District Energy Systems

Canada and Ontario's Missing Infrastructure

TorchLight Bioresources

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Overview

1. What is a District Energy System?

2. Why is DES infrastructure important?

3. How does Canada compare?

4. Successful examples

5. How can Ontario's communities benefit from DES development?

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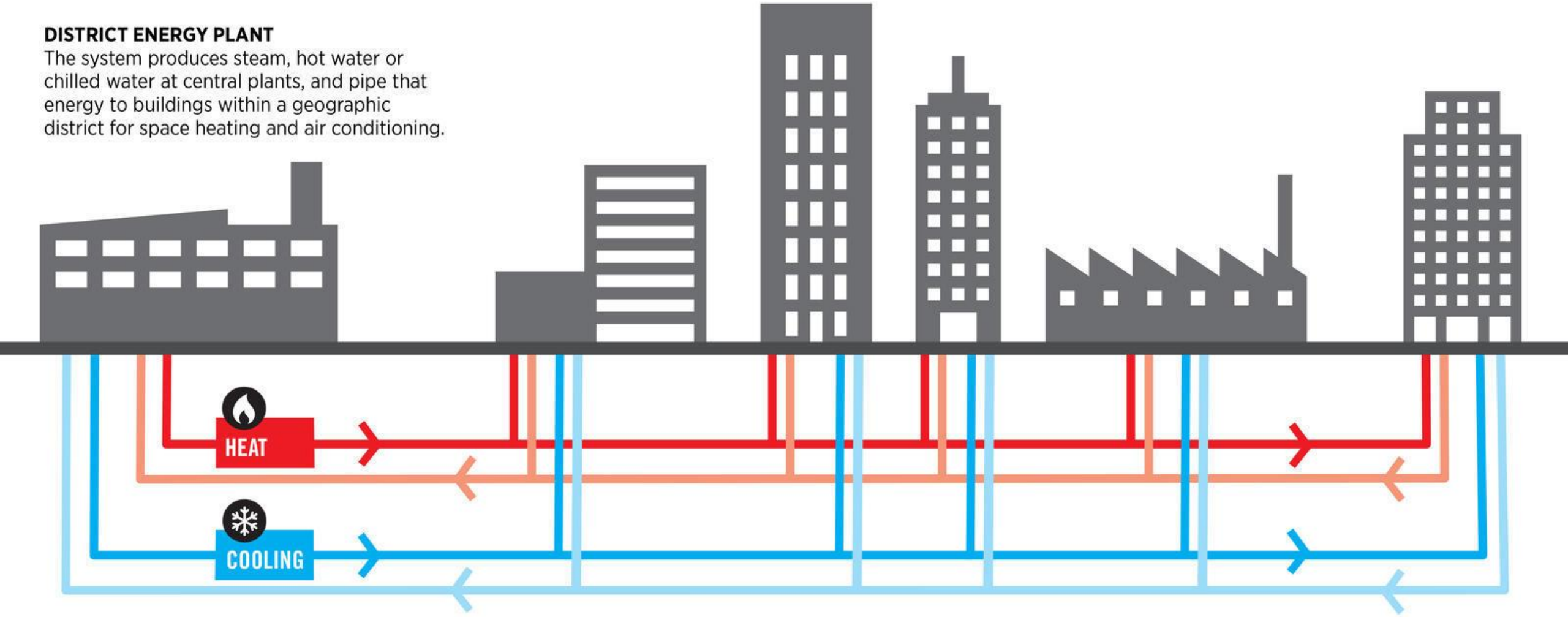
District Energy System



District Energy System

- Central energy plant producing heat, cooling, and/or electricity
- Fuelled by biomass/wood, natural gas, municipal waste, waste heat
- Connect buildings large and small using hot/cold water pipes
- Energy transferred to buildings using heat exchangers
- Buildings do not have separate furnaces/boilers
- Larger buildings, older buildings, closer together = more economical
- Municipally-owned, P3, private, co-operate ownership models
- Canada examples: Toronto (Enwave), Ottawa (PSPC), Vancouver (Creative), London, Guelph, Sudbury, Markham, universities, DND bases, hospitals (~160 DES in Canada)

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District Energy System

DES Benefits

- Utilize local, Ontario fuels (biomass, waste heat)
- Fuel flexibility
- Increased fuel efficiency
- Reduce air pollution, even if switching to solid fuels
- Reduce greenhouse gas emissions
- Co-generate electricity near demand (resilience)
- Utility structure, even if no natural gas
- Extra space in buildings, lower energy operating costs
- Income for municipalities

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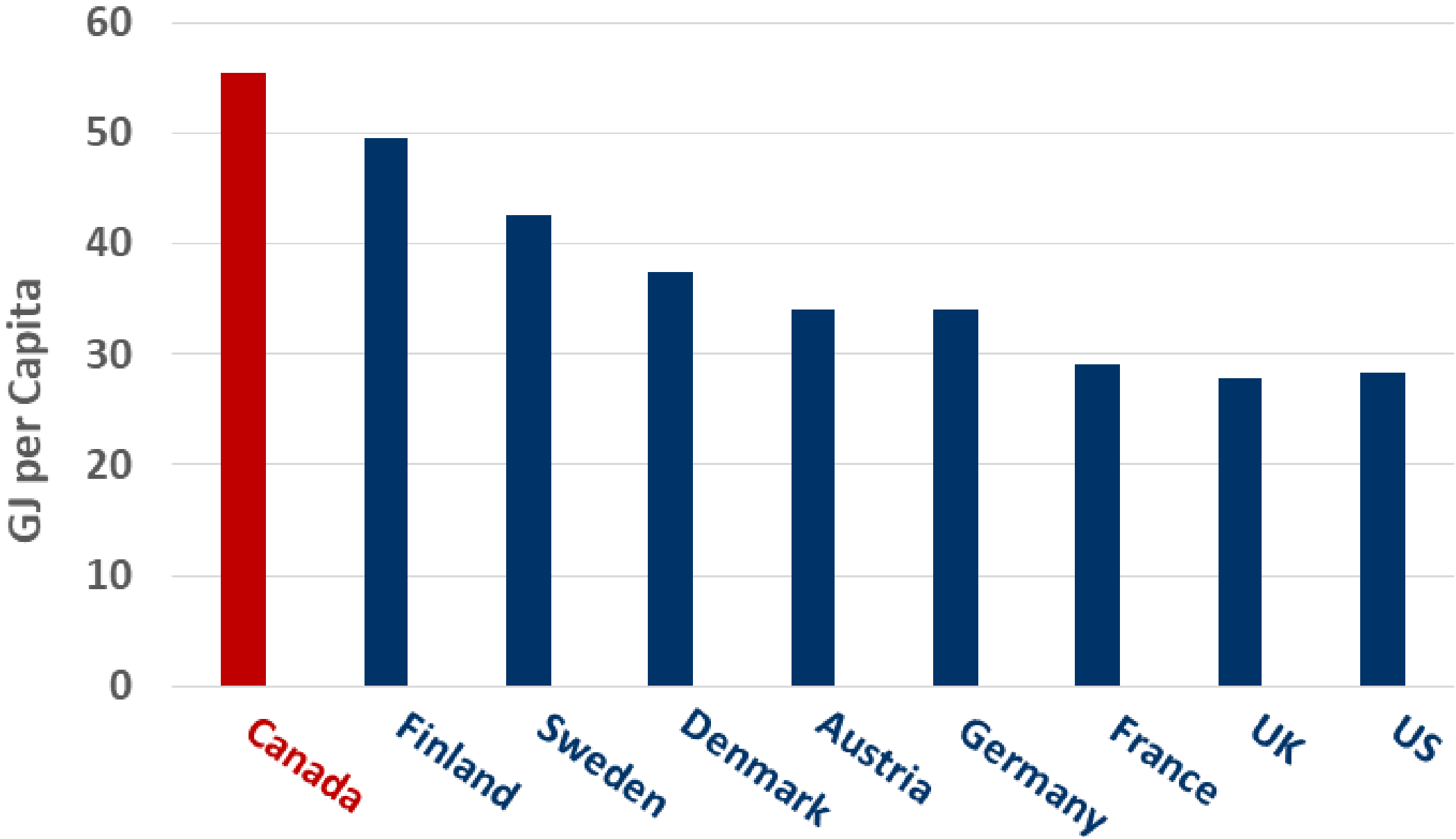
Space and Hot Water Demand



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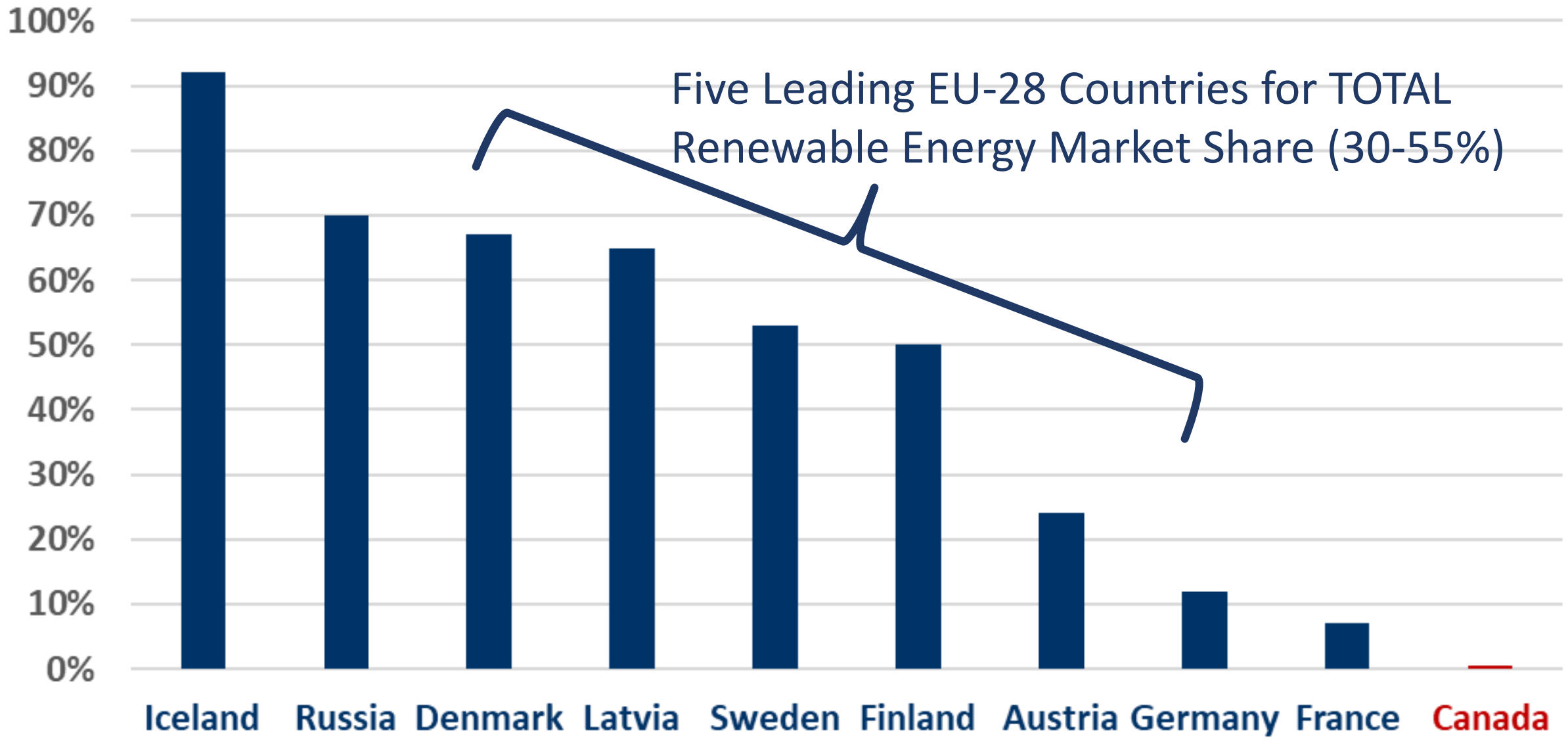
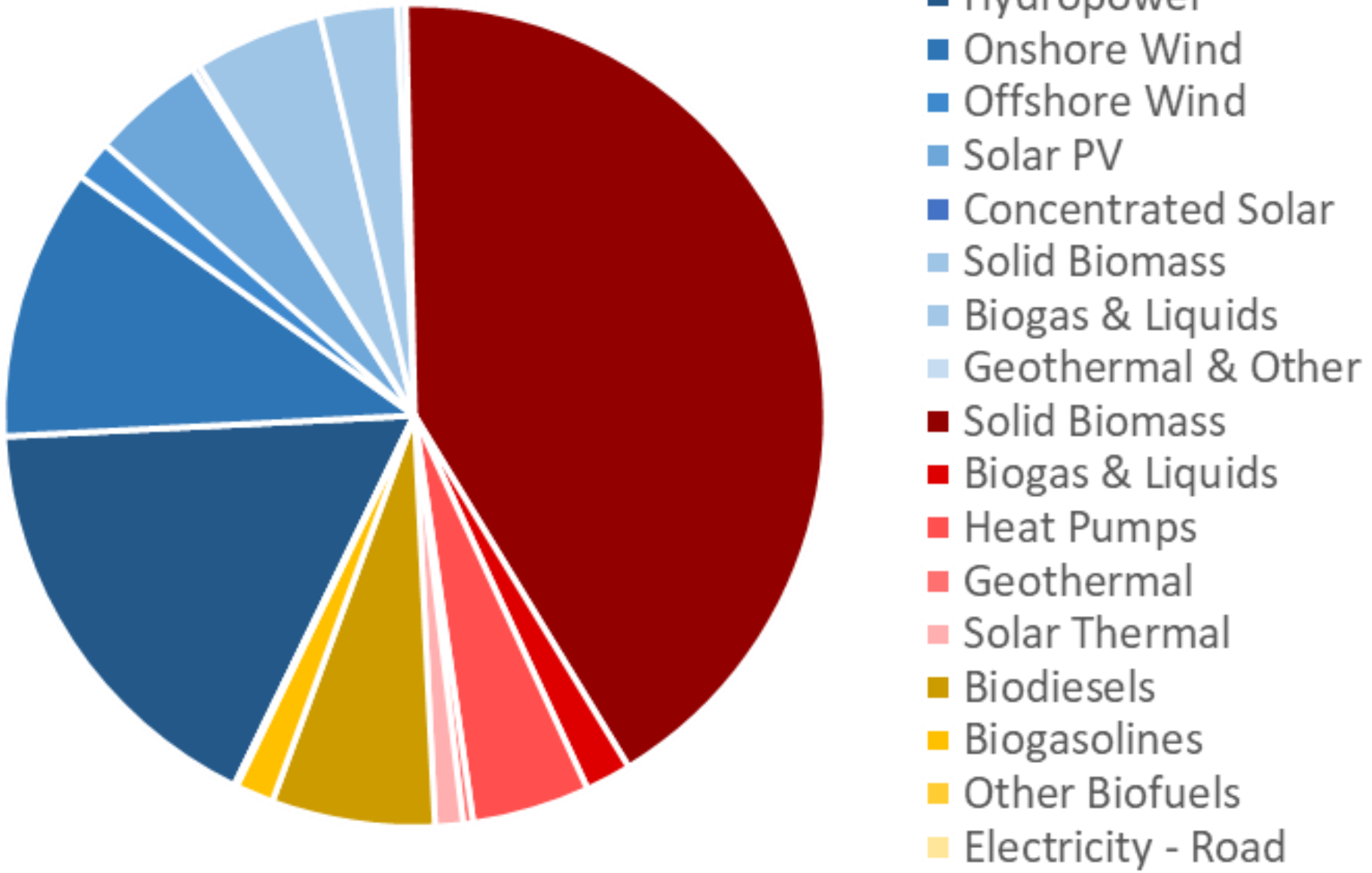
Population Served by DES



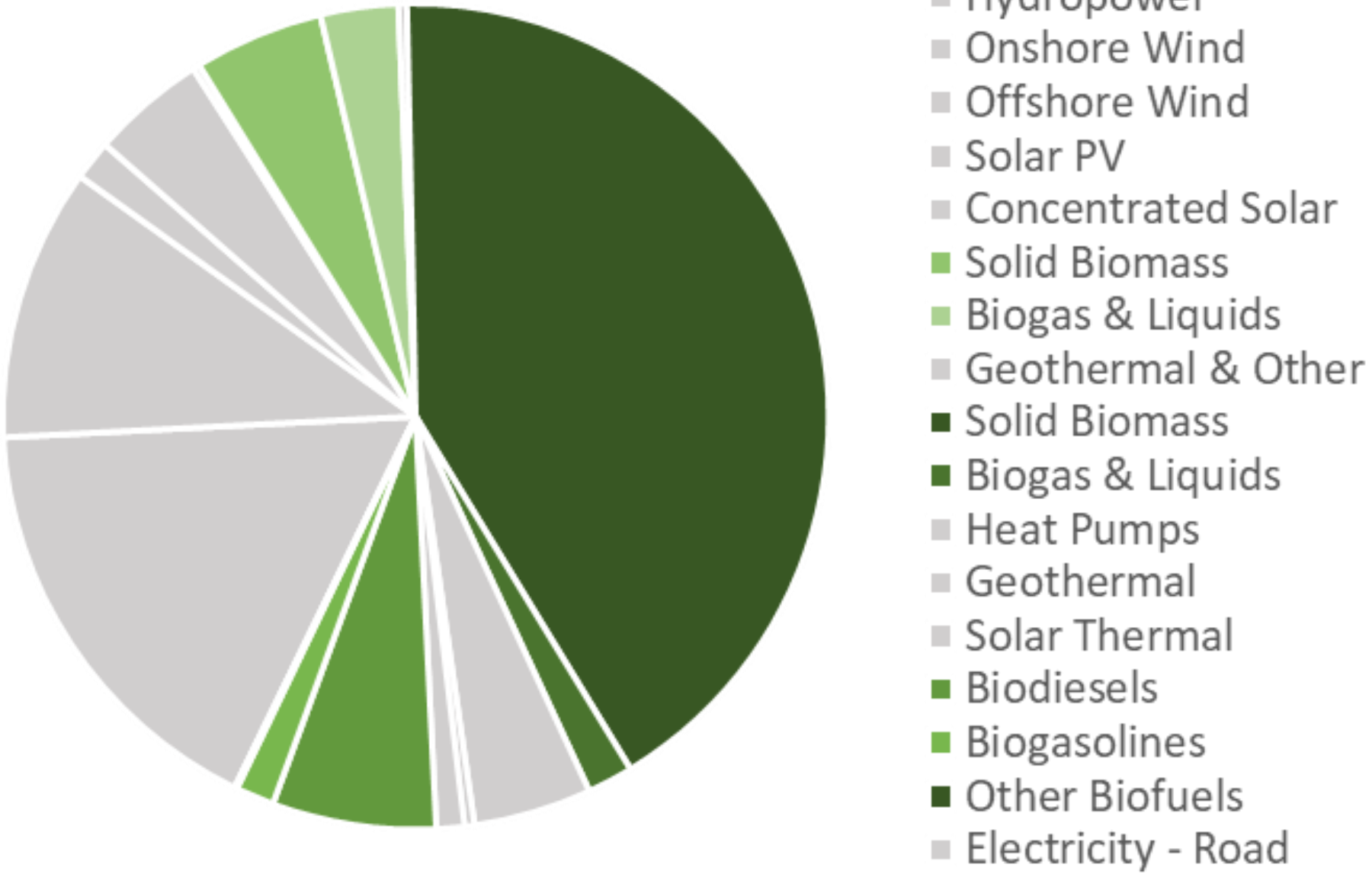
Renewable Energy in the EU

Total: 8.5 EJ

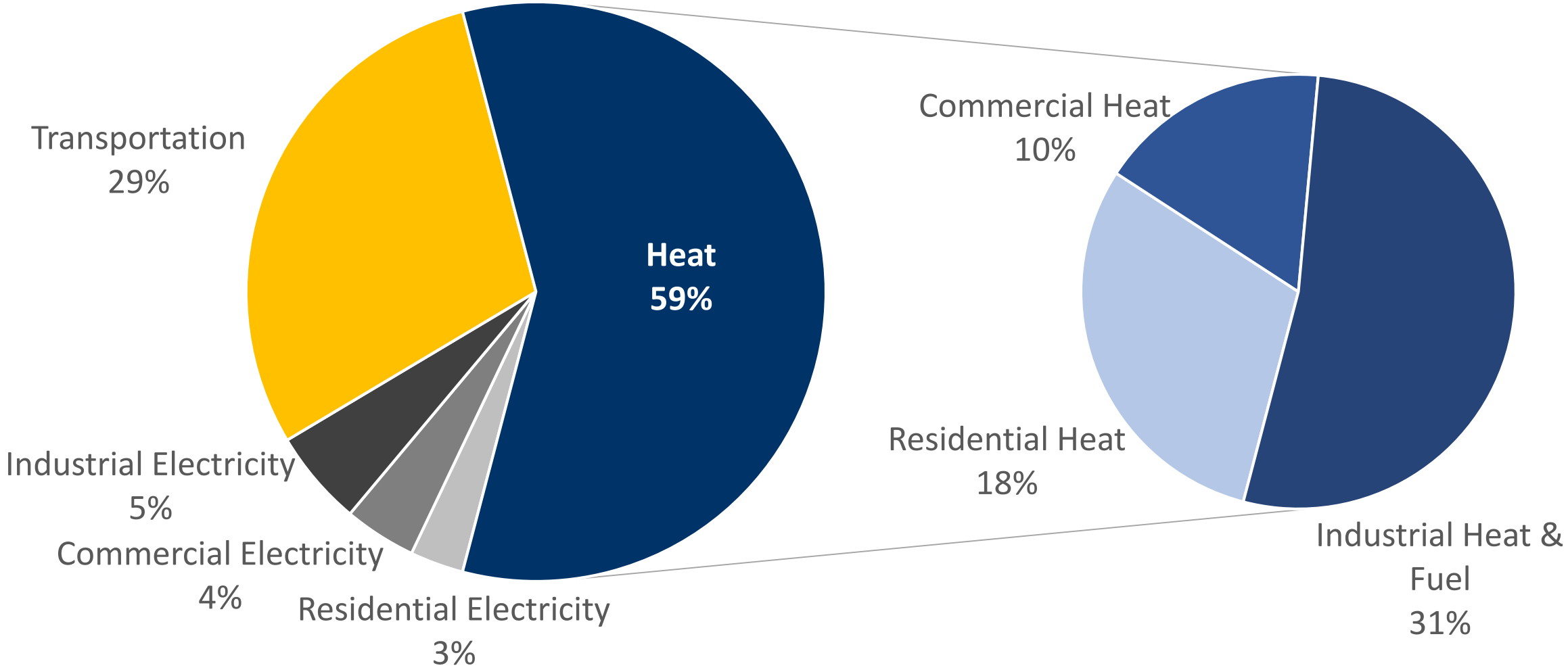


Bioenergy in the EU

Bioenergy in 2017:
211 Mt CO_2e reductions

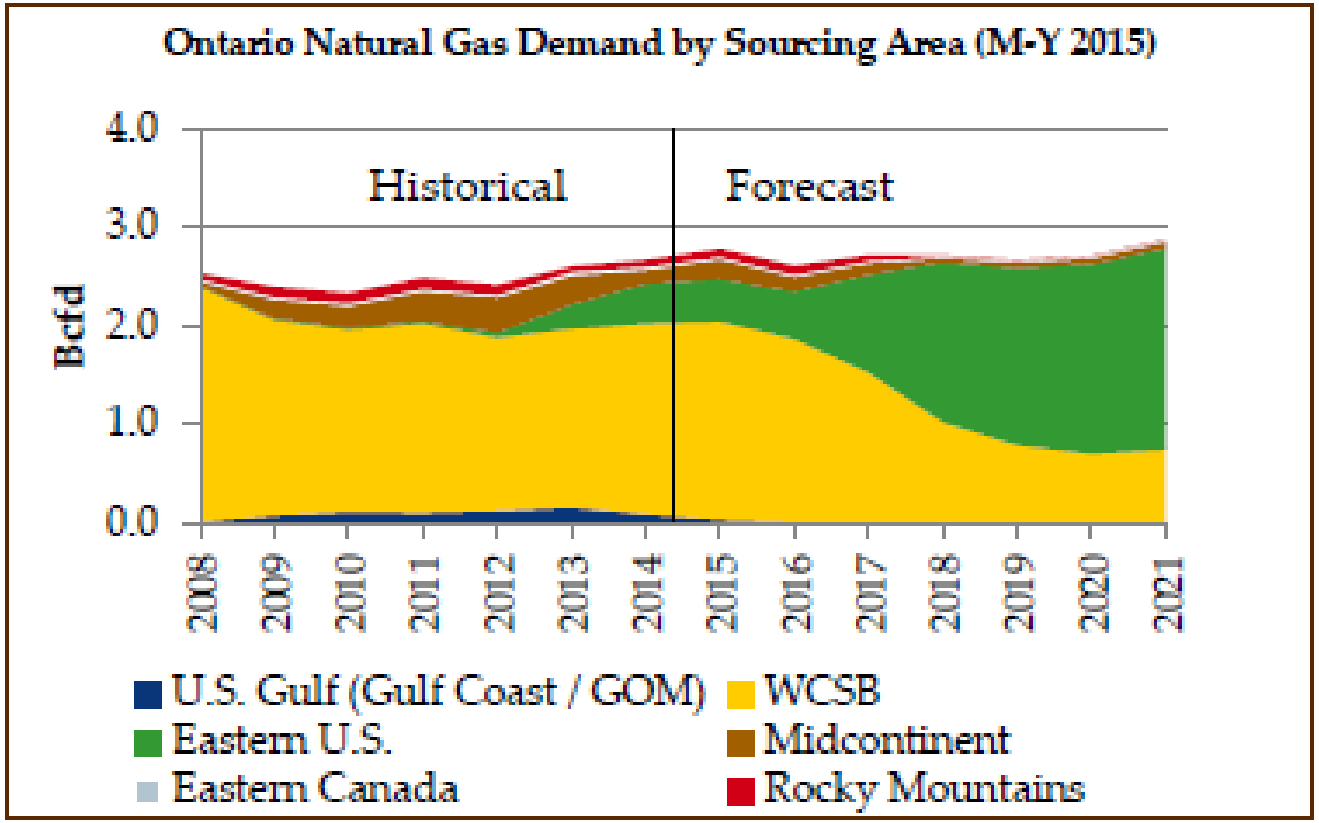


Energy Demand in Ontario



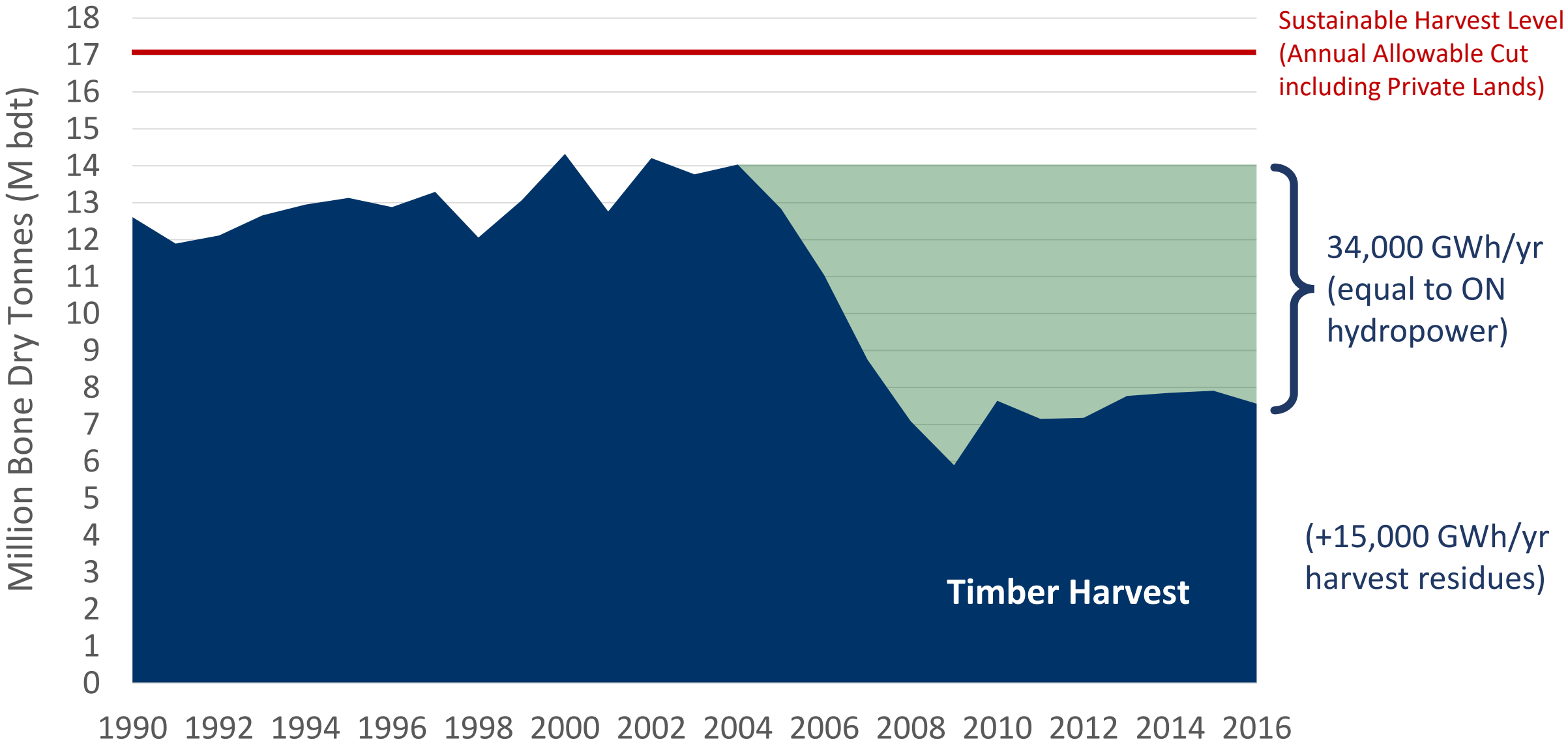
Infrastructure for Ontario Fuels

- ~99% of Ontario's fossil fuels imported
- 75% of natural gas will be from U.S. by 2021 – no benefit to W. Canada
- 90% of expenditures on fossil fuels leave the province
- 80% of expenditures on Ontario wood fuels stay in the province
- DES is REQUIRED INFRASTRUCTRE for Ontario renewable fuels
- $4 B/yr stays IN ONTARIO (0.5% GDP)

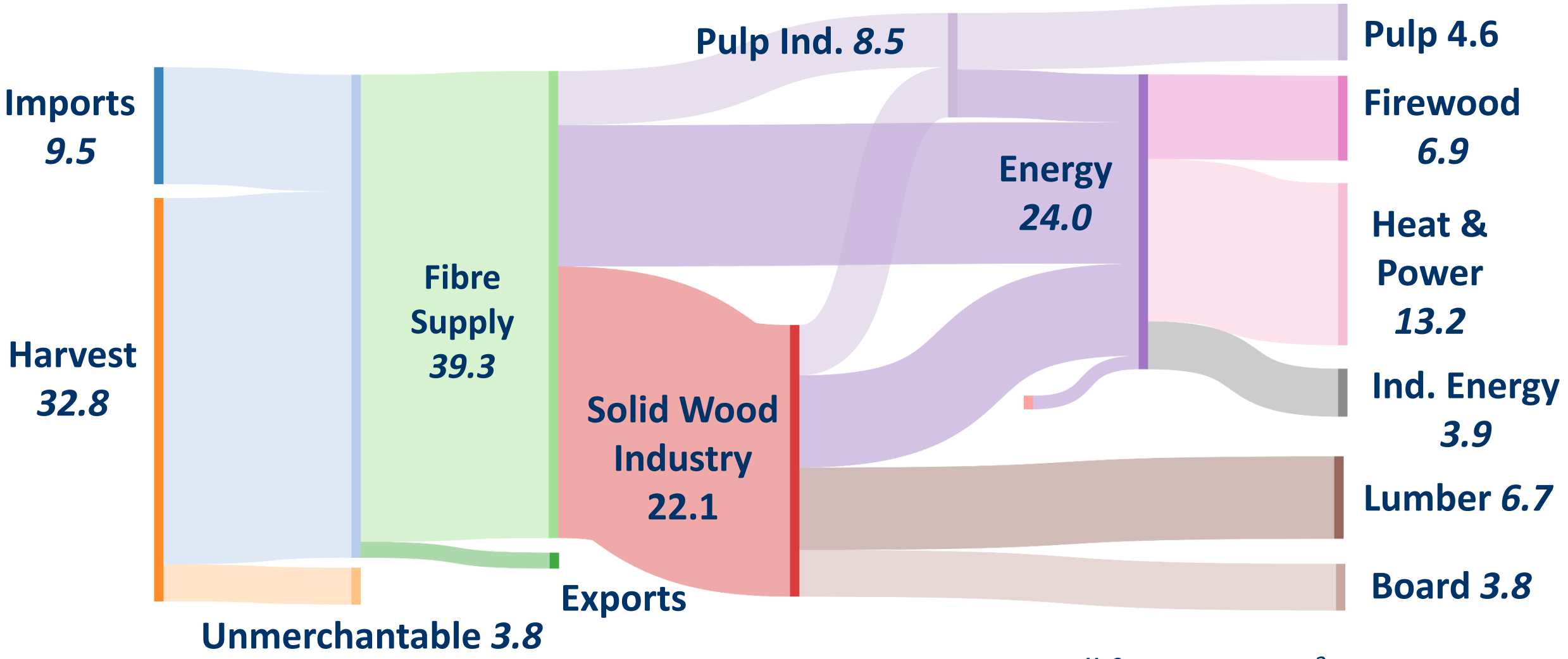


*Navigant Consulting Inc., 2015 for Ontario Energy Board

Timber Harvest in Ontario



Example: Austrian Forest Sector



All figures in Mm^3

Total Fibre Supply in ON ~34 M m^3

Highly profitable mass timber industry supported by heat market

Example: Stockholm

Stockholm DES

- 7,350 GWh/yr; 4,000 MW* (580 MWe) peak capacity
- 350 km of transmission pipes; 2,800 km of distribution pipes
- 90% of buildings in Stockholm
- 80% renewable (100% by 2030); wood chip combined heat & power, waste-to-energy
- Will spend C$2.4 B by 2023 to add renewables (largely biomass) capacity

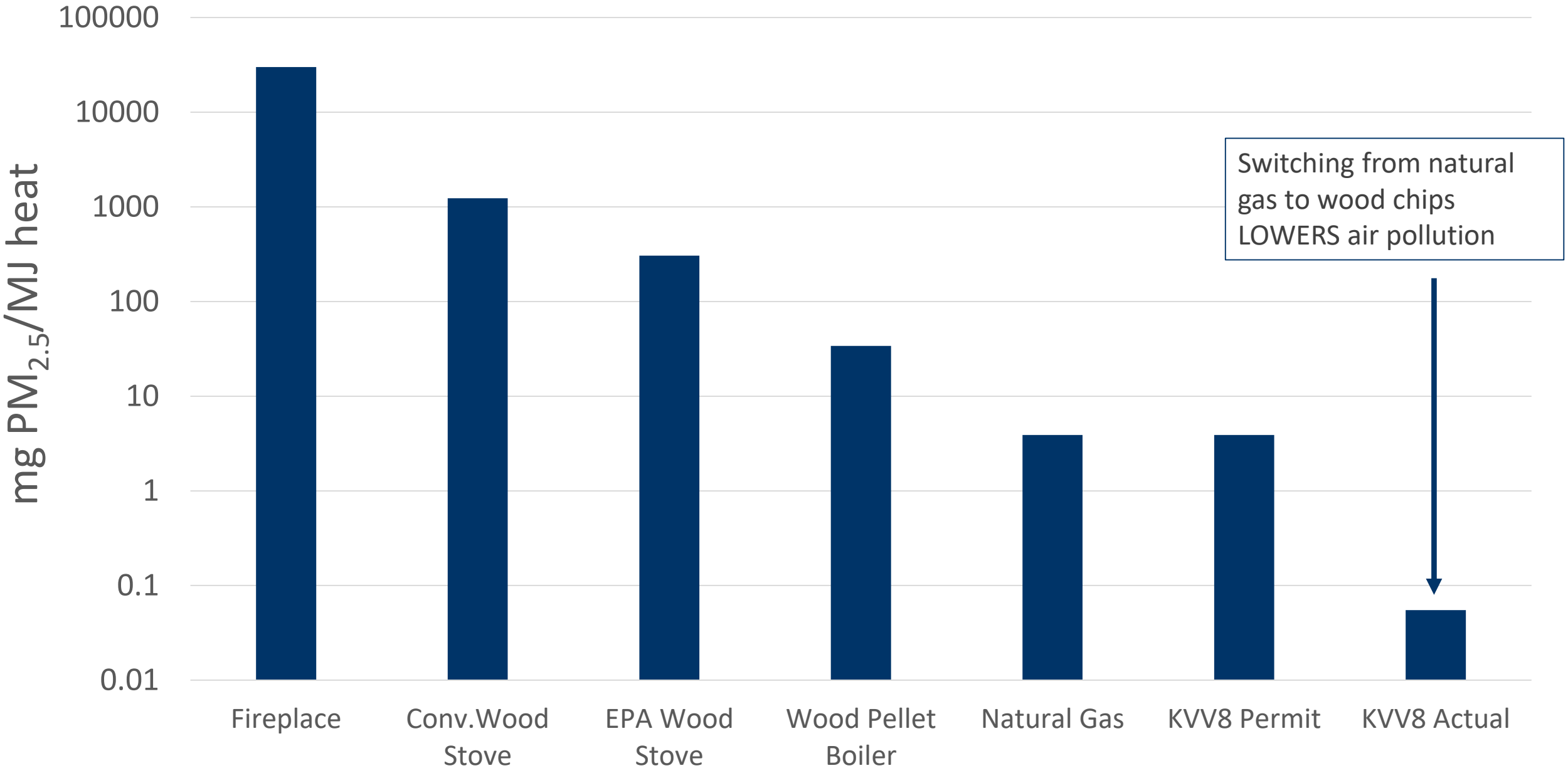
	Canada	Sweden
GDP Per Capita (USD)	48,100	51,300
GHG Emissions Per Capita (t CO_2e)	19.4	5.4
GHGs Per Capita (t CO_2e), incl. LULCF	18.6	1.0

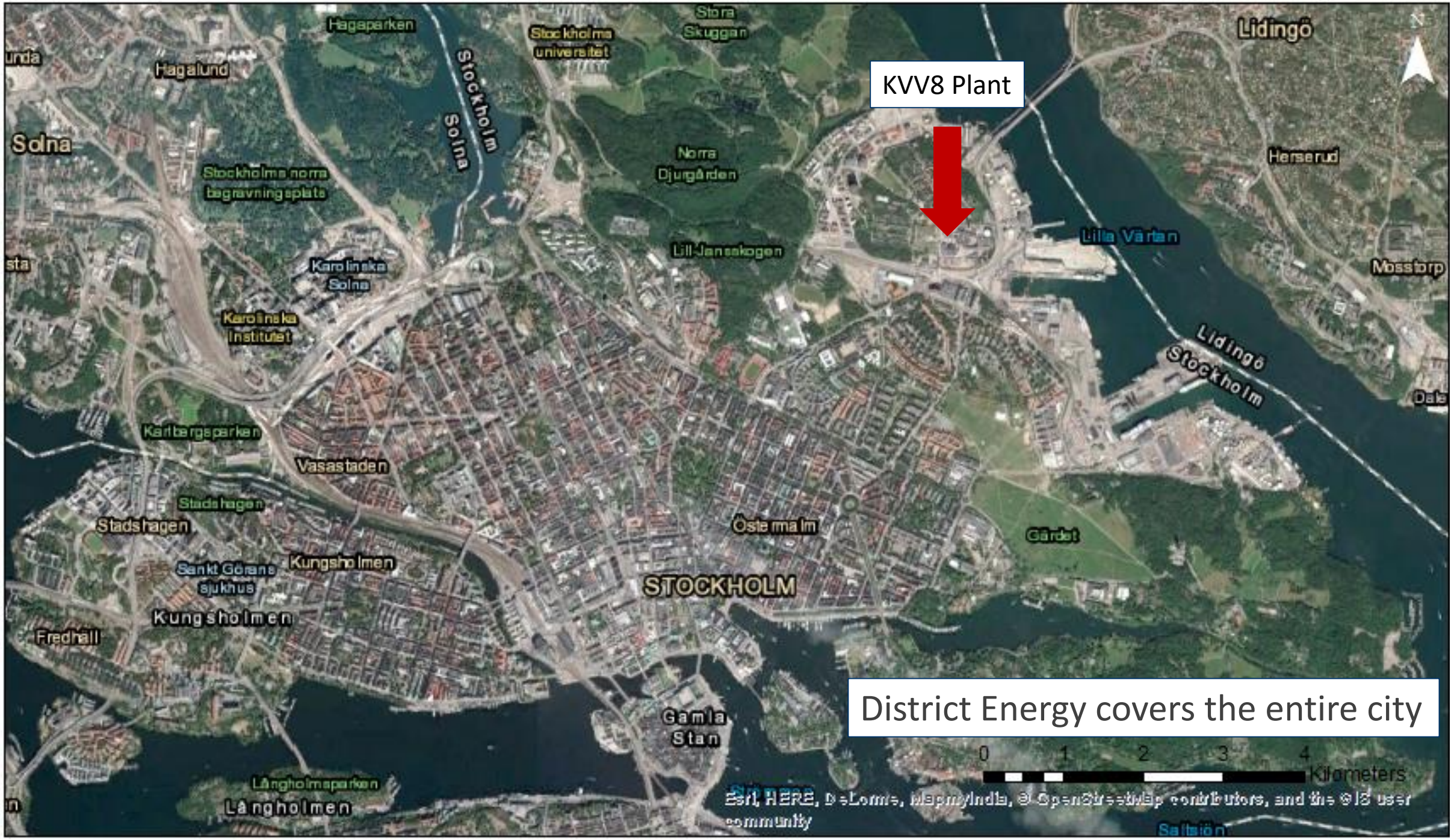
*Current Toronto (Enwave) DES peak ~380 MW; 761 GWh/yr

Stockholm Värtaverket KVV8 Biomass CHP Plant

- 400 MW_{th}
- Heats 190,000 homes via DES
- 100% wood chips (3,500 t/day)
- Commissioned in 2016
- CapEx: C$750 M
- 1,700 GWh heat (>2x Enwave)
- 750 GWh electricity
- 60% marine/40% rail
- Reduce: 650,000 t CO_2e/yr
- Footprint: 6,000 m^2
- PM emissions < natural gas
- Requires DES for operation

Fine Particulate Matter ($PM_{2.5}$) Emissions




KVV8 Plant
District Energy covers the entire city
Hagaparken
Stockholms universitet
Stora Skuggan
Lidingö
Hagalund
Solna
Stockholm
Norra Djurgården
Herserud
Stockholms norra begravningsplats
Lill-Jansskogen
Lilla Värtan
Karolinska Solna
Karolinska Institutet
Mosstorp
Lidingö
Stockholm
Dale
Kristbergsparken
Vasastaden
Stadshagen
Stadshagen
Östermalm
Gärdet
Kungsholmen
Sankt Görans sjukhus
STOCKHOLM
Kungsholmen
Fredhäll
Gamla Stan
Långholmsparken
Långholmen
0 1 2 3 4 Kilometers
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Residential
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KVV8 Plant
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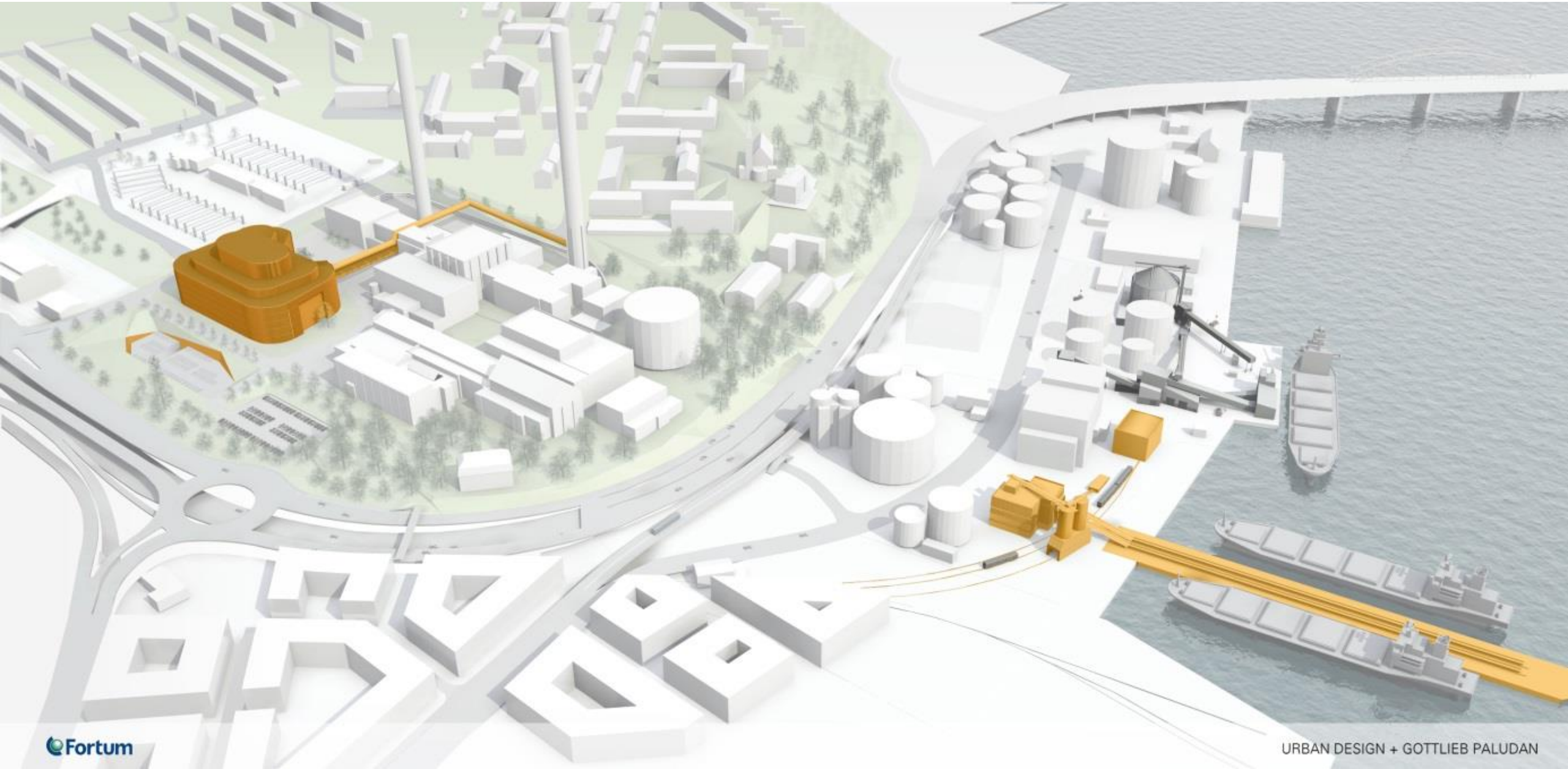
Meters



Fortum

URBAN DESIGN + GOTTLIEB PALUDAN


Fortum
85
innofreight


innofreight
sappi


innofreight
green cargo


innofreight
KR 200
WOODY...stephoun

Example: Copenhagen

Copenhagen DES (Zero Carbon by 2025)

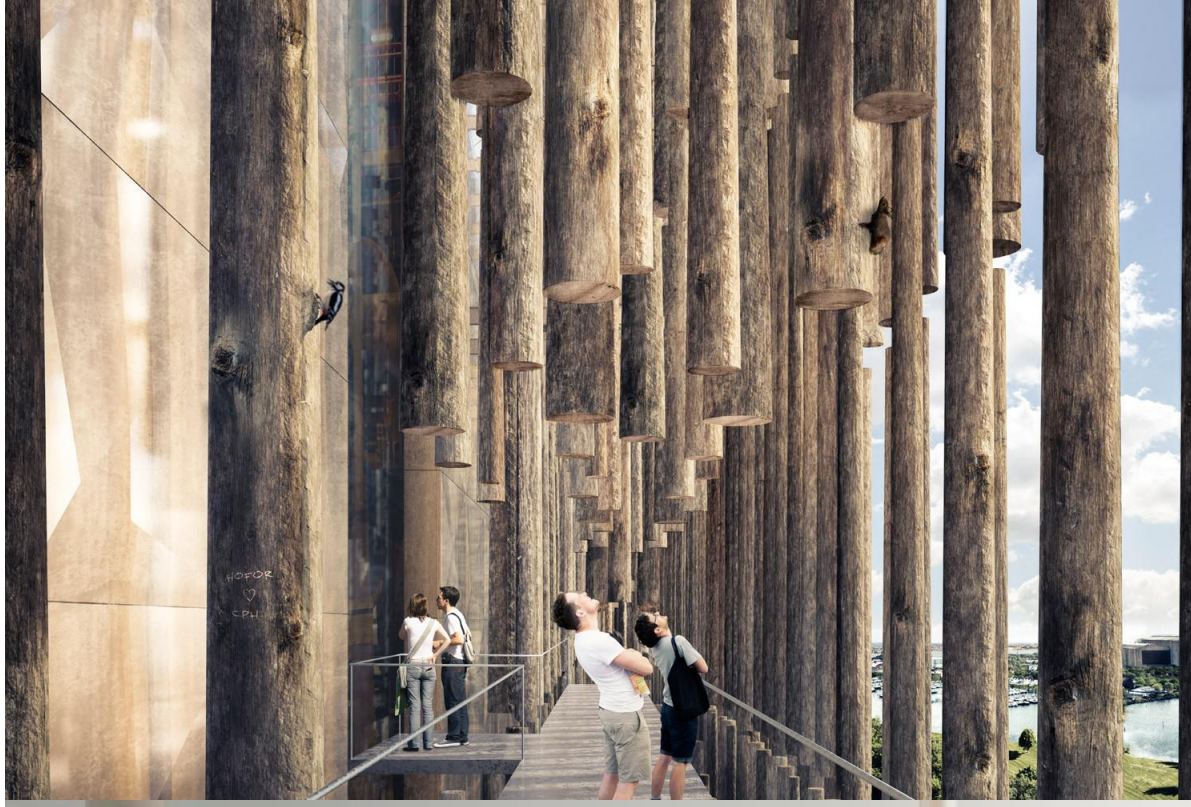
- 8,350 GWh; 4,000 MW peak capacity
- 180 km of transmission pipes to 21 distribution systems (1,500 km)
- 99% of buildings in Copenhagen; >800 M sq ft
- 3 large biomass CHP; 3 large WtE; 2 sludge incinerators; 50 gas peakers
- 74,000 m^3 buffer storage
- Denmark has ~300 DES – most municipality-owned or co-operatives

	Canada	Denmark
GDP Per Capita (USD)	48,100	49,600
GHG Emissions Per Capita (t CO_2e)	19.4	9.0
GHGs Per Capita (t CO_2e), incl. LULCF	18.6	10.0

Bioenergy consumption in Denmark 3x greater than wind

Copenhagen Amagerværket Biomass CHP Plant

- 500 MW_{th}
- Heats 210,000 homes
- 100% wood chips (4400 t/day)
- Commissioning (start-up: 2020)
- CapEx: C$1 B
- 2700 GWh heat (>3.5x Enwave)
- 1000 GWh electricity
- 100% marine
- Reduce: 1,200,000 t CO_2e/yr
- 25% of city heat demand
- PM emissions < natural gas
- Requires DES for operation




N
København NV
Hospital
Fælledparken
Østerbro
København Ø
Rigshospitalet
Yderhavnen
Kastellet
Assistens
Kirkegård
Nørrebro
Frederiksberg
Kongens
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Inderhavnen
Frederiksberg
Frederiksberg C
KØBENHAVN
København K
Frederiksberg
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Vesterbro/Kongens
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Tivoli
København V
Kløvermarken
Søndermarken
Valby
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Sydhavnen
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Kilometers
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Residential
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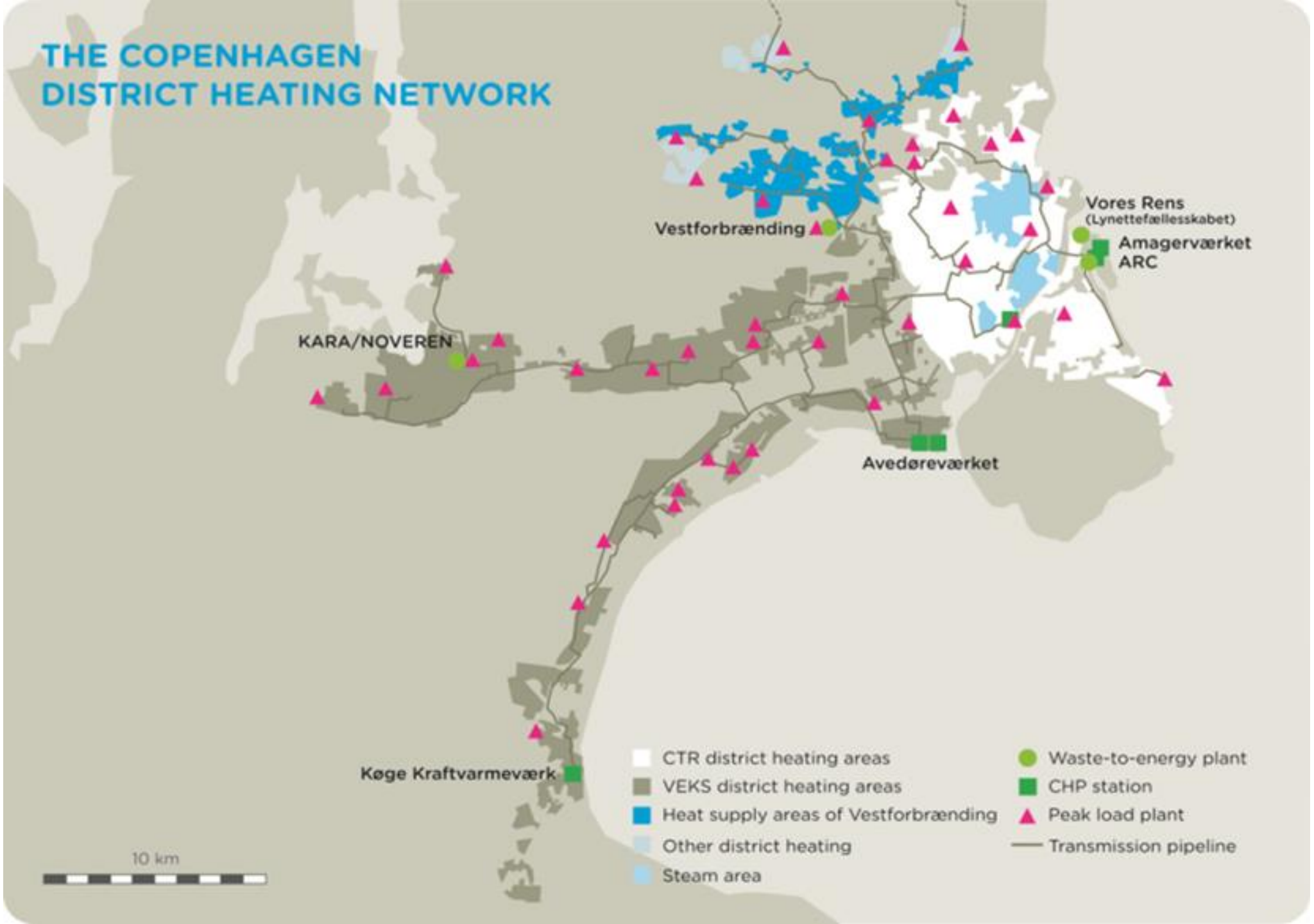
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


THE COPENHAGEN
DISTRICT HEATING NETWORK
Vestforbrænding
Vores Rens
(Lynettefællesskabet)
Amagerværket
ARC
KARA/NOVEREN
Avedøreværket
Køge Kraftvarmeværk
10 km
CTR district heating areas
VEKS district heating areas
Heat supply areas of Vestforbrænding
Other district heating
Steam area
Waste-to-energy plant
CHP station
Peak load plant
Transmission pipeline

Benefits for Ontario

- **Ontario fuels create Ontario jobs**
  - Re-create 30,000 lost forestry jobs (& support existing)
- **Keep fuel expenditures in Ontario**
  - Up $4 B/yr boost to provincial economy
- **Lower ongoing fuel costs**
  - Stable fuel pricing and fuel savings once investment made
- **Insulate Ontarians from federal climate policy**
  - Higher & uncertain energy prices due to carbon pricing, Clean Fuel Standard

Benefits for Ontario

- **Income for Municipalities**
  - Energy expenditures benefit community, not natural gas producers & utilities
- **Attract $5-7 B institutional capital investment to Ontario using P3s**
  - Typical DES investors are pension funds and sovereign wealth funds
- **Reduce air pollution and wildfires**
  - Create a market for low grade wood allows for fire reduction programs
  - Avoid catastrophic fire loss
- **Reduce greenhouse gas emissions**
  - Ontario leading on electricity, transportation (biofuel) decarbonization but lags on heat

Potential Structure

- **Federal infrastructure dollars flow to Municipalities**
  - Essential that municipalities participate in development but have limited fund access
  - Federal funds used to ‘buy equity’ in system to make economics viable
- **P3s established between Municipalities and Investors**
  - Operations initially managed by private sector, but could be transferred
  - Systems could be build, own, operate, transfer to public (after debt repaid)
- **Proven Models**
  - 400 community district energy systems in Denmark – from villages to cities
  - Stockholm system is P3; most systems public or P3