Smart City Challenge

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Iqaluit, Nunavut

- The capital and only city of Nunavut. [1]
- Population of around 7700 people [1]
- The name of the town signifies “place of fish” in the Inuktitut language.[2]
- Main industries: government, communications, transportation, fishing, sealing, carving/handcrafts, and tourism-service [3]
- Most perishable food is flown year-round into the city. [4]
- Non-perishable food items and hard goods come in by sea. [4]

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Responsible Wastewater Management And Energy Needs Fulfillment (Themes 1 and 2)

Wastewater Management in Iqaluit

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Iqaluit has a developed treatment system

- Indoor plumbing with holding tanks (septic system) [5]
- Regular trucked collection service [5]

However:

- Wastewater is often dumped untreated into Frobisher Bay
- Potentially tainting fresh water and food supply
- Potential damage to local marine ecosystems

Energy Supply in Iqaluit

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Iqaluit relies entirely on imported petroleum products to meet its energy needs [6].

- 6.7 PJ consumed by the city in 2017 [7]
- 49% towards industrial, commercial and residential activities [7]
- No distribution infrastructure: gasoline and diesel tanks outside of residents' homes. [8]

Issues:

- Security concerns with no local energy production
- Government of Nunavut spends a significant portion of their budget on these imported petroleum products. [9]
- Greenhouse gas production

Two Birds with One Stone:

Convert Solid Waste from Wastewater into Energy

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Combustion of Solid Waste
and
Conversion to Biogas for Heating and Electricity Production

The Power of Poop

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As a solid fuel

- 24MJ/kg HHV [10]
  - Higher than wood/biomass and some coals!
- 600°C combustion can be maintained at 60 wt% moisture[10]
- Burned as is with after drying

As a gaseous fuel

- 24.3 MJ/kg HV [11]
- Can be produced passively by mixing solid waste with water in sealed containers.
- Easily distributed via pipelines or compressed gas containers.

Advantages

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- From a population of 7700 adults, rough calculations shows that 26.8 PJ/year is stored in faeces of Iqaluit's population - 4 times the energy needs of Iqaluit (see last slide for calculations)

- Significant reduction in solid waste that must be disposed of.

- Theoretical net-zero carbon emissions:
  - CO2 in air -> Plant matter -> Food -> Poop -> CO2 emissions

- Domestic energy production dramatically increases energy supply security

Construction of Production Plant

- Plant would dry solid waste and convert it to pellets for solid combustion.
- Plant would also produce biogas.
- Inexpensive conversion of existing wastewater infrastructure.

Conversion and Deployment to Larger Consumers

- Large consumers of energy with onsite power generation (hospitals, large buildings, industrial activities)
- Existing boilers/generators are converted to burn solid waste or biogas in addition to current fuels.
- Serves as an excellent test case for more widespread deployment

Conversion and Deployment to Residential Units

- Once the technology is proven, and deployment to residential units begins.
- Residential heating systems are upgraded to gas burning units.
- Residents are supplied with a compressed gas tank which is periodically filled by truck.

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Navigating COVID-19

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- This problem existed long before COVID-19.
- Following COVID-19 guideline, people have remained home, increasing energy consumption.[12]
- COVID-19 can be detected in stool. [13]
- Increased energy demands from hospitals. [14]
- The workers who will take part in the modifications will have to take precautions against COVID-19, increasing the time needed. [11]

Feasibility of the Solution

Faeces as fuel is a proven technology, and is often suggested for use in developing nations with lack of wastewater treatment infrastructure.

However, deployment on this scale would be **expensive**.

- Upgrades to wastewater plant
- Development of distribution infrastructure
- Conversions and upgrades to existing energy systems (industrial, commercial and residential)

But compare to **cost of petroleum imports**

- Depending on success of the program, costs could be recouped in less than a decade.

Conclusion

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- Iqaluit has both a wastewater management problem, and an energy problem
- Combustion of faeces, whether as a solid or gas, would contribute to the solution of both of these problems
- It is a proven technology, environmentally responsible, sustainable, and cost effective given enough time.

This group recommends faeces combustion for energy production and waste management for Iqaluit.

References

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(Very Rough) Energy Calculations

End use demand in Iqaluit was 6.7 PJ in 2017. 51% was used for transportation, the rest for industrial, commercial and residential energy needs (thermal and electric) [7]

0.49*6.7 PJ/year = 3.283 PJ/year

The average adult produces 145 kg of faces per year [16]. There are approximately 7700 residents in Iqaluit. The higher heating value (HHV) of solid human waste is about 24 MJ/kg [10]. So,

145 kg/person-year * 7700 persons * 24 MJ/kg = 26,796,000 MJ/year = 26.8 PJ/year

Therefore there is a potential **26.8 PJ to be reclaimed** in the faeces of the inhabitants of Iqaluit.

These are very rough calculations, and do not reflect efficiencies of energy production processes.