

# CHARGING HUB ECONOMIC AND COSTING TOOL (CHECT)



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# AGENDA

- CHECT Introduction
- CHECT Demo
- CHECT Resources

# CHECT'S PURPOSE AND KEY FEATURES

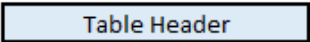
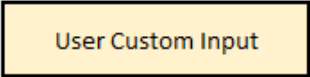
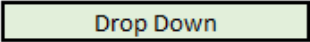
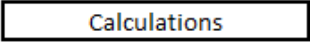
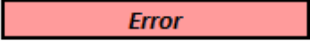
**CHECT is for property owners, private companies, or utilities considering the installation of EV charging hubs.**

- Uses a robust techno-economic analysis framework.
- Enables users to estimate charging costs (\$/kWh) at charging hubs. Users can:
  - Input custom inputs or use defaults (cited)
  - Develop scenarios to evaluate
- Performs sensitivity analysis, ownership model comparisons, and state comparisons.
- Includes a clear, detailed README document describing each table.

# CHECT OVERVIEW

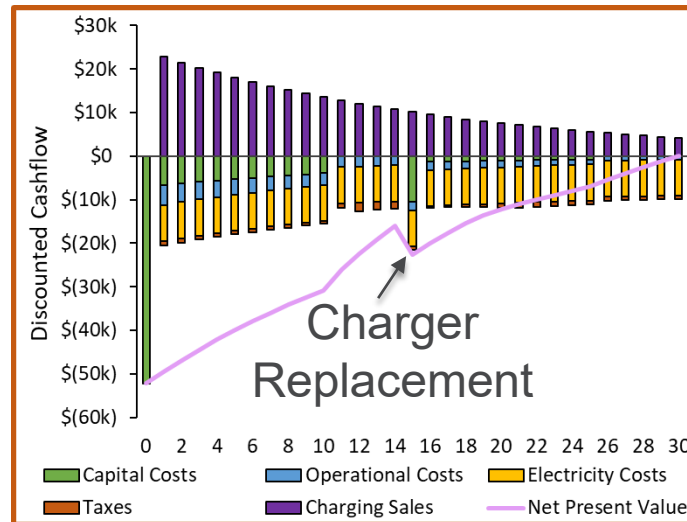
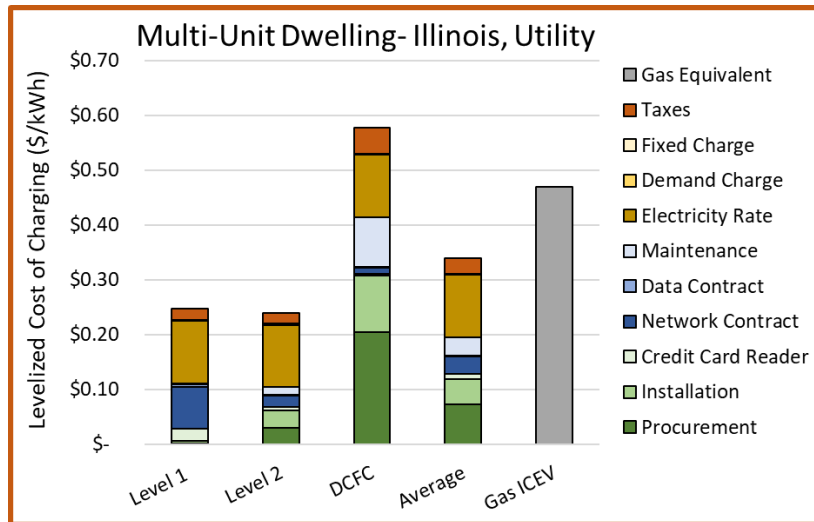
- **Based in Microsoft Excel**
- **Estimates the Levelized Cost of Charging (\$/kWh)**
  - Discounted cashflow rate-of-return analysis
  - Price of charging for a Net Present Value of zero
- **Multiple scenario options**
  - Multi-Unit Dwelling or Public
  - Ownership model
    - Residential, utility, or private company
  - Number of chargers
    - Level 1, Level 2, and/or DCFC
  - Charging schedule
  - Residential and commercial utility rates in 50 states

# COLOR SCHEME FOR CELLS IN CHECT

<b>Color Scheme for Cells in the CHECT Tool</b>	
 Table Header	Blue cells are for table headers
 User Custom Input	Yellow cells are key assumptions that users can change with their data. Filling in a blank yellow cell will override the defaults used in the calculation with its value. Return to blank to get defaults.
 Drop Down	Green cells are key options that users will select from a drop-down menu.
 Calculations	Clear cells are for calculations and secondary assumptions. These cells are recommended not to be changed.
 <i>Error</i>	Red cells display that the cell value needs to be updated.

# LEVELIZED COST OF CHARGING

- Solves for the levelized cost of charging of the hub
  - Based on scenario selections
- Break out cost for each charger type



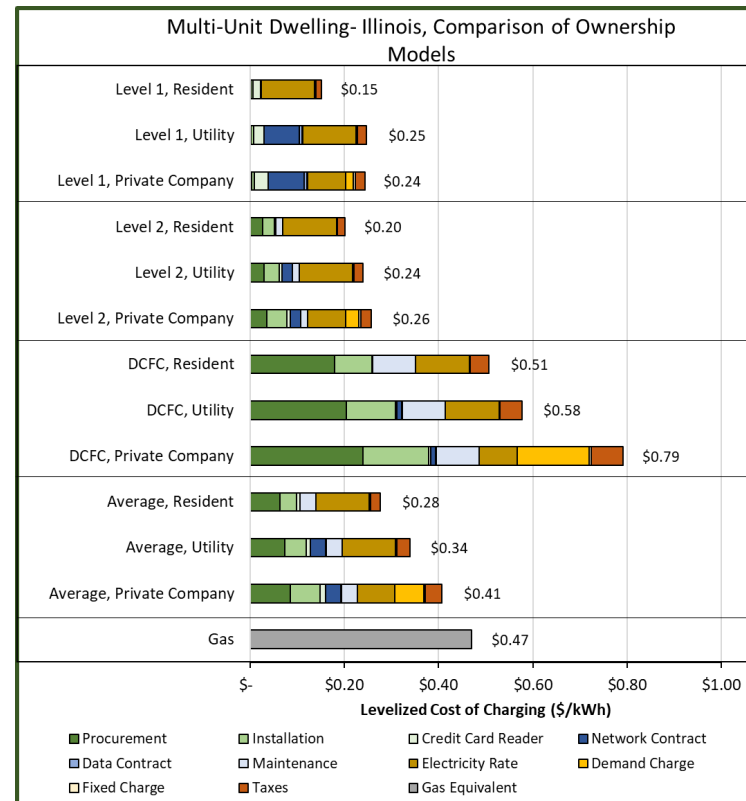
# COMPARISON OF OWNERSHIP MODELS

- Compares charging cost for multiple ownership models

Update Ownership Model Comparisons for Location (<1 sec)

- Applicable utility rate\*
  - Residential: Residential & Utility
  - Commercial: Private Company
- Network and Data Contracts\*
  - Yes: Utility and Private Company
  - No: Residential
- Internal rate of return\*
  - 3%: Residential
  - 6%: Utility
  - 10%: Private Company

\*Can be adjusted in CHECT

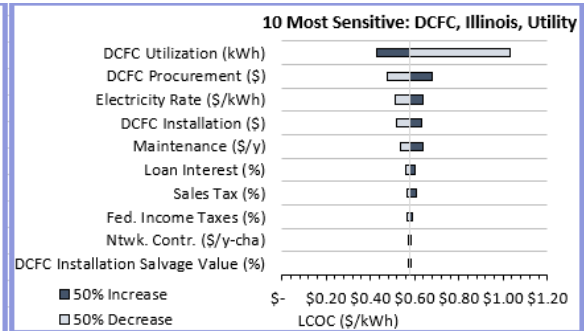
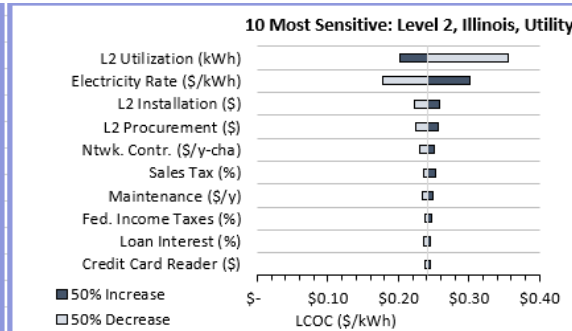
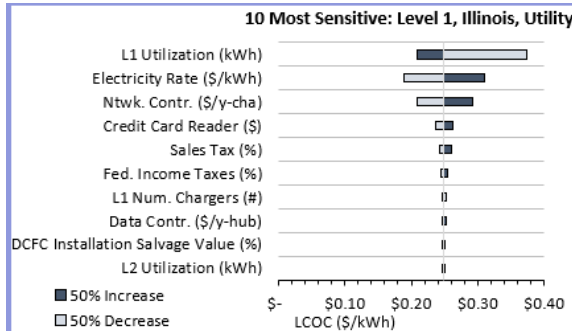


# SENSITIVITY ANALYSIS

- Runs sensitivity analysis for all 45 inputs
  - Determine the most sensitive inputs of the selected scenario
- Reports 10 most sensitive inputs
  - Broken out for Level 1, Level 2, and DCFC
  - Updates charts

Update Sensitivity Analysis of Selected Scenario (<1 min)

Economic Scenario Controller	
Charging Hub Type	Multi-Unit Dwelling
Service Location/Electricity Rate	Illinois
Analysis Period (years)	30
Ownership Model	Utility
Buy Credit Card Reader	Yes
Default Costs	Mean
Year of Analysis (PPI Dependent)	2022
Adjust Nominal Utility Rates to Analysis Year	Yes
Gasoline ICEV Comparison	Passenger Car
Custom Gasoline Cost (\$/gallon)	
Custom BEV Fuel Economy (MPGGE)	
Custom Gasoline ICEV Fuel Economy (MPGGE)	
Sensitivity Analysis Change (+/-)	50%

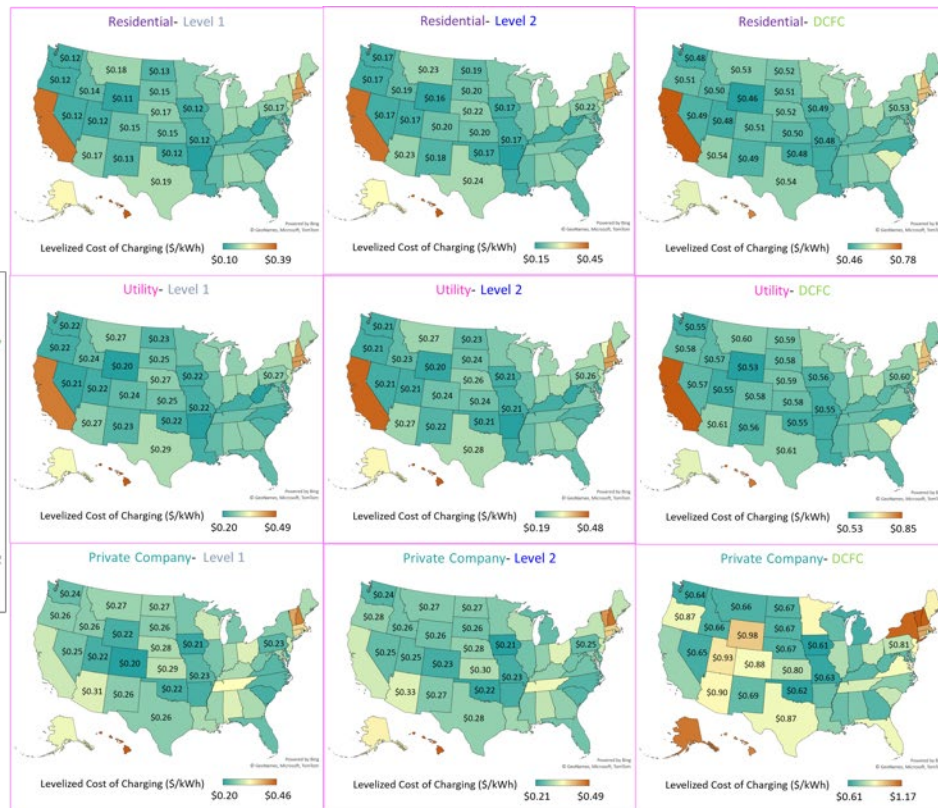
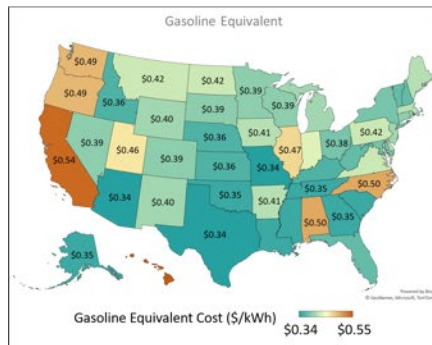




# COMPARISON BY STATE

- Can compare results of multiple states for selected scenario
  - Runs for all ownership models

Update State Comparisons (<1 min)

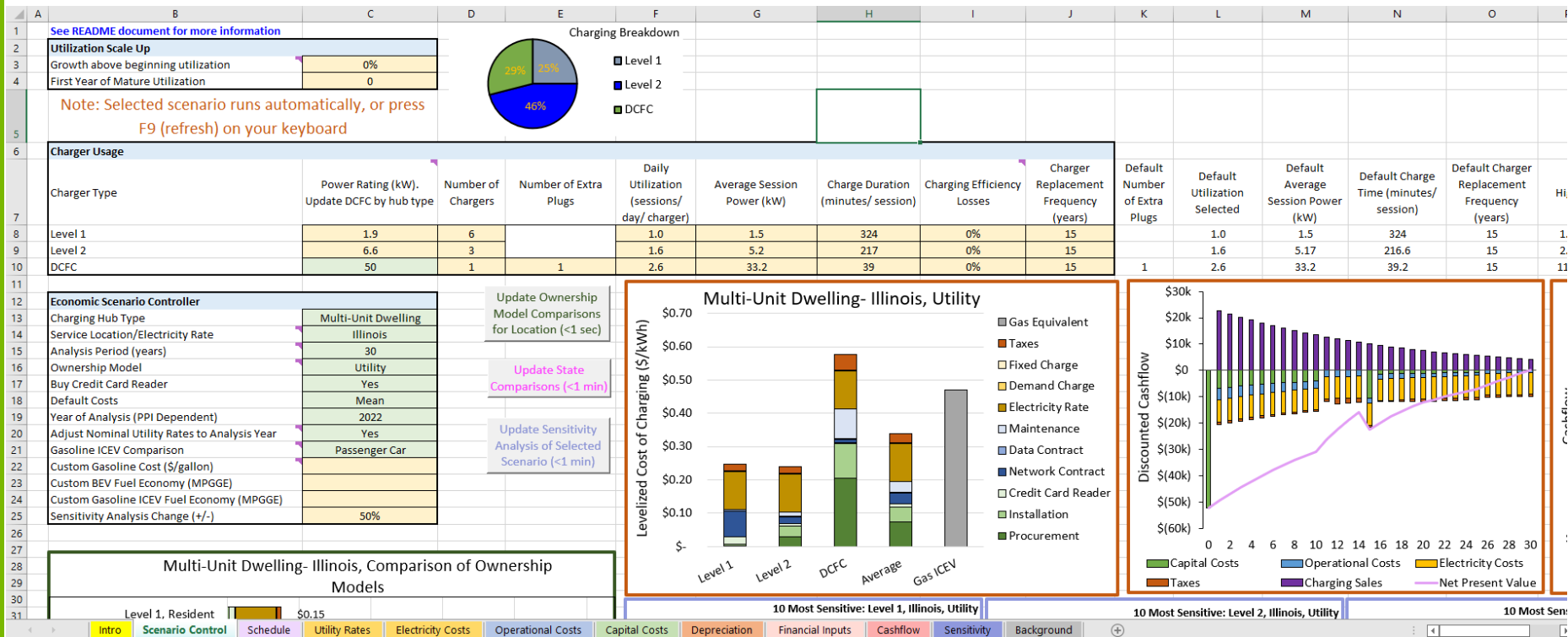


# SCENARIO CONTROLLER

- Charging hub type
  - Multi-unit dwelling or public
- Service location or custom
- Analysis period (1-30 years)
- Ownership model
- Credit card reader
- Year of analysis (2011-2022)
  - Scale costs to year
- Compare BEV charging costs to gasoline ICEV fueling costs
  - Fuel economies and fuel price

Economic Scenario Controller	
Charging Hub Type	Multi-Unit Dwelling
Service Location/Electricity Rate	Illinois
Analysis Period (years)	30
Ownership Model	Utility
Buy Credit Card Reader	Yes
Default Costs	Mean
Year of Analysis (PPI Dependent)	2022
Adjust Nominal Utility Rates to Analysis Year	Yes
Gasoline ICEV Comparison	Passenger Car
Custom Gasoline Cost (\$/gallon)	
Custom BEV Fuel Economy (MPGGE)	
Custom Gasoline ICEV Fuel Economy (MPGGE)	
Sensitivity Analysis Change (+/-)	50%

# SNAPSHOT OF SCENARIO CONTROL SHEET



# CAPITAL COSTS

- **Can enter custom costs or use default costs**
  - Defaults differ for Multi-Unit Dwelling and Public
- **Capital costs include:**
  - **Procurement**, the cost to acquire & replace the chargers
  - **Installation**, the make-ready costs of the site and installation costs of the chargers
    - Varies highly by site and should use custom value
  - **Credit card reader**, the device used to collect payment from users at each station

Capital Total	\$ 104,466	
<b>Level 1</b>		
Charger Procurement Cost	\$ 71	Modeled
Installation Cost	\$ 196	Custom
Number of Chargers	6	
Total Charger Procurement Cost	\$ 426	
Total Charger Installation Cost	\$ 1,176	
<b>Level 2</b>		
Charger Procurement Cost	\$ 3,161	
Installation Cost	\$ 4,890	
Number of Chargers	3	
Total Charger Procurement Cost	\$ 9,483	
Total Charger Installation Cost	\$ 14,670	
<b>DCFC</b>		
Charger Procurement Cost	\$ 37,219	
Installation Cost	\$ 29,317	
Number of Chargers	1	
Cable Cost	\$ 3,335	
Number of Extra Cables	1	
Total Charger Procurement Cost	\$ 40,554	
Total Charger Installation Cost	\$ 29,317	
<b>Credit Card Reader</b>		
Reader Cost Each	\$ 884	
Level 1 Reader Cost	\$ 5,304	
Level 2 Reader Cost	\$ 2,652	
DCFC Reader Cost	\$ 884	
Total Reader Cost	\$ 8,840	

# OPERATIONAL COSTS

- **Data contracts,\*** which provide internet capabilities to the charging hub.
- **Network contracts,\*** which collect usage data and enable smart charging.
- **Maintenance,** cost of warranty or maintenance of the chargers

\*Not applicable to residential charging hubs

<u>Operational Total</u>	\$ 4,792								
<b>Network Contracts</b>	Modeled	Custom	Min	Mean	Max	CPI Year	CPI	Ref	
Network Contracts (each)	\$ 227		\$ 202	\$ 227	\$ 253	2019	1.01	[1]	
Level 1- Network Contracts	\$ 1,362								
Level 2- Network Contracts	\$ 681								
DCFC- Network Contracts	\$ 227								
<b>Data Contracts</b>									
Data Contracts (each)	\$ 164		\$ 85	\$ 164	\$ 242	2019	1.01	[1]	
Level 1- Network Contracts	\$ 98								
Level 2- Network Contracts	\$ 49								
DCFC- Network Contracts	\$ 16								
<b>Maintenance</b>									
Annual Maintenance Cost (% of Charger Cost)	5%		1%	5%	10%			[4],[10]	
Level 1- Maintenance Cost	\$ 24		\$ -	\$ 4	\$ 36				
Level 2- Maintenance Cost	\$ 474		\$ 29	\$ 158	\$ 344				
DCFC- Maintenance Cost	\$ 1,861		\$ 267	\$ 1,861	\$ 4,776				

# ELECTRICITY COSTS

Computed Rate Name	Commonwealth Edison Co: BES - Residential Without Electric Space Heat Delivery Class (Flat)		
Computed Rate Row (1-235)	175		175
	Level 1	Level 2	DCFC
Electricity Rate	\$ 2,025	\$ 3,761	\$ 2,337
Demand Charge	\$ -	\$ -	\$ -
Fixed Charge	\$ 42	\$ 77	\$ 48

- Broken out by:
  - **Electricity rate (\$/kWh)**, which is scaled by the energy sold.
  - **Demand charge (\$/kW-month)**, which is scaled by the maximum 15-minute demand of the station each month.
  - **Fixed charge (\$/site-month)**, the metering fee of the site.
- Automatically selects **appropriate rate** such that it:
  1. matches the selected service location;
  2. matches the schedule type for the ownership model: Residential or Commercial;
  3. is within the power demand limit range; and
  4. is a rate specifically for electric vehicles OR has the lowest electricity cost among other applicable rate options.

# CHARGER UTILIZATION

- Utilization changes over time

Utilization Scale Up	
Growth above beginning utilization	0%
First Year of Mature Utilization	0

- Add in **custom** values or use defaults to determine utilization and design of station

- Number of chargers
- Power level of chargers (DCFC: 50, 150, 350 kW)
- Charging session frequency and parameters
- Charger life

Charger Usage								
Charger Type	Power Rating (kW). Update DCFC by hub type	Number of Chargers	Number of Extra Plugs	Daily Utilization (sessions/ day/ charger)	Average Session Power (kW)	Charge Duration (minutes/ session)	Charging Efficiency Losses	Charger Replacement Frequency (years)
Level 1	1.9	6		1.0	1.5	324	0%	15
Level 2	6.6	3		1.6	5.2	217	0%	15
DCFC	50	1	1	2.6	33.2	39	0%	15

# CHARGING SCHEDULE

- Add in **custom** schedule or use default
  - Can add in specific kWh and kW values to override
- Can scale utilization to be different for each year

Select % Model:	EV/kWhs				Level 1 Energy (kWh) Level 2 Energy (kWh) DCFC Energy (kWh) Level 1 Demand (kW) Level 2 Demand (kW) DCFC Demand (kW)				Total Demand (kW)	
Hour	Level 1 Daily Usage	Level 2 Daily Usage	DCFC Daily Usage	Level 1 Energy	Level 2 Energy	DCFC Energy	Level 1 Demand	Level 2 Demand	DCFC Demand	Total Demand
0	5.88%	2.87%	0.84%	2.57	5.13	0.59	3.00	5.17	33.20	41.37
1	5.06%	4.84%	0.88%	2.46	4.27	0.69	3.00	5.17	33.20	41.37
2	4.89%	3.95%	0.88%	2.34	3.89	0.68	3.00	5.17	33.20	41.37
3	4.52%	3.39%	0.89%	2.20	2.89	0.45	3.00	5.17	33.20	41.37
4	4.27%	2.49%	1.84%	2.06	2.26	0.92	3.00	5.17	33.20	41.37
5	3.88%	1.91%	0.27%	1.69	1.72	0.16	3.00	5.17	33.20	41.37
6	3.54%	1.95%	0.83%	1.72	1.40	0.67	3.00	5.17	33.20	41.37
7	3.14%	1.45%	1.87%	1.51	1.31	1.09	3.00	5.17	33.20	41.37
8	2.39%	1.70%	3.36%	1.41	1.54	1.77	1.50	5.17	33.20	39.67
9	2.88%	2.16%	4.85%	1.48	1.68	2.23	1.50	5.17	33.20	39.67
10	2.39%	2.95%	4.58%	1.41	2.30	2.40	1.50	5.17	33.20	39.67
11	2.88%	2.84%	4.68%	1.45	2.56	2.52	1.50	5.17	33.20	39.67
12	3.09%	3.95%	4.52%	1.50	2.97	2.76	1.50	5.17	33.20	39.67
13	3.30%	3.59%	5.84%	1.60	3.24	3.28	3.00	5.17	33.20	41.37
14	2.90%	3.32%	8.20%	1.70	3.59	4.66	3.00	5.17	33.20	41.37
15	2.78%	4.26%	8.85%	1.89	3.65	4.57	3.00	5.17	33.20	41.37
16	3.97%	4.70%	6.84%	1.93	4.25	3.45	3.00	5.17	33.20	41.37
17	4.34%	5.38%	6.81%	1.85	4.85	4.72	3.00	5.17	33.20	41.37
18	4.60%	6.20%	8.36%	2.33	5.60	5.25	3.00	10.34	33.20	48.54
19	6.10%	6.74%	9.28%	2.49	6.08	6.20	3.00	10.34	33.20	48.54
20	5.38%	7.07%	7.89%	2.62	6.28	4.53	3.00	10.34	33.20	48.54
21	5.56%	7.17%	4.38%	2.70	6.47	2.41	3.00	10.34	33.20	48.54
22	6.66%	6.96%	2.24%	6.28	6.28	1.27	3.00	10.34	33.20	48.54
23	6.47%	6.43%	1.83%	2.66	5.60	0.95	3.00	10.34	33.20	48.54

Hour	Level 1 Energy (kWh)	Level 2 Energy (kWh)	DCFC Energy (kWh)	Demand Level 1 (kW)	Demand Level 2 (kW)	Demand DCFC (kW)
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
Total/Max	0	0	0	0	0	0

Level 1 Daily Usage	Level 2 Daily Usage	DCFC Daily Usage
0	100.0%	100.0%
1	0.0%	0.0%
2	0.0%	0.0%
3	0.0%	0.0%
4	0.0%	0.0%
5	0.0%	0.0%
6	0.0%	0.0%
7	0.0%	0.0%
8	0.0%	0.0%
9	0.0%	0.0%
10	0.0%	0.0%
11	0.0%	0.0%
12	0.0%	0.0%
13	0.0%	0.0%
14	0.0%	0.0%
15	0.0%	0.0%
16	0.0%	0.0%
17	0.0%	0.0%
18	0.0%	0.0%
19	0.0%	0.0%
20	0.0%	0.0%
21	0.0%	0.0%
22	0.0%	0.0%
23	0.0%	0.0%
Total	100.0%	100.0%

Charging Schedule: Line graph showing the percentage of daily charging for Level 1 (blue), Level 2 (green), and DCFC (red) over a 24-hour period. Level 1 shows a peak in the morning, Level 2 peaks in the afternoon, and DCFC peaks in the evening.

Charging Energy: Line graph showing the hourly energy discharged in kWh for Level 1 (blue), Level 2 (green), and DCFC (red) over a 24-hour period. Level 1 peaks in the morning, Level 2 peaks in the afternoon, and DCFC peaks in the evening.

Charging Demand: Line graph showing the hourly energy discharged in kW for Level 1 (blue), Level 2 (green), and DCFC (red) over a 24-hour period. Level 1 peaks in the morning, Level 2 peaks in the afternoon, and DCFC peaks in the evening.

Year	Level 1 % of Beginn	Level 2 % of Beginn	DCFC % of Beginn	Level 1 % of Beginn	Level 2 % of Beginn	DCFC % of Beginn	Level 1 % of Beginn	Level 2 % of Beginn	DCFC % of Beginn
1	100%	100%	100%	100%	100%	100%	100%	100%	100%
2	100%	100%	100%	100%	100%	100%	100%	100%	100%
3	100%	100%	100%	100%	100%	100%	100%	100%	100%
4	100%	100%	100%	100%	100%	100%	100%	100%	100%
5	100%	100%	100%	100%	100%	100%	100%	100%	100%
6	100%	100%	100%	100%	100%	100%	100%	100%	100%
7	100%	100%	100%	100%	100%	100%	100%	100%	100%
8	100%	100%	100%	100%	100%	100%	100%	100%	100%
9	100%	100%	100%	100%	100%	100%	100%	100%	100%
10	100%	100%	100%	100%	100%	100%	100%	100%	100%
11	100%	100%	100%	100%	100%	100%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%	100%
26	100%	100%	100%	100%	100%	100%	100%	100%	100%
27	100%	100%	100%	100%	100%	100%	100%	100%	100%
28	100%	100%	100%	100%	100%	100%	100%	100%	100%
29	100%	100%	100%	100%	100%	100%	100%	100%	100%

EV/kWhs	Level 1 Daily Usage	Level 2 Daily Usage	DCFC Daily Usage
0	5.88%	2.87%	0.84%
1	5.06%	4.84%	0.88%
2	4.89%	3.95%	0.88%
3	4.52%	3.39%	0.89%



# FINANCIAL INPUTS

- **Loan parameters**
  - Investor equity
  - Loan interest
  - Loan term
  
- **Taxes**
  - Sales tax
  - State income rate
  - Federal income rate
  - Income tax paid is adjusted for taxable income through MACRS depreciation schedules
  
- **Criteria for each ownership model**

Economic Assumptions	User Input	Custom	Default
Initial Capital Investment	\$ 104,466		
Initial Equity	50%		50%
Initial Investor Capital Investment	\$ 52,233		
Initial Loan Interest	6%		6%
Initial Loan Term (years)	10		10
Initial Annual Loan Payment	\$ 7,097		
Replacement Equity	50%		50%
Replacement Loan Interest	6%		6%
Replacement Loan Term (years)	10		10
Internal Rate of Return	6%		6%
State Taxes	6%		6%
Federal Taxes	21%		21%
Total Tax Rate	25.7%		
Sales Tax	4.5%		4.5%
Inflation	2.3%		2.30%

Variables by Ownership Model			
Ownership Model	Internal Rate of Return	Data & Network Contracts (1= yes, 0= no)	Rate Type
Private Company	10%	1	Commercial
Utility	6%	1	Residential
Resident	3%	0	Residential

# DEMO

- **Scenario Control**
  - 10 Level-2 chargers
  - Utilization scale up of 100% over 10 years
  - Location of Illinois
  - Analysis period of 15 years
- **Financial inputs:**
  - Property manager has 12% internal rate of return (IRR)
  - State taxes of 9.5%
  - Sales tax of 8.8%
  - Equity of 20%
- **Capital cost**
  - Installation cost of \$5,000/charger
  - Procurement cost of \$2,500/charger
- **Custom utility rate**
  - Electricity rate: \$0.30/kWh on-peak, \$0.10/kWh off-peak
- **Override schedule with specific demand values**

# THANK YOU!

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Home charging for all: Techno-economic and life cycle assessment of multi-unit dwelling electric vehicle charging hubs

Noah Horesh <sup>a, b</sup>, Yan Zhou <sup>a</sup>  , Jason Quinn <sup>b</sup>



<https://doi.org/10.1016/j.jclepro.2022.135551>



Argonne provides tools and capabilities for EV charging hub owners and operators and fleets.

<https://www.anl.gov/esia/decision-support-for-ev-charging-cost-analysis>

