Greener construction materials and processes
How developers and owners are considering embodied carbon to create carbon neutral developments
Ryan Zizzo, Zizzo Strategy  ~  Katie Ross, Microsoft  ~  Panu Pasanen, Bionova
## Agenda

<table>
<thead>
<tr>
<th>Duration</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>5 min</td>
<td>Intro: Embodied Carbon; Buy Clean California; Speaker intros</td>
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<tr>
<td>25 min (~8 min x 3)</td>
<td>Three deep green case studies, with a focus on embodied carbon: 1. Evergreen Brick Works, Toronto (Ryan) 2. Microsoft new development (Katie) 3. Norwegian Government (Panu)</td>
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<tr>
<td>15 min</td>
<td>Summarize key learnings from breakout session + panel insights</td>
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<td>1 min</td>
<td>Wrap-up</td>
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Embodied Carbon

[Diagram showing the lifecycle of embodied carbon from manufacture to decommissioning.]
Building Carbon - Yesterday

Operating Carbon

Embodied Carbon

Year 1 - Construction

Year 60+ - Demolition
Building Carbon - Tomorrow

- Embodied Carbon
  - Year 1 - Construction

- Operating Carbon
  - Year 60+ - Rehabilitate
Embodied Carbon

Why Care?

1. Embodied carbon is ~ 20% of total GHGs in construction sector.

2. Operating energy / carbon is legislated, tracked and reduced. Embodied carbon is not, therefore becoming a bigger relatively source of emissions over time.

3. Fuels -- a major source of embodied carbon -- are not addressed by green electricity.

4. Embodied carbon reductions can be large and “immediate”.
Buy Clean California

- Applies to state and university public works
- Eligible materials limited to: (1) carbon steel rebar, (2) flat glass, (3) mineral wool board insulation, (4) structural steel.
- State will publish a max acceptable GWP per material (industry average)
- Exemptions possible if technically infeasible or if significant increase in cost or timeline, or if only available from one manufacturer.
- Values to be updated every three years
- Successful bidder to provide evidence (facility-specific EPDs)
- 2019: facility-specific EPD REQUESTED
- 2020: facility-specific EPD REQUIRED
- 2021: facility-specific EPD REQUIRED below limit
Three International Case Studies Dealing with Embodied Carbon

• Evergreen’s carbon neutral Living Cities Centre in Toronto, Canada
• Microsoft Campuses Globally
• Norwegian Government’s carbon solution
Speaker & Facilitator

- Ryan Zizzo, Technical Director, Zizzo Strategy (Toronto, Canada)
- Climate change consultant and engineer
- Focus on embodied carbon, green buildings and infrastructure
- Will provide overview of Evergreen’s carbon neutral Living Cities Centre
Speaker & Panelist

• Katie Ross, Sustainability Program Manager, Microsoft (Redmond, Washington)

• In charge of sustainability for Microsoft’s global real estate portfolio

• Committed to high performance, healthy, sustainable buildings

• Will provide overview of Microsoft’s commitment to reducing carbon (including embodied carbon)
Speaker & Panelist

• Panu Pasanen, CEO, Bionova (Helsinki, Finland)
• Provides sustainability solutions to the construction industry, including One Click LCA software
• Consults with regulators, governments, standardization bodies, and certification organizations
• Will present Norwegian government’s carbon tracking / optimization solution
Project Example 1:
Evergreen’s Carbon Neutral Kiln Building Redevelopment
Evergreen

- Environmental capacity building organization
- Working with other city builders to convene, collaborate and catalyze ideas into action
- Their Brick Works campus is Canada’s first large-scale community environmental centre
- It is a dynamic venue for exploring ideas and leading-edge green technologies, and a vibrant public space where visitors can engage in a broad suite of hands-on environmental programming
The Brick Works

- In 2002, the crumbling Don Valley Brick Works was a shell of its former city-building purpose, an industrial brownfield that had been abandoned for 20 years.
- Sitting on 16.4-hectares of land in Toronto’s Don Valley, surrounded by an extensive ravine network, highways and residential neighbourhoods.
- For 100 years, the site functioned as one of Canada’s pre-eminent brick works factories, at its peak producing over 43 million bricks annually.
- Evergreen has repurposed the site and it is now one of Toronto’s highlights.
The “Kiln Building” is now the Future Cities Centre
The “Kiln Building” is now the Future Cities Centre

- Historic 53,000 sq ft (5,000 m²) building housed the brick kilns (ovens)
- In early 2017, the adaptation of the space begun.
- The project has become a test site to advance and accelerate the shift to more sustainable construction design and practices.
- Upon completion, the project will be one of the first carbon neutral sites in Canada.
- Features include:
  - Seasonal thermal energy storage via solar-thermal roof collectors integrated with geo-exchange field and new radiant floor
  - Adapted reuse of existing building envelope wherever possible
  - Material minimization
  - Embodied carbon calculations through building Life Cycle Assessment (LCA)
  - Offset strategy for project carbon
Radiant floor, fed through solar thermal-collected, geo-exchange-stored renewable heat
Material strategy

1. Reuse existing material wherever possible

2. Where new material is needed:

   A) Minimize
      - Used raised cavity floor system called ‘Cupolex’ which minimizes materials

   B) Low Carbon
      - Concrete floor has 25% less CO2 than typical concrete
      - Maximized recycled materials
      - Post-industrial recycled materials and recycled concrete aggregates
      - Certified responsibly-sourced aggregates (Cornerstone Standards Council Certified – using the Responsible Aggregate Standard)
Embodied Carbon Calculations

- Initial estimate found that reuse of existing materials saved carbon equivalent of annual emissions from 47 homes in Toronto.

- Construction phase included detailed tracking of:
  - All construction material deliveries
  - Origin of delivery trucks (to calculate transportation related emissions)
  - On-site equipment use

  - Currently working to turn the above into a robust carbon calculation
  - Evergreen has committed to creating a carbon offset strategy to pay off the carbon debt’ associated with construction, and to include any carbon emissions associated with operations.
Lessons

• Start early, and have someone in charge of carbon other than mechanical designer or construction team

• Follow a guideline or standard to help with scoping

• Plan ahead and strategize an efficient approach
  – On-site fuel use tracking plus construction electricity sub-meter instead of tracking construction equipment operation

• Don’t let the perfect be the enemy of the good. Start somewhere and be OK with imperfect information!
New Report on Low Carbon Procurement

- New report just released by Evergreen
- [www.futurecitiescanada.ca](http://www.futurecitiescanada.ca)
- Strategies and suggestions on low-carbon infrastructure procurement
- Includes LCA and embodied carbon strategies
Empower every person and organization on the planet to achieve more.
Microsoft Sustainability

Physical Operations + Technology Development = Societal Impact
Carbon Commitments

**OPERATIONAL GOAL**
Reduce carbon emissions 75% by 2030 relative to 2013 base year, and offset what we do not reduce.

**SOCIETAL GOAL**
Enable faster and better measurement, management, and reduction of global carbon emissions.
100% carbon neutral

- 21 billion kWh purchased and applied (green power)
- 9.6 million mtCO2e carbon reduction (green power reductions only)
- 7.5 million people impacted (carbon offset community projects)
- 5.1 million acres protected (forestry and land management carbon offset projects)
There’s still more to do.
Investing to grow right here at home

At a time when space is at a premium and many companies are looking for room to grow, we recognize that our 500-acre campus in Redmond, Washington, is a unique asset. Neighboring a vibrant urban core, suburban towns, lakes, mountains and miles of forest, it’s one of Microsoft’s crown jewels. And as we continue to grow and look to create the best workplace in the tech sector, Microsoft will invest right here in Redmond, our home for more than 30 years.
Understanding Embodied Carbon

SEATTLE MIDRISE: ‘HIGH EMBODIED CARBON’
BASELINE EUI of 38

Embodied Emissions: 45,900 tons of CO2
Operational Emissions: 180 tons of CO2/yr

- 4,222 houses’ annual energy use
- 10,762 passenger vehicles on the road for a year
- A 747 flying for 70 days
- 172,897 barrels of crude oil

It will take 255 years of building operation to equal the amount of embodied carbon produced during manufacturing and construction.
Understanding Embodied Carbon

SEATTLE MIDRISE: ‘LOW EMBODIED CARBON’ BASELINE EUI of 38

Embodied Emissions: 17,200 tons of CO2
Operational Emissions: 180 tons of CO2/yr

2,015 houses’ annual energy use
5,137 passenger vehicles on the road for a year

26,200 tons of CO2 over 50 years

66 % embodied
34 % operational

A 747 flying for 35 days
82,530 barrels of crude oil

It will take 96 years of building operation to equal the amount of embodied carbon produced during manufacturing and construction.
Create a specific Project Profile for tracking and reduction, or look at comparable buildings already in database for benchmarking exercise.
Find and compare materials for input into your building’s Project Profile, or do a quick materials search for on demand materials selection by GWP.

CONCRETE SEARCH BY PROPERTIES

Additional Attributes

Strength Min: 5000 psi
Curing Time: 28d
SCM Min: 0

Min Strength: 5000 psi
Curing Time: 28d
SCM Min: 0

Search by what you currently know re: material performance and criteria

Quickly understand CO2e range of a specific material

Number of manufacturer EPDs currently in database that meet material parameters
Sort compliant manufacturers by GWP (CO2e) to find lowest emitting options. See details and automatically download the associated EPD.
Select to use the conservative average CO2e of all compliant manufacture EPDs, or a specific manufacturer’s CO2e. Selection auto fills into Project Profile and becomes a part of the CO2e footprint calculated and visualized.
A Refreshed Campus
Cutting carbon from concept to commissioning: best practises from the Norwegian government

Panu Pasanen, Bionova / One Click LCA
Statsbygg of Norway aims for climate neutral portfolio by 2030

Statsbygg - Norwegian Directorate of Public Construction and Property advises, owns, manages and develops government properties. Statsbygg owns all government properties, including all embassies, and invests some $650 million in construction annually.

Projects reduce 30% carbon against baseline - verified by external expert

- **Pre-project**: 2-5 years pre-design
  - 1. Site selection
  - 2. Programming
  - Review site impacts
  - Fix carbon target and reference

- **Design**: ~1 year of design
  - 3. Technical design
  - Find solutions

- **As built**: ~1 year building
  - 4. Construction
  - Prioritize electric vehicles & machines
  - Require EPDs for main materials
  - Validate carbon target is met

Carbon Smart Day 2018 – Panu Pasanen, One Click LCA: Best practises from Norway’s Statsbygg
The Norwegian baseline is the market average, which already captures all the advances the market has done. This includes 98% renewable energy, wood as the majority market share material and rapidly electrifying transport sector. This is the case to beat.

Baseline for carbon reductions is the Norwegian average

BEATING NORWEGIAN MARKET BASELINE IS NO MEAN FEAT IN ITSELF

FULLY RENEWABLE ENERGY
98% of energy supply renewable

WOOD VERY WIDELY USED
Majority market share in most building types

TRANSPORT ELECTRIFYING FAST
Third of passenger car sales electric, trucks follow
Norway’s carbon accounting methodology – NS 3720 is one of the world’s most comprehensive. It covers cradle-to-grave impacts for materials, transport, construction process, operating energy, user and operational transport. It also considers biogenic and LULUC carbon.

All included: embodied, operating, transport, biogenic & LULUC* carbon

*LULUC = Land Use and Land-Use Change
The first step (early phase) is to advise client on possible solutions to fulfill a property need. Main focus is to ensure that the transport impacts are not going to be extremely high, but also foundation conditions and limitations in energy supply may be considered.

Step 1: Evaluate site options for carbon and recommend one.

**COMPARE SITES**

3-5 options

**FOCUS:** TRANSPORT

**POSSIBLE:** FOUNDATION, ENERGY SUPPLY

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Example of carbon comparisons in a site impacts study:

- Downtown, loose soil
- Inner city, loose soil
- Outside city A, good soil
- Outside city B, good soil
- Nearby city, good soil

- Embodied carbon, foundations
- User transport, 60 years

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**SITE SELECTION IMPACTS TOOL**

2. Transport modes for employees, residents and visitors

- Transport modes by main form of travel
- Number of daily trips per year is in the Quantity field.

3. Transport calculation settings

- Average opening days for employees/residents
- Average visitor travel days
- Parking availability factor
- Average trip length for goods transport

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Carbon Smart Day 2018 – Panu Pasanen, One Click LCA: Best practices from Norway’s Statsbygg
Second step (programming) considers available options, and carbon reference is fixed, and solutions for 30% reduction are identified. Solutions are not binding for designers— they are able to propose other solutions too, but must study specified ones as well.

Step 2: Programming sets project target and reference carbon

SET TARGET

3+ options

FOCUS: MATERIALS, ENERGY & TRANSPORT.

CARBON DESIGNER TOOL

Project materials scope

Building parameters
- Foundations and substructure
- Ground Slab
- Structure
- Enclosure
- Finishes

Building type, size and number of floors

Choose type of reference
- Norwegian/Nordic reference building

Building type
- Office buildings

Gross internal floor area
- 5500 ft²

Number of above ground floors
- 4

More options
In the design step, external designers design the building to make sure it meets the requirements, including the carbon target. This will also involve reporting on all the required options. In this phase, carbon design uses detailed design tools and often also BIM.

**Step 3 : Technical design develops solution meeting the target**

**Design Building**
- **specified options**

![Carbon Impacts of the Specified Options](image)

**Detailed Carbon Design**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Global warming kg CO2e</th>
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<tbody>
<tr>
<td>A1-A3 Construction Materials</td>
<td>1,663,110</td>
</tr>
<tr>
<td>A4 Transportation to site</td>
<td>48,919</td>
</tr>
<tr>
<td>A5 Construction/Installation process</td>
<td>14,830</td>
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<tr>
<td>B4-B5 Material replacement and refurbishment</td>
<td>53,726</td>
</tr>
<tr>
<td>B6 Energy use</td>
<td>3,181,181</td>
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<tr>
<td>B8 Operational transport</td>
<td>1,471,763</td>
</tr>
<tr>
<td>C1-C4 Deconstruction</td>
<td>32,890</td>
</tr>
<tr>
<td>D External impacts (not included in totals)</td>
<td>-93,019</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,465,318</td>
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Carbon Smart Day 2018 – Panu Pasanen, One Click LCA: Best practises from Norway’s Statsbygg
In the construction process, construction firms have to show they meet the carbon targets with actual quantities and actual products used. High impact materials have to deliver an EPD and meet carbon thresholds for them. Energy use is measured in commissioning.

**Steps 4-6: Construction firm has to prove carbon target is met**

**BUILD IT**

Options: rare

FOCUS: MATERIALS, SITE IMPACTS, MEETING GIVEN TARGETS FOR ENERGY PERFORMANCE.

**CARBON IMPACTS FOR ACTUAL QUANTITIES AND PRODUCTS**

**CARBON LIMITS:**

Limits always for:

CONCRETE, STEEL GYPSUM AND INSULATION. MORE IN MOST PROJECTS.
Statsbygg developed and operated an inhouse carbon tool for a decade. In late 2016 Statsbygg started looking for market-based solutions, which resulted in One Click LCA being selected. It has been adapted to Statsbygg requirements.

The whole process uses a customized version of One Click LCA

EARLY PHASE

BENCHMARKS

LANGUAGE

BASELINES

STANDARDS

BIM STRATEGY

Carbon Designer

Baseline CO2e  Optimized CO2e  Carbon savings +11.89%

Embedded carbon benchmark

Office buildings, North America

Embedded carbon by lifecycle stage

Norwegian

Local baseline model

NS 3720
NS 3541
...

Carbon Visualisation

LCA & Model Checkers

Type

Issue

Implausible thickness ?

Geometry errors ?

Non-material objects ?
One Click LCA is the world’s most widely used commercial built environment LCA software. It’s used in 50+ countries today, and supports almost all national certifications and standards for which third party developers can achieve compliance, including LEED v4.

One Click LCA is a life-cycle platform for the built environment

SOME OF THE CAPABILITIES

<table>
<thead>
<tr>
<th>INTEGRATIONS</th>
<th>VERIFIED DATABASE</th>
<th>CERTIFICATIONS</th>
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<tr>
<td>8</td>
<td>10 000+</td>
<td>30+</td>
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SOME OF THE BUSINESSES WE ARE PROUD TO SERVE

Carbon Smart Day 2018 – Panu Pasanen, One Click LCA: Best practices from Norway’s Statsbygg
Statsbygg has set climate requirements for construction projects and products since 2007. And it works! Introducing new requirements for new types of systems like building installations is today only done in pilot projects, general requirements apply to all works.

Carbon reduction that works: set requirements & verify

#1 REQUIRE CARBON CUTS
Fix the targets. Put them in contracts.

#2 VERIFY THE CARBON CUTS
Assign expert to verify the results.

#3 START ON CARBON EARLY
Avoid lock-in to high carbon trajectory.

#4 UNDERSTAND FEASIBILITY
Develop view of what can be done today.
Case study: new national museum halved it’s carbon footprint

“GREEN NATIONAL MUSEUM” – OPENING IN 2019

SOLUTIONS E.G.

- Dense building shape
- Good air tightness
- Heat pump based supply
- Material choices
- Material sourcing
- Limited parking

Read all about it: https://www.futurebuilt.no/Forbildeprosjekter#!/Forbildeprosjekter/Nytt-nasjonalmuseum

Carbon reduction by scope - kg CO2e / m² / year
Thank you for your attention!

One Click LCA

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Breakout Sessions (15 minutes)
1. Define an embodied carbon strategy for owners and/or developers to adopt
2. Identify the post probably or stubborn barriers to scaling this strategy
3. Suggest strategies for success to over come those barriers

Summary of findings + insights from panel (15 minutes)
Let’s Get to Work!

• Projects around the world are already taking action to minimize carbon (including embodied)
• Solutions exist for owners and developers who are bold and visionary
• Let’s inspire, equip, and lead by doing!

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