Marginal Emission Factors for Grid Electricity in Consequential LCA for Building Energy Systems

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Overview

Objective

- Investigate how marginal emissions factors should be used within assessments for changes in a building's operational energy use

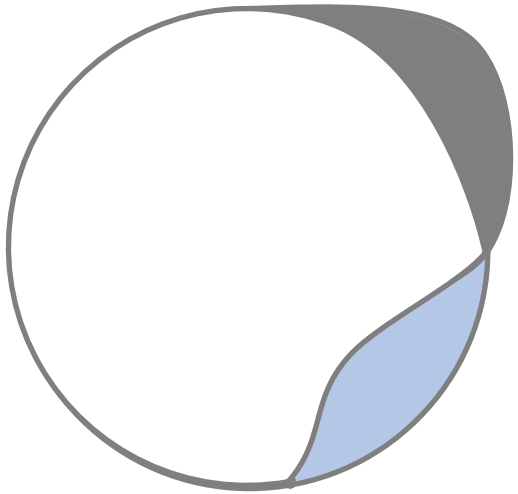
Approach

- Assess how on-site renewables and on-site storage influence a building's energy demand
- Compare how average and marginal emissions factors differ at times of import and export
- Assess how the choice of marginal and average emissions factors influences conclusions from the assessment

Consequential Life Cycle Assessment

Fundamentals:

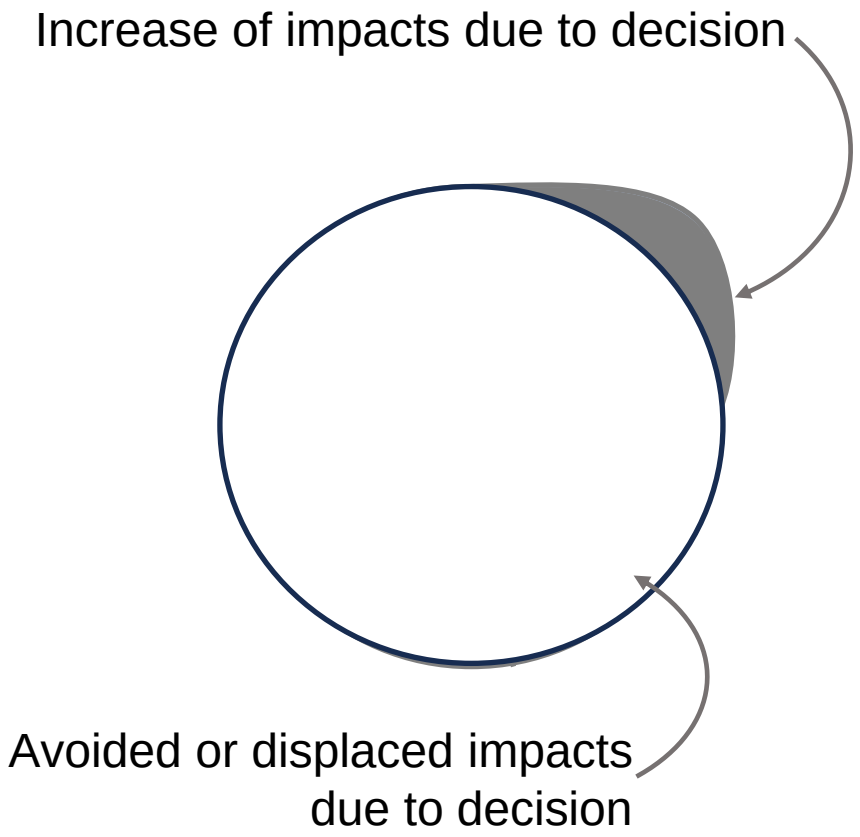
- Assesses how a decision changes global environmental impacts
- Evaluates impact against a situation when the decision was not taken
- The decision leads to a change in demand
- Only considers the processes that change in response to a change in demand



Consequential LCA for energy analysis

Questions to ask:

- What is the decision being assessed?
- What is the baseline that you are evaluating your decision against?
- What are the discretionary energy loads placed on the electricity grid?
- What generation plant is being used to meet those discretionary loads?



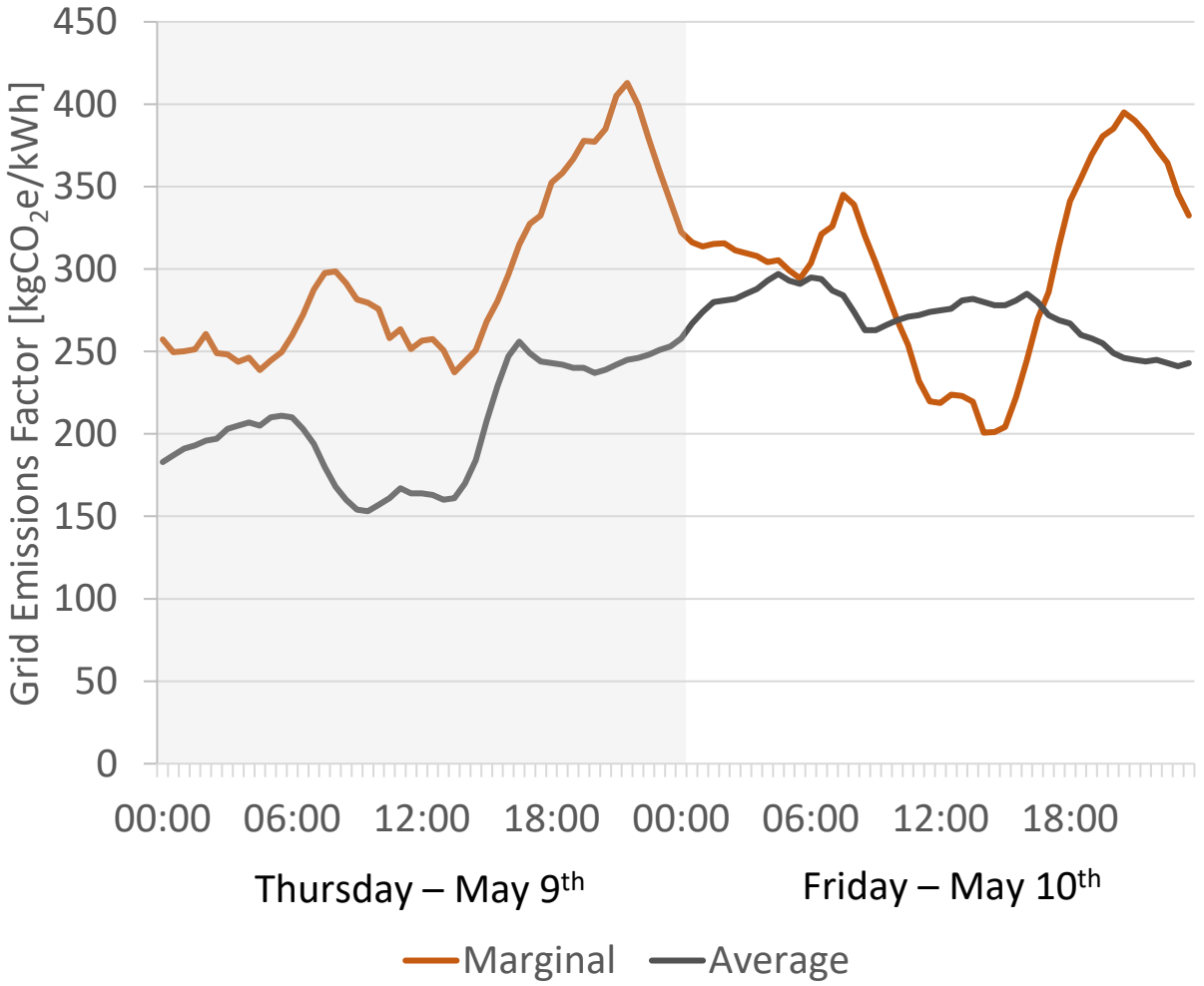
Grid Electricity Emissions Factors

Average Emissions Factors

- Average impact for producing a unit of electricity at a given time
- All types of generation plant used to produce electricity

Marginal Emissions Factors

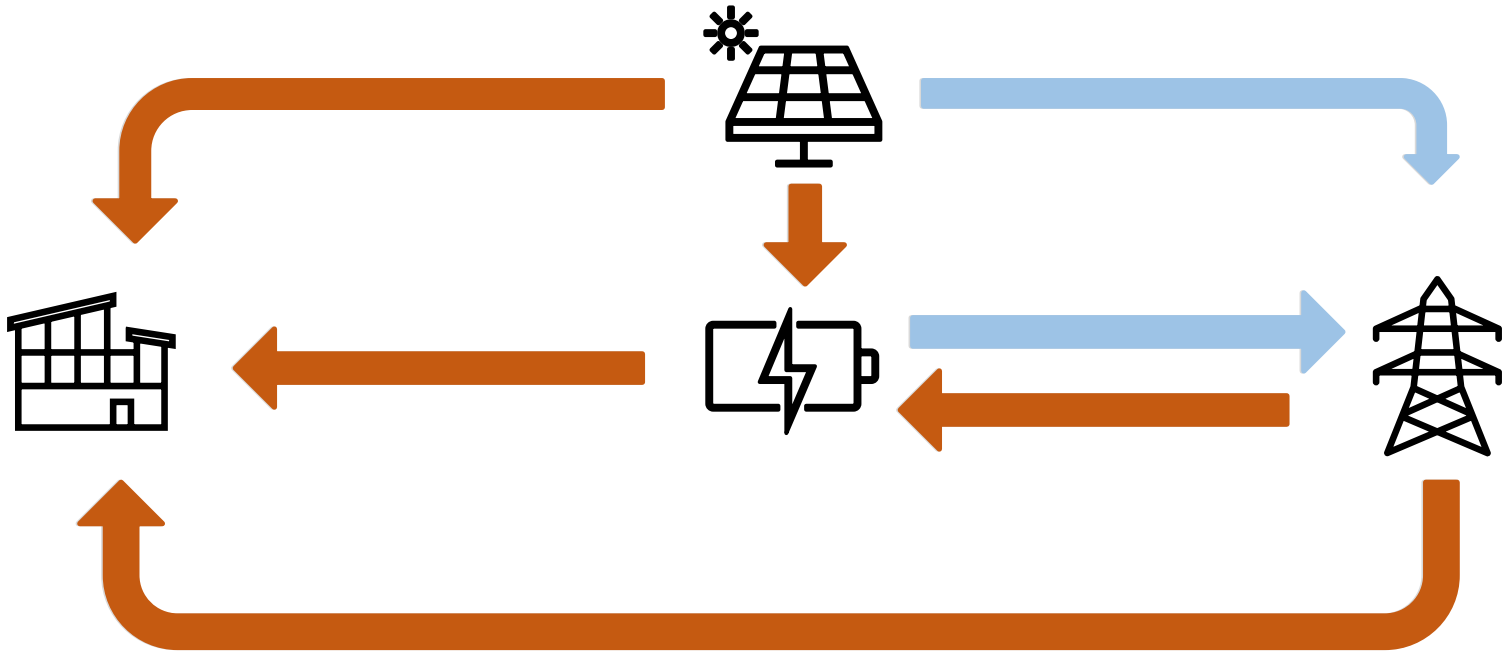
- Impact from changing demand for grid electricity
- Only accounts for plant that changes capacity to meet a change in demand



Case Study: Net Zero Energy Building

What is the impact for including the energy storage system within the building's energy use strategy?

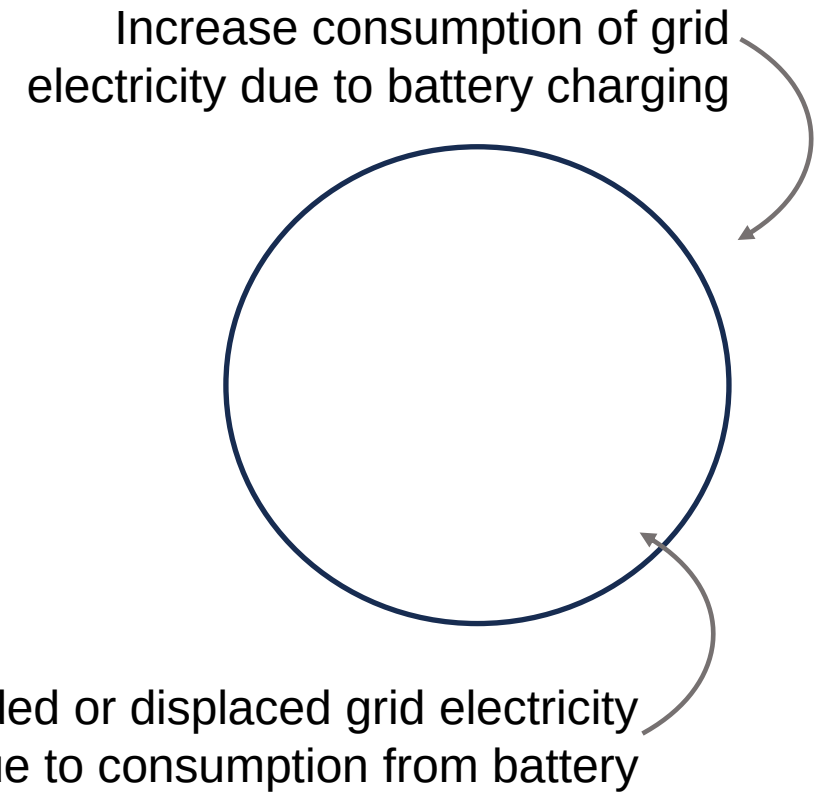
Case Study Building Energy Flows



Consequential LCA of operational energy use

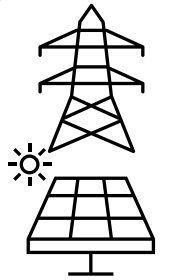
Baseline Scenario:

- All energy demands met by grid electricity at time of use



Evaluated Scenario:

- Energy demands met by a combination of:
  - Import from grid
  - On-site generation
  - On-site storage



Baseline results

Building demand met by: **grid electricity**

- 27,550 kWh/year imported from grid

Type of Grid Emissions Factors: **Average**

- Building demand is not dependent on decision studied

Impact for grid electricity use:

Case study building with on-site energy generation

Building demand met by: **Photovoltaic and Grid Electricity**

- 21,000 kWh/year imported from grid

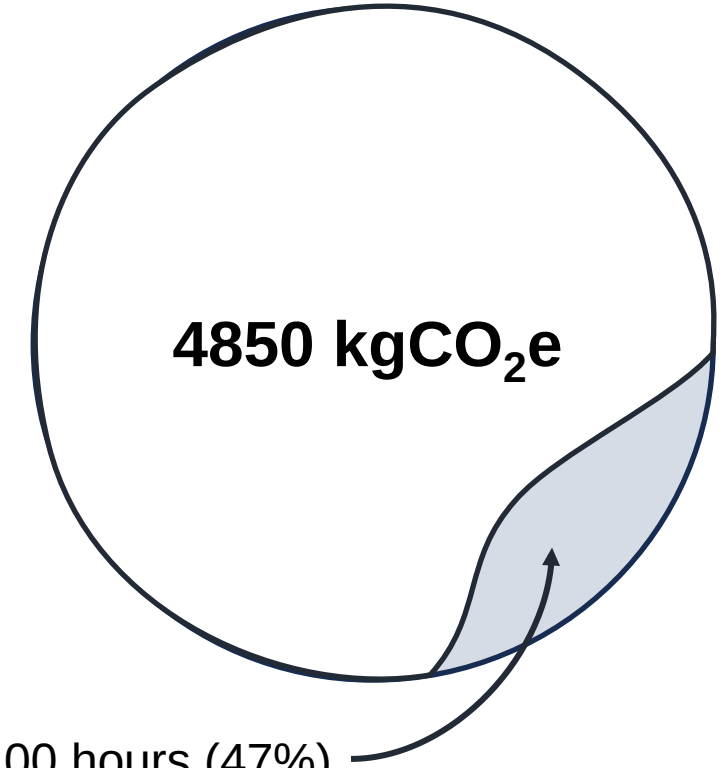
Type of Grid Emissions Factors: **Average**

- Building demand is not dependent on decision studied

Export of Electricity to Grid **[Module D]**

- 8300 kWh exported when generation > demand

Impact for grid electricity use:



Case study building

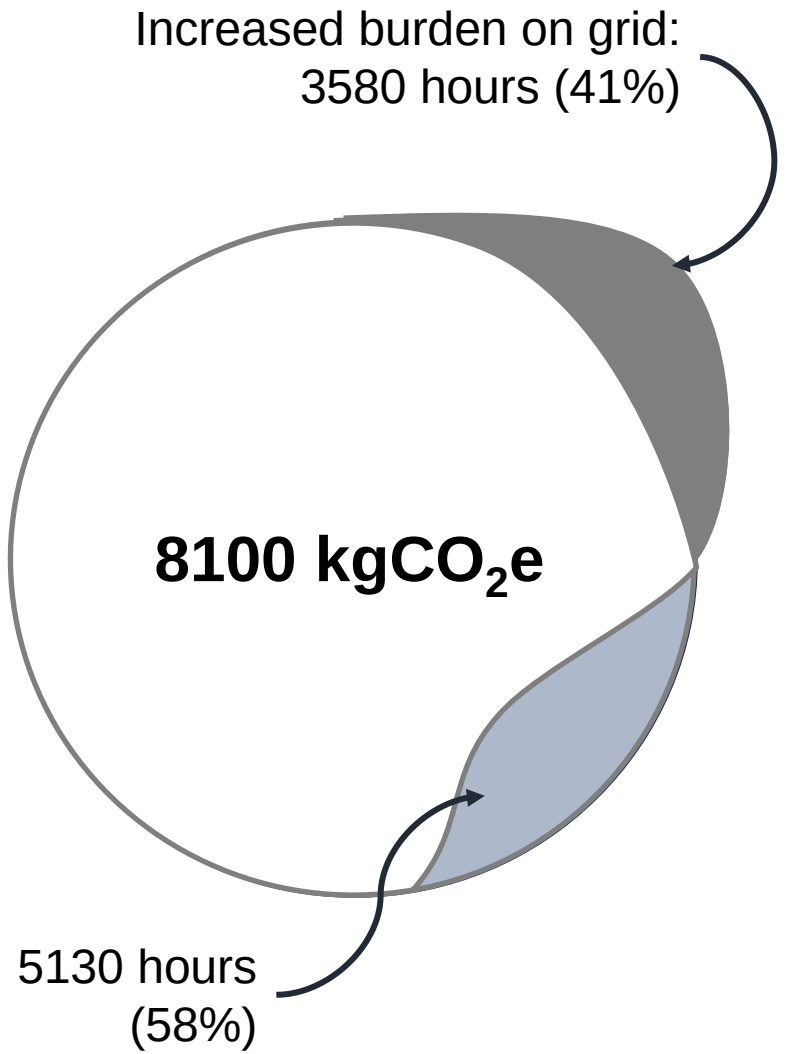
Building demand met by: **Photovoltaic, Grid and Battery**

- Electricity imported from grid:
  - 13,250 kWh for direct consumption **(AEF)**
  - 18,900 kWh to charge battery **(MEF)**

Type of Grid Emissions Factors: **Average and Marginal**

Export of Electricity to Grid **[Module D]**

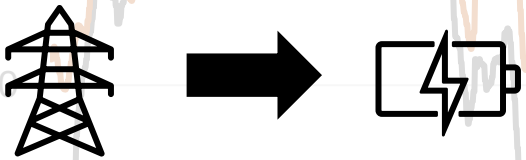
- Direct export from PV: 5450 kWh
- Export from battery: 5000 kWh



Comparison Between Average and Marginal Emissions Factors

Marginal Emissions Factor (MEF) > Average Emissions Factor (AEF): 7540 hours (86%)

Battery was charged using grid electricity for 3800 hours (43%) while **MEF > AEF**



Grid Electricity to Battery

Impact for charging battery with grid electricity

AEF: 3625 $kgCO_2e$ **MEF: 5100 $kgCO_2e$**

increase of 41% when using MEF to account for the discretionary load placed on the grid by charging the battery with grid electricity

Final Thoughts and Next Steps

Consequential LCA:

- Can assess environmental impacts from changing a building's energy profile
- Captures the burden placed on the electricity grid by adding more technology within a building
- Marginal Emissions Factors should be used for discretionary loads added to the grid

Next Steps

- Formalize guidance for assessing changes in a building's energy demand profile using consequential LCA
- Investigating other applications of consequential LCA within the built environment

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