LONG-TERM INTEGRATED ENERGY PLANNING FOR LOW-CARBON DISTRICT ENERGY

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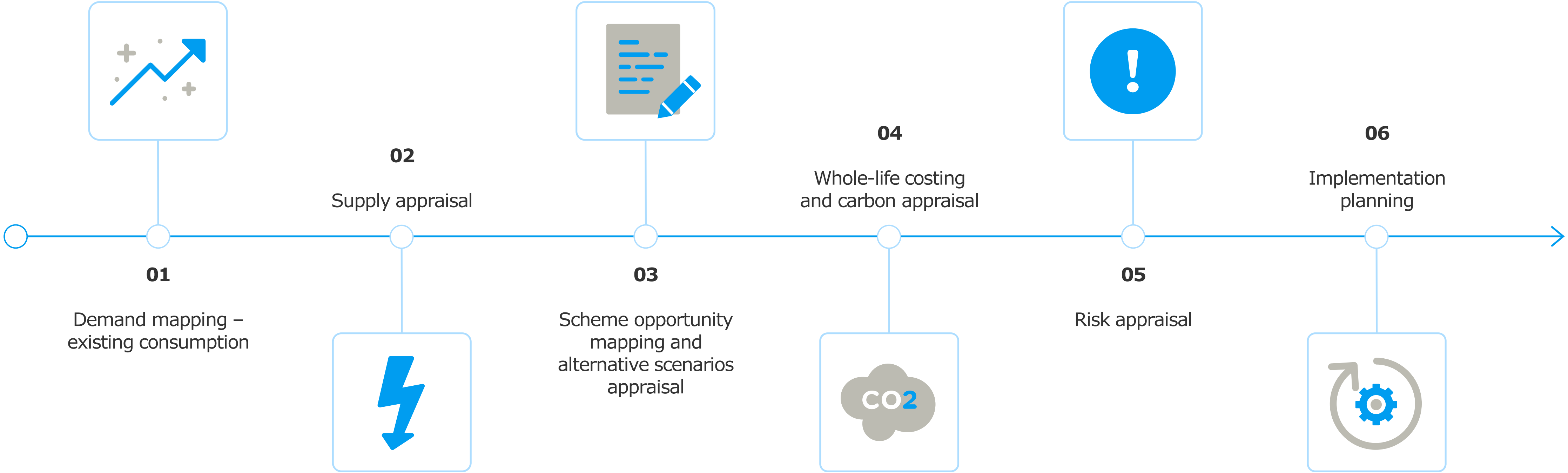
IDEA 2019

RAMBOLL Bright ideas. Sustainable change.

Image: Skidmore, Owings & Merril LLP/MIR

ENERGY MASTERPLANNING PROCESS



OUR PROCESS
APPROACH TO ENERGY PLANNING "WHERE IT STARTS"

SCOPING ASSESSMENT

Height, density and orientation of buildings

Consumption of energy for electricity, heating and cooling

Daylight and degree day impacts

Understanding existing infrastructure and other influences

DETAILED ENERGY MODELING

Using software tools running multiple scenarios

ENERGY SUPPLY STRATEGIES

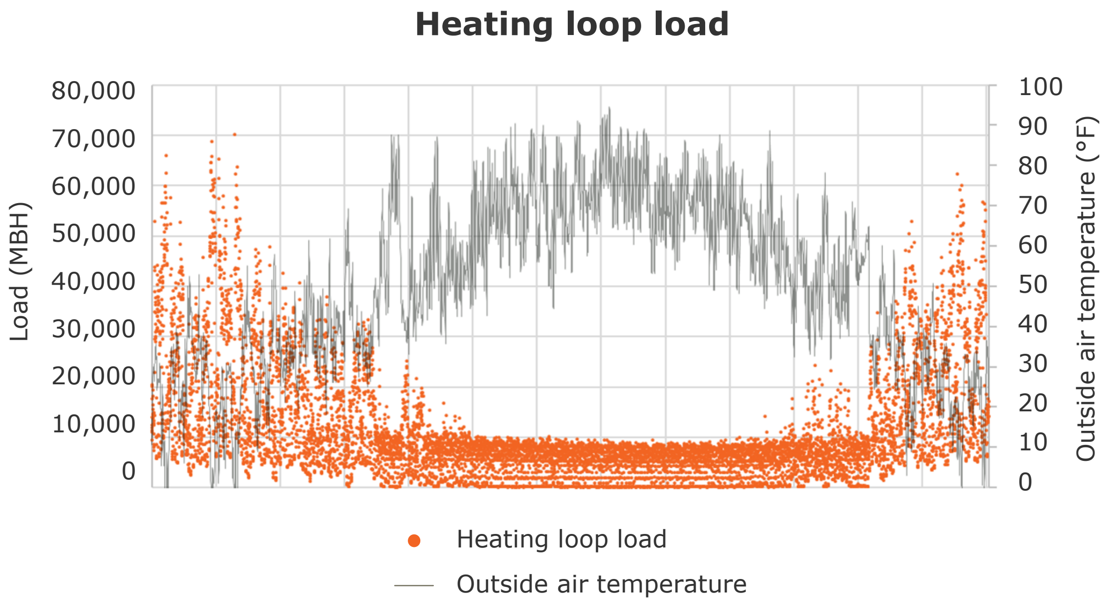
Geographic distribution of the heating, cooling and electricity loads of an urban area

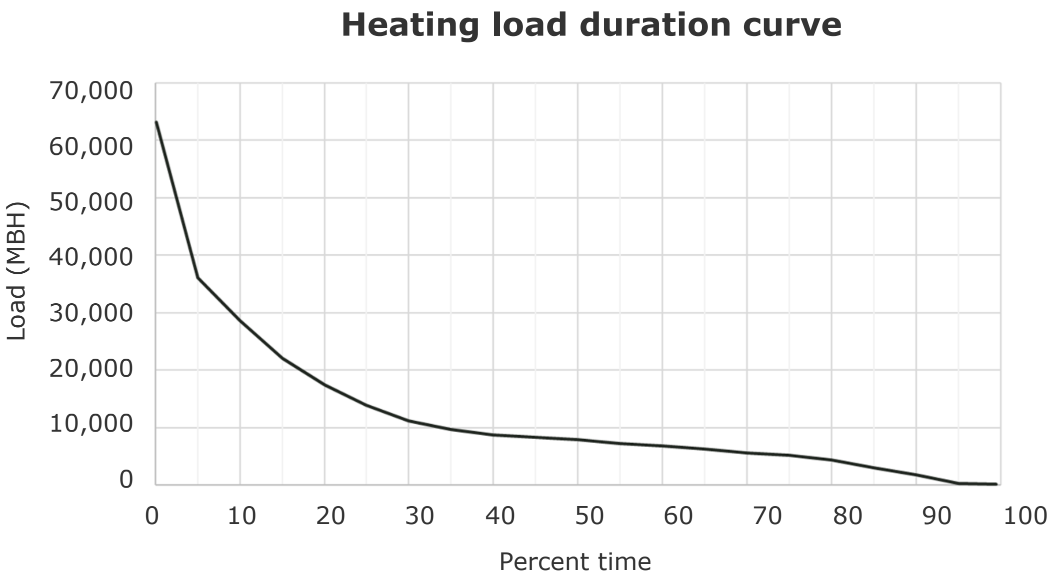
Costs and benefits analysis of district energy (heating/cooling) against individual systems

Assessment of alternative energy supply options, such as wind energy, solar, combined heat and power, heat pumps, thermal energy storage, geothermal, etc

UNDERSTANDING ENERGY USE - EXAMPLE HEATING DATA ANALYSIS

INTERVAL DATA





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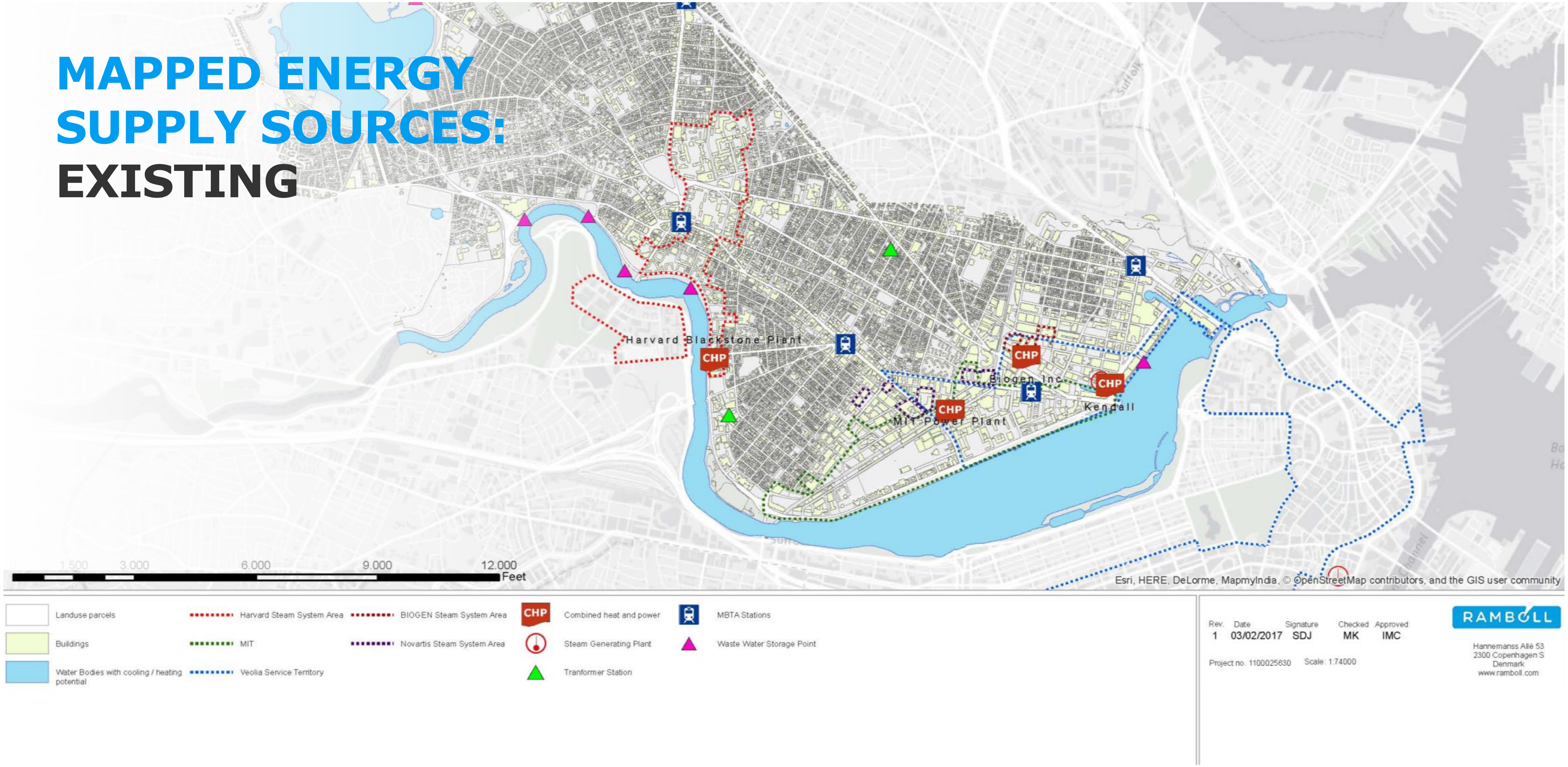
MAPPED ENERGY SUPPLY SOURCES: EXISTING



SUPPLY APPRAISAL

District energy infrastructure allows communities to capture thermal energy from a wide range of sources

Identify alternative supply options

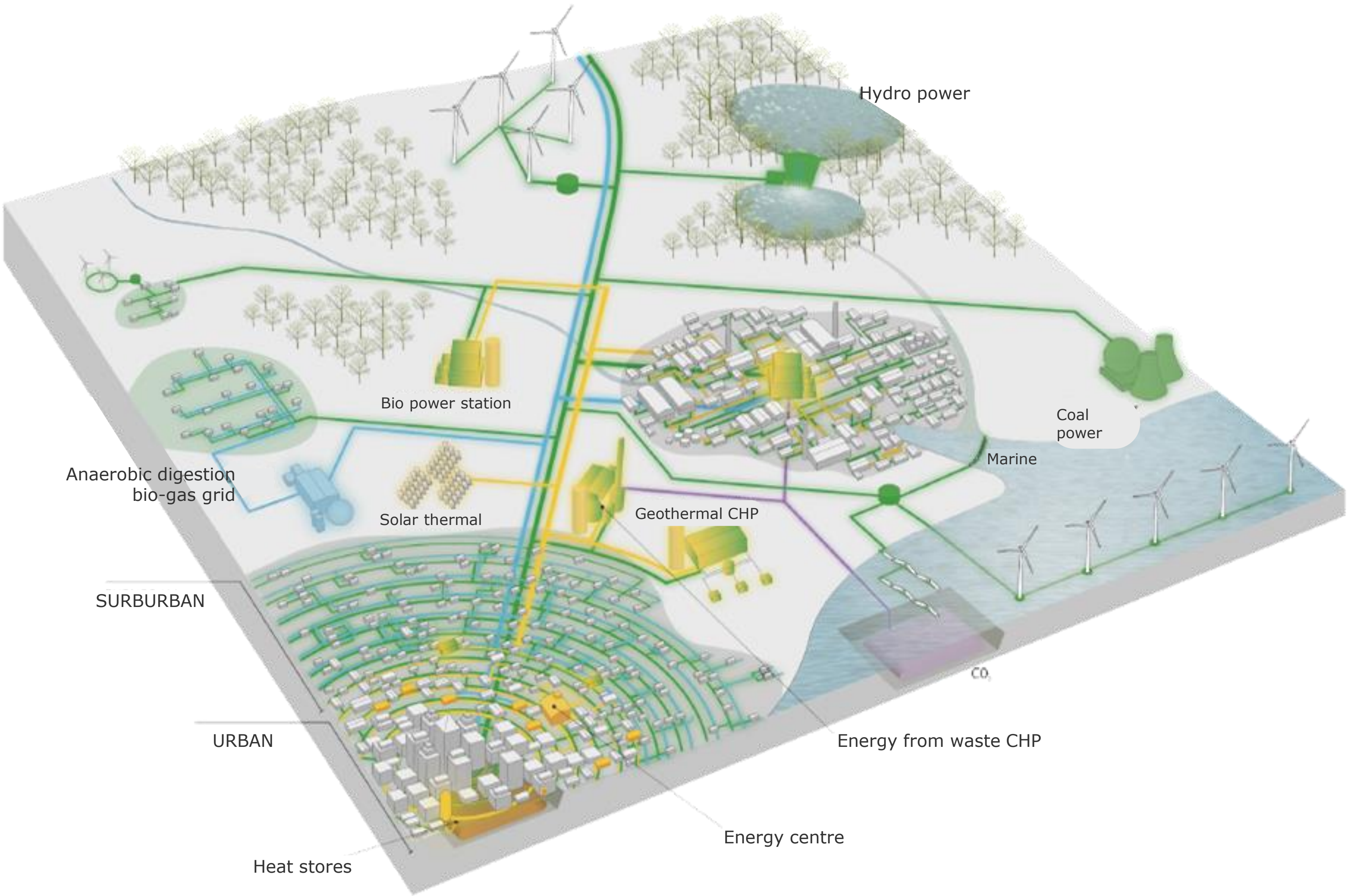


Photo credit: UK ADE

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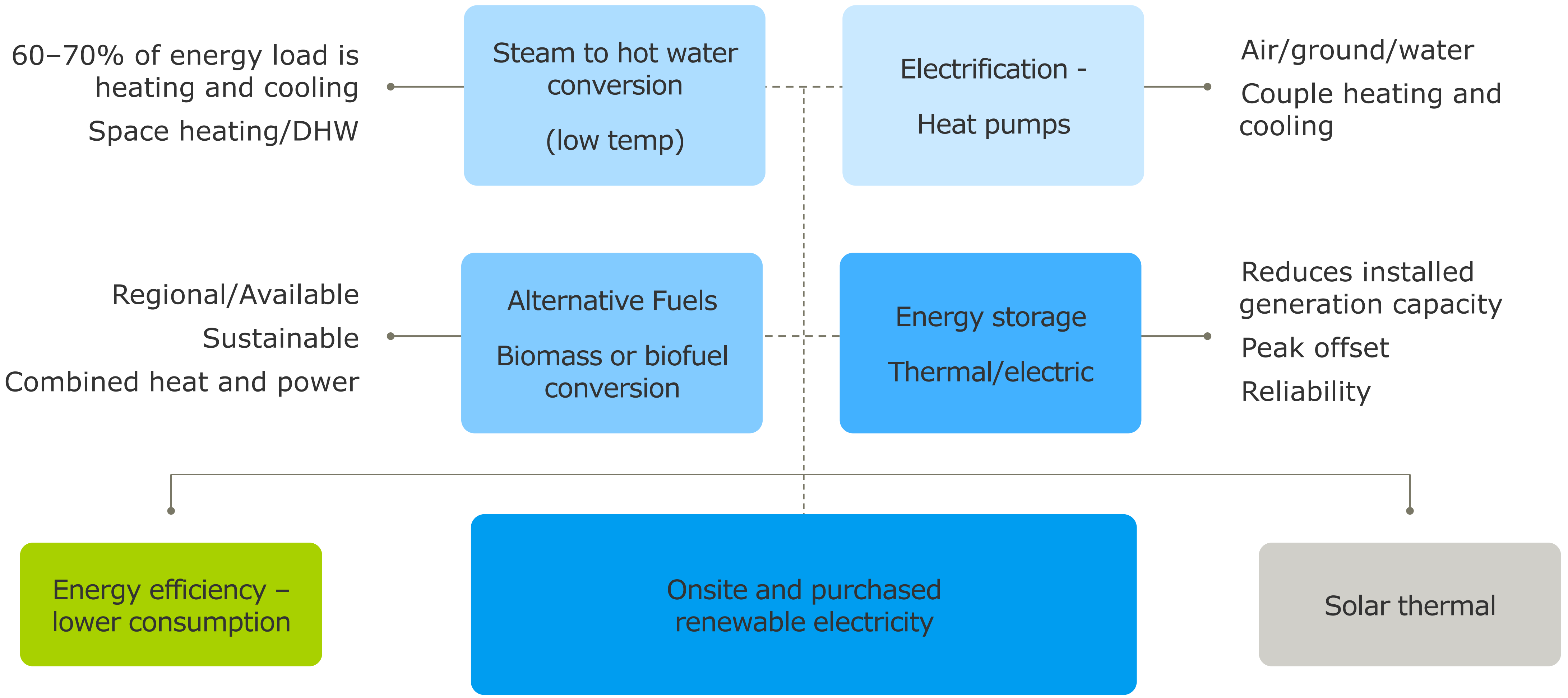
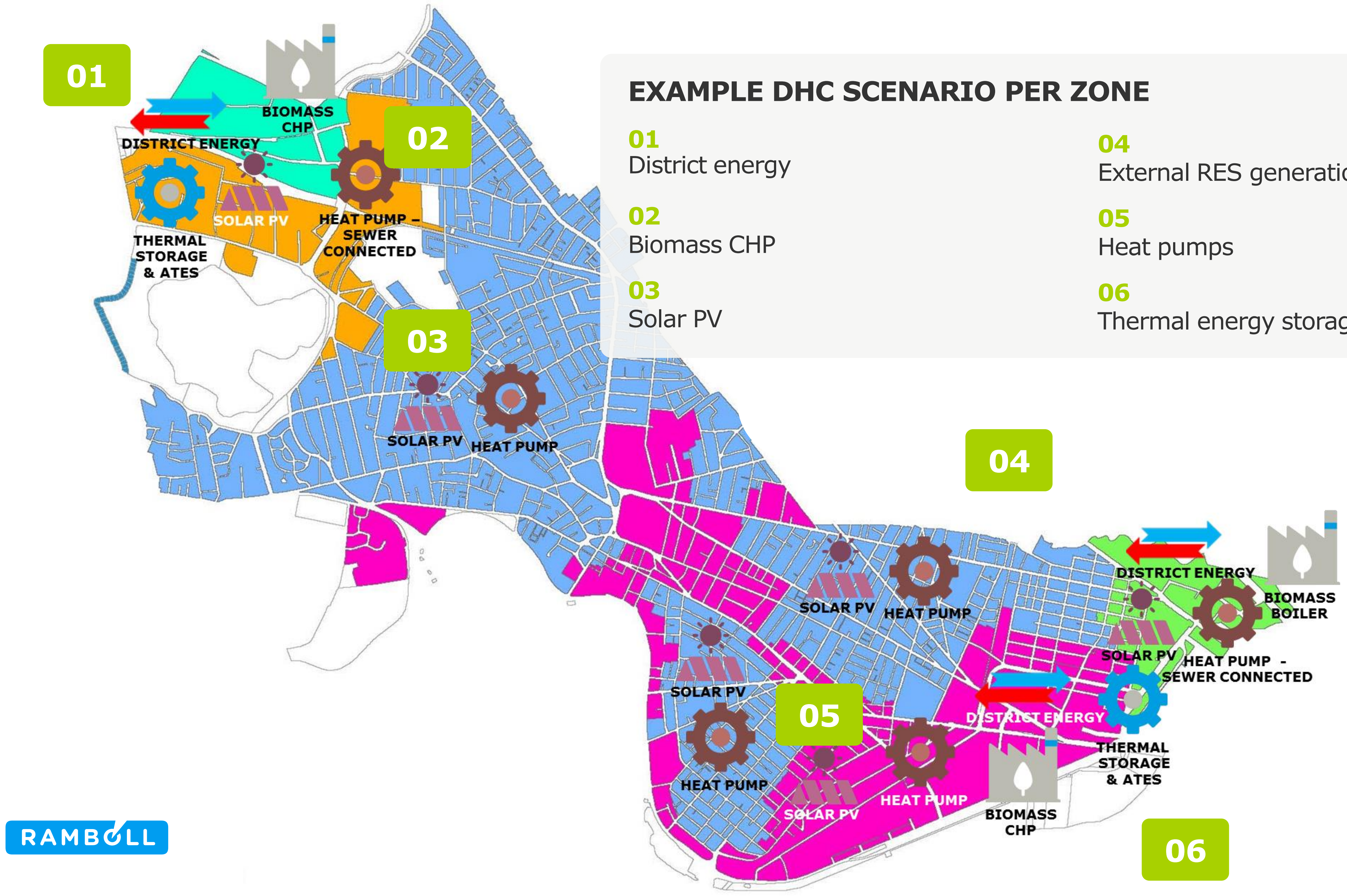
POTENTIAL LOW-CARBON ENERGY SUPPLY OPTIONS





EXAMPLE DHC SCENARIO PER ZONE

01
District energy

02
Biomass CHP

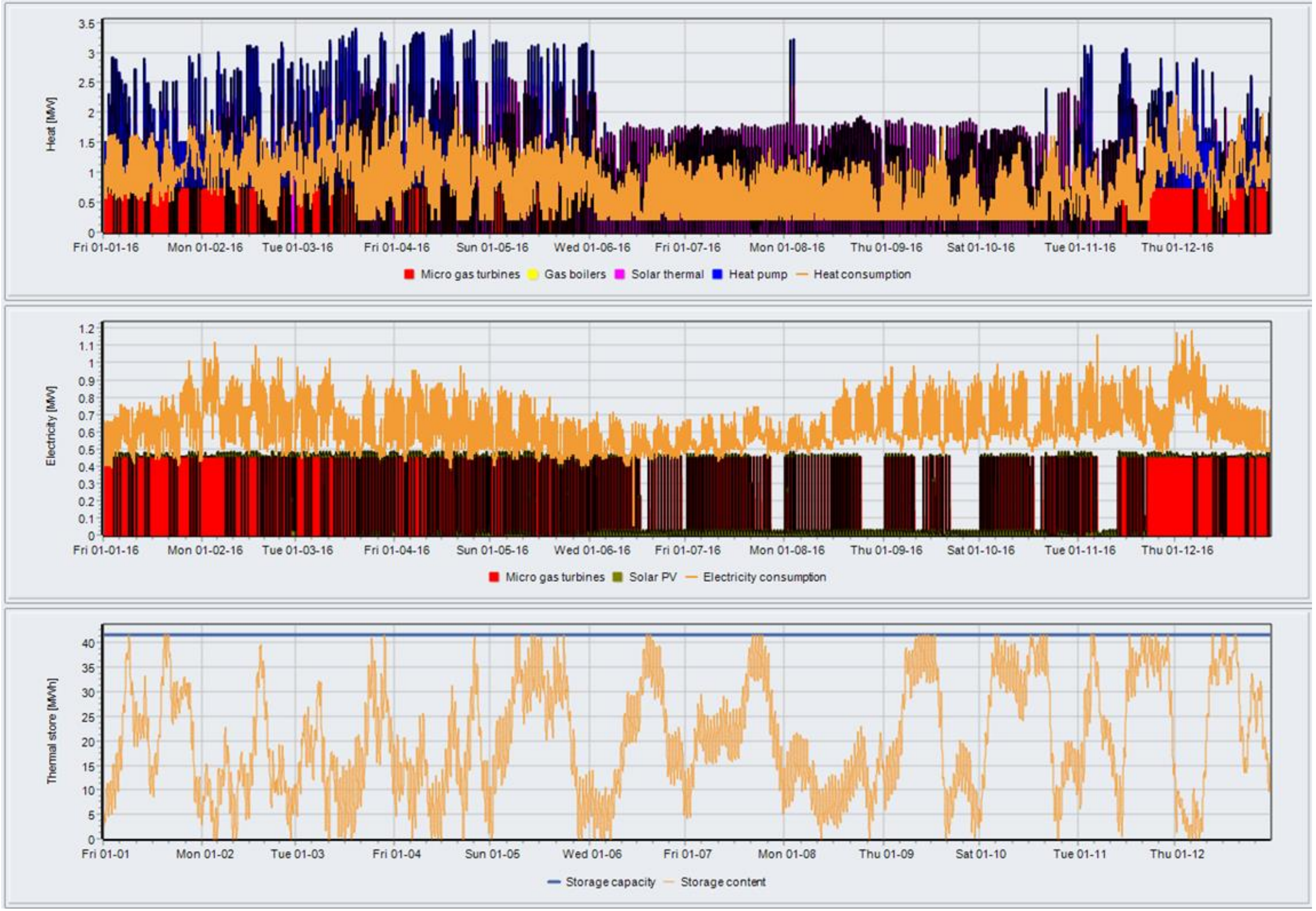
03
Solar PV

04
External RES generation supply

05
Heat pumps

06
Thermal energy storage

COMBINING TECHNOLOGIES AND SOURCES
SIZING GENERATION OPTIONS



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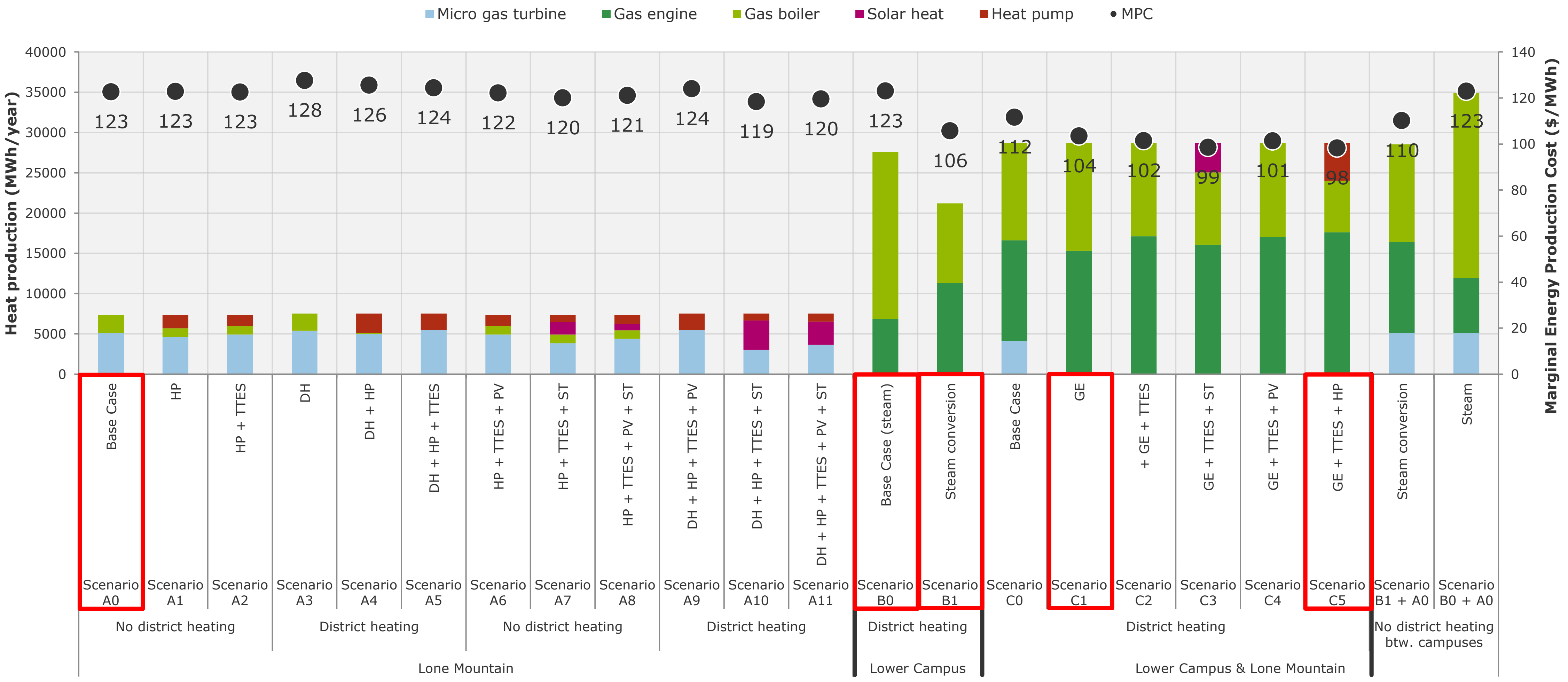
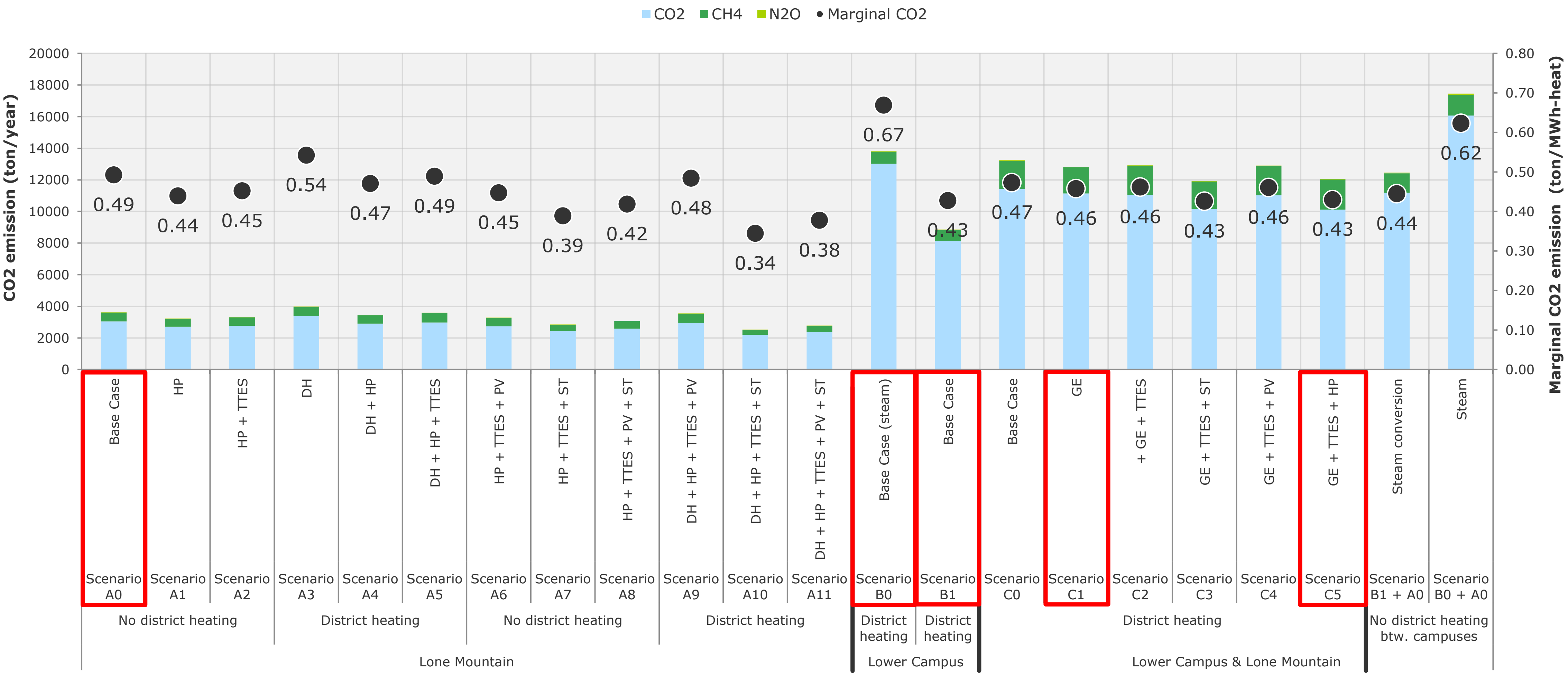
EVALUATING & SCORING OPTIONS

LONG-TERM MARGINAL ENERGY PRODUCTION COST COMPARISON



EMISSION COMPARISON



SCORING MATRIX
COMPARING OPTIONS

Project	Description	Carbon reduction	Lifecycle cost	CAPEX	OPEX	Innovative technology	Impact to infrastructure	Reduction to water consumption	Social/campus benefit
01	Steam to hot water conversion								
02	Connect campus distribution systems								
03	Biofuels conversation								
04	Geothermal + heat pumps								
05	Thermal storage								
06	Projects 1-3								
07	Projects 1-2 and 4								
08	Projects 1-4								
09	Projects 1-3 and 5								
10	Projects 1-2 and 4-5								
11	Projects 1-5								

Scoring matrix, 1 = Least impactful / benefit / or highest risk, 5 = Most important / benefit / or least risk

Operational cost comparison	Units	Total cost	Annual cost (per year)	Annual savings (per year)	Total savings over 20-year period	Marginal carbon emission (ton/MWh)
Continuous operation on Microturbine and steam system (Base case, both campuses) (A0 + B0)	Million $	68.90	3.45	---	---	0.62
Continuous operation on Microturbine and conversion of steam system (A0 + B1)	Million $	61.75	3.09	0.36	7.15	0.44
New DH network covering all of campus with central energy center (gas engine) (C1)	Million $	58.04	2.90	0.54	10.86	0.46
New DH network covering all of campus with central energy center (gas engine + heat pump + TTES) (C5)	Million $	55.10	2.75	0.69	13.80	0.43

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IMPORTANT CONSIDERATIONS

- **Goal setting** – carbon neutrality by 2035, transparent, resilient
- **Campus growth / reductions**
- Leverage **existing infrastructure** and condition assessments
- **Long-term thinking** – multi-year and phased approach
- Planning **must be flexible** to account for technology, market and policy changes
- Ownership and engagement – supported by all

Carbon Neutral Cities Alliance/Cambridge Energy Supply characteristics ambition:

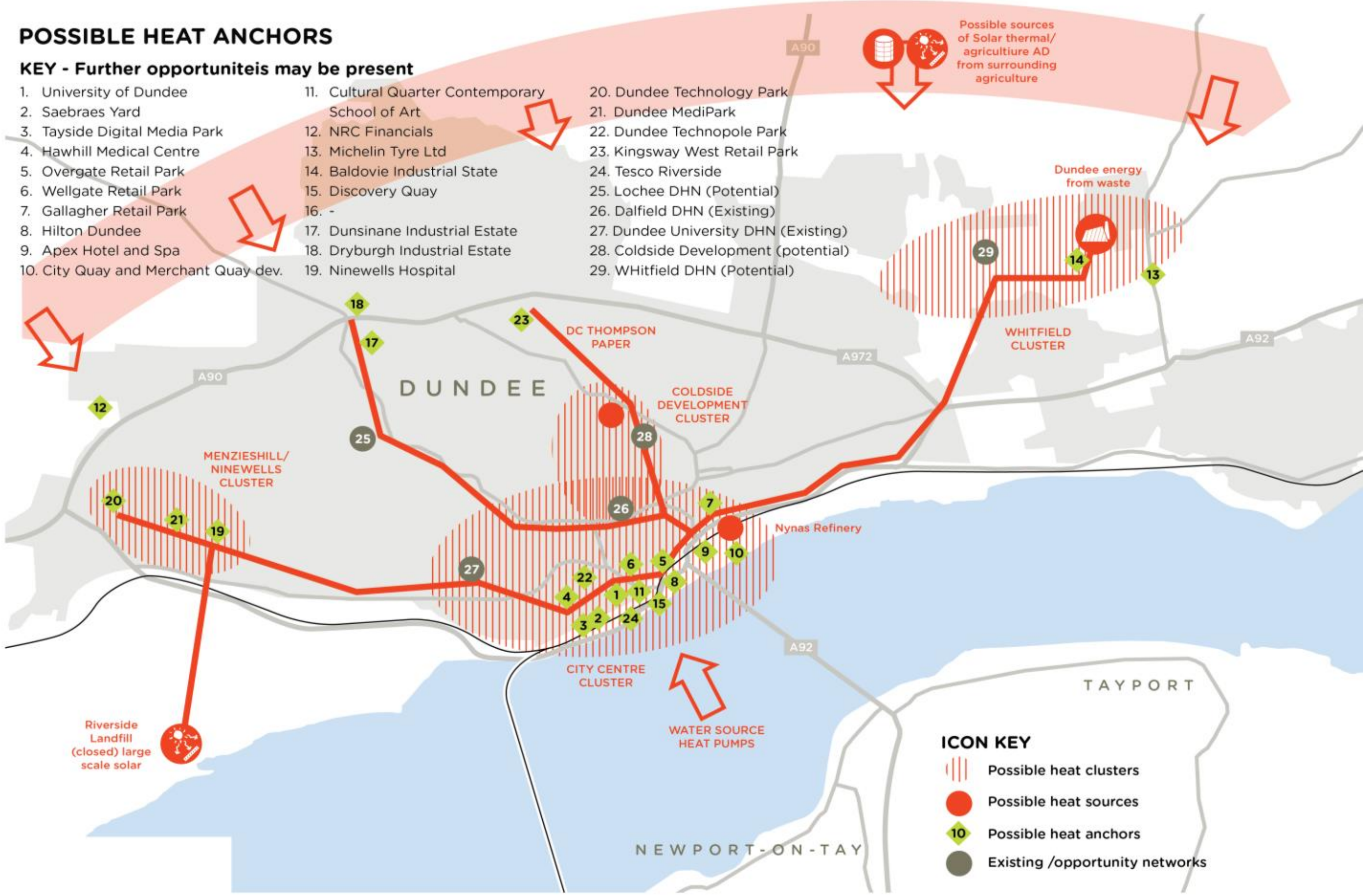
- Clean
- Reliable
- Affordable
- Predictable
- Transparent
- Local control
- Wealth creating
- Innovative
- Just

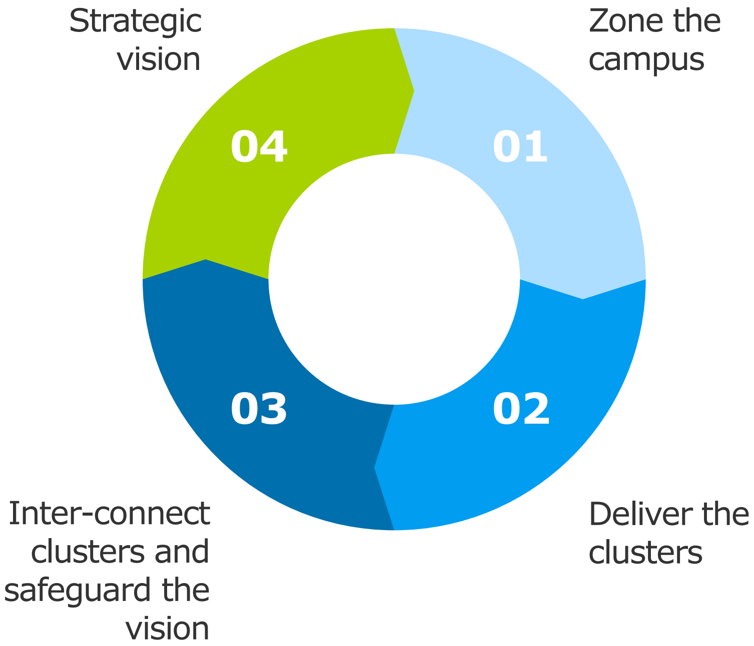
CLIMATEACTION WR Reducing Emissions. Enriching Lives.

Second Nature

PHASING & IMPLEMENTATION

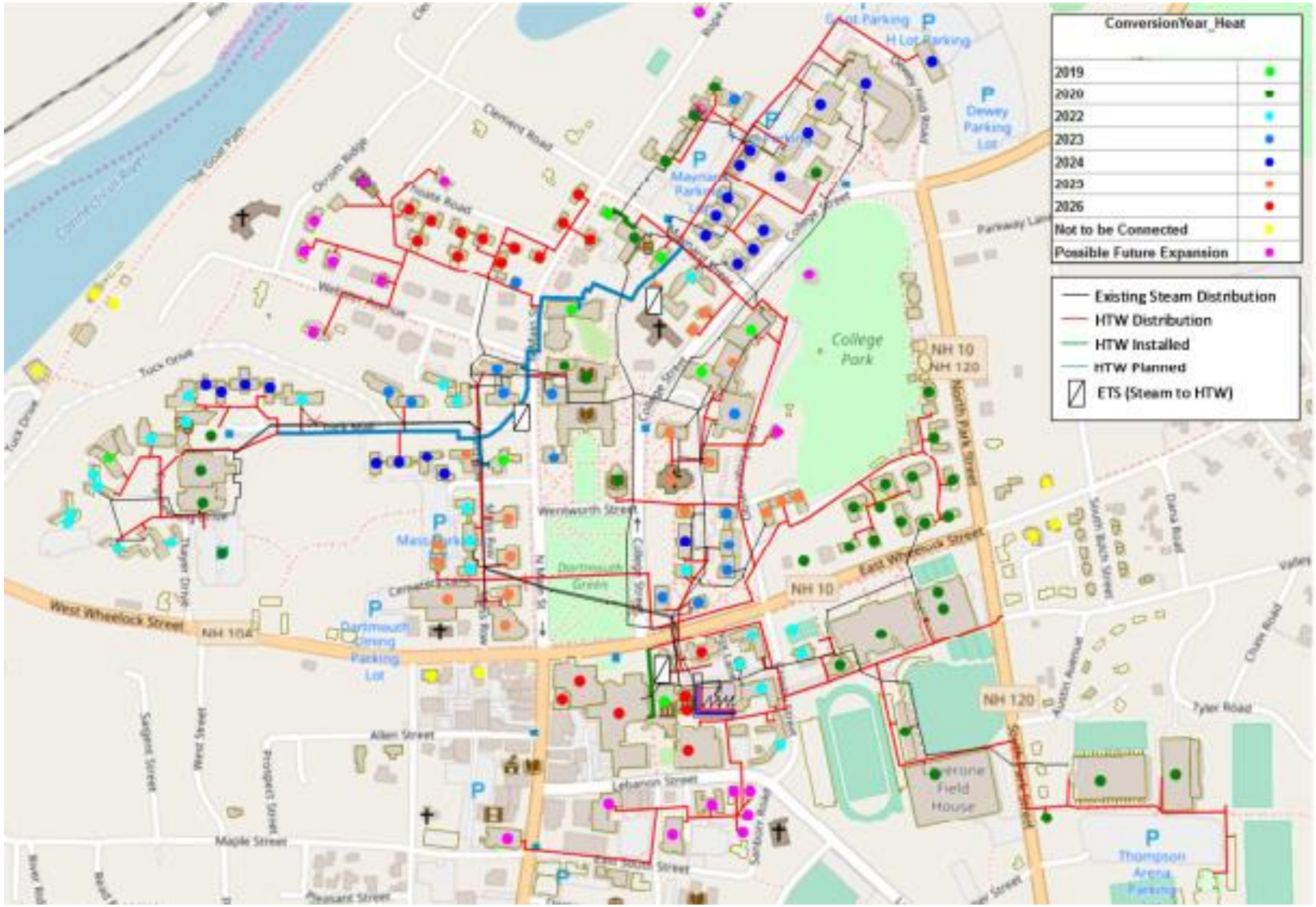
PLANNING & DELIVERING DE OVER TIME





EXAMPLE
PHASING PLAN BY YEAR

- Safety
- Minimize Impact to Campus Operations
- Maintain Supply
- Reliability
- Capacity of staff
- Achieve carbon / energy reduction milestones



CHALLENGES TO BE ADDRESSED AS PART OF PROJECT IMPLEMENTATION

COMMERCIAL & FINANCIAL

High investment costs and long development timescales

Complex stakeholder arrangements

CAPACITY & APPETITE TO DELIVER

Internal resources, funds, relevant skills

Access to finance

TECHNICAL CHALLENGES

Retrofitting costs (building temperatures and heating systems)

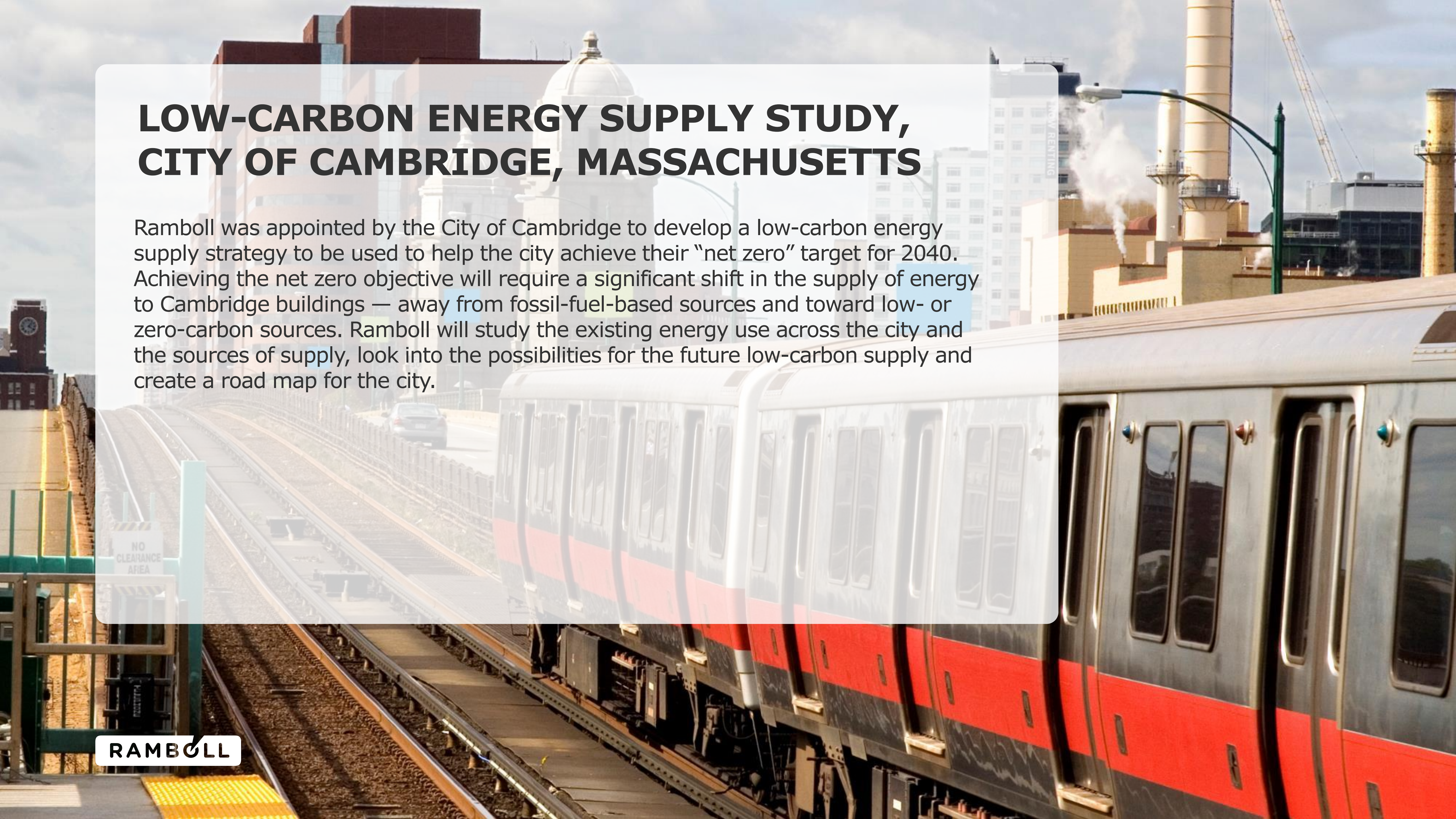
Energy demand density

Existing utilities and grid connection

PROJECT HIGHLIGHTS – WHAT ARE PEOPLE DOING

LOW-CARBON ENERGY SUPPLY STUDY, CITY OF CAMBRIDGE, MASSACHUSETTS

Ramboll was appointed by the City of Cambridge to develop a low-carbon energy supply strategy to be used to help the city achieve their “net zero” target for 2040. Achieving the net zero objective will require a significant shift in the supply of energy to Cambridge buildings — away from fossil-fuel-based sources and toward low- or zero-carbon sources. Ramboll will study the existing energy use across the city and the sources of supply, look into the possibilities for the future low-carbon supply and create a road map for the city.



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CAMPUS DECARBONIZATION PLAN - BROWN UNIVERSITY

75% Reduction by 2025 and Carbon Neutral by 2040

2020 – 40 MW Solar PV / 8 MW Wind / Thermal Efficiency Project – remove steam and lower hot water temperature 50% total carbon reduction

2023 - Liquid Biofuel Conversion of Central Plant – 80-85% scope 1 carbon reduction

2024-2035 – Building renovations / Lower hot water loop temperature to 185° F

*Continue to evaluate low carbon technologies

2035-2040 – Electrical upgrades and convert CEP to Air Source Heat Pumps (ASHP)

CAMPUS CARBON NEUTRALITY AND ENERGY PLAN - TUFTS UNIVERSITY

Carbon Neutral by 2050

Local ordinance must see carbon reduction every 5 years & New Combined heat and power plant – natural gas as transition fuel

Years 1-5 – Liquid biofuels conversion of all boilers / 450 kW Solar PV / Geothermal GSHP on East Campus

Years 6-10 – Steam to hot water conversion of DH system / Building renovations / 450 kW Solar PV over geothermal field / 1 MW Fuel Cells on Lower Campus / Expand Centralized District Cooling

Years 10-20 – Re-evaluate CHP system and optimize hot water network

Year 20 & Beyond – Convert CHP to low carbon technology or carbon neutral fuel

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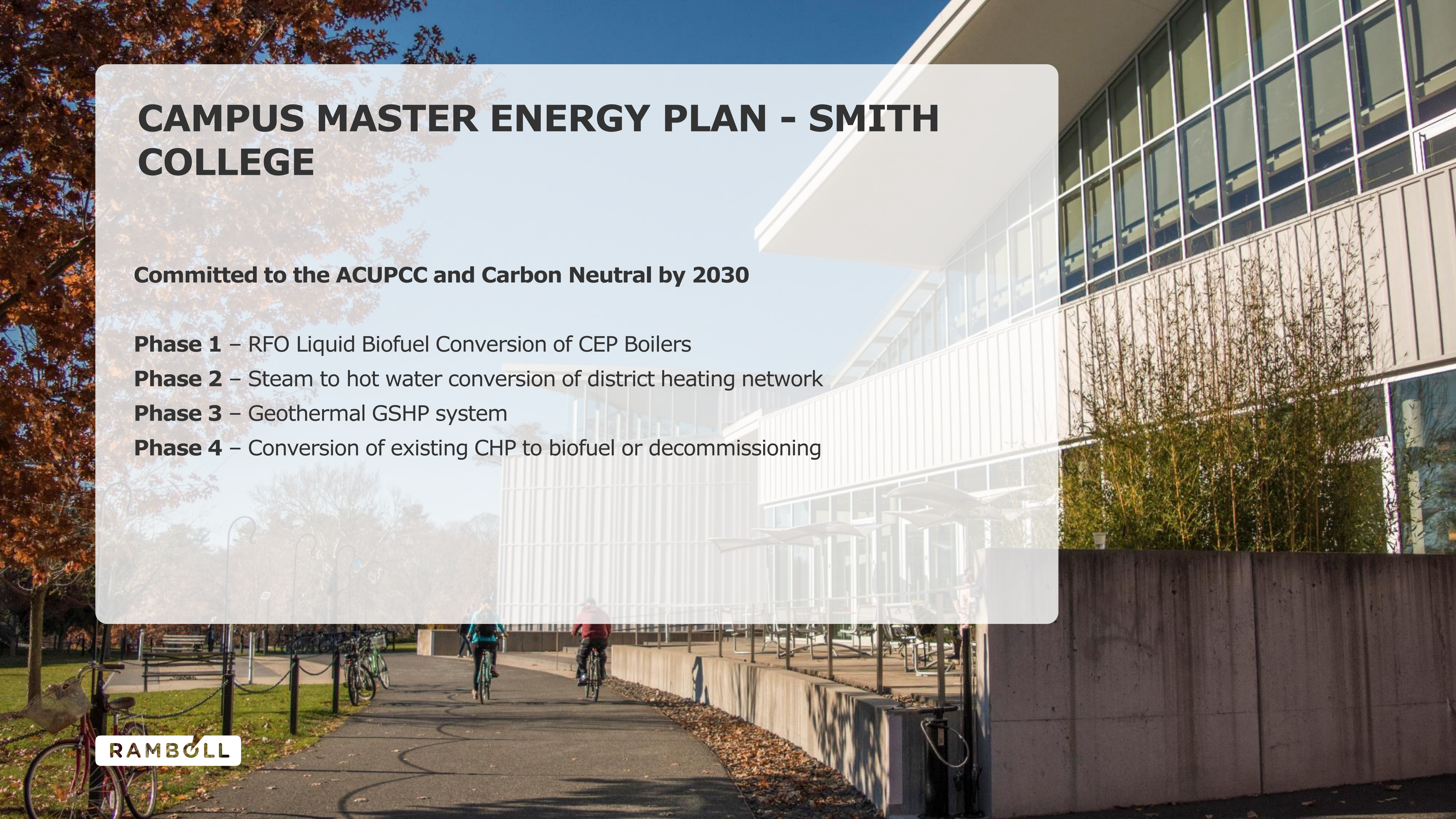

CAMPUS MASTER ENERGY PLAN - SMITH COLLEGE

Committed to the ACUPCC and Carbon Neutral by 2030

Phase 1 – RFO Liquid Biofuel Conversion of CEP Boilers
Phase 2 – Steam to hot water conversion of district heating network
Phase 3 – Geothermal GSHP system
Phase 4 – Conversion of existing CHP to biofuel or decommissioning

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GREEN ENERGY PROJECT - DARTMOUTH COLLEGE

Improve transmission & distribution efficiency by 20% by 2030

Energy supply from renewable sources – 50% by 2025 and 100% by 2050

Reduce Scope 1 & 2 GHG Emissions – 50% by 2025 , 80% by 2050, and carbon negative by 2051

<u>2020-2025</u>

Buildings – converting from steam to hot water / efficiency improvements

District energy – convert from steam to hot water and expand central cooling

Solar PV and renewable electricity procurement

<u>2026-2030</u>

Generation – Build new wood biomass central plant (CHP possible) with liquid biofuel backup / peaking boilers

Continued development of renewable electricity sources

CAMPUS MASTER INTEGRATED ENERGY PLAN - HUMBER COLLEGE, TORONTO, ONTARIO

Reduce source **energy use** by 50% / SF by 2034

Reduce **water** use by 50% by 2034

Reduce total **GHG** emissions by 30% by 2034**

Phase 1 – Building renovation and efficiency improvements

Phase 2 – Steam to hot water conversion

Phase 3 – Convert CEP to low carbon or electrified source

- Geothermal GSHP
- Sewer based WSHP
- Natural gas fired CHP system (negative impact to GHG vs. Electric grid)

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CAMPUS ENERGY CONVERSION - PRINCETON UNIVERSITY

Campus Integrated Master Plan – addresses infrastructure, expansion, and sustainability

Phase 1 – Building renovations / Eliminate steam / Construct low temperature hot water distribution network / Procure 100% renewable electricity

Phase 2 – Construct new East Energy Center based on geothermal GSHP technology / Couple heating and cooling / Thermal storage systems

Phase 3 – Decommission CHP & Convert existing West Energy Center to Geoexchange GSHP technology and connect to networks

CORNELL UNIVERSITY, ITHACA, NEW YORK

100% Carbon Neutral Energy Campus by 2035 using renewable energy

Greenest of the Ivy League Schools – according to AASHE's STAR program

Lake Source district cooling – no refrigerants & reduces electrical consumption for cooling by 85%

What's next:

North Campus Expansion Solar PV Project

Campus district heating steam to hot water conversion

Deep Geothermal GSHP system with thermal energy storage

Hybrid biofuels for backup and peaking

THANK YOU

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