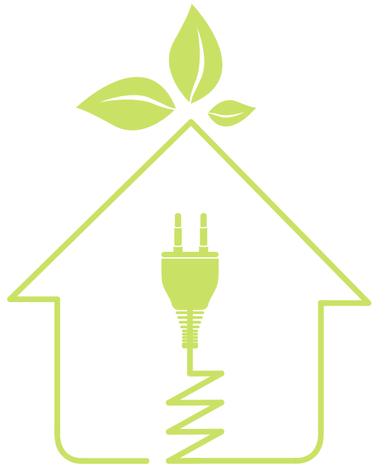
Shaving Peak Power Demand: A Comparative Life Cycle Assessment



Energy Star Home Energy Management System
vs
Tesla Powerwall II

01

What is Demand Shaving?

Peak demand: period of time where consumer electricity demand is significantly higher than average.

The Concern

- Electricity demand spikes can lead to blackouts
- Renewable energy not as available during peak demand
    - reliance on fossil fuels

Current Solutions

- **Demand Side Management:** Utility providers rely on consumers to reduce energy consumption during periods of peak demand
    - Two approaches to energy optimisation:
        1. Energy storage in a battery
        2. Energy management system

02 Project Focus

Tesla Powerwall II

vs

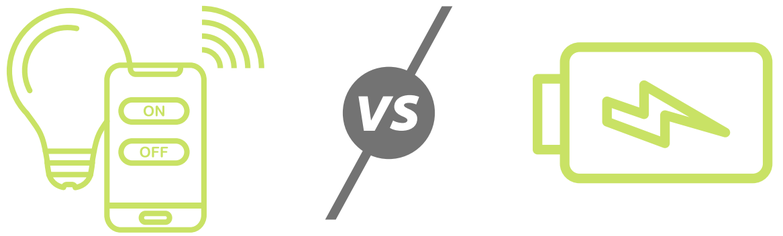
Energy Star Home Energy Management System

Goals

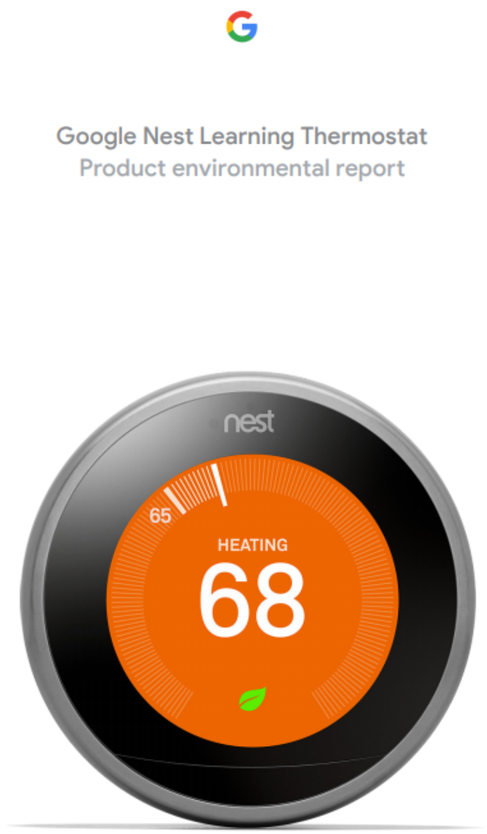
- Research and understand product and technological systems
- Conduct LCA of Tesla Powerwall II and Energy Star HEMS

Objectives

- Compare relative impacts and peak demand shaving capabilities
- Determine which is environmentally and economically preferable



Current Literature?



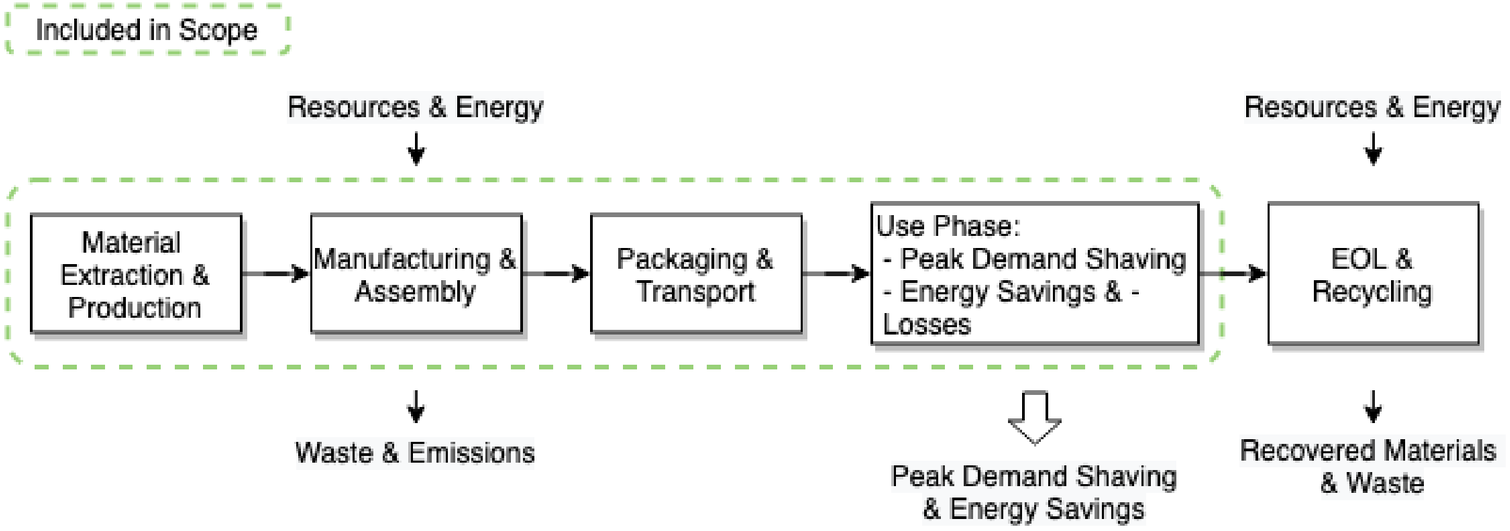
- Company environmental impact reports
- Peer-reviewed literature consensus
  - Batteries: materials and chemistry
  - HEMS: use phase
- Renewable grid mix --> reduced impact

Functional Unit & System Scope

- Functional unit:

  kWh of peak demand shaved across a 10 year lifetime

- Inventory and impacts from cradle to gate, excluding EOL & recycling
  - Global warming potential and energy consumption



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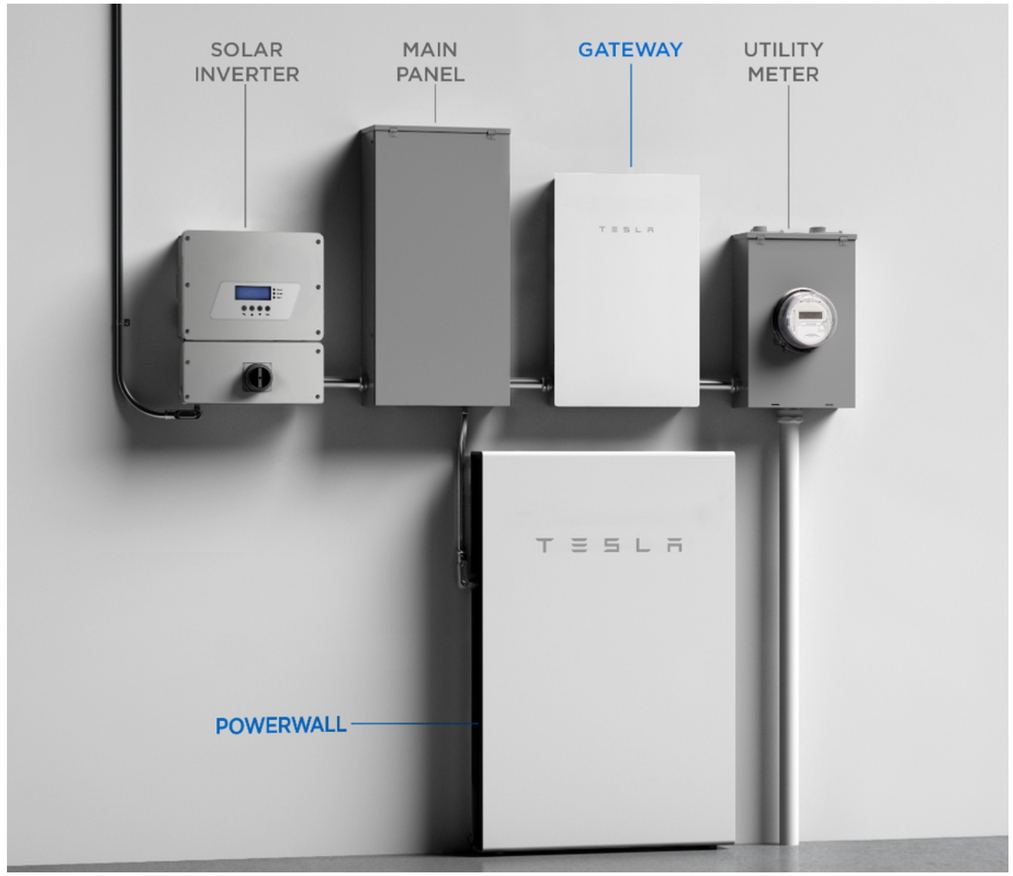
home energy demand & grid settings are kept constant throughout analysis

Tesla Powerwall II: Components



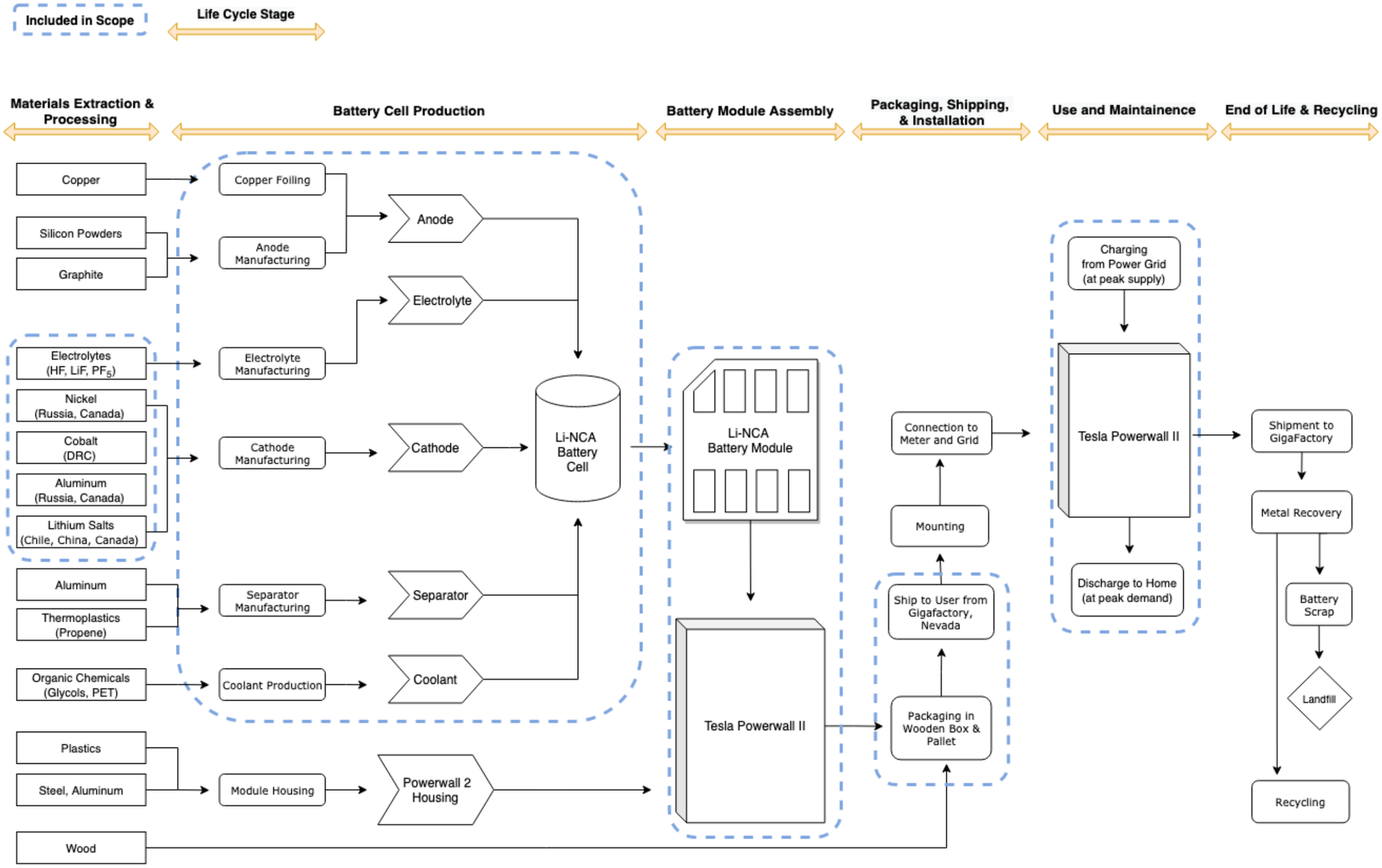
1. **Tesla Powerwall II**

   Rechargeable Lithium-Ion NCA Battery (focus of this study)

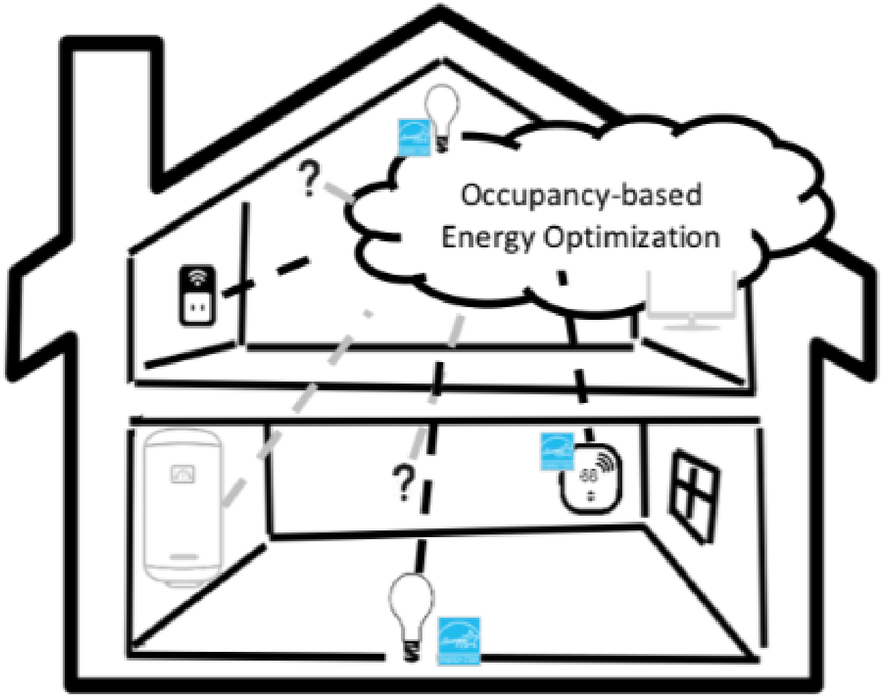
2. **Tesla Backup Gateway**

   Controls Battery Activities (not included in scope due to lack of information & relative impact)

System Boundaries: Tesla Powerwall II

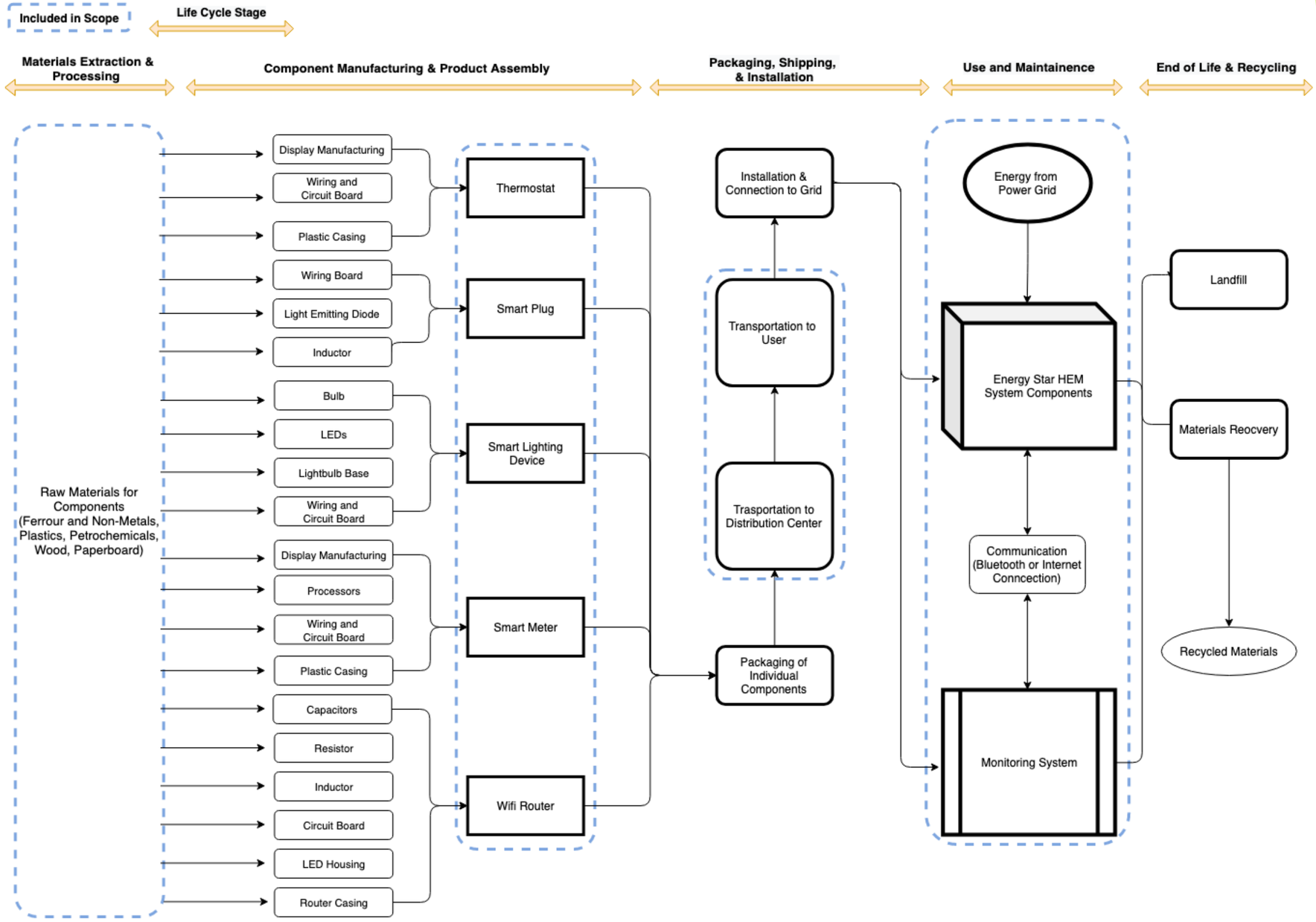


HEMS: Components



1. **Management Devices**
   a. Retrieve, collect, store information through mobile app (out of scope)
   b. Smart meter
2. **Field devices**
   a. Smart plugs
   b. Smart thermostat
   c. LED Smart bulbs
   d. Internet system

System Boundaries: HEMS



Methods: Data Collection & LCA Tools

Inventory Data (Secondary):

- Federal Agencies (DOE, EPA, DOC, etc.), Environmental Organizations
- Google Scholar, USC Libraries, etc.
- Product specification sheets, Impact Reports

Impact Assessment & LCA Software:

- **EIO-LCA:** Carnegie Mellon tool for estimating impacts from economic activity
- **PackageSmart:** EarthShift Global tool for estimating impacts resulting from packaging designs
- Conversion factors from literature

Methods: Inventory & Impact Calculations

Inventory Calculations (whenever literature was unavailable):

1. Research literature to shape system boundaries
2. Determine mass of relative material inputs
3. Use secondary data to estimate energy inputs for production
4. Determine packaging materials and shipping methods
5. Use specs to calculate energy loss during use for Powerwall

Impact Calculations:

1. Use EIO-LCA tool to calculate impacts for material extraction and production
2. Use conversion factors to find impacts from production and assembly
3. Use PackageSmart tool to calculate impacts for packaging
4. Use conversion factors to find impacts from transport
5. Convert energy losses to GWP impacts for Powerwall

Methods: Peak Shaving Calculations

Peak Demand Time for Southern California: 4-9 pm

Peak Shaving for HEM System:

- **Appliances Attached**
  - Dishwasher
  - Clothes washer & dryer
  - Air Conditioner
  - Rechargeable electronics
- Calculated average daily energy consumption using typical appliance power outputs and duration of use

Peak Shaving for Powerwall System:

- Average Peak Demand in California per day was calculated using the EIA hourly demand monitor
- Powerwall Demand shaving and recharging methodology during peak supply was modeled to optimize cost.

Total average shaving potential can then be assessed on a daily, yearly, or lifetime basis

Limitations

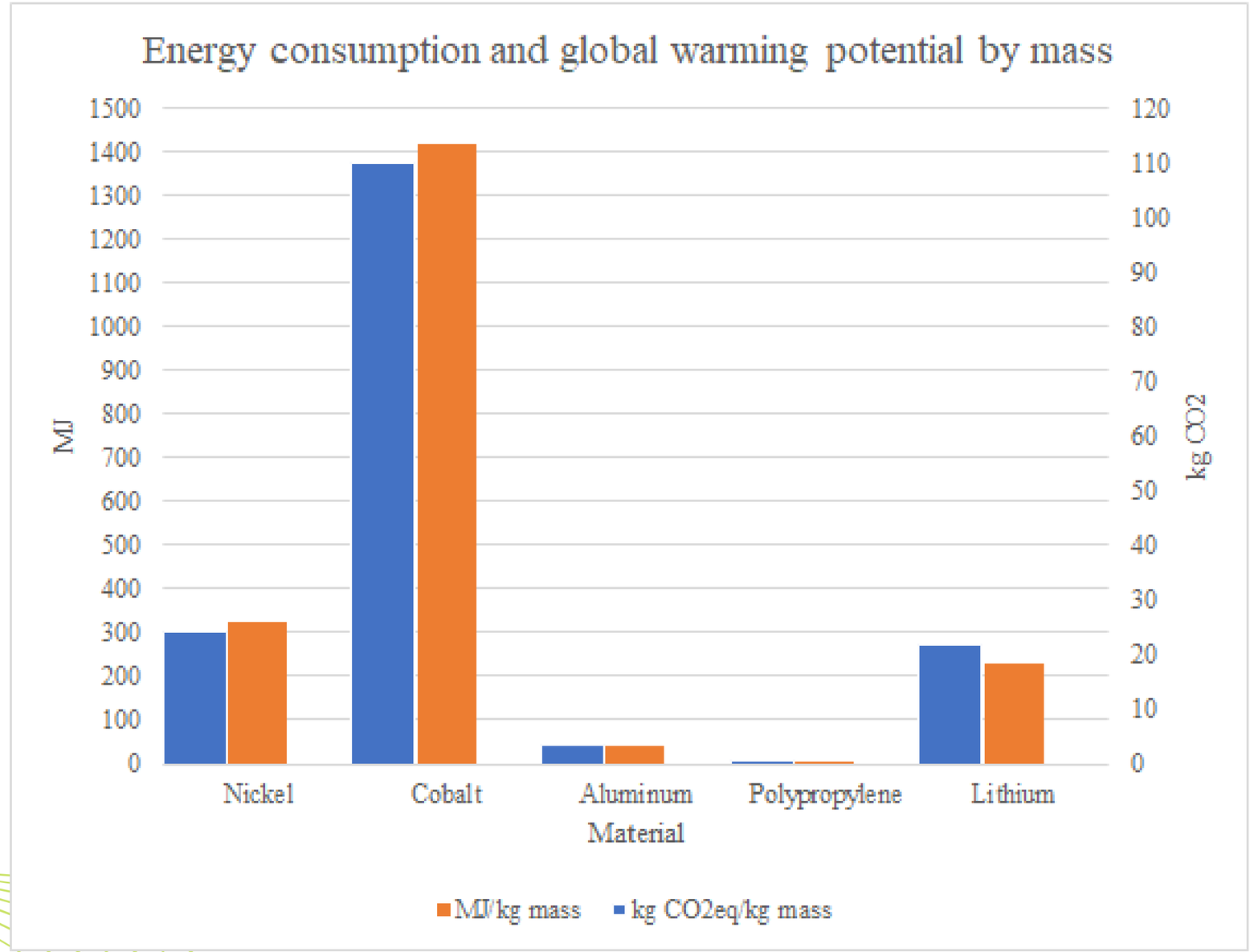
Data:

- Relying on only secondary data
- Incomplete data sets due to diversity in literature, incomplete information, or hard-to-find figures
- Mandatory assumptions at the different stages of the LCA regarding the relative prices of components, the composition of the devices, and the processing methods
- Impossibility to assess a diversity of impacts

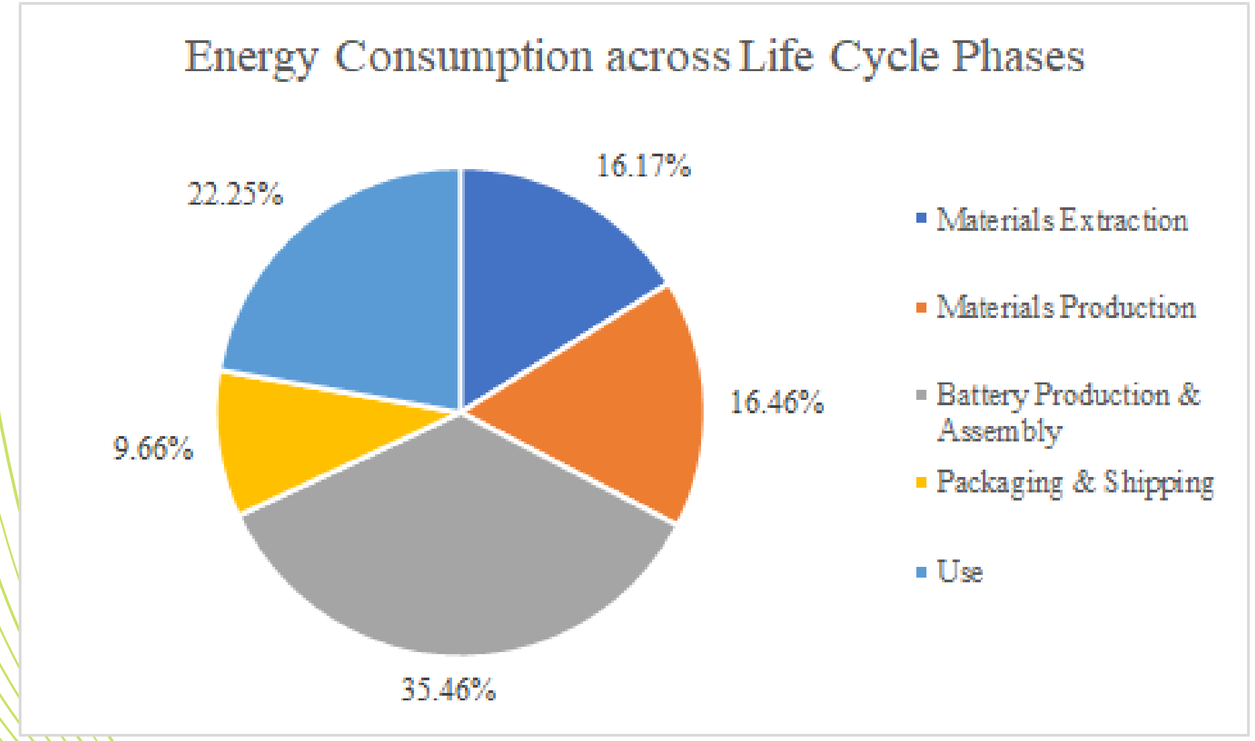
System Arrangement:

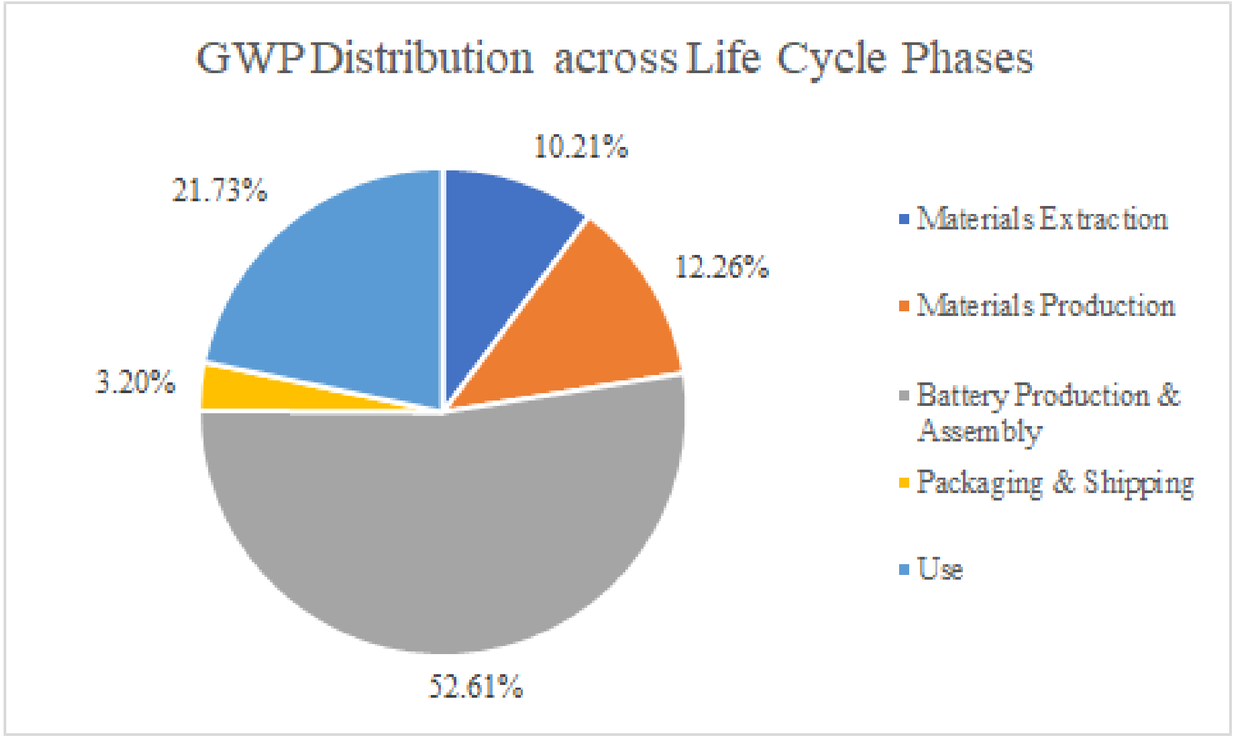
- The HEMS considered in the analysis represents the minimal case scenario (basic system components) with the addition of a smart meter and an internet system
- The Tesla Powerwall II considered in the study excludes the backup gateway due to the lack of available information
- The energy is exclusively obtained from the grid which would lead to significant modifications in overall impacts and shaving figures
- Household size, occupancy, and demand assumed

13 Analysis: Powerwall Inventory Impacts

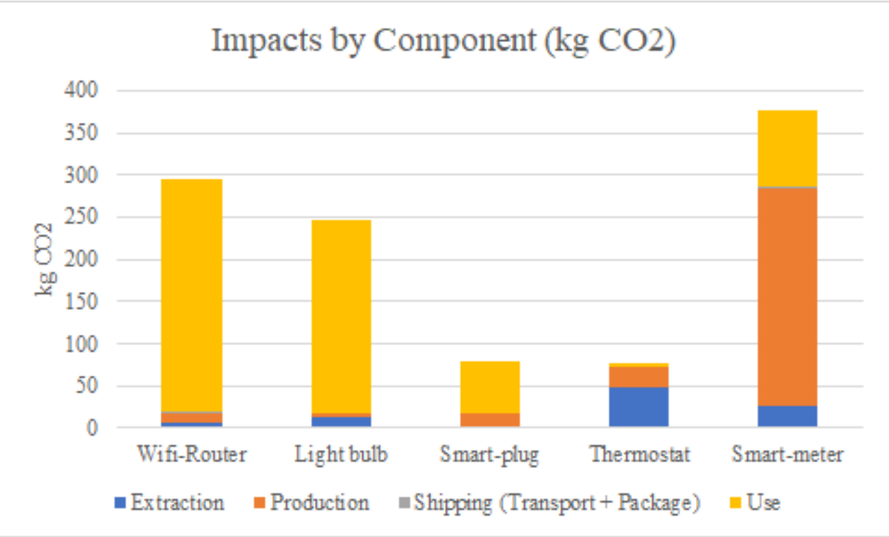


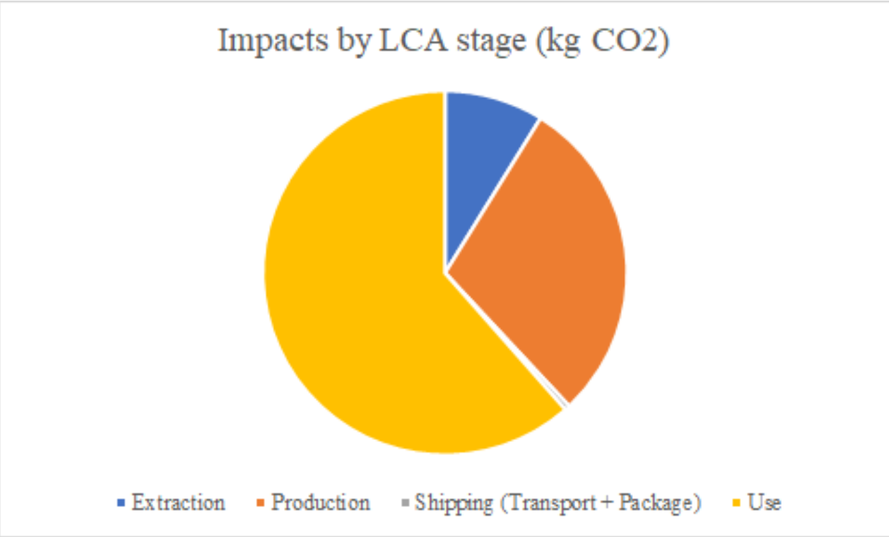
14 Analysis: Powerwall Inventory Impacts

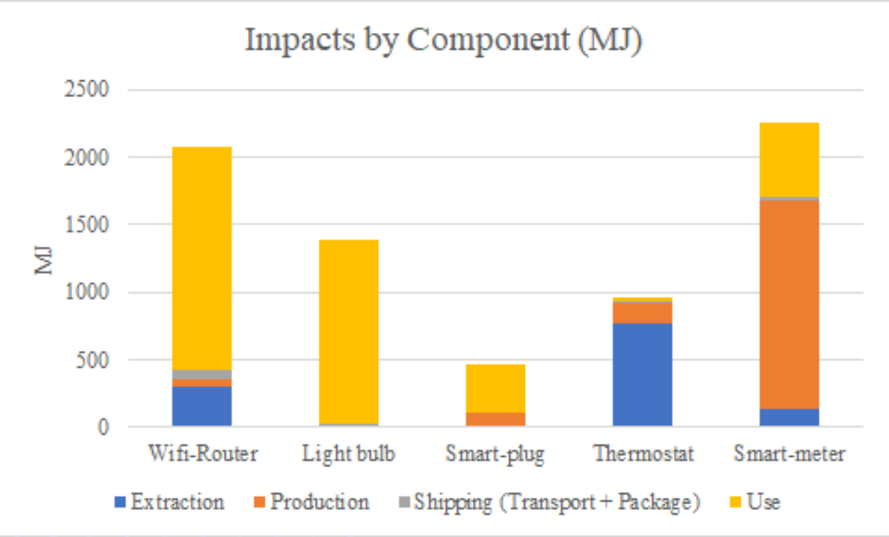


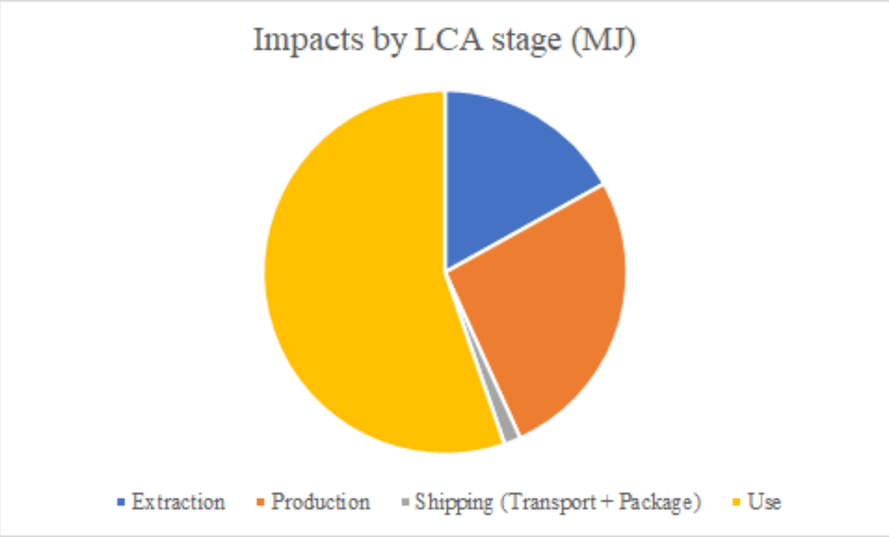


15 Analysis: HEMS Inventory Impacts







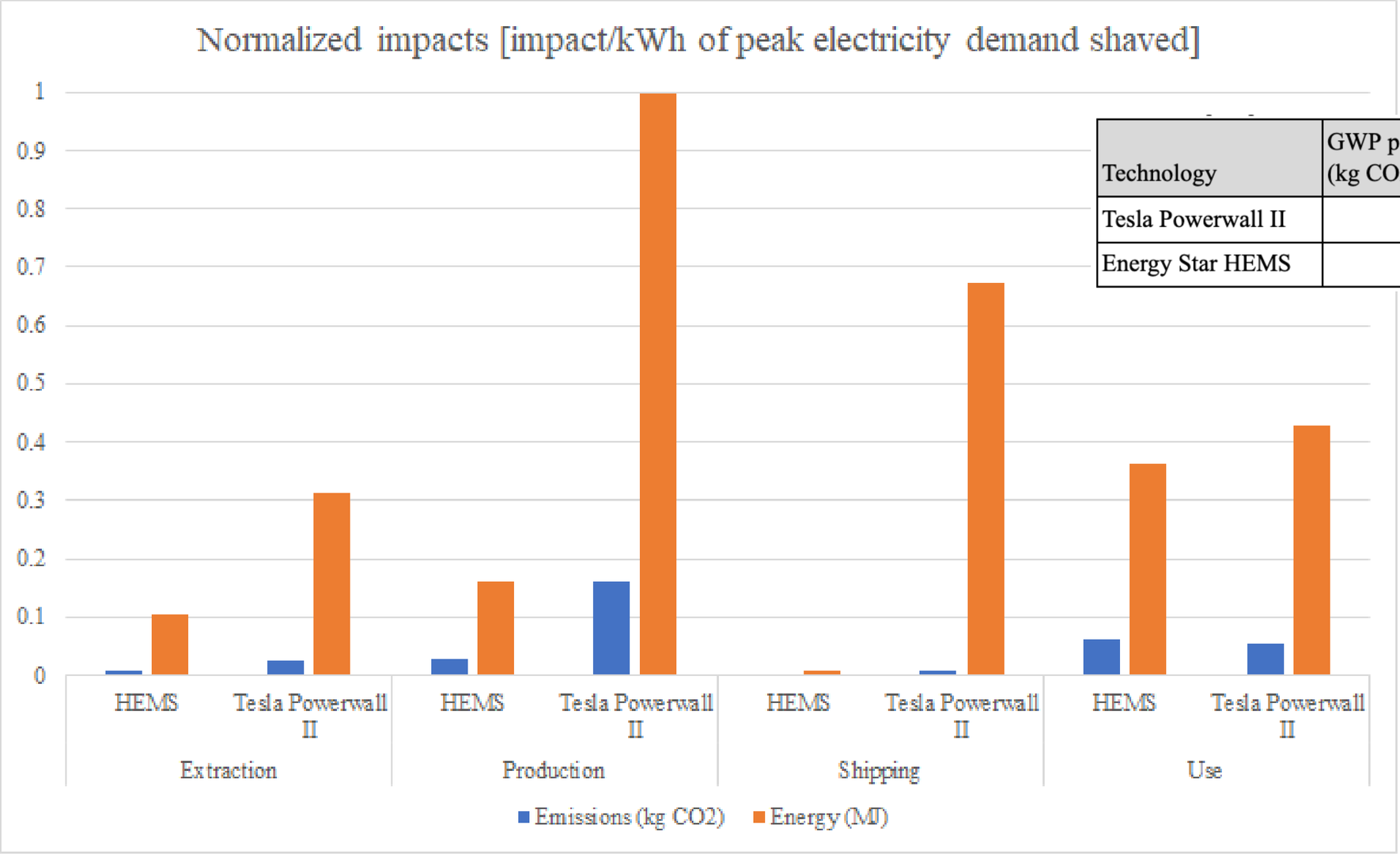


16 Analysis: Peak Shaving

Powerwall System Peak Shaving		
Daily shavings:	5.20	kWh
Yearly shavings:	1925	kWh
10 year lifetime:	19250	kWh

HEMS System Peak Shaving		
Daily shavings:	3.188	kWh
Yearly shavings:	1,163.62	kWh
10 year lifetime:	11,636.2	kWh

Comparative Analysis



Technology	GWP per kWh shaved (kg CO2eq / kWh)	Energy consumption per kWh shaved (MJ / kWh)
Tesla Powerwall II	0.25	2.41
Energy Star HEMS	0.096	0.64

Cost/Benefit Analysis

COST ANALYSIS:		POWERWALL	HEMS
COST OF TECHNOLOGY	Intial cost of	$9,600.00	$442.50
	Use phase cost + maintenance	$600.00	$600.00
	TOTAL	$10,200.00	$1,042.50
COST SAVINGS in 10 Years	Peak Shaving	$1,105.46	$1,396.66
	Energy Optimization	$0.00	$2,360.00
	TOTAL	$1,105.46	$3,756.66
	Difference	$1,105.46	$6,116.66

Conclusion and Recomendation

Recommendations:

- For this grid setting, the Energy Star HEMS is the preferable option for shaving peak demand
- The Tesla can shave more peak demand, but is much more environmentally impactful and expensive
- The HEMS also reduces your energy consumption by roughly 10%

Future studies:

- Use more sophisticated LCA tools not limited to Package Smart and EIO-LCA
- Incorporate "grave" phase
- Utilize primary data
- Geographically ample study
- Inclusion of broader components (i.e. solar panels, full HEMS system)

ISE 576 | FINAL PROJECT PRESENTATION

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Questions