LEADING THE WAY
CampusEnergy2022

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INTERNATIONAL DISTRICT ENERGY ASSOCIATION

LAVAL UNIVERSITY

An Example of District Wide Energy Recovery For 15 Years

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Campus Energy Boston

Plan

Context

Decarbonisation Main Steps

District Energy System

Energy Intensity Use

Energy Sources

GHG Emissions

Carbon Reduction Measures

Conclusion

CONTEXT

Laval University

Context

- University Community :
  - 47 000 students
  - 9 500 employees
- The Campus :
  - Campus area : 1,8 km^2 (0,70 $mile^2$)
  - 30 major buildings (1955 to present)
  - Building surface : 716,000 m^2 (0,28 $mile^2$)

Laval University

History

- Université Laval was the very first French-language university in North America.
  - In 1663 Monsignor François de Montmorency-Laval, the first bishop of New France, founded the colony’s first educational institution: Séminaire de Québec.
  - Nearly 200 years later, in 1852, this institution became a university and the first building block for all French-language higher education in Québec, Canada, and North America.

Education

- 17 faculties
- Over 60 departments, schools, and institutes
- More than 7,000 courses

Université Laval

Weather

- 5202 HDD by year (Celsius)

Or 2890 HDD (Fahrenheit)

- -35°C (-31F) during the winter
- +35°C (95F) during the summer
- Located in Quebec City, Canada.

DECARBONISATION MAIN STEPS

Laval University

Based on ISO 50 001 – Plan – Do- Check - Act

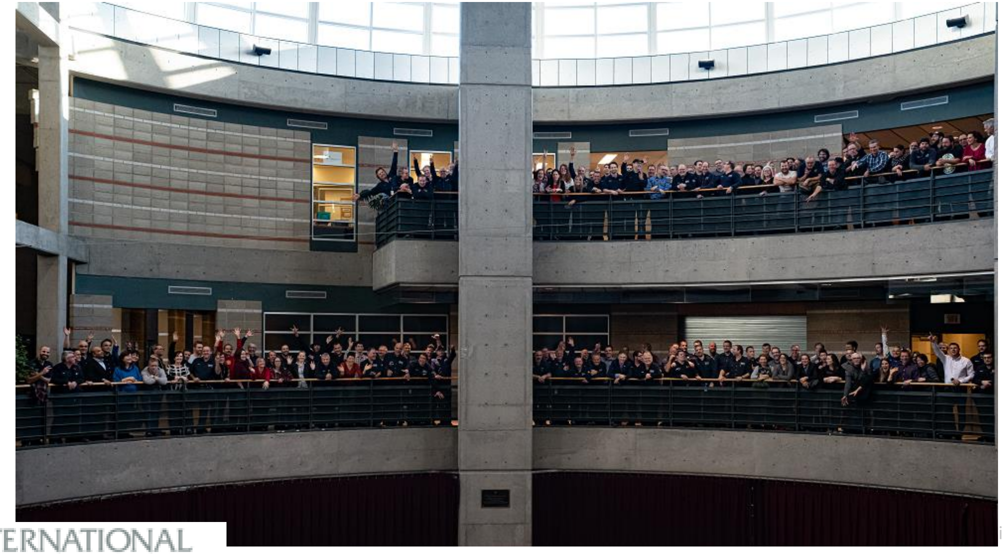
- Institutional Sustainable Development Policy 2008
  - Article GES 5.4.6 and 5.4.7
  - https://www.ulaval.ca/fileadmin/developpement_durable/documents/PolitiqueDD-CA.pdf
- Institutional orientation in terms of sustainable development
- https://www.ulaval.ca/fileadmin/notre_universite/Plan-strategique-UL-2017-2022.pdf
- Institutional Energy Management Policy 2018
- https://www.ulaval.ca/fileadmin/Secretaire_general/Politiques/Politique_gestion_energetique.pdf
- Energy Master Plan and Action Plan

Laval University

- Continuous monitoring of individual energy source and water for each building
- Monthly monitoring of consumption and comparison with the reference scenario
- Action if the building deviates from its energy baseline
- Energy team monthly brainstorming on improvements and projects identification in regards to the action plan
- Energy management plan, consistent with the 2040 real estate development projections

Laval University

- Facilities management
  - Projects management, Maintenance, Operations and Optimisation of the buildings and district energy
    - More than 200 employees



DISTRICT ENERGY SYSTEM

District Energy

- Two power plants
  - Steam production
  - Chilled water production
  - Compressed Air production
  - Domestic Water Treatment
- Electricity distribution at 25 kV (2 X 15 MVA)
- Centralised HVAC Control systems
- More than 7km of service tunnels and pedestrian corridors

Steam Power Plants

- Put in operation in 1956 with major improvements since then and to come.
  - Global efficiency of the plant : 87%
- Plant 1 East : 3 dual fuel steam boilers, gas and oil #6:
  - Boiler 1 : 15 MW (51 MMBtu/hr)
  - Boiler 3 : 30 MW (102 MMBtu/hr)
  - Boiler 2 : 45 MW (153 MMBtu/hr)
  - Boiler 4 (electric) : 6 MW (20 MMBtu/hr)
- Plant 2 West :
  - Boiler of 30 MW (102 MMBtu/hr)
- Peak heating requirement :
  - 50MW (170 MMBtu/hr)

Electricity infrastructures

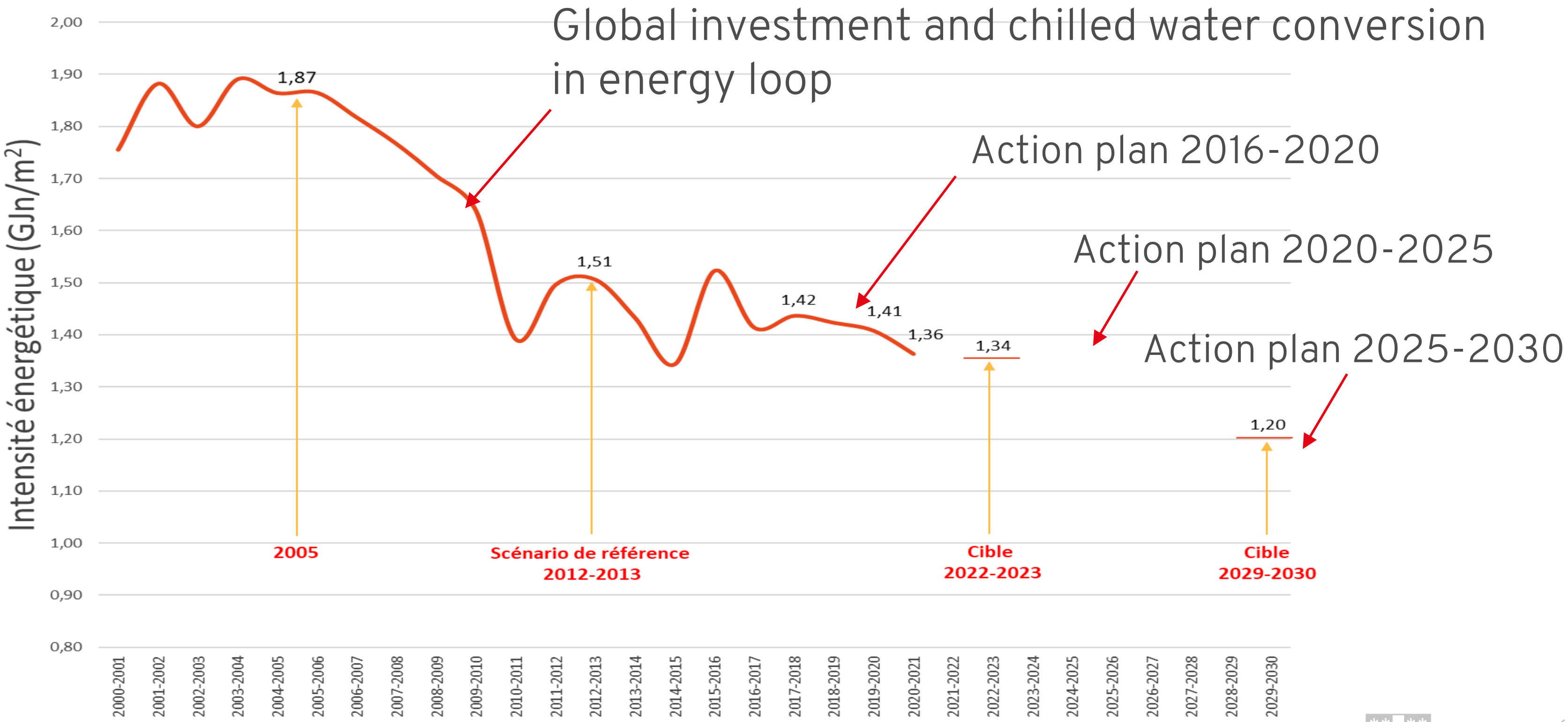
- Maximum capacity of 30 MW is available with the current power infrastructure
  - Lighting, ventilation systems, motors, chemical hoods, office and computer equipment.
  - Electricity annual cost : ≈ 8 MM CAD$
  - Participation in the Demand response program (DR)
    - During the winter, the public utility Hydro-Quebec ask us to reduce our demand to be able to heat residential homes
    - We apply this strategy during the summer, with the cooling peak requirements in order to optimize the energy cost.

Chilled water production

- 7 centrifugal coolers
  - Total capacity of 9 400 tons
- Feed temperature:
  - 4.4° Celsius (40 F)
- Return temperature:
  - 13.0° Celsius (95 F)

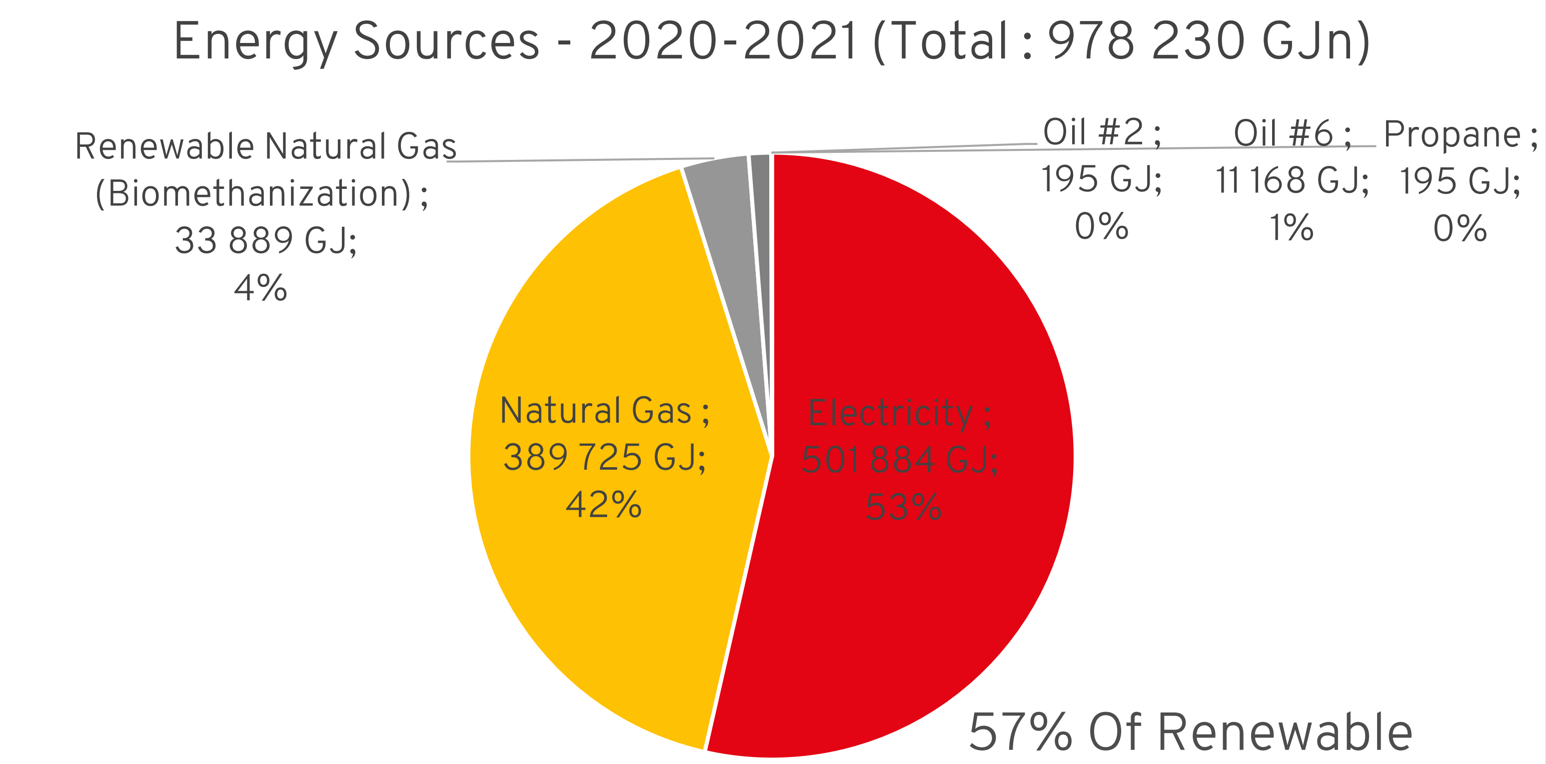
ENERGY INTENSITY USE (EIU)

Energy intensity use (GJn/m²)



ENERGY SOURCES

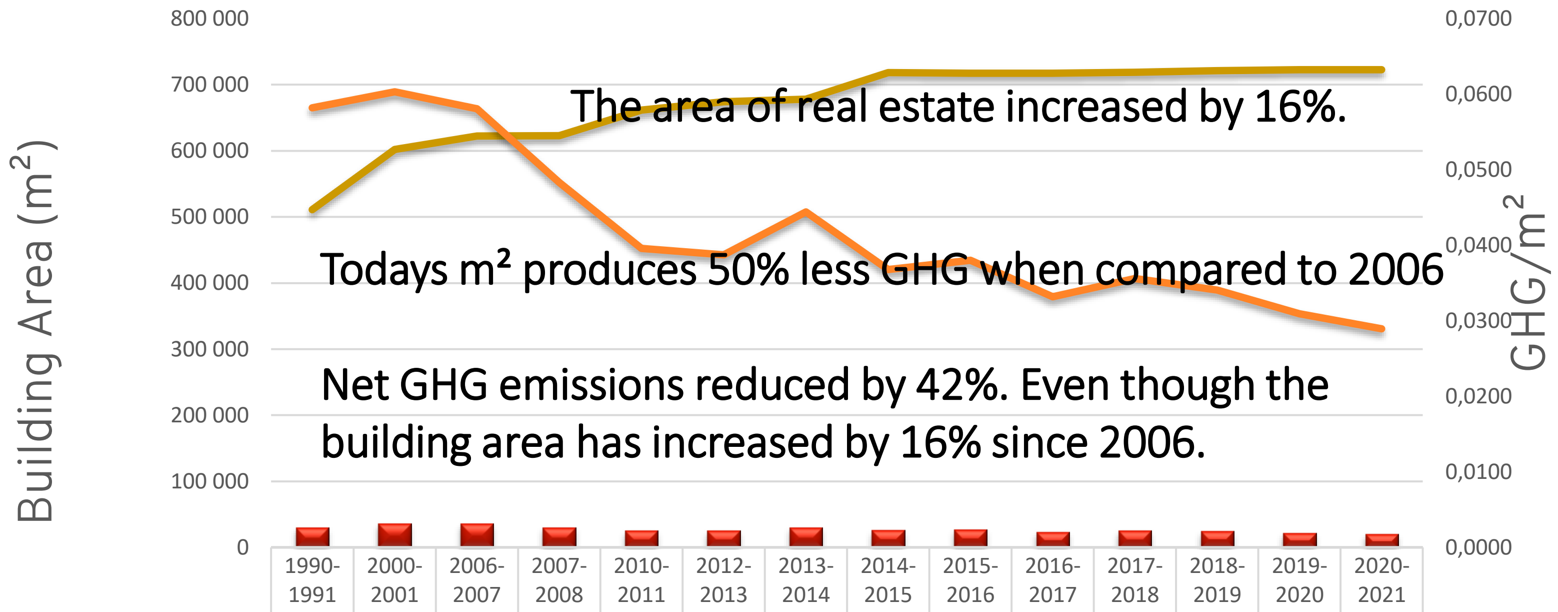
Energy Sources



57% Of Renewable Energy sources

EMISSIONS

GHG Emissions



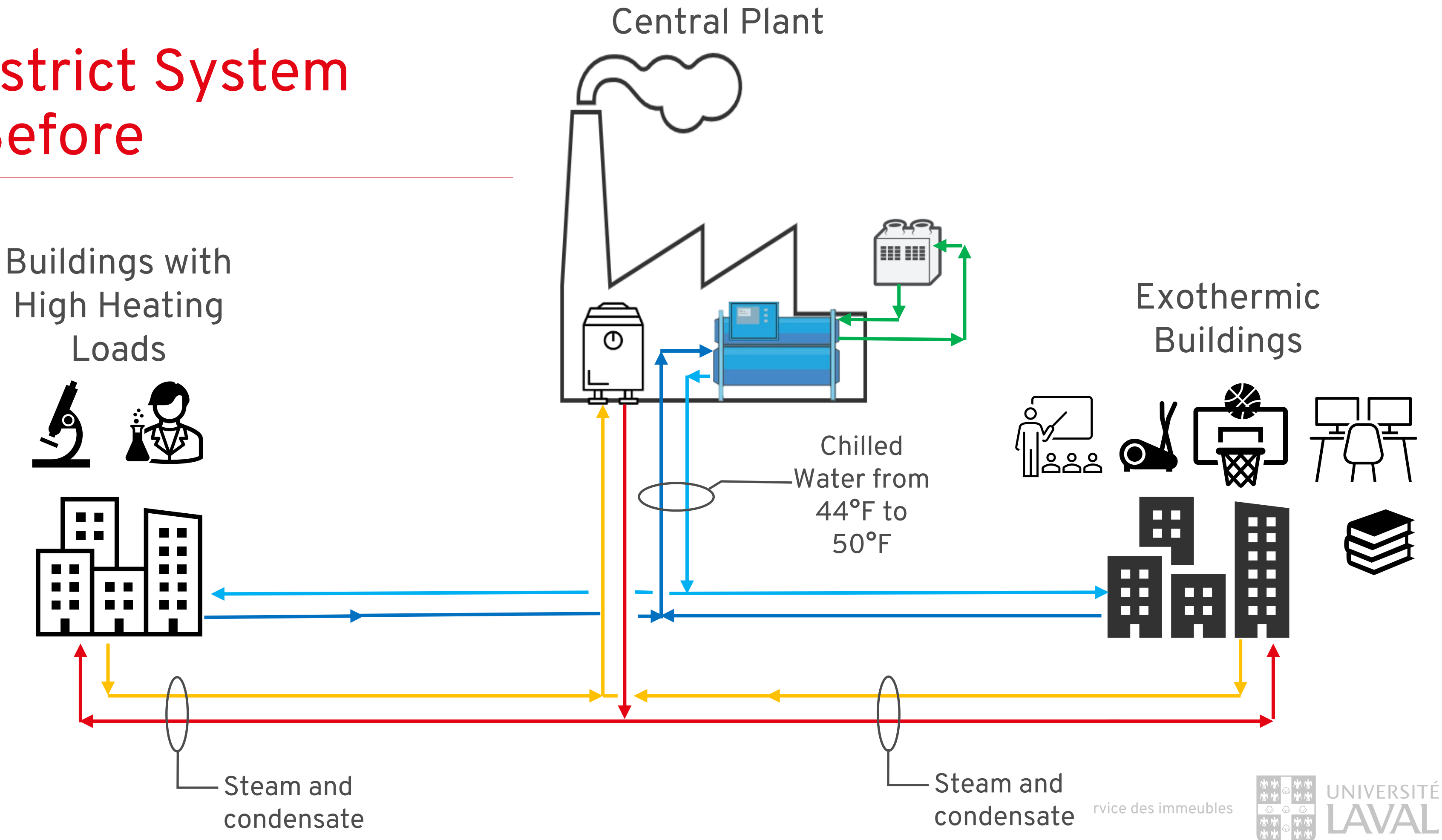
	1990-1991	2000-2001	2006-2007	2007-2008	2010-2011	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
GES (tCO_2eq)	29 744	36 324	36 142	30 081	26 207	26 138	30 126	26 425	27 278	23 820	25 598	24 562	22 359	20 933
Superficie (m^2)	511 240	602 190	622 250	622 710	661 930	674 500	678 230	718 410	717 550	717 550	718 840	721 125	722 970	722 970
GES/m^2 (tCO_2eq/m^2)	0,0582	0,0603	0,0581	0,0483	0,0396	0,0388	0,0444	0,0368	0,0380	0,0332	0,0356	0,0341	0,0309	0,0290

CARBON REDUCTION MEASURES

Conversion of a 3rd Generation District to a « New Generation »

- In 2007, replacement of part of steam production by electricity
- Discontinuance of the use of fuel oil for steam production (except in ermergencies)
- In 2005, the chilled water network became an energy loop to transfer heat between networks.
- 24 heat pumps were installed over 10 years in 14 buildings, for a total of 1,750 tons of cooling.
- Heat pumps produce low temperature heating water (110°F max) replacing steam produced using natural gas.
- Estimated reduction of 5,000 tonnes of GHG yearly.
- High efficiency heat pumps with COP’s between 6 and 7.

District System -Before



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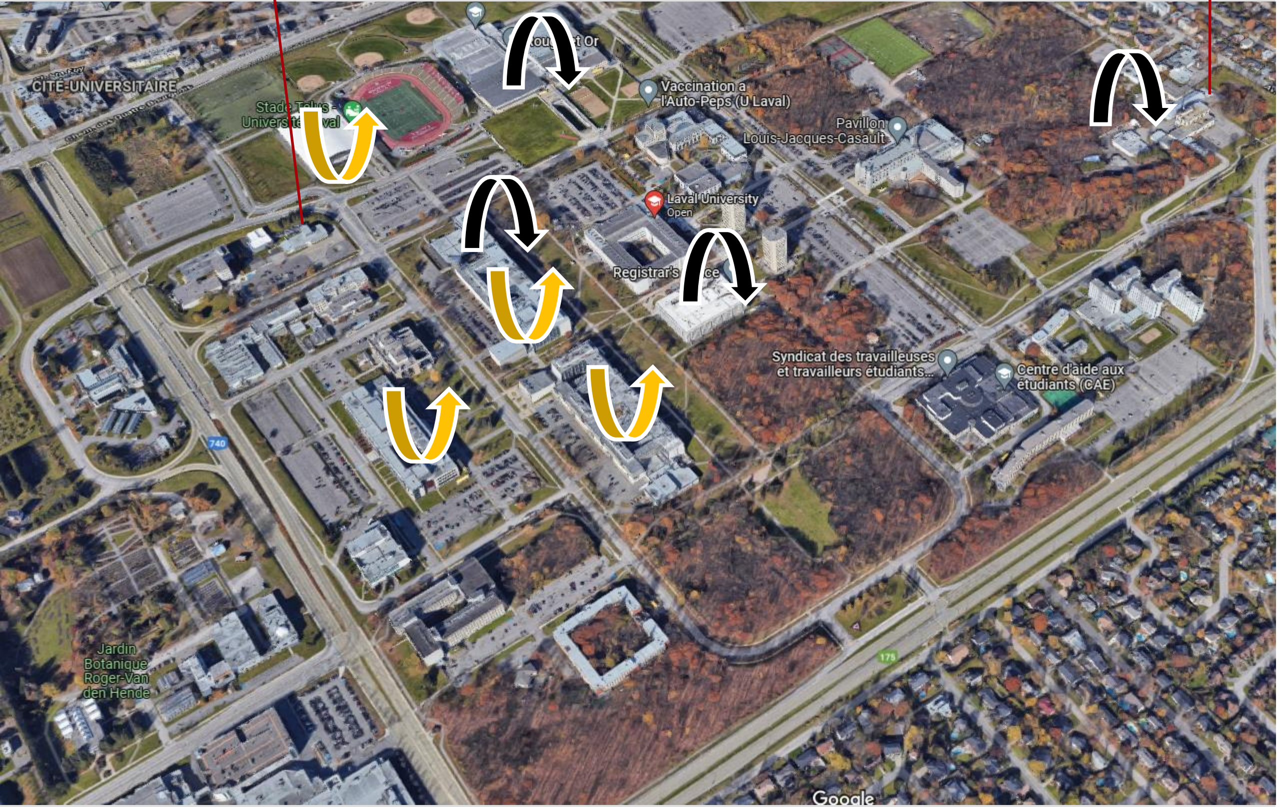
UNIVERSITÉ LAVAL

West Cooling Plant

East Cooling Plant



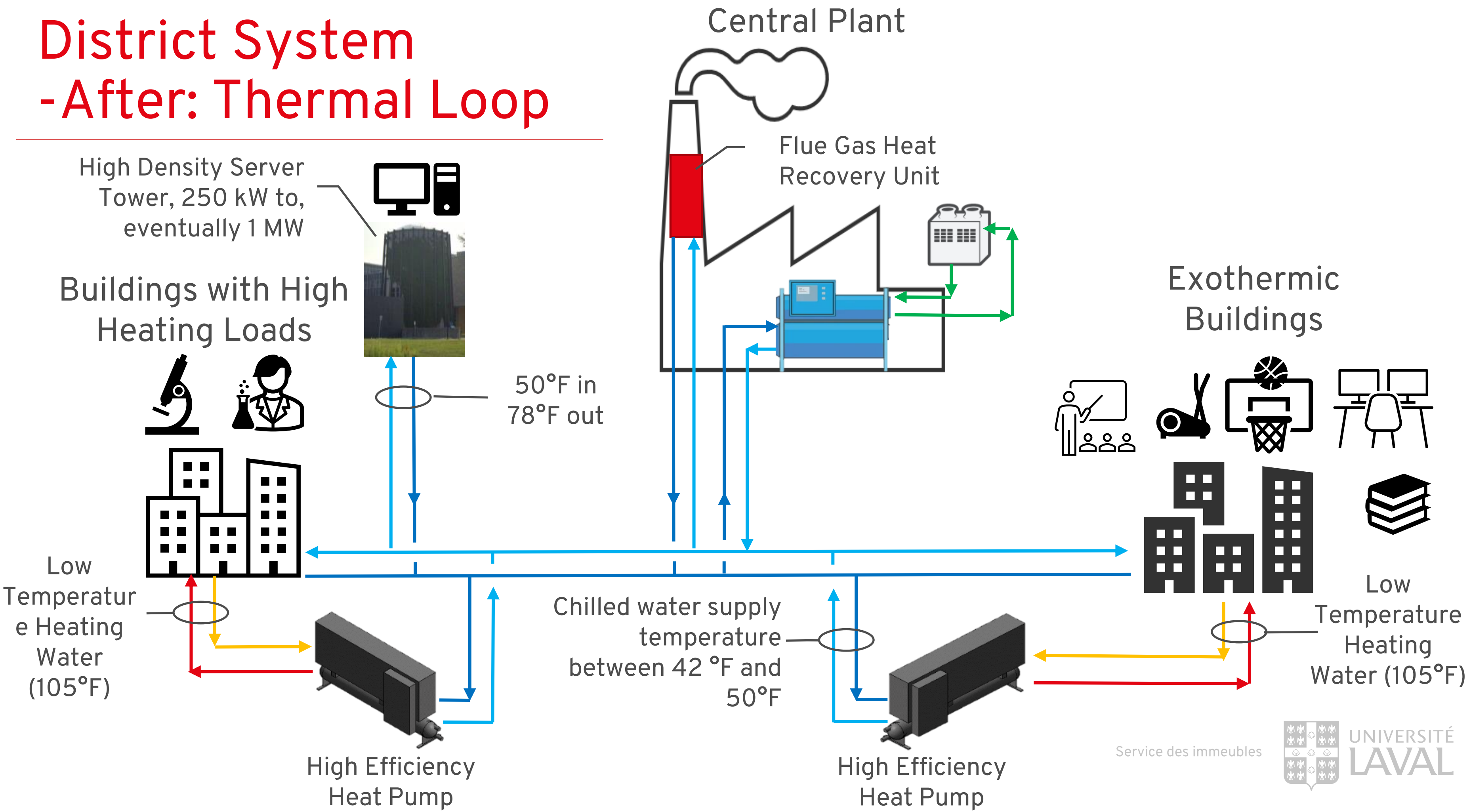
Laval University Energy Sharing

Building with excess heat

Building requiring heat

The campus sports complex, data centers and administrative spaces' excess heat in winter is recovered and shared with buildings on campus that have high heating loads. This energy sharing is done using the chilled water network (energy network).

District System -After: Thermal Loop

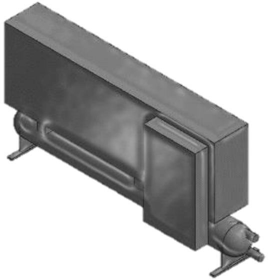


Heat Recovery Sources

- Internal heat gains from exothermic buildings such as the sports complex, ice rink, library, office spaces and classrooms.
- Prioritize mechanical cooling instead of free cooling.
- Heat rejection from high density server tower
- Flue gas recovery unit

Lessons learned after 15 years of operation

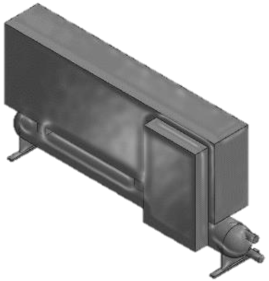
After more than 15 years in operation with heat pumps, many operational aspects were encountered:



- Control sequence challenges with minimum supply of 50°F on campus in winter.
- Winter 2011, the campus had a major fire in the service tunnel , which forced the steam plant's shut-down. Buildings with heat pumps could continue to be heated while buildings relying only on steam had to be shut down.

- Conversion of buildings to 45°C heating water is relatively simple, which allows to capture +/- 75% of heating demand.

Lessons learned after 15 years of operation



- Inertia of chilled water system must be considered.
- Manufacturer recommendations to consider. All heat pumps/chillers are not created equal. Some heat pumps are more reliability than others when operating at 40°C. Control sequences must be stable and tunned so no swings make heat pump trip.
- Do not oversize heat pumps:

  Consider installing thermal storage to avoid operational « swings ».

  If possible, consider using two units in parallel.

- - Heat pumps with multiple scroll compressors are interesting. They are efficient, cost less and require less maintenance. For larger capacities, good results were generated from screw chillers.

CONCLUSION

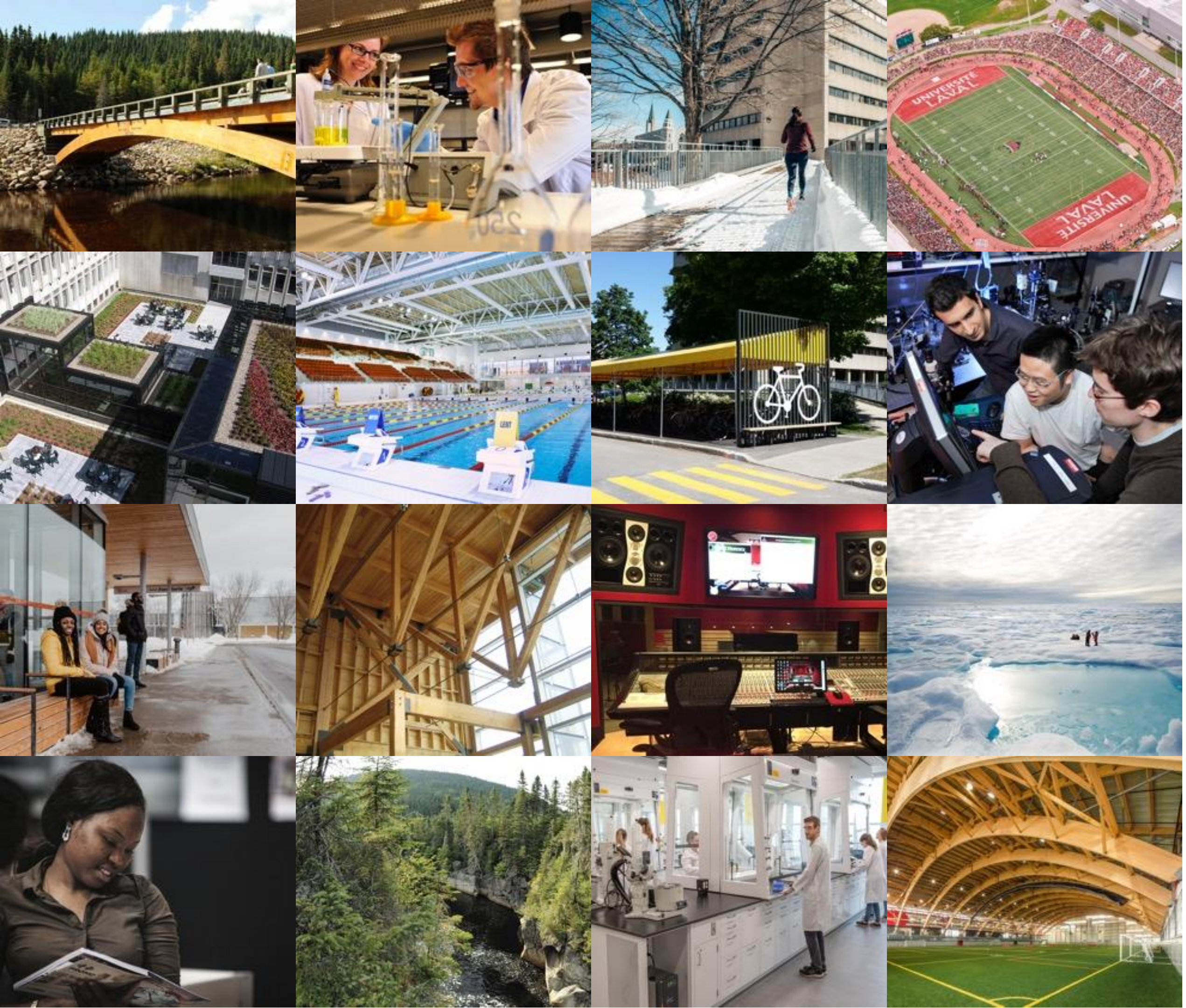
Conclusion

- We have reduced emissions while the campus has expanded.
- The conversion of the chilled water system into an energy loop was a major opportunity to increase efficiency
  - It's a part of our strategy to reduce GHG and EIU for all future buildings and all Major renovations
- For new buildings, integrate from the outset a less energy-intensive design aim to surpass the energy efficiency codes in line with the government reduction targets (enveloppe, HVAC, ligthning...)

Sustainable development is

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs“.

Mrs. Gro Harlem Brundtland, Norwegian Prime Minister (1987).



Service des immeubles

UNIVERSITÉ
LAVAL

Merci !
ThankYou !

Université Laval
www.ulaval.ca

Steam Power Plants Major improvements eff :87%

- Increased the efficiency of the three boilers of the Eastern Thermal Power Plant by more than 7%
    - by reducing the temperature of the combustion gases through an adequate heat transfer in the boiler and an optimal energy recovery,
    - by reducing the excess of combustion air,
    - by installing new very sophisticated and precise combustion controls,
    - by carrying out a continuous monitoring of the operating parameters.
- Complete refurbishment of the refractory and lagging of the boilers (1% increase in thermal efficiency) and improved insulation on the network and in the power plants.
- Reduction of energy losses associated with the operation of the boilers by keeping them hot when required and by using a preheating coil, by reducing the number of boilers in simultaneous operation, by using the most efficient boiler according to the steam demand profile.
- Installation of a new 6 MW electric boiler using off-peak electricity Implementation
- Installation of new burners to improve combustion efficiency and reduce nitrogen oxide (NOx) emissions.
- Installation of variable frequency drives on boiler supply and exhaust fans to improve combustion efficiency.
- Rigorous inspection, calibration and preventive maintenance program for the various assets of the system (measuring instruments, control valves, steam traps, safety valves, piping).
- Overpressurization of the steam system to increase the operating pressure to 175 psig (increase in distribution capacity).

Steam Power Plants Major improvements eff :87%

- Installation of low-pressure steam preheat coils in the boiler sludge tank to keep the boilers at a hot stop without burner shutdowns.
- To improve combustion efficiency, refurbishment of the combustion air tube preheater (flue gas to combustion air heat exchanger) in Boiler #1 and the regenerative air preheaters (heat wheels) in Boilers #2 and #3.
- Reconditioning and optimization of the control of the preheating coil on boiler No. 2 during oil operation 6.Replacement of the air compressors and optimization of the sequences and efficiency of the boiler soot blowers (tube cleaning).
- Optimization of the boiler water treatment program, progressive cleaning of internal tube deposits.
- Installation of a heat recovery system from the condensate tank vent to heat the make-up water.
- Rehabilitation of the plant's condensate tanks to eliminate leaks.
- Renovation and optimization of the deaerators and their exchangers.
- Recovery of steam condensate used for oil preheating.
- Rehabilitation of the ventilation system for the make-up air in the eastern thermal power plant.
- Centralization of steam meters from the buildings to the power plant.
- Upgrading of all steam flow meters in the buildings and implementation of alarms to monitor consumption; implementation of a reporting software to validate the accuracy of production/consumption flows.
- Installation of two continuous emission measurement systems (CEMS).