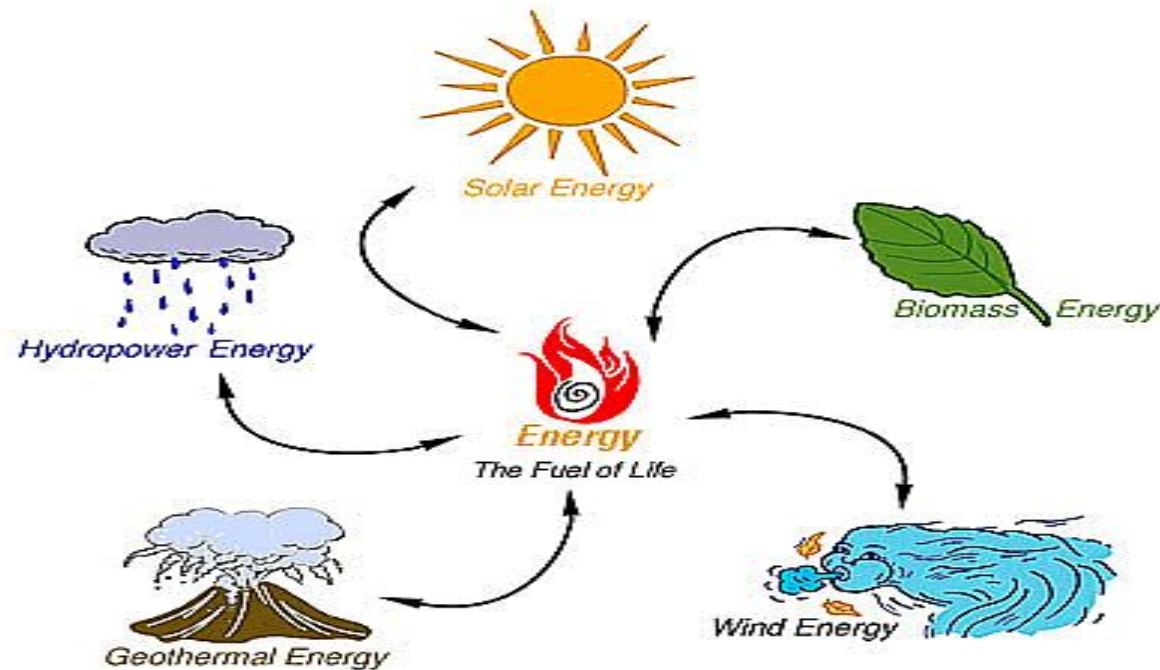


Ranking Energy Options for a District Heating System in Vancouver

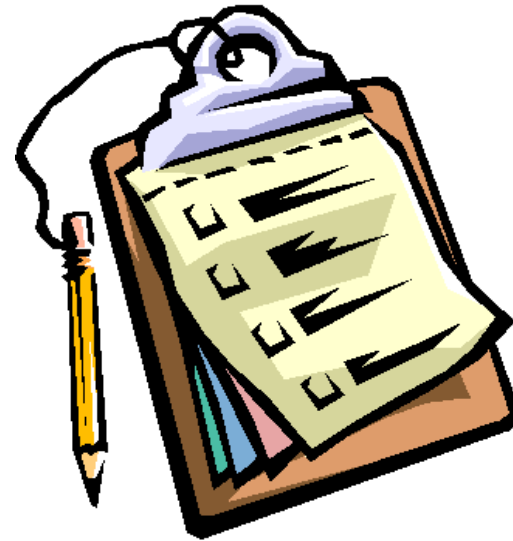


Taraneh Sowlati, Saeed Ghafghazi, Shahab Sokhansanj, Staffan Melin

IEA Bioenergy 2009

Agenda

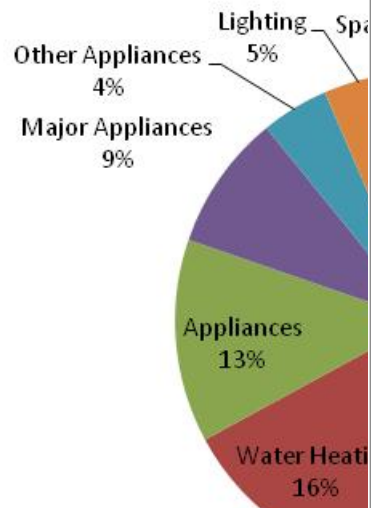
- Background
- Case study
- Method used
- Results
- Conclusion



Energy consumption in Canada

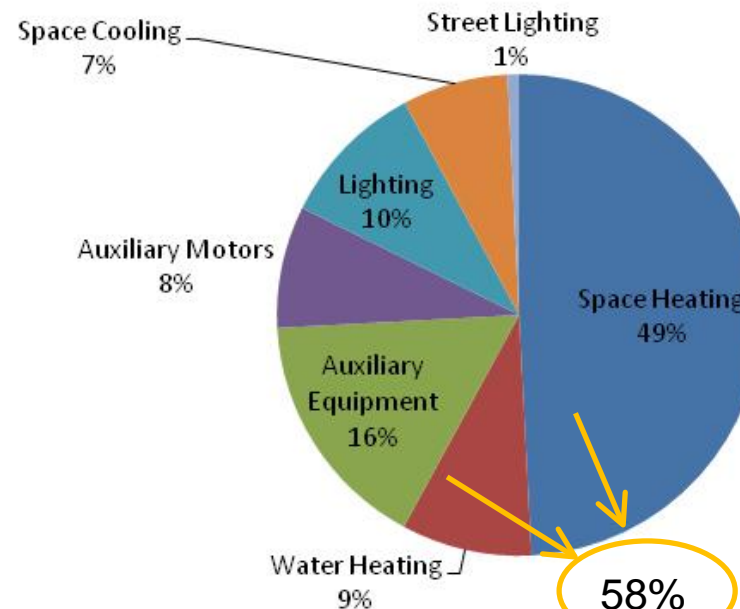
- Canada is a huge consumer of energy.
 - Total primary and secondary energy use in Canada was 7,968 PJ in 2007.

Energy use in residential sector - 2006



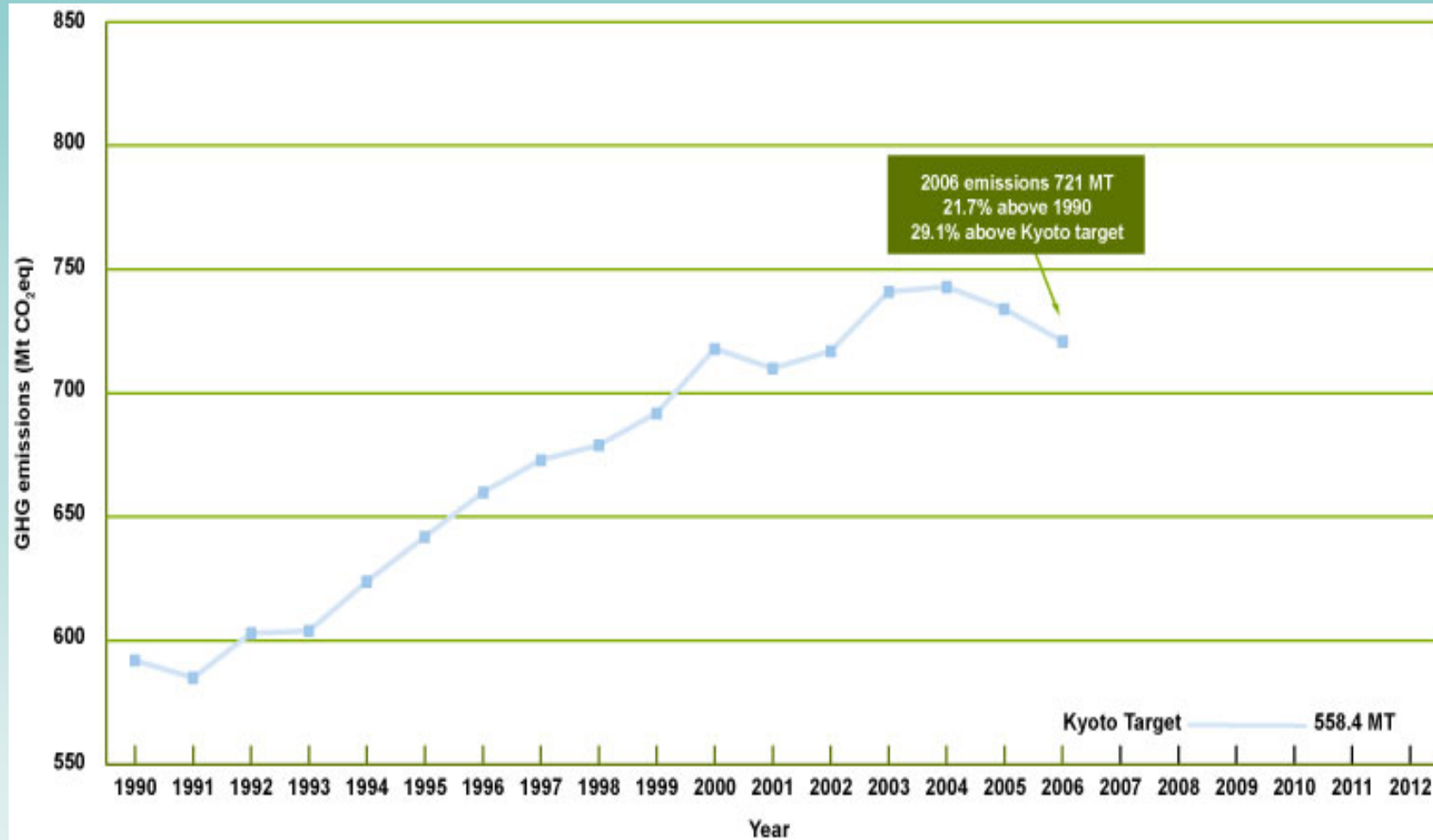
77%

Energy use in commercial/ institutional sector - 2006



58%

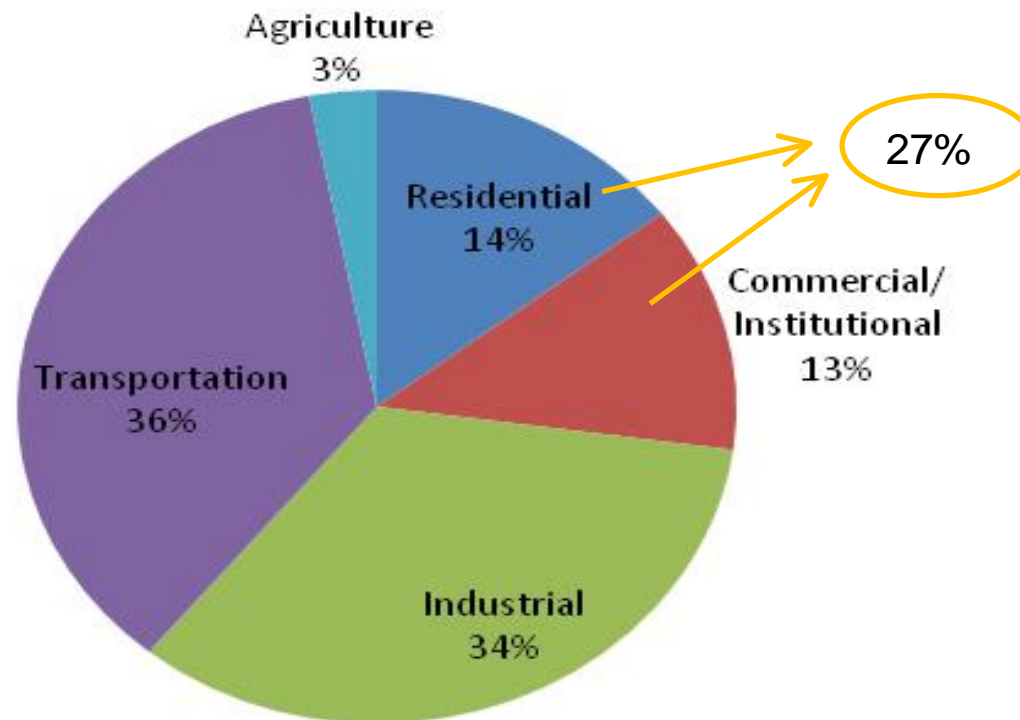
GHG emissions in Canada



Source: Environment Canada, 2008. National Inventory Report, Greenhouse Gas Division, 2008.

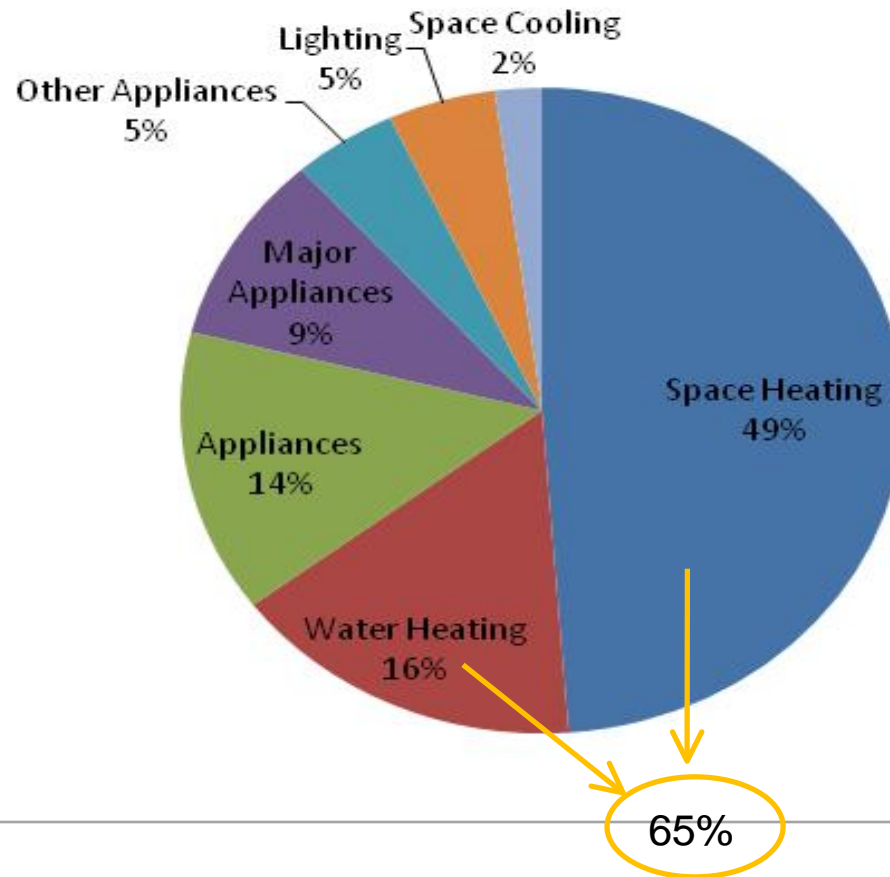
GHG emissions by sectors

Canada's GHG emissions by sectors - 2006

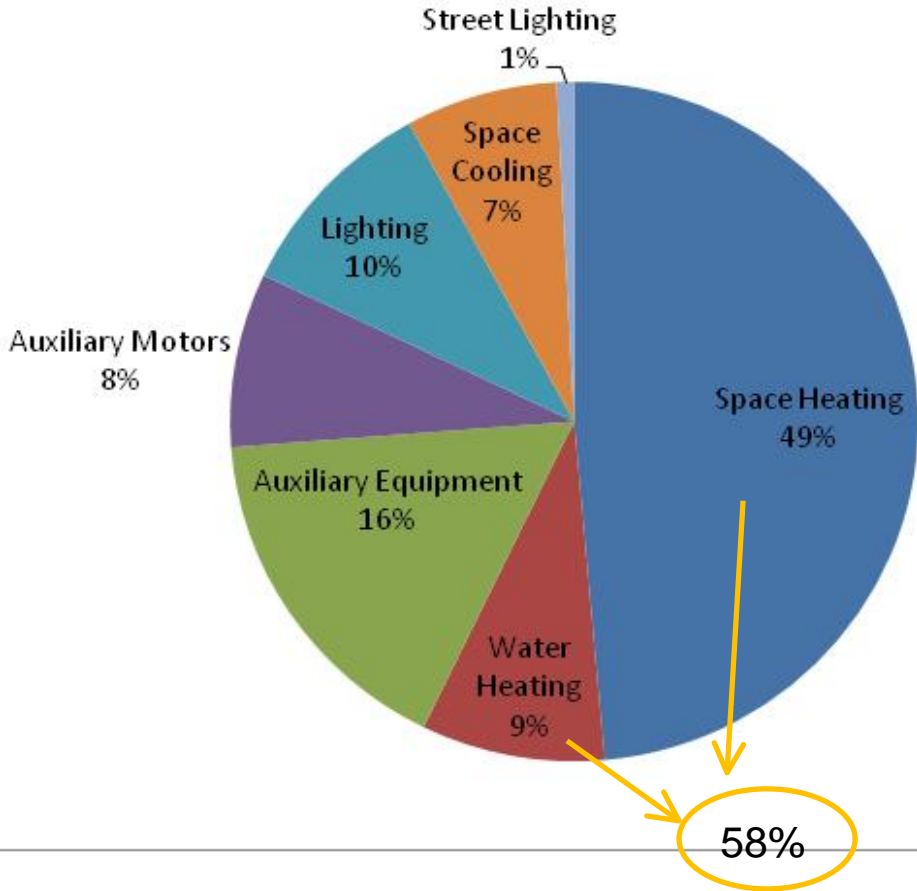


Total GHG emissions in 2006: 478.4 Mt of CO₂e

GHG emissions in residential sector - 2006

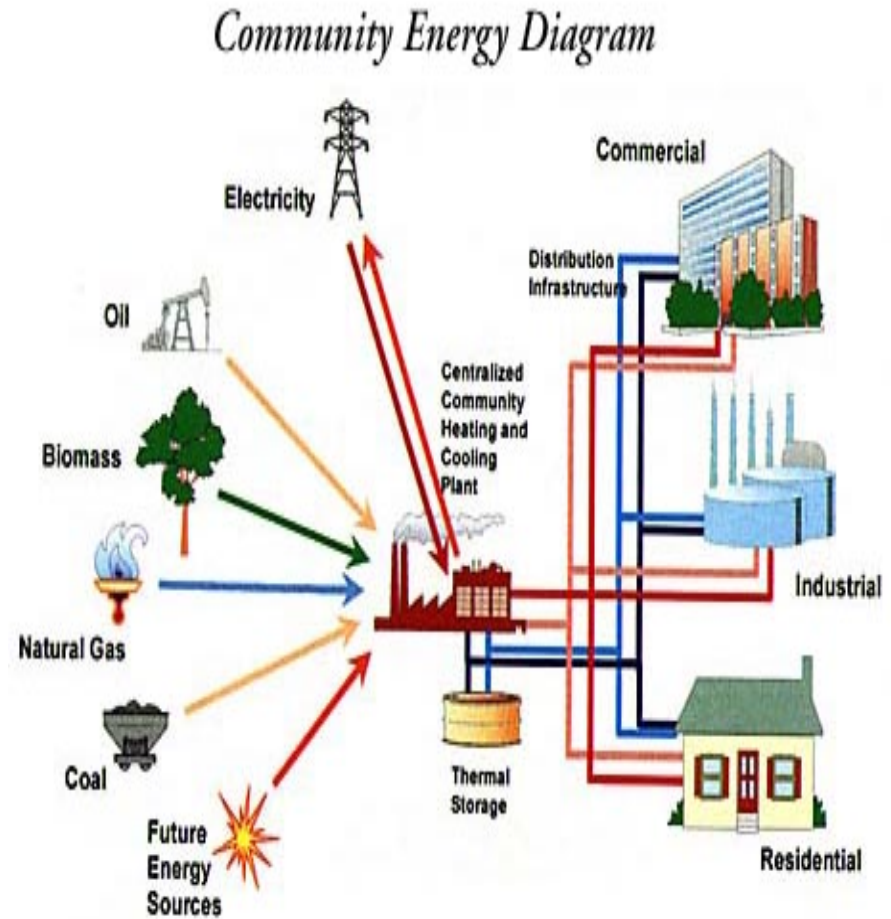


GHG emissions in commercial/ institutional sector



District Heating Systems

- District heating systems
 - centralized system to provide heat for residential and commercial buildings
- Several advantages over decentralized systems
 - increased energy and performance efficiencies
 - reduced life cycle costs
 - augmented control over environmental impacts
 - renewable energy sources can be exploited



District energy systems in Canada

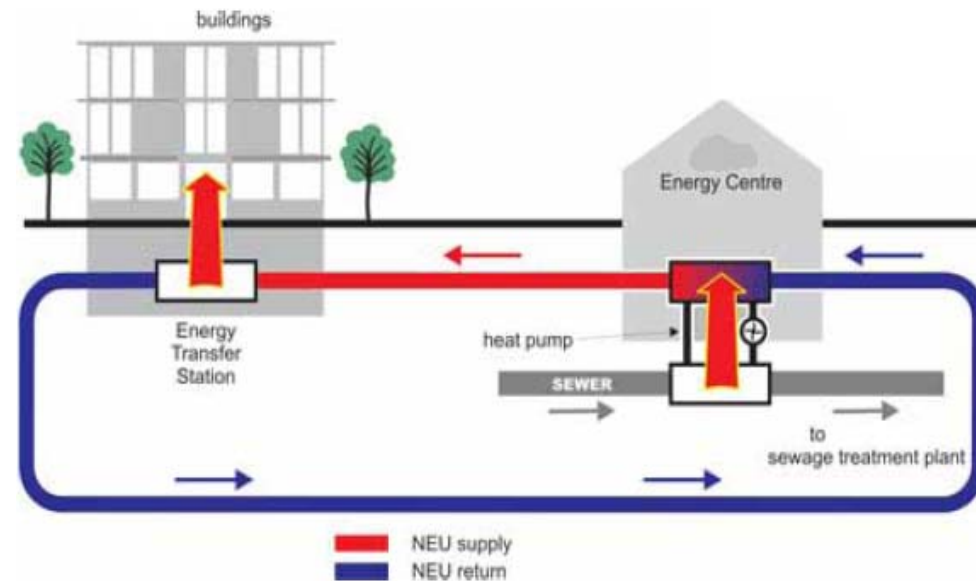
- In Canada, district energy was introduced in the early 1880s in London, Ontario, to meet the heating needs of university, hospital and government complexes.
- There are 112 district energy plants across Canada (48 in Ontario). [Canadian Census of District Energy, Sept. 2007]
- Most of them use gas as their primary fuel, a small portion use biomass.
- Drivers:
 - Climate change
 - Growing demand and energy security
 - Employment and local training

Case study

- A district heating system to provide thermal energy to 350,000 m² floor area in Vancouver
 - 12.5 MW system capacity
 - 10 MW peaking and backup: natural gas
 - Cheap
 - Easy to use
 - Secure
 - Developed technology
 - 2.5 MW base-load: four options
 - Sewer heat recovery
 - Geothermal exchange system
 - Natural gas
 - Biomass (wood pellets)

Sewer heat recovery

- Captures heat from waste water
- Low emission, local renewable source
- Limited experience world wide
- Limited capacity
- Higher capital cost
- Energy security
- Electricity use



Source: <http://vancouver.ca/sustainability/documents/sewageheatrecovery.pdf>

Geothermal heat exchange

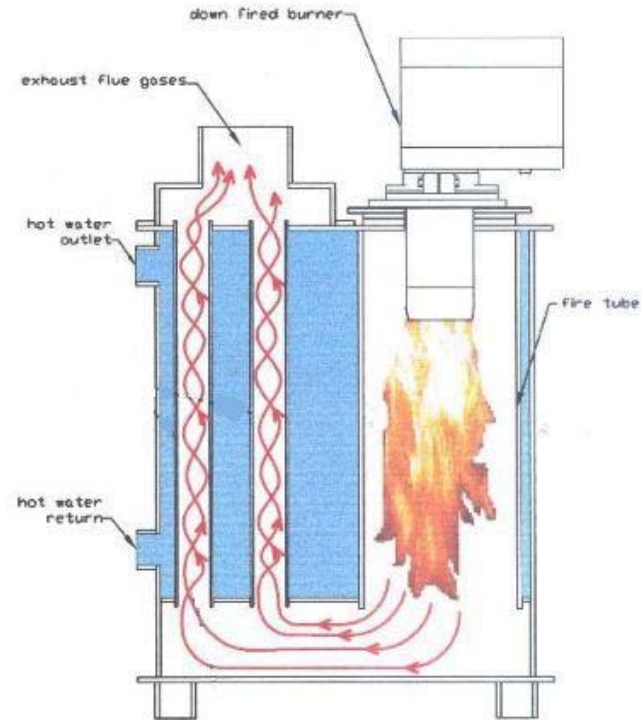
- Captures heat from ground
- Low emission, local renewable source
- Capital intensive
- Electricity use



Source:
http://www.strose.edu/Alumni_and_Parents/Center_For_The_Arts/images/Massry_geothermal_HVAC.jpg

Natural gas

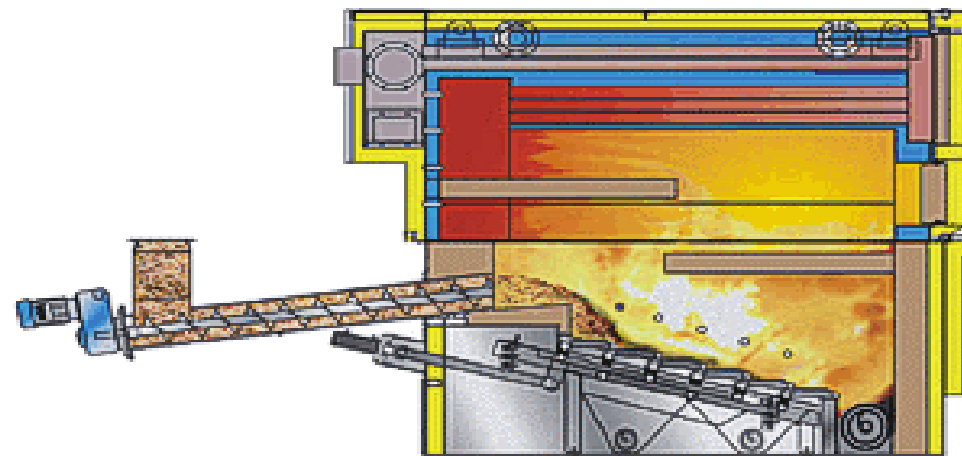
- Easily accessible energy
- Developed network in BC
- Reliable and secure energy
- Low capital cost
- Developed technology
- Fossil fuel
- Emission concerns
- Resource depletion



Source:http://www.dexterboilers.com/mediac/400_0/media/boiler-diagram.JPG

Biomass (wood pellets)

- Low capital cost
- Well developed burning technology
- GHG neutrality
- Cheap fuel
- PM emission concern
- Local traffic concern
- Fuel security concern



Source: http://www.kiv-uk.com/images/tpvb_with_firebox.gif

Decision making characteristics

- Different alternatives are available that should be evaluated based on different factors:

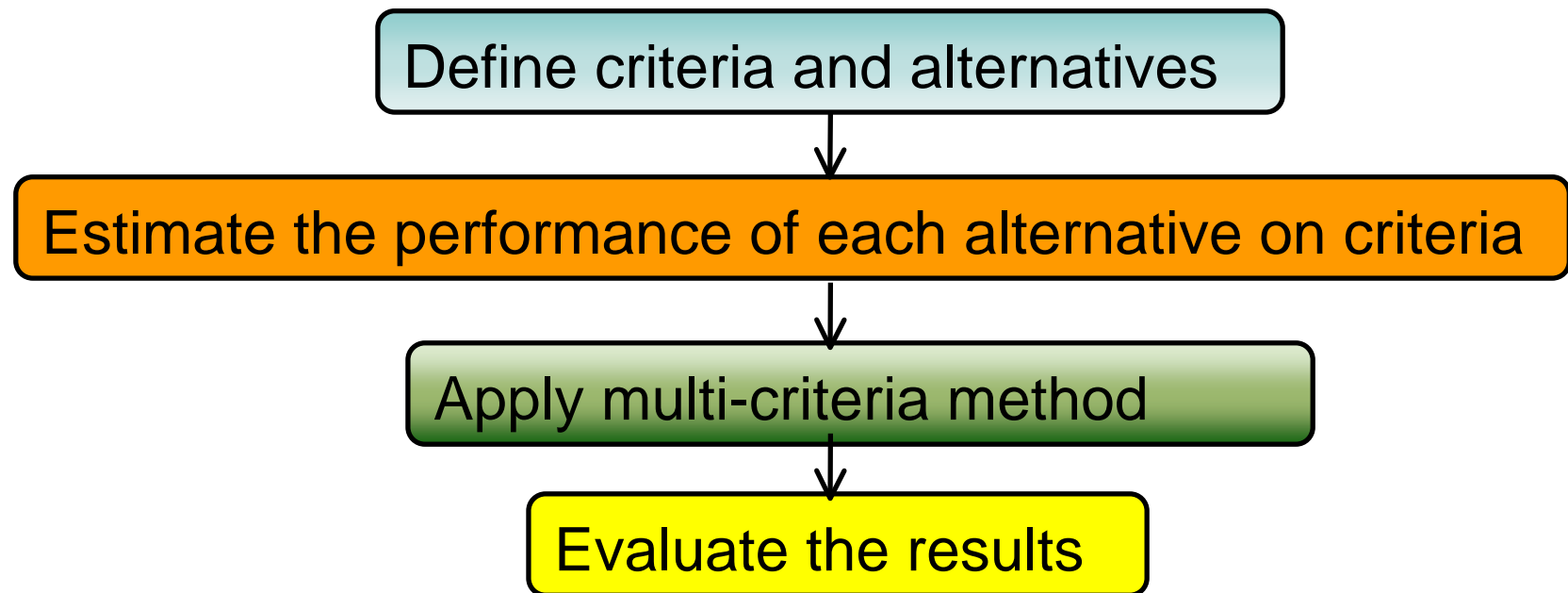
- Economic
- Technical
- Environmental
- Social



- Different stakeholders are involved in the decision making.

A system approach in decision-making

- Multi-criteria decision making approach to incorporate different criteria and different decision makers' viewpoints



Decision makers and criteria

- Six criteria were considered
 - ❑ Capital cost
 - ❑ Maturity of technology
 - ❑ PM emission
 - ❑ GHG emission
 - ❑ Local source
 - ❑ Traffic load
- Three general stakeholder groups
 - ❑ DES Developer
 - ❑ Environmental organization
 - ❑ Community pressure groups

Alternatives/Criteria Matrix

Criteria	Units	Alternatives			
		Natural gas	Biomass	Sewer heat	Geothermal
Cost	10 ³ CAD \$	16,875	14,688	19,041	23,521
GHG emission	Tonne/ yr	7,875	2,564	3,635.2	4,081.28
PM _{2.5}	Tonne/ yr	0.14	2.40	0.04	0.04
Maturity of technology	Qualitative scale (1-5)	5	4	1	2
Local source	Binary value (0,1)	0	0	1	1
Traffic load	Binary value (0,1)	0	1	0	0



Scenario I – no communication

- Feasibility analysis carried out by DES developer could not be presented to other stakeholders.
- Criteria ranking assigned to stakeholders:
 - DES developer
Cost>Maturity of technology>GHG emissions>PM emissions>Local source=Traffic load
 - Environmental organization
PM emissions>GHG emissions>Cost=Maturity of technology=Local source=Traffic load
 - Community pressure groups
PM emissions>Local source=Traffic load>Cost=Maturity of technology=GHG emissions

Scenario II - communication facilitated

- Traffic load is not significant.
- Biomass supply can be secured.
- Criteria ranking assigned to stakeholders:
 - DES developer
Cost > Maturity of technology > GHG emissions > Local source
 - Environmental organization
GHG emissions > Local source = Cost = Maturity of technology
 - Community pressure groups
Local source = Cost = Maturity of technology = GHG emissions

Results

Ranking of alternatives for each stakeholder based on PROMETHEE II

		Ranking			
Stakeholders		1	2	3	4
Scenario I	Developer	Biomass	Natural gas	Sewer heat	Geothermal
	Environmental group	Sewer heat	Geothermal	Biomass	Natural gas
	Community group	Sewer heat	Geothermal	Natural gas	Biomass
Scenario II	Developer	Biomass	Natural gas	Sewer heat	Geothermal
	Environmental group	Biomass	Sewer heat	Geothermal	Natural gas
	Community group	Biomass	Sewer heat	Natural gas	Geothermal



Conclusions

- A multi-criteria decision making approach can help in incorporating different factors and different viewpoints in the analysis and give a ranking of energy options.
- Two different scenarios were defined here to show that consensus is more likely to happen with communication among stakeholders.
- Without communication, sewer heat recovery and biomass are competing options.
- Biomass is a more preferable renewable energy source with communication.

Acknowledgement

- Chris Baber – City of Vancouver

