbo-expander
    - Natural gas pressure reduction to sites is through valves, but this dissipates energy
    - Pressure can be reduced through a turbine and electricity is generated

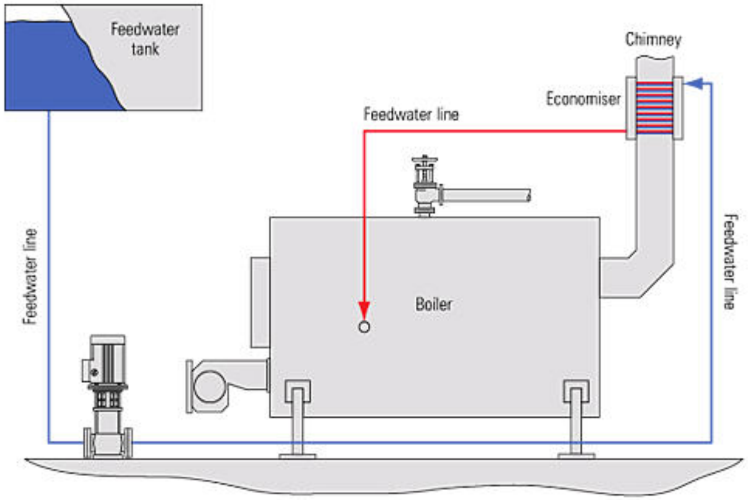
TECHNOLOGY

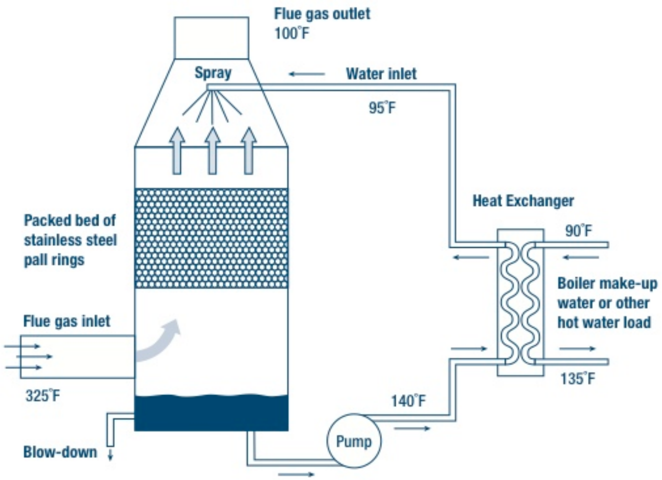
- Heat to Electricity
  - Organic Rankine Cycle (ORC)
  - Kalina Cycle
  - Thermoelectric



TECHNOLOGY

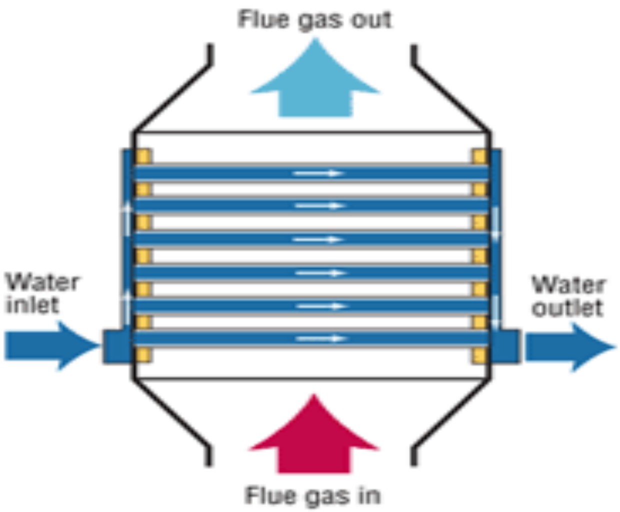
- Heat Capture
  - Non-condensing Heat Exchanger
  - Condensing Heat Exchanger



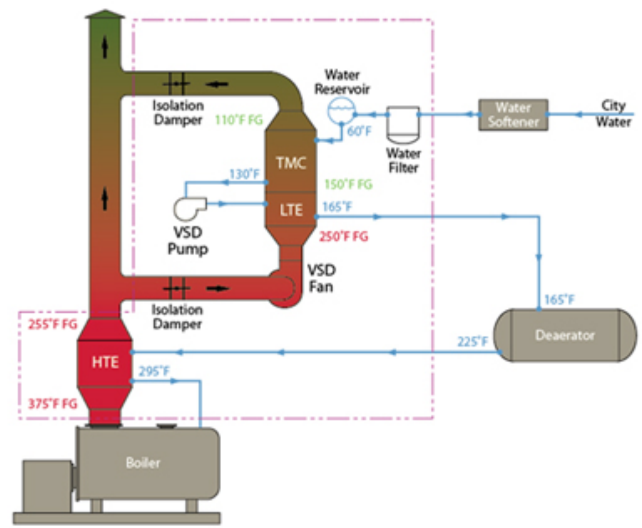


TECHNOLOGY

- Heat Capture
  - Transport Membrane Condenser
  - Heat Pipes



Flow through a transport-membrane-condenser bundle.

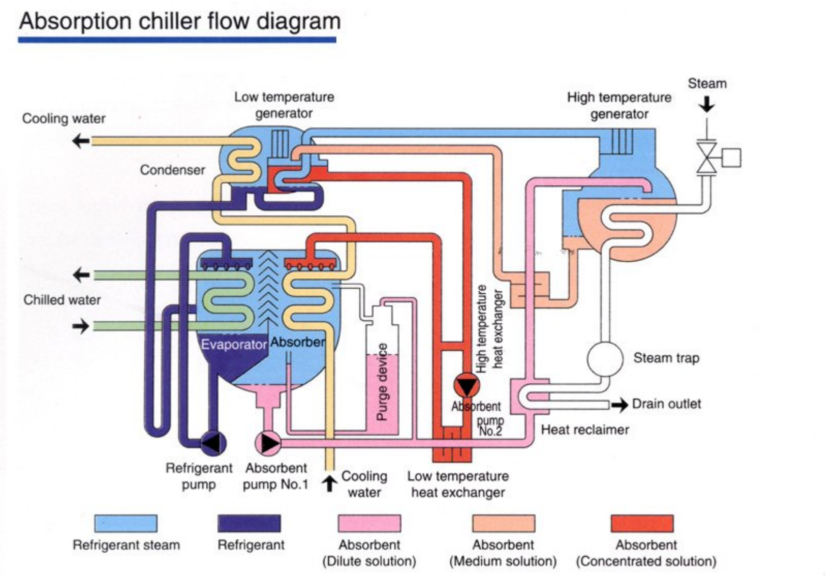


TECHNOLOGY

- Heat Upgrade
  - Steam recompression
  - Heat Pump

TECHNOLOGY

- Heat to Cooling
  - Absorption Chiller



TECHNOLOGY

- End Uses for Heat

  - Combustion air pre-heat
  - Boiler feed-water pre-heat
  - Load Pre-heat
  - Process Heating
  - Office area heating / cooling
  - District heating for municipality

SUMMARY OF TECHNOLOGIES

- Proven technologies are available
- Innovative opportunities to explore
- Higher Temperatures = Higher Value
- Produce Electricity with the right conditions
- Condense flue gases to access latent heat
- Cascade waste energy through many end uses
- Low temperature waste heat (~80 C) is useful for space heating
- Lots of buildings (commercial and residential) can access heat through District Heating

FURTHER INVESTIGATION

Given the significant amounts of waste heat available, there are a number of opportunities within these energy islands that warrant further investigation and should be considered in the future. These include:

- **Electricity generation from waste heat streams** by routing the mid-grade waste heat identified in this study to technologies such as Organic Rankine or Kalina Cycle systems.

- **Natural gas pressure letdowns** that result from the large amounts of natural gas consumed in each of these industrial areas could be used to generate electricity.

- **High temperature energy sources** identified could be sufficient to support the installation of third-party operated power generation systems on selected sites.

- **Heating of intermediate product tanks** by using waste heat from primary operations.

FURTHER INVESTIGATION

Regional Steam Utilities should be explored as a way to increase the overall level of steam security on industrial sites, making it less likely that an interruption in steam supply would trigger a site shutdown. Such utilities could incorporate COGEN and such a utility would also lower the capital costs associated with developing new industrial sites in the region.

Redevelopment opportunities within sites and between sites represent a significant opportunity for COGEN and possibly even 'sub-regional' steam systems if ways can be found to locate other industrial sites close to these plants.

District heating systems in neighbouring communities are presently challenging given the large distances between the heat sources and neighbouring municipal development; and given that some of the surrounding municipal development is low-density, single-family houses. Further collaboration with municipalities neighbouring these industrial areas is needed to drive future development with the characteristics needed to take advantage of the identified energy resource.

WASTE ENERGY MAPPING ACROSS CANADA

WASTE ENERGY MAPPING ACROSS CANADA

- With the success of waste energy mapping in Alberta Industrial Heartland, CMC Research Institutes is engaged in conducting feasibility studies that lead to GHG reduction in any regional industrial cluster area in Canada.

For information regarding waste energy mapping opportunities across Canada, please contact:

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