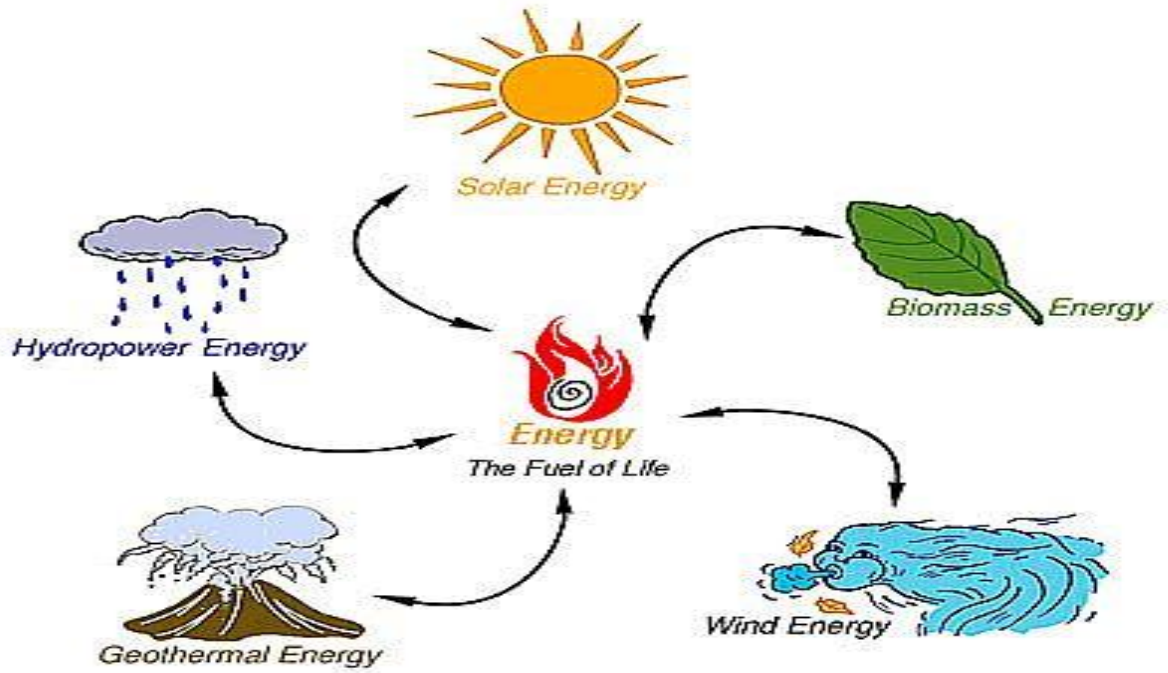
Ranking Energy Options for a District Heating System in Vancouver



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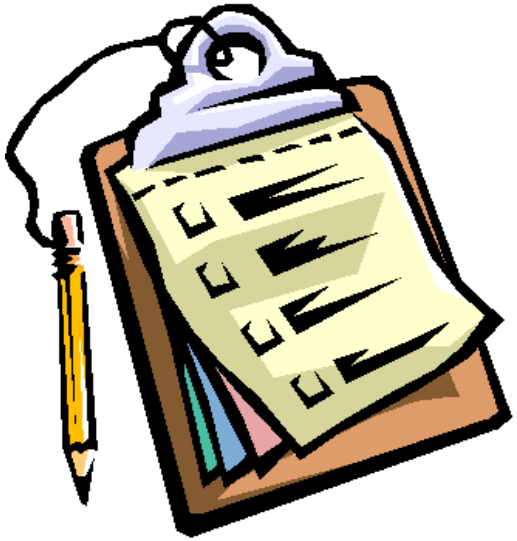
IEA Bioenergy 2009

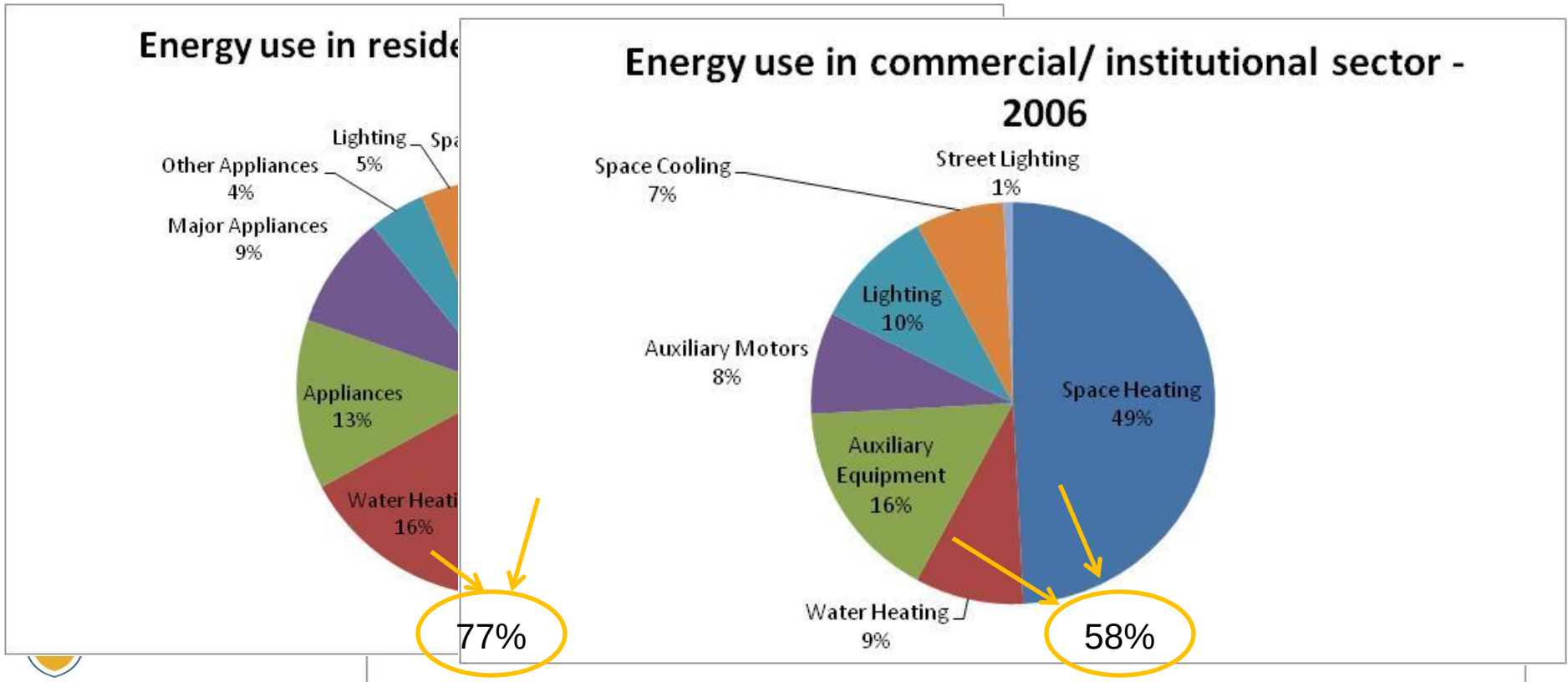
Agenda



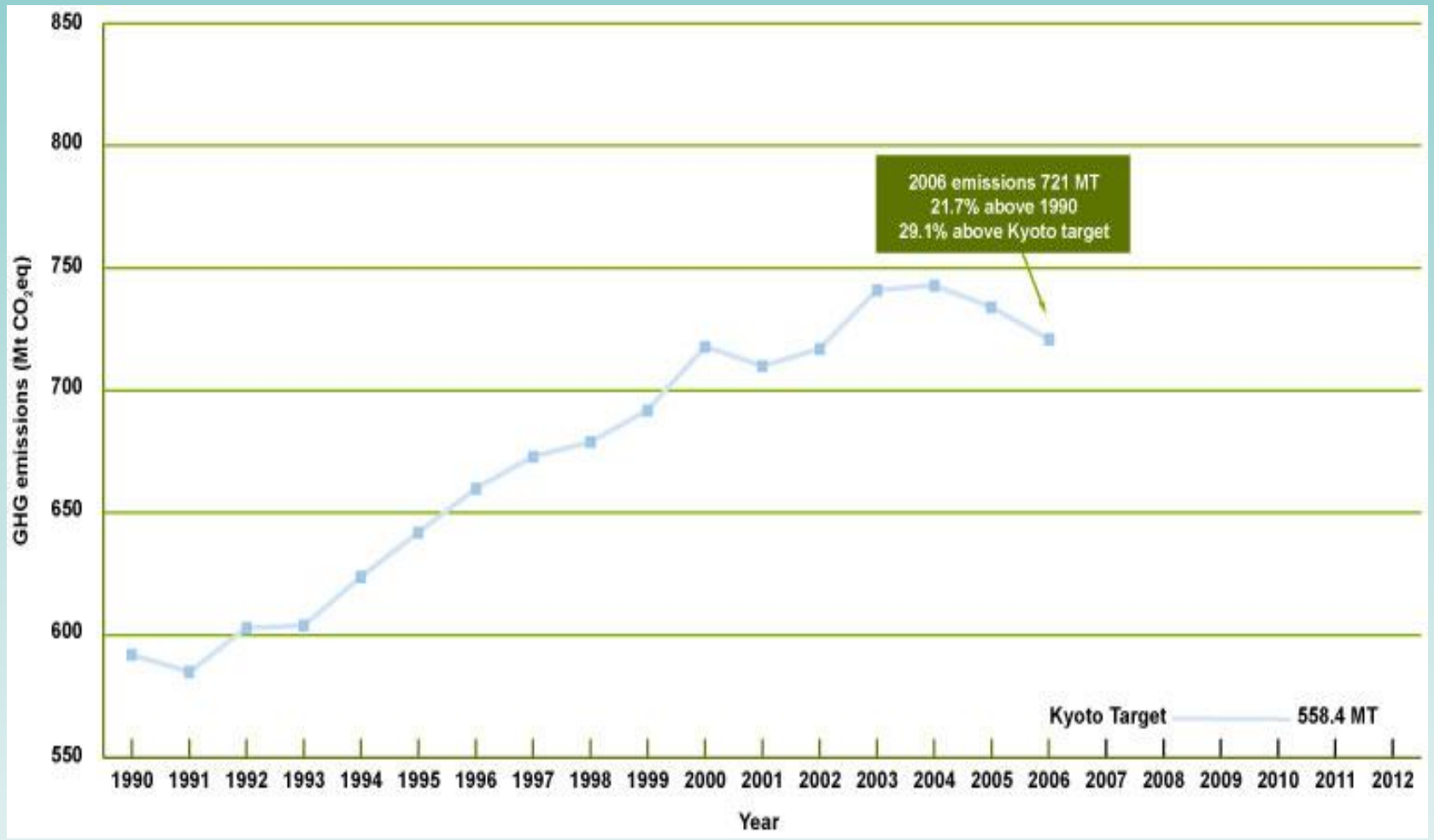
- Background
- Case study
- Method used
- Results
- Conclusion

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.

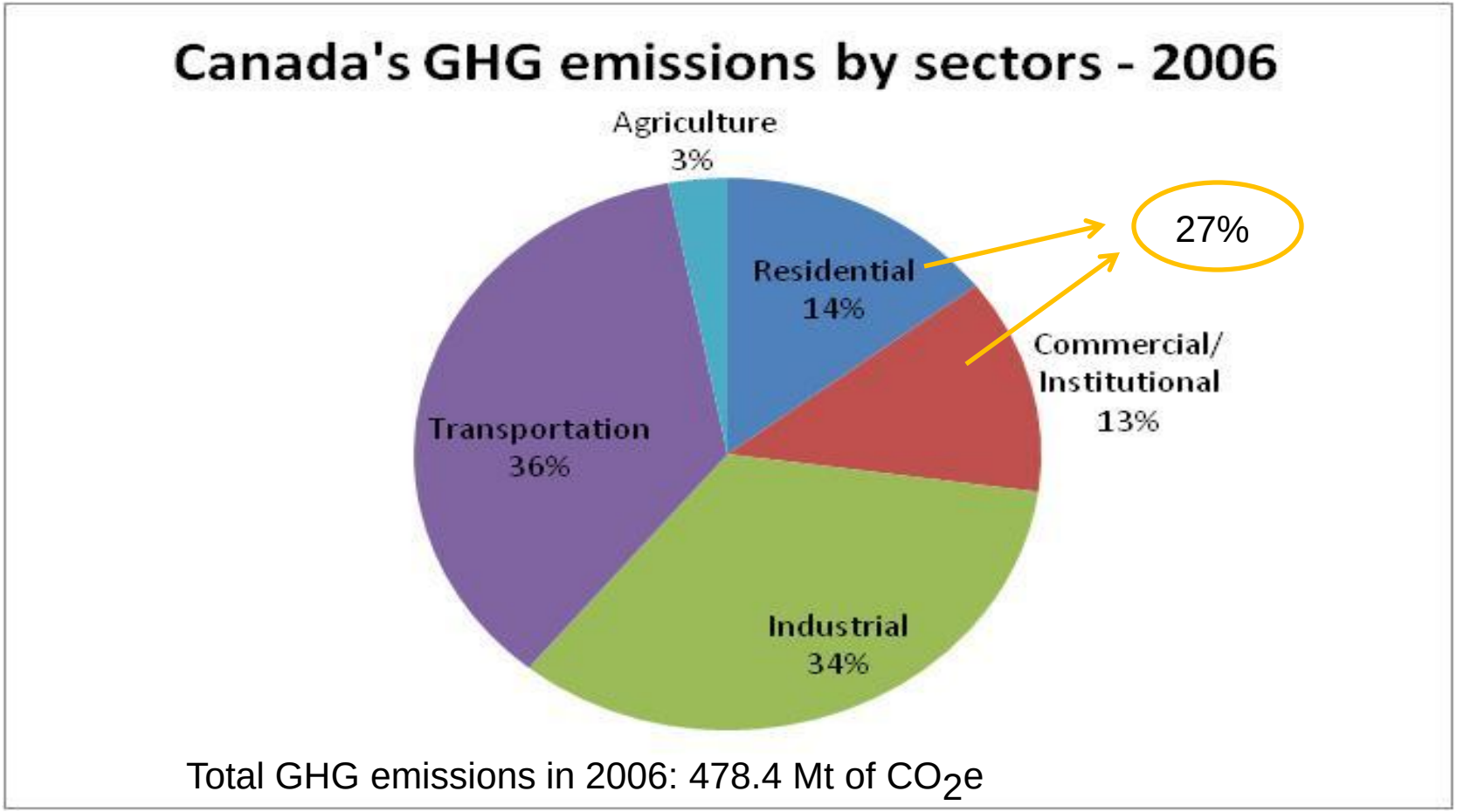


GHG emissions in Canada

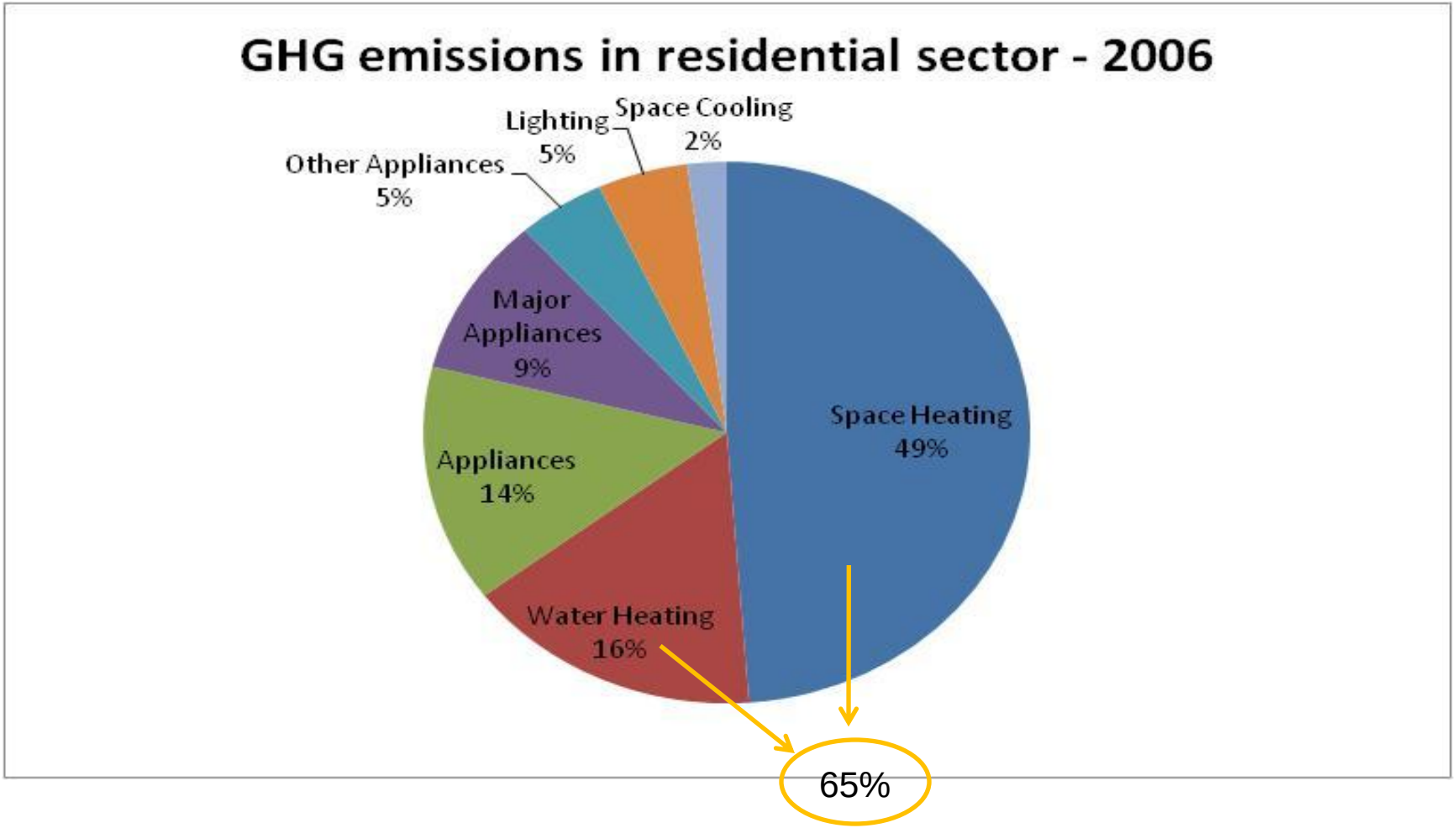


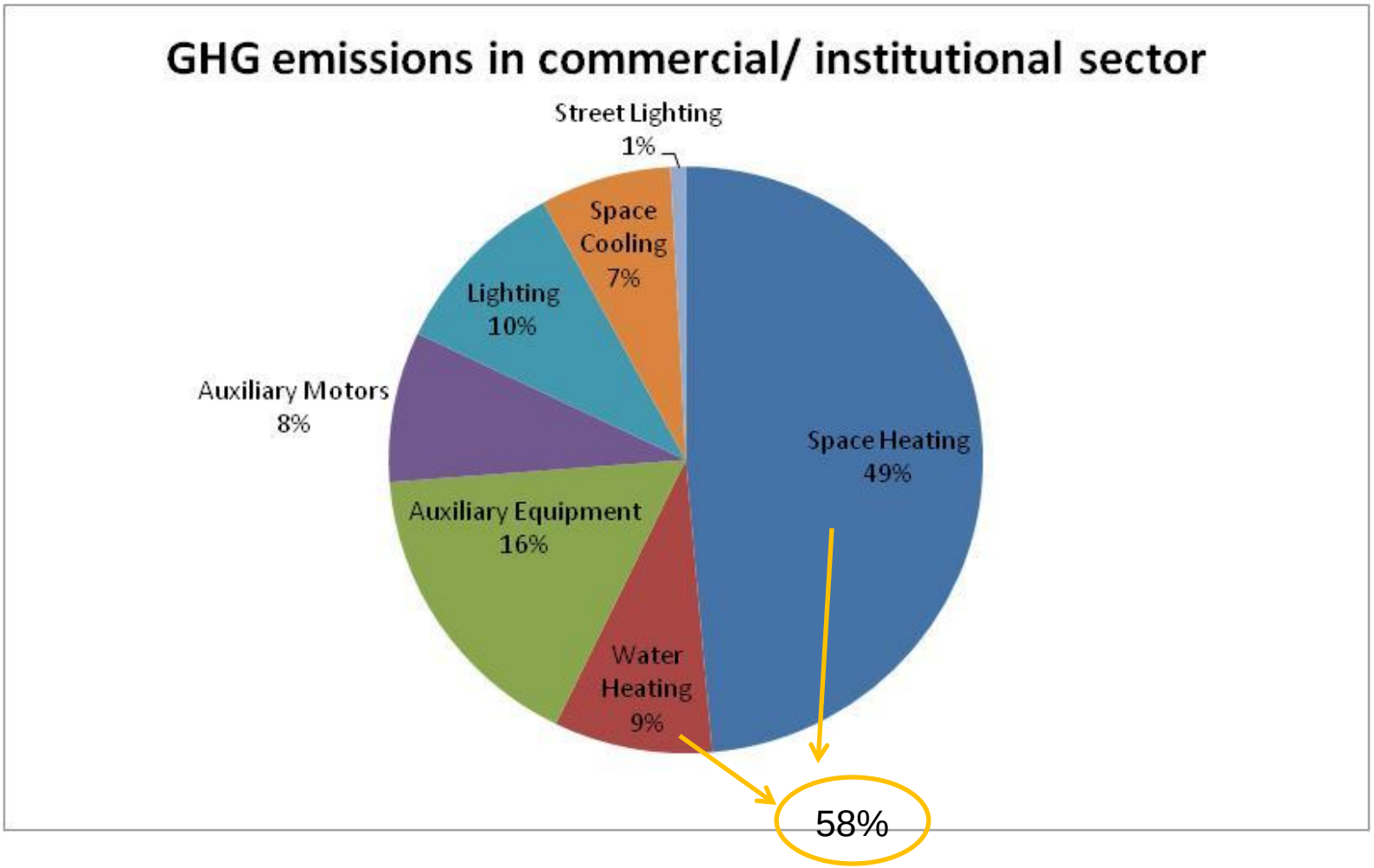
Source: Environment Canada, 2008. National Inventory Report, Greenhouse Gas Division, 2008.

GHG emissions by sectors



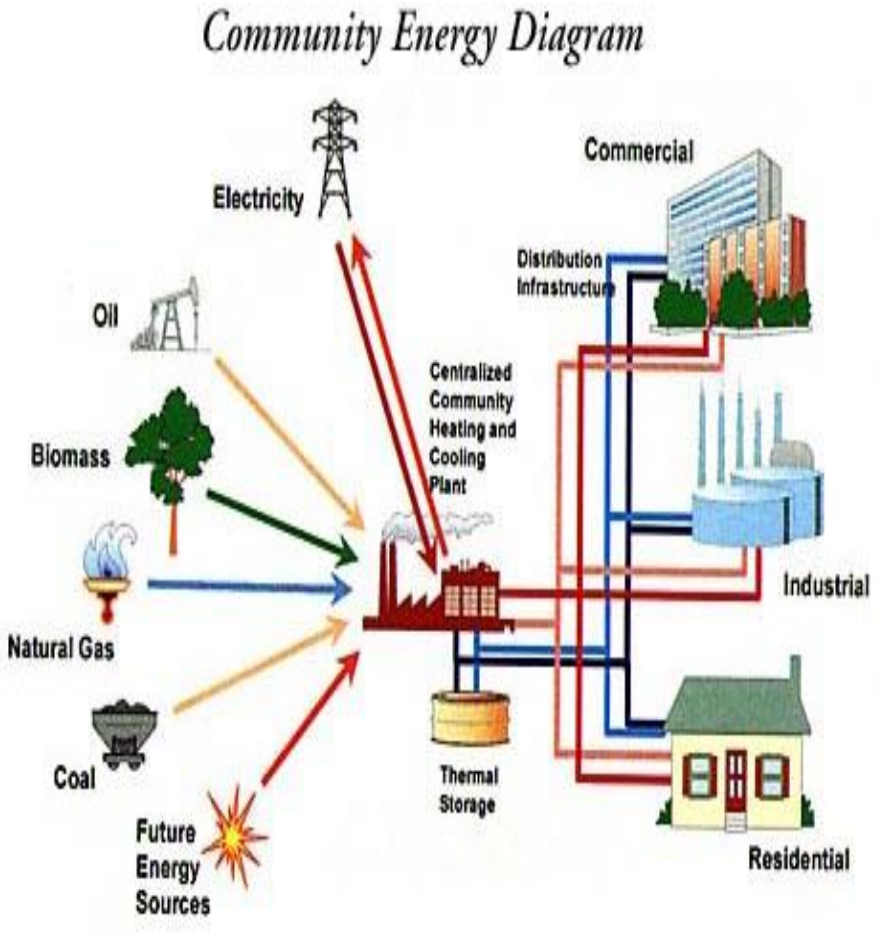
Total GHG emissions in 2006: 478.4 Mt of CO_2e


GHG emissions in residential sector - 2006
Lighting 5%
Space Cooling 2%
Other Appliances 5%
Major Appliances 9%
Space Heating 49%
Appliances 14%
Water Heating 16%
65%


GHG emissions in commercial/ institutional sector
Street Lighting 1%
Space Cooling 7%
Lighting 10%
Auxiliary Motors 8%
Space Heating 49%
Auxiliary Equipment 16%
Water Heating 9%
58%

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

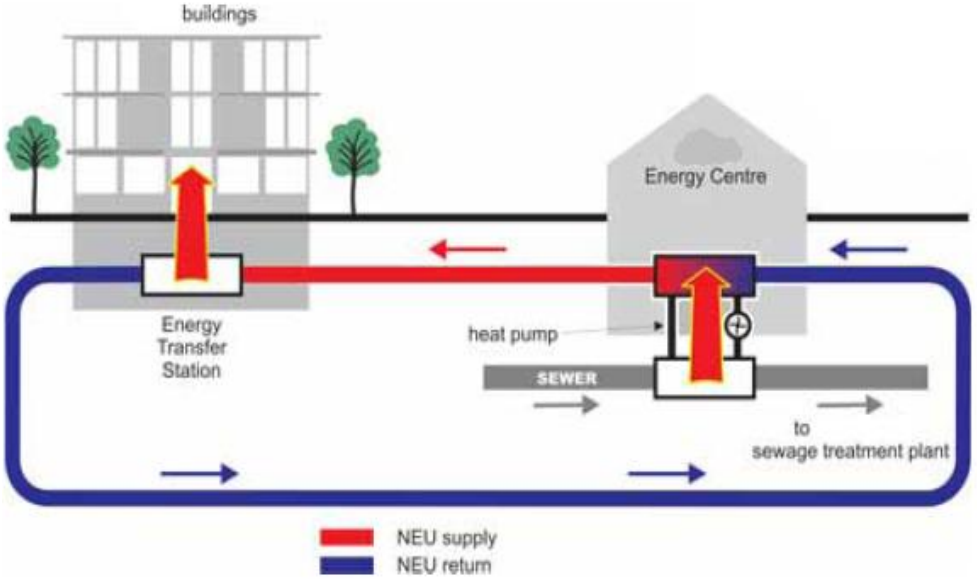
- In Canada, district energy was introduced in the early 1880s in London, Ontario, to meet the heating needs of university, hospital and government complexes.
- There are 112 district energy plants across Canada (48 in Ontario). [Canadian Census of District Energy, Sept. 2007]
- Most of them use gas 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 m^2 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

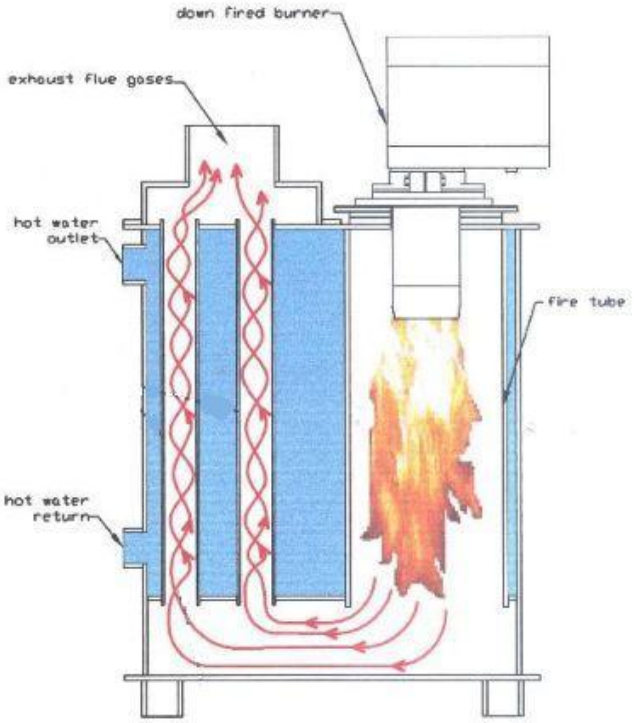
Geothermal heat exchange

- 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

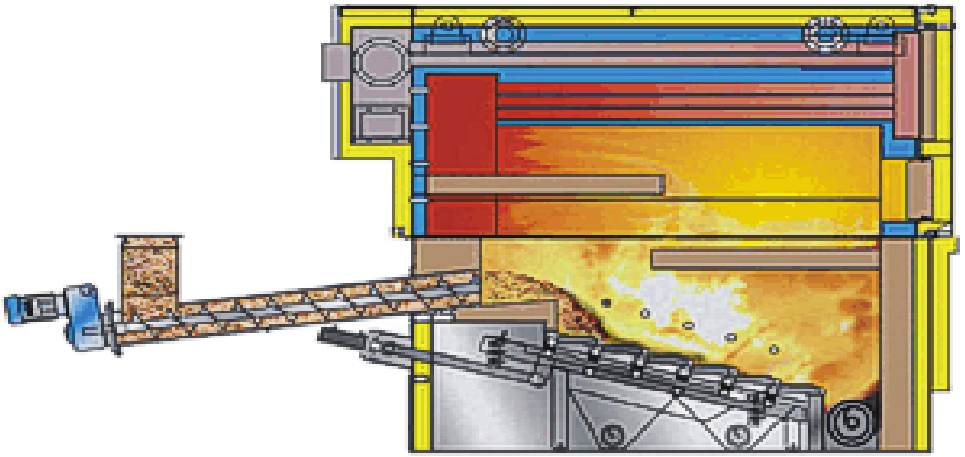
- Easily accessible energy
- Developed network in BC
- Reliable and secure energy
- Low capital cost
- Developed technology
- Fossil fuel
- Emission concerns
- Resource depletion



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

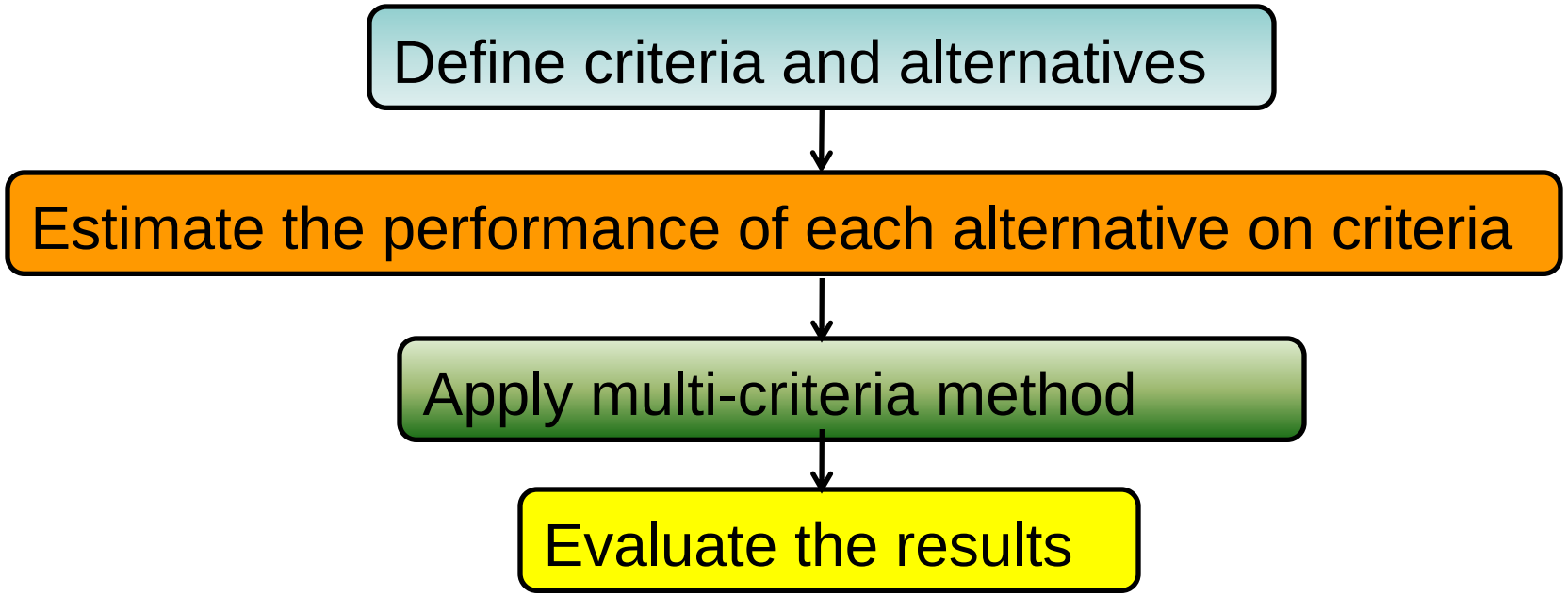
Decision making characteristics

- 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

- NSERC