Preliminary Integrated Renewable Energy Deployment Analysis for Davis, California

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Valley Climate Action Center
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January 13, 2015

General Introduction

- Question: Can most of a specific small city's energy needs be supplied by a mix of local solar and wind resources, resulting in a near zero local carbon footprint within two decades?
- Research hypothesis: that truly integrated local renewable energy deployment planning requires locally specific assumptions and data:
  - Energy usage trends
  - Preferred local renewable electricity supply portfolios
  - Energy service options, variations and limitations
  - Usage and supply technology deployment status and progress rates
- Analysis results are location and community specific. The results that follow are <u>preliminary</u>.

Content Outline

- Local energy usage and production
- Scenarios, change drivers and integrated model
- Reference case results
- Local power cases
- Supply/demand balancing
- Comparisons: carbon footprint and economic
- Conclusions and uncharted territory

Introduction – Davis

Statistics (city only)

Total Population: 60308
- 15 to 19 years: 11.46%
- 20 to 24 years: 22.71%
- 25 to 34 years: 14.95%

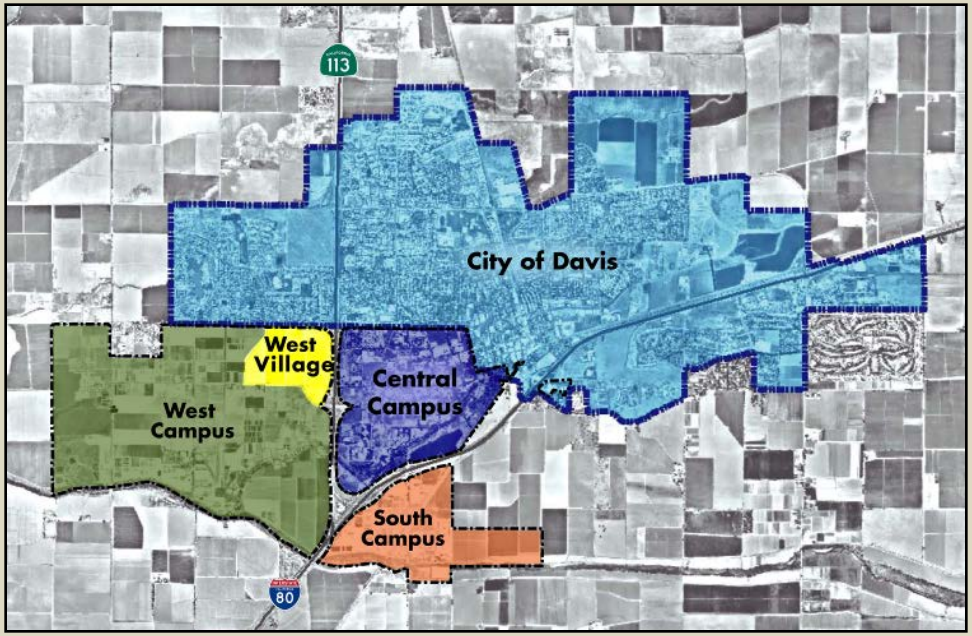
Housing units: 22948
- Owner-occupied: 44.6%
- Renter-occupied: 55.4%
- Single fam. homes: 57%
- Multi-family units: 43%

Median Income*: $60,114

* Per household

http://quickfacts.census.gov/qfd/states/06/0618100.html
http://davis.areaconnect.com/statistics.htm

City and University



Source: UC Davis West Village Energy Initiative

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Davis Energy Profile - 2012

Table 2. Usage

Davis Energy Usage - 2012		
	GWh	GWh
Building Electricity		**282**
Residential	144	
Non-residential	138	
Building Natural Gas		**120**
Residential	88	
Non-residential	31	
Transportation Fuels	84	**84**
Total	486	**486**

Table 3. Costs and Carbon

Davis Costs and Emissions - 2012		
	Annual Energy Bill	**Carbon Footprint**
	$ millions	Metric Tons
Electricity	43.5	66966
Natural Gas	16.4	63436
Transportation		
Light vehicles	23.1	59251
Heavy trucks		41765
Total	83.1	231419

Note: End use rather than source energy metrics were used consistently throughout the model and analysis.

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Comparative Electricity Statistics

Davis Statistics - 2012									
City	Population and Energy						Customer Mix		
	Pop. (x1000)	Cust.	GWh/yr	MWp	MWh/ cust.	Load Factor	Res %	Com%	Ind %
Alameda	74.69	30119	389.7	67.2	12.94	0.66	37.2	62.8	0
Palo Alto	65.68	25710	971.8	170.1	37.80	0.65	16.9	56.6	26.5
Redding	90.20	36907	804.7	212	21.80	0.43	49.2	49.1	1.7
Ukiah	15.98	6164	120.1	29	19.48	0.47	36.5	62.1	1.4
Lompoc	42.92	12966	135.8	23.8	10.47	0.65	44.5	20.9	34.6
Lodi	62.95	22970	452.7	114.5	19.71	0.45	34.3	35.3	30.4
Davis	65.99	28403	281.7	66	9.92	0.49	51	49	0
Sacramento	1400	604053	12074	3000	19.99	0.46	45.7	52.9	1.4

Note: Sacramento statistics included for reference. Davis GWh/yr includes direct access usage.
Data sources include: City of Davis consultant reports, NCPA and PG&E

Local Renewable Power

Davis Solar Electricity Deployment Status		
	2012	2015
Sites	1039	1800
Cumulative Capacity (MW)	7.4	19.6
Annual Production (GWh)		
Building Scale (< 1 MW)		
Residential PV (1)	10.5	20.0
Non-res PV	3.2	16.0
Other (>1MW)	0.0	0.0
Total Annual Production (GWh)	13.7	35.9

Yolo County Renewable Power Status		
	2012	2015
	Annual GWh	
Existing Biomass/WTE	199	195.5
Existing Wind Power	0	3.733
UC Davis Solar	12.25	43.75
City of Davis Solar	13.7	35.9
Other Yolo Solar*	0	0
Total	225	278.9
* not estimated		

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Introduction - DavisFREE

DavisFREE Research Topics:

- Integrated Renewable Energy Deployment Scenarios - IRESN
- Use of City GIS Systems for Energy Planning – VCAC
- Local Solar Electricity Sites and Resources
  - Rooftop and Parking Area Solar Electricity Potential - BIRA
  - Assessment of Solar Garden Sites - UCD
- Utility Scale Renewable Energy Opportunities - UCD
- Utility Scale Renewable Energy Supply Curves - KEMA
- Net Zero Residential Retrofit Program Design - BIRA
- Local Solar Thermal Sites and Resources – Aztec

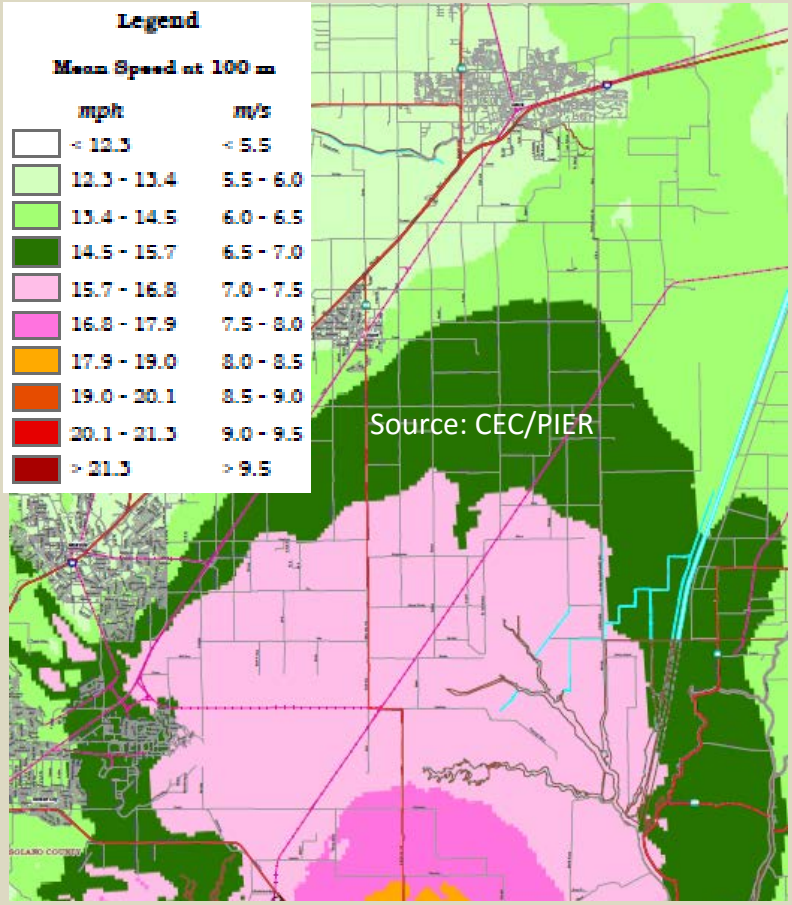
Community Solar and Wind

City Controlled Community Solar Sites

Property	Acres	MW
Davis Municipal Golf Course	149	20
Old City Landfill/PVUSA Site	186	25
Wastewater Treatment Plant	224	30
Howatt/Clayton Ranch	773	103
Wastewater Treatment Plant	2	0
Playfields Park	1	0
Mace Park and Ride	1	0
Pubic Works Corp Yard	4	1
Parks Corp Yard	2	0
Totals		179

Source: City of Davis/UCD

Community Wind Resource Area



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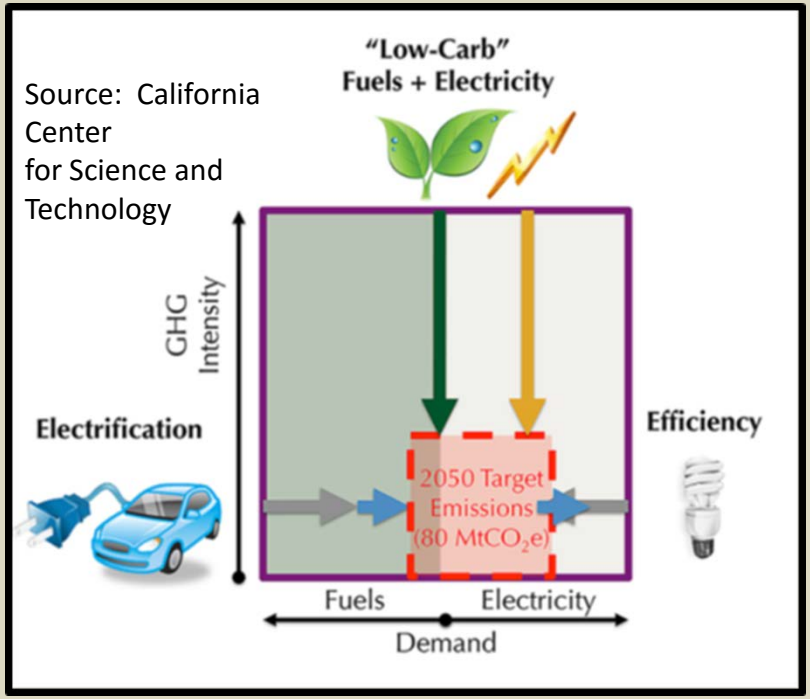
Scenarios

- Reference case (IOU): Electricity and natural gas service by incumbent for-profit utility (PG&E)
- Locally accountable electricity supply (CCE): Same as reference case but with a local Community Choice Energy agency sourcing electricity for delivery within the community
- Locally accountable electricity service (POU): Electricity service by a new municipal utility; natural gas service by PG&E

Analysis Guidelines

- Assume no changes in current state policies, IOU business models, and local goals, i.e. Davis's Climate Action Plan and 2050 Carbon Neutrality Goal
- Consider:
  - Solar and EV adoption trends unique to Davis
  - Effects of local planning and operation on energy usage and local renewable deployment
- Determine how changes in each major usage or supply category affect others
- "End Use" vs. "source" energy metrics, i.e. MWe and GWh
- Quantify economic and carbon footprint impacts

Keys to Local Carbon Neutrality



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Model Specification

- For each scenario, estimate:
  - Energy Usage
  - Local Energy Supply
  - Usage/Local Supply/Import Balance
  - Usage and Supply Variability
  - Carbon Footprint
- 2015 baseline, five year updates (2015-2035)
- Assumptions:
  - Specific to Davis
  - Informed by other DavisFREE tasks

Reference Case Building Usage

Trends 2005 to 2012

- Residential:
  - electricity usage (51%)* changed by -6.2% since 2005
  - natural gas usage (74%)* has changed by -1.8% since 2005
- Non-residential:
  - electricity usage (49%)* has changed by 12.4% since 2005
  - natural gas usage (26%)* has changed by 5.3% since 2005

Reference Case

Davis Building Energy Use - IOU Scenario					
	2015	2020	2025	2030	2035
	Annual GWh				
Building Electricity	283.4	288.3	295.5	306.0	321.1
Residential	137.9	129.6	122.4	117.1	115.1
Non-residential	145.5	158.7	173.1	188.9	206.1
Building Natural Gas	119.6	118.1	116.9	114.2	108.5
Residential	87.8	86.7	85.5	84.4	83.4
Non-residential	31.8	33.0	34.3	35.6	37.0
Building Solar Heat	0.0	0.8	1.5	3.1	6.1
Total	402.9	407.1	413.9	423.2	435.8

* Trend information (source energy basis) was provided by the PG&E Green Communities Program

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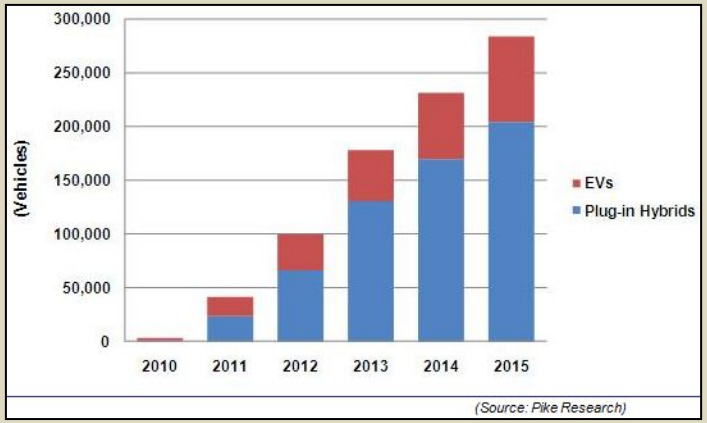
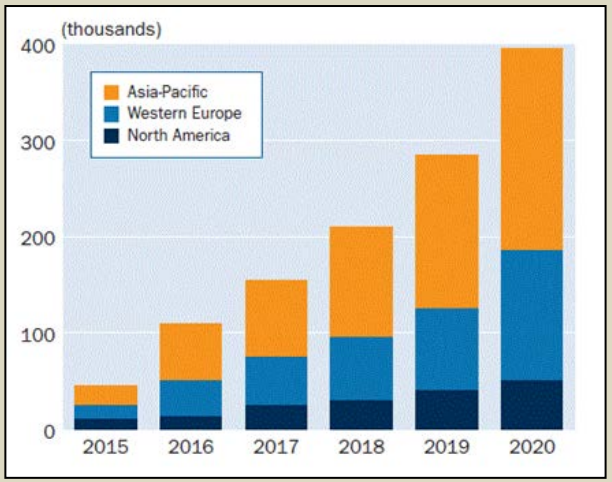
Reference Case Transportation Usage

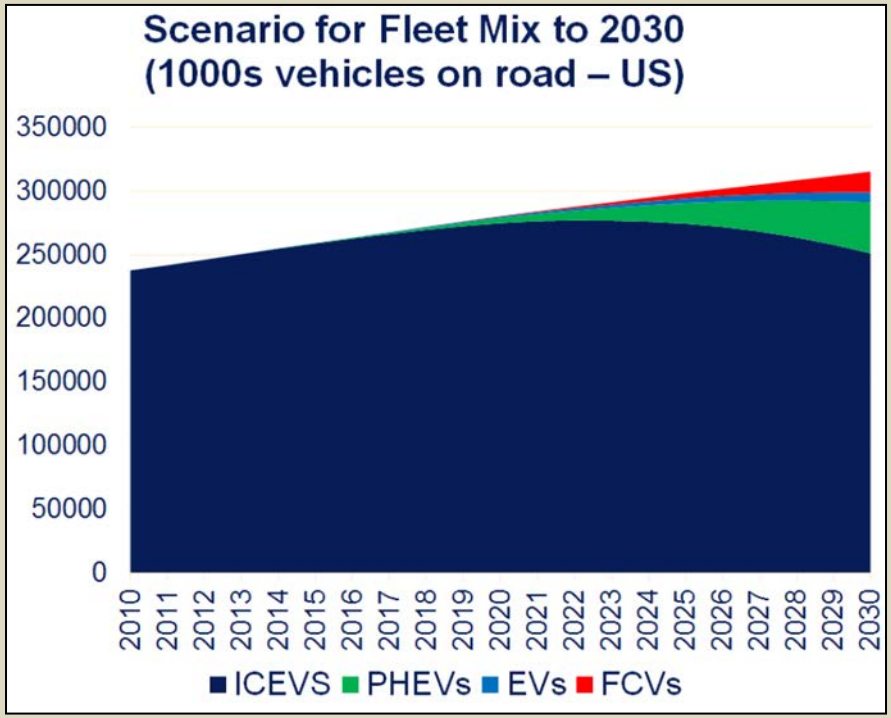
Trends 2010 to 2020



Top: US PHEV and BEV Sales
Bottom: FCEV growth projections



Future



EV/PHEV Source: Pike Research
FCEV Source: http//:www.platts.com/news-feature/2013/electricpower/powergen/fuelcellcars
Future Source: http://steps.ucdavis.edu/files/08-13-2014-08-13-2014-NextSTEPS-White-Paper-Hydrogen-Transition-7.29.2014.pdf

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Reference Case Transportation Usage

Davis Transportation Energy Use - IOU Scenario					
	2015	2020	2025	2030	2035
	Annual GWh				
Car					
ICEV gasoline	29.8	28.7	26.6	22.9	17.1
EV - elect.	0.6	1.1	2.3	3.7	6.0
FCEV - NG H2	0.0	0.2	0.5	0.9	1.9
FCEV - Solar H2	0.0	0.1	0.4	1.6	3.2
Van/Lt. Truck liq.	39.1	39.1	37.1	33.3	27.9
Van/Lt. Truck elec.	0.0	0.0	0.9	1.8	2.9
Heavy Trk/Bus liq.	30.6	24.5	18.4	12.3	6.1
Heavy Trk/Bus NG	0.0	6.1	12.3	18.4	24.5
Other	0.4	0.4	0.4	0.4	0.4
Totals	100.5	100.3	98.8	95.3	89.9

Reference Case Renewable Power

City of Davis Renewable Power Deployment - IOU Scenario					
	2015	2020	2025	2030	2035
Solar Target (Annual GWh)	N/A	N/A	N/A	N/A	N/A
Wind Target (Annual GWh)	N/A	N/A	N/A	N/A	N/A
On Site Solar (GWh)	35.9	44.9	52.4	57.1	60.3
Community Solar (GWh)	0.0	0.0	0.0	0.0	0.0
Community Wind (GWh)	0.0	0.0	0.0	0.0	0.0
Total (Annual GWh)	35.9	44.9	52.4	57.1	60.3
Solar Capacity (MW)	19.6	24.9	29.1	31.7	33.5
Wind Capacity (MW)	0.0	0.0	0.0	0.0	0.0

Renewable Power Deployment Trends

New US Generation Capacity
H1 2014

Solar	53%
Natural Gas	30%
Coal	0%
Wind	14%
Other	3%
Total	100%

Source: FERC

New US Solar PV Capacity
GW

	US	CA
2014E	**6.5GW**	**3.3GW**
Residential	20%	25%
Non-Res	30%	10%
Utility	50%	65%
2018E	**9GW**	**3.1GW**
Res	35%	60%
Non-Res	35%	25%
Utility	30%	15%

Source: SEIA, GTM Research, Other

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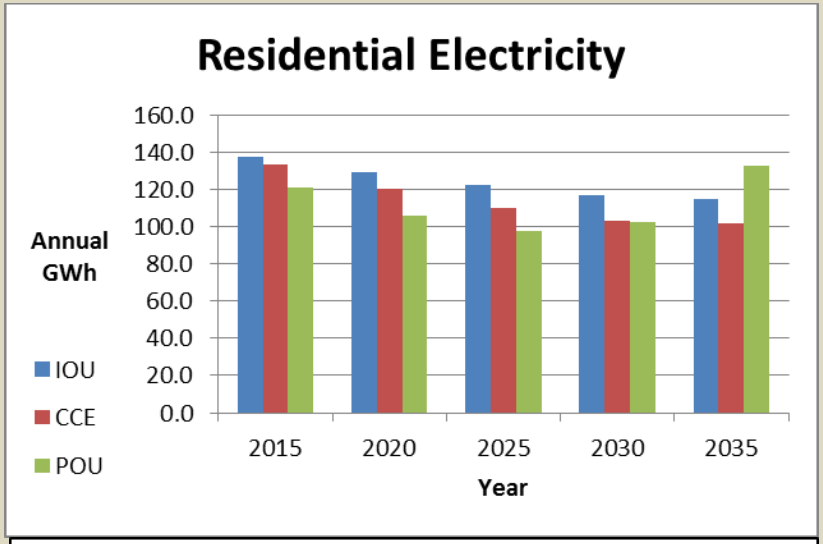
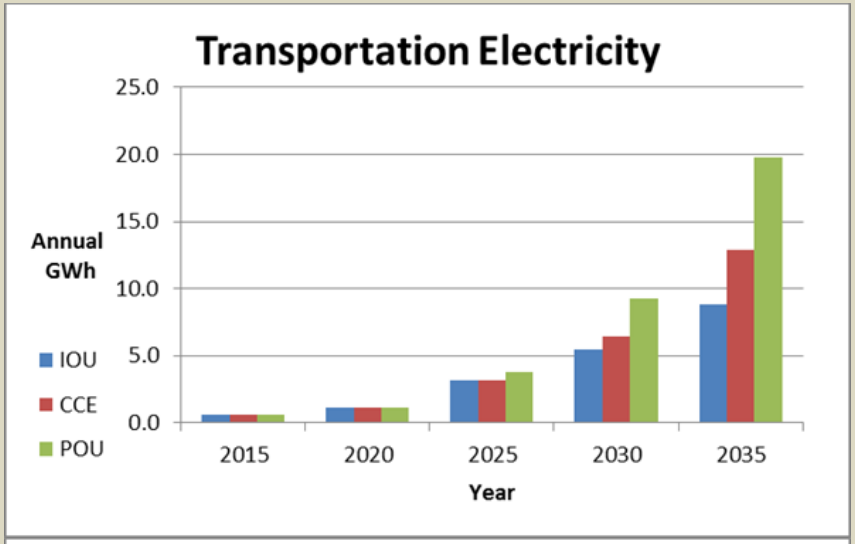
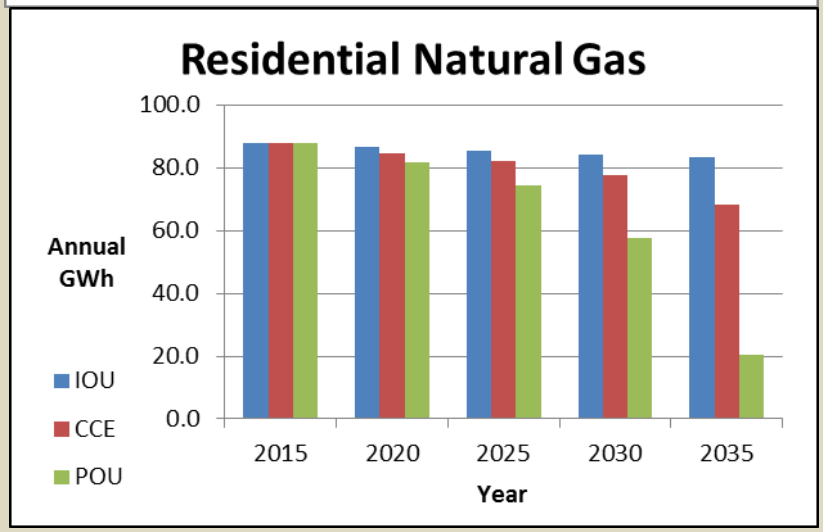
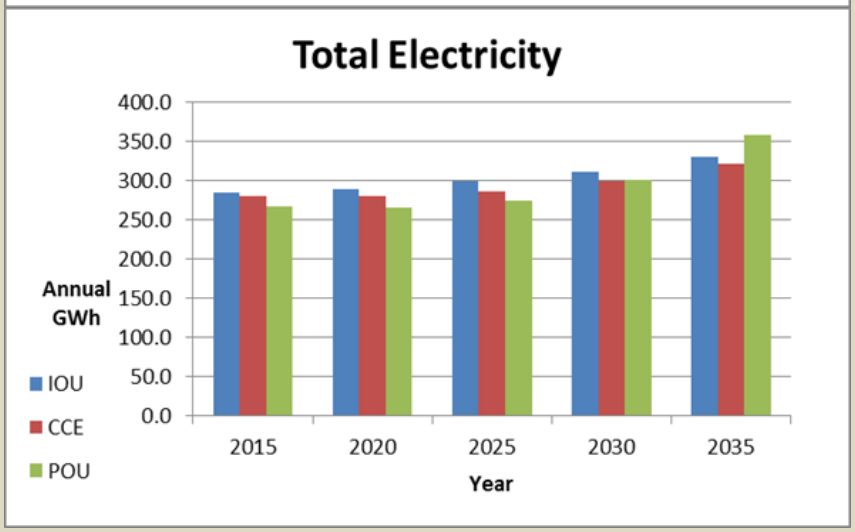
Local Power Cases - Usage









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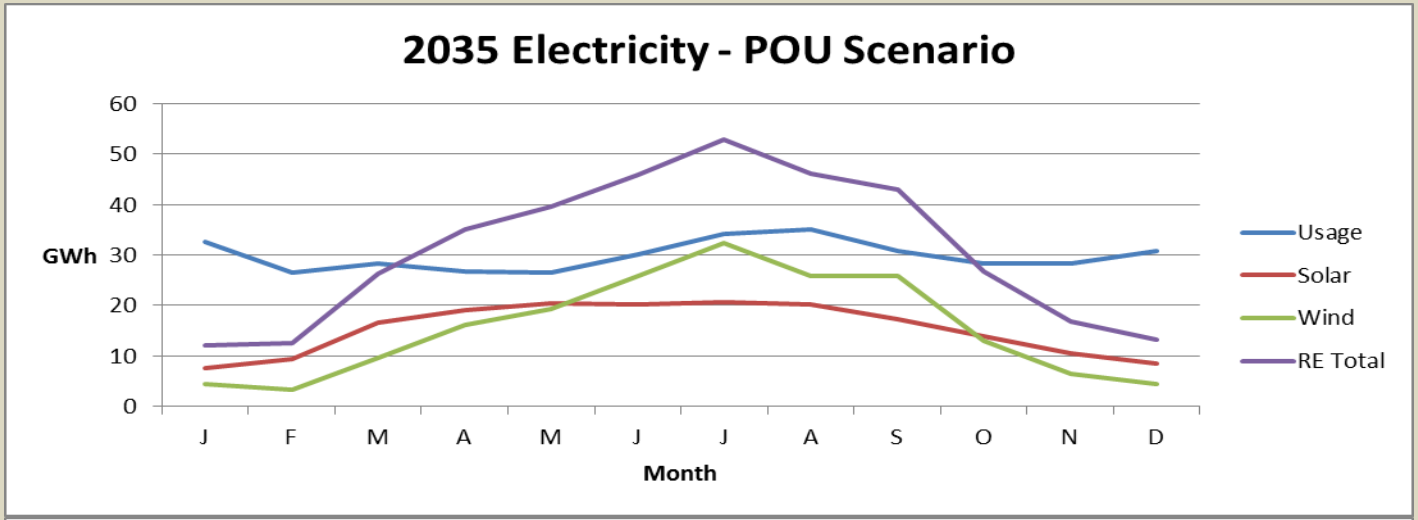
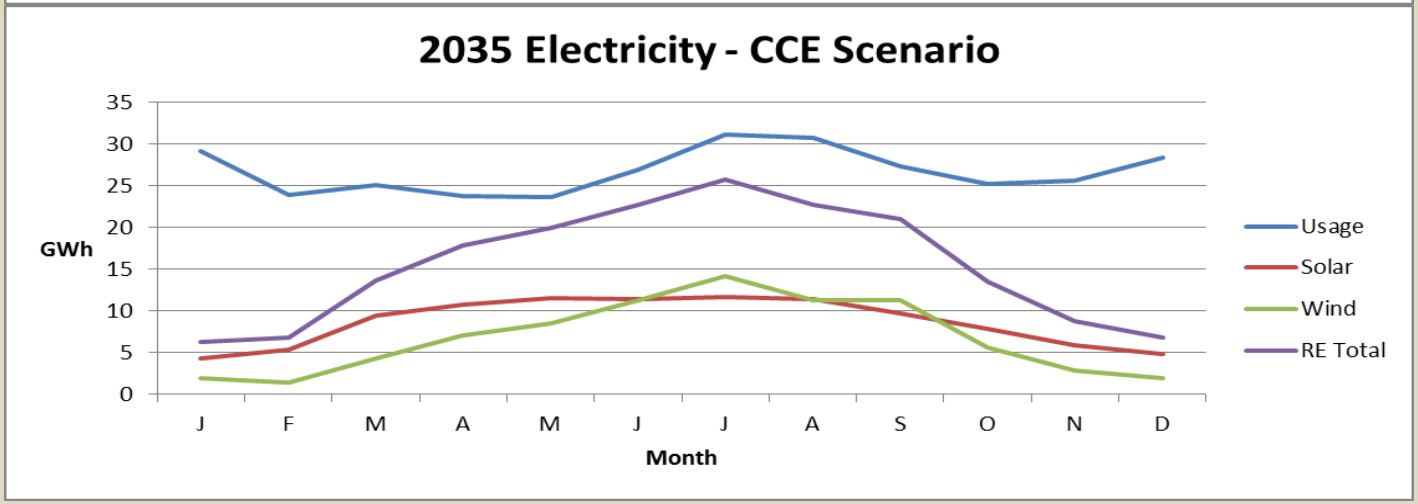
Local Power Cases – Renewable Power





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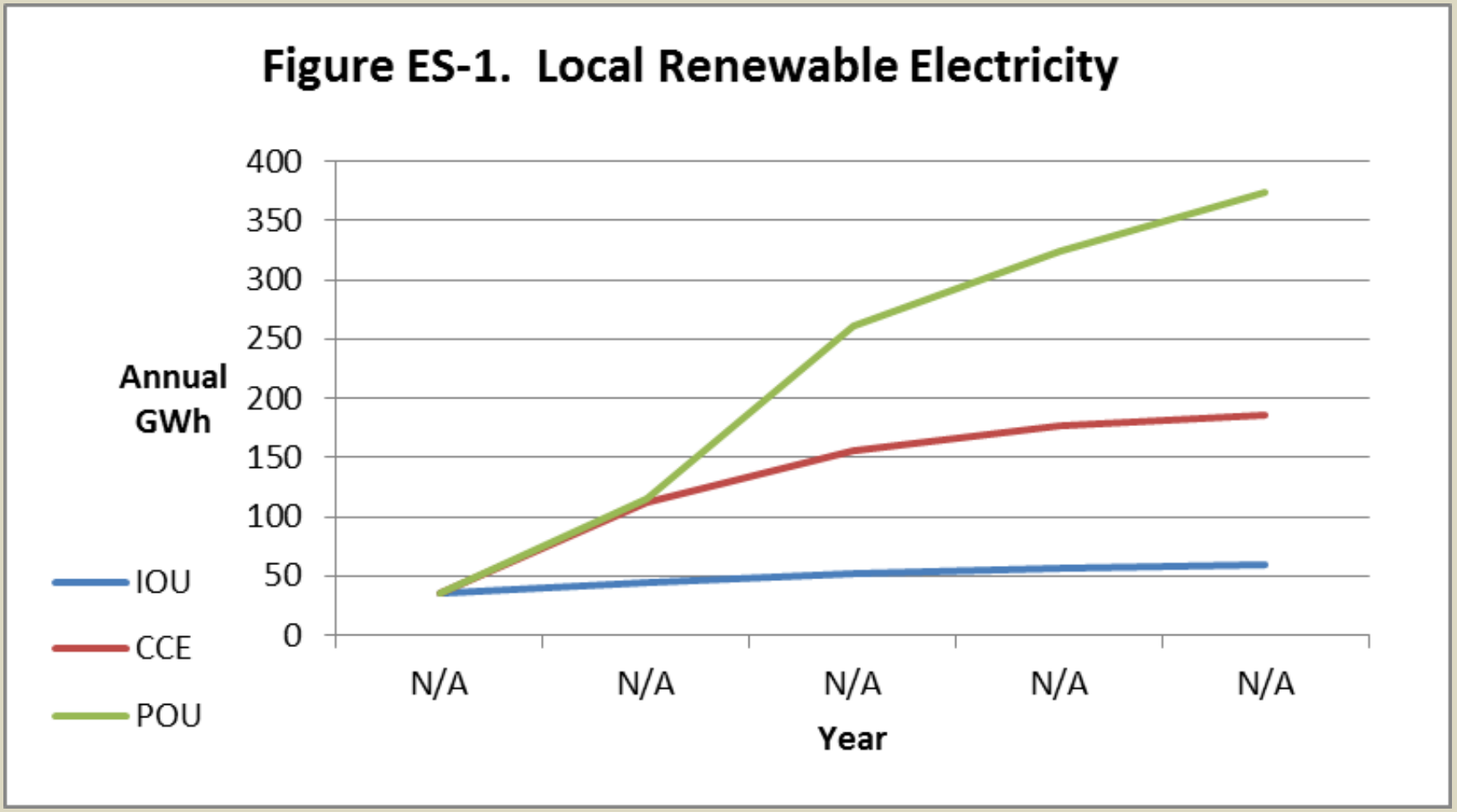
Local Power Cases – RE Electricity



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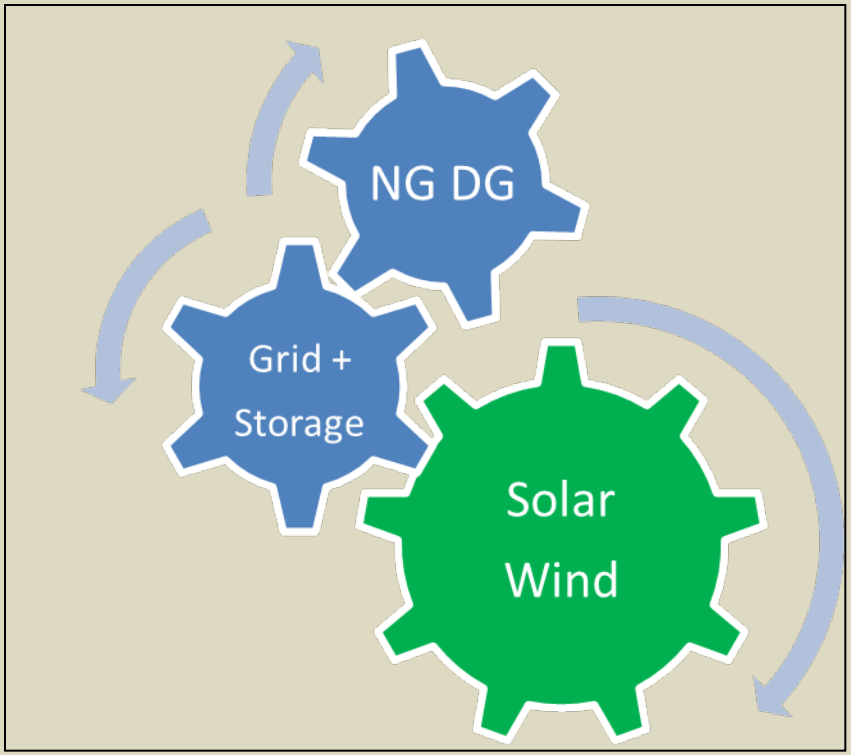
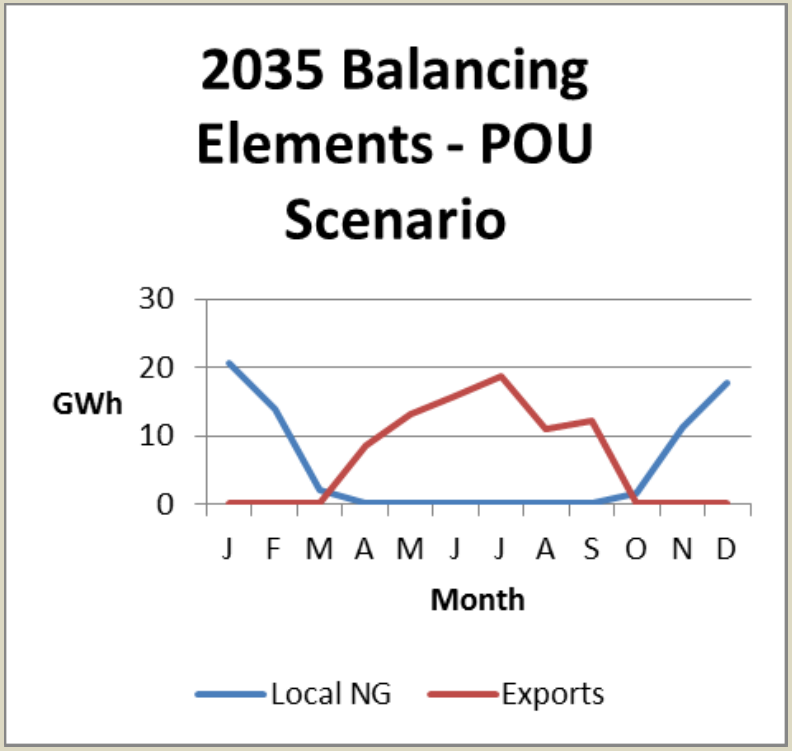
Seasonal Supply/Demand Balancing





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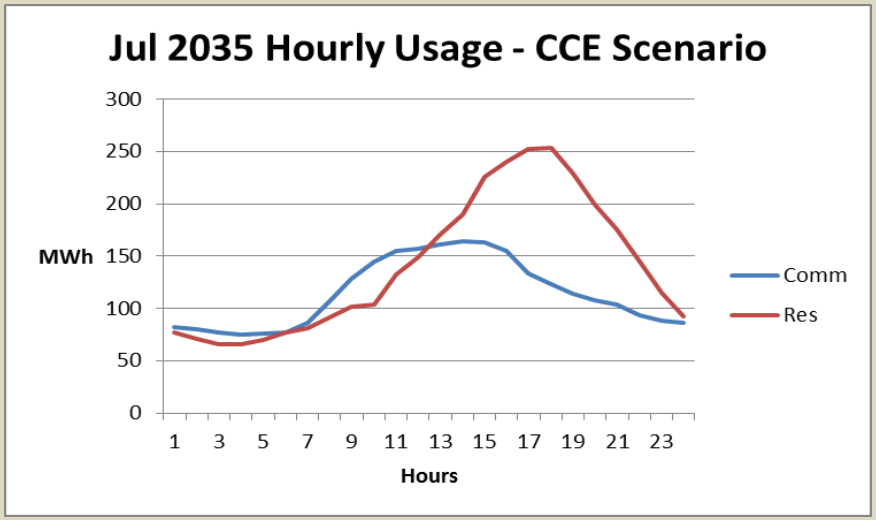
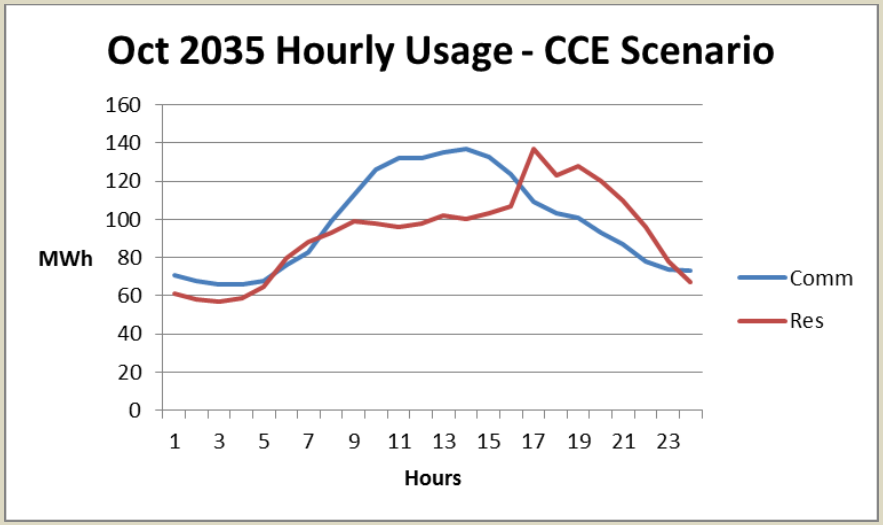
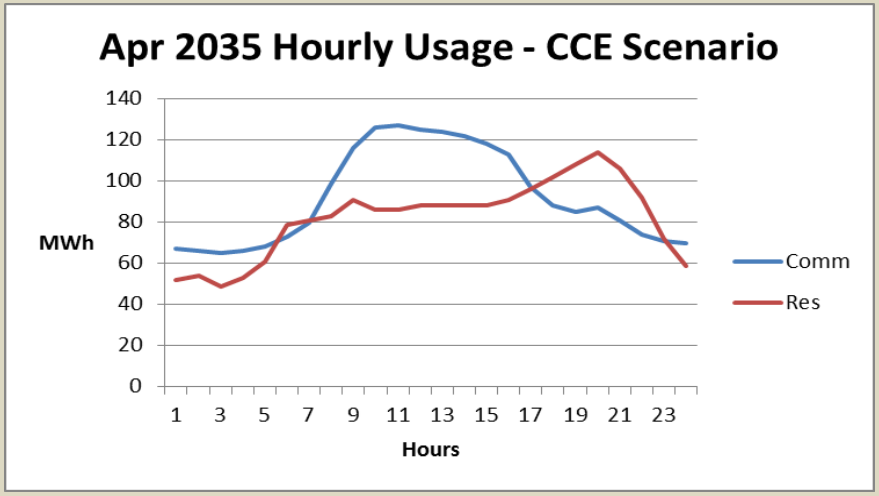
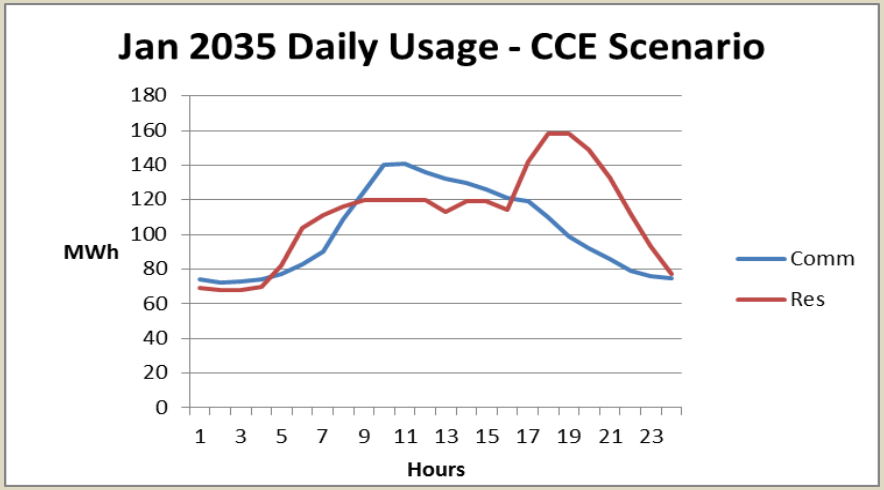
Daily Building Usage Profiles









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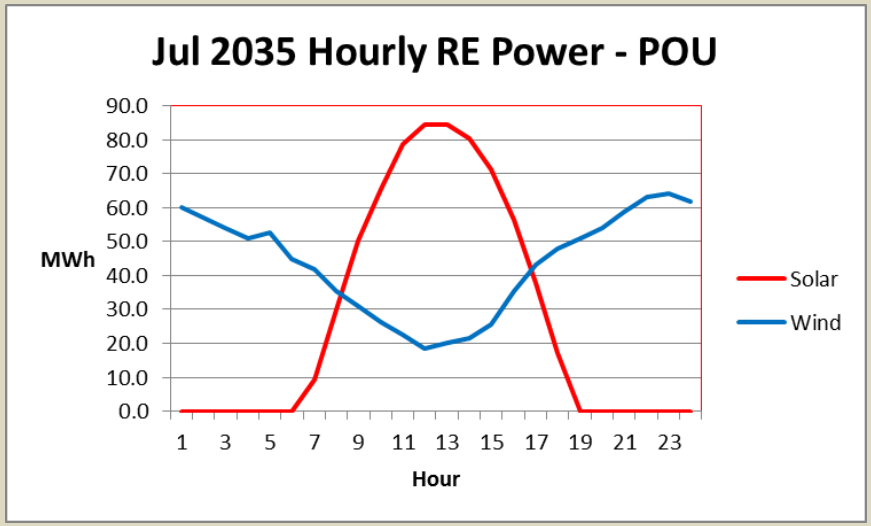
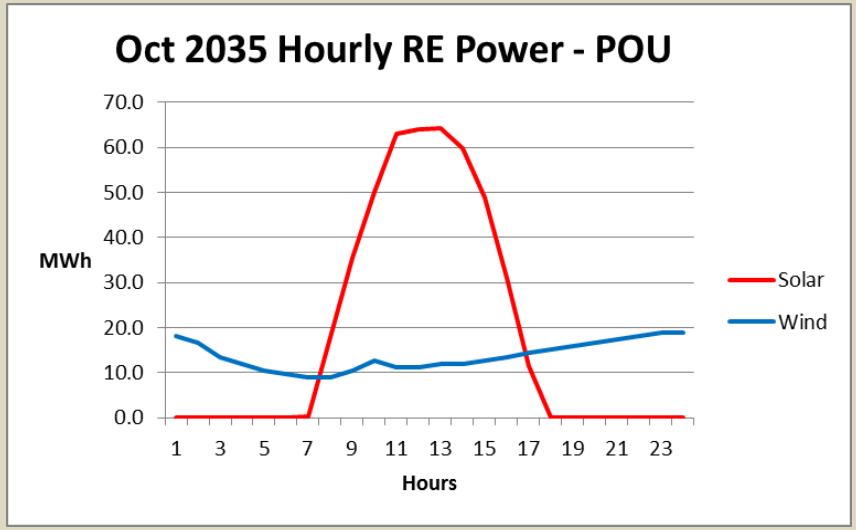
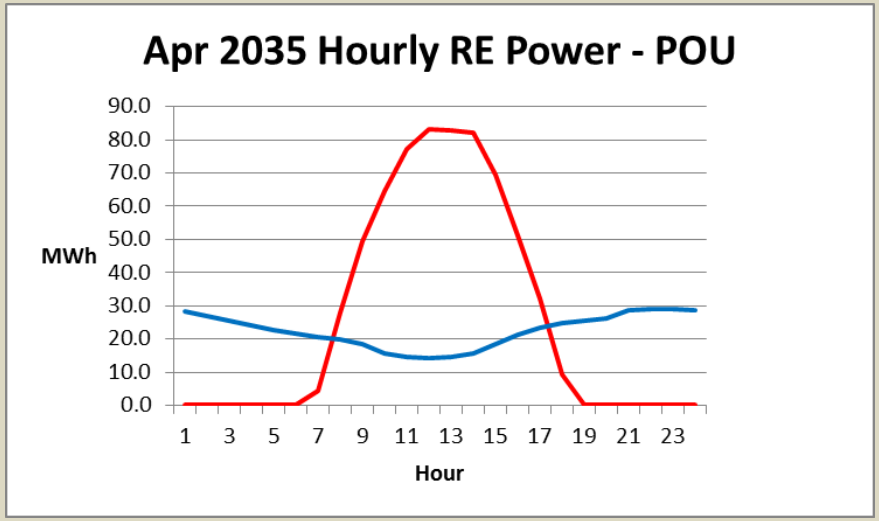
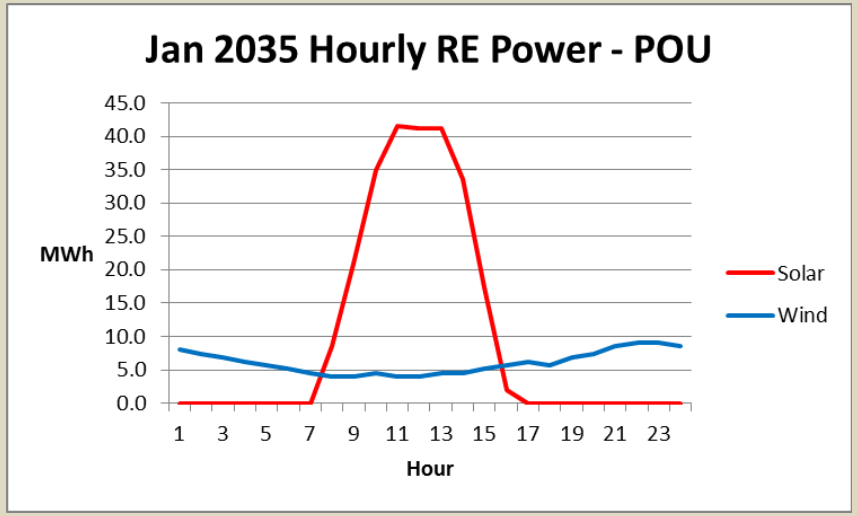
Daily Solar and Wind Profiles









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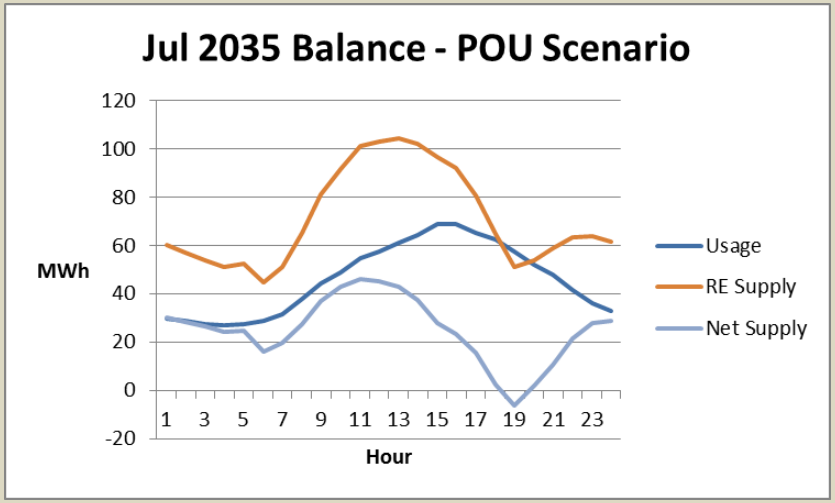
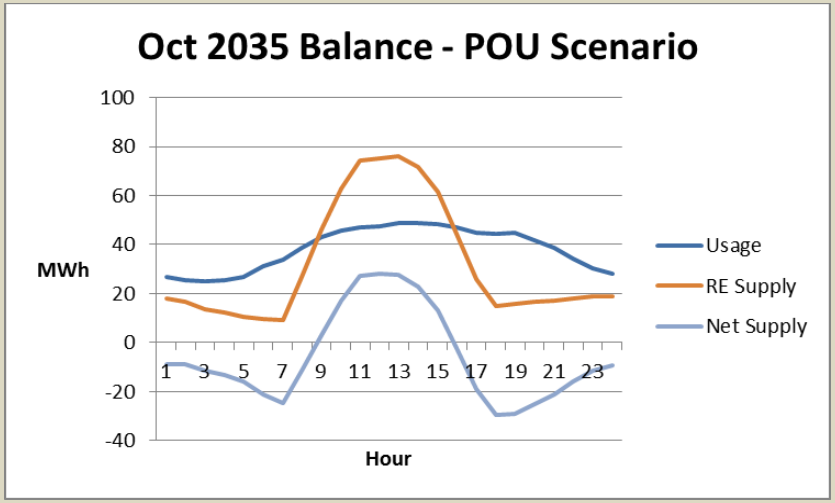
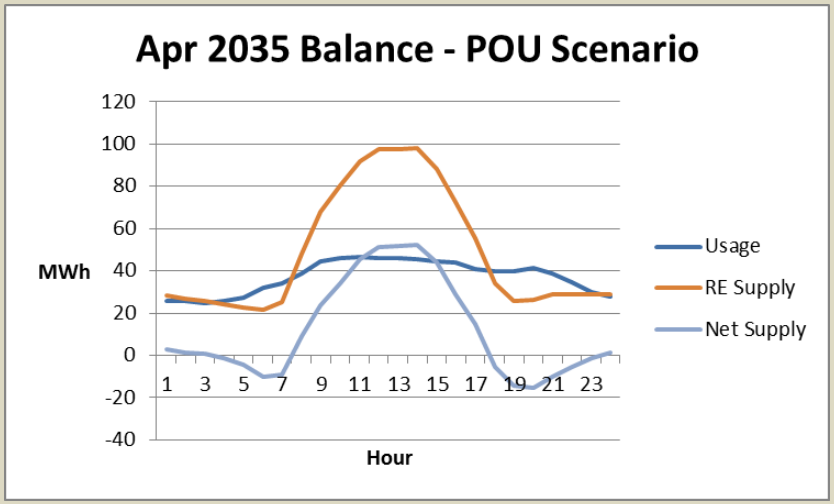
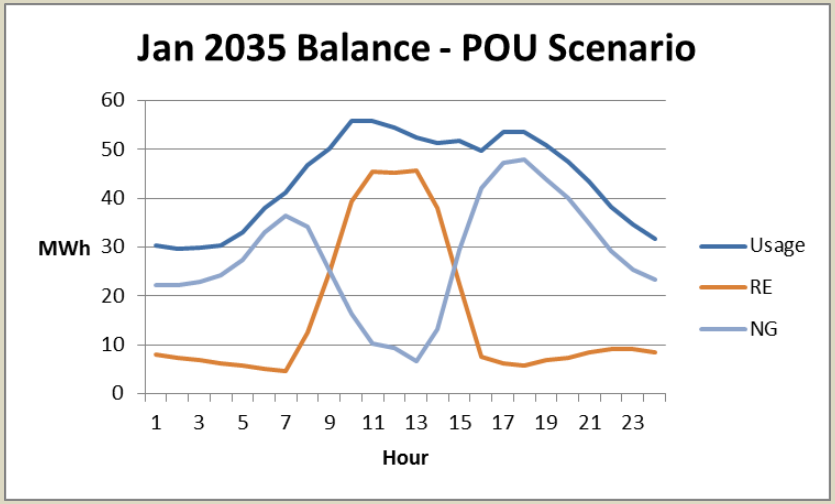
Hourly Building Use Net Supply









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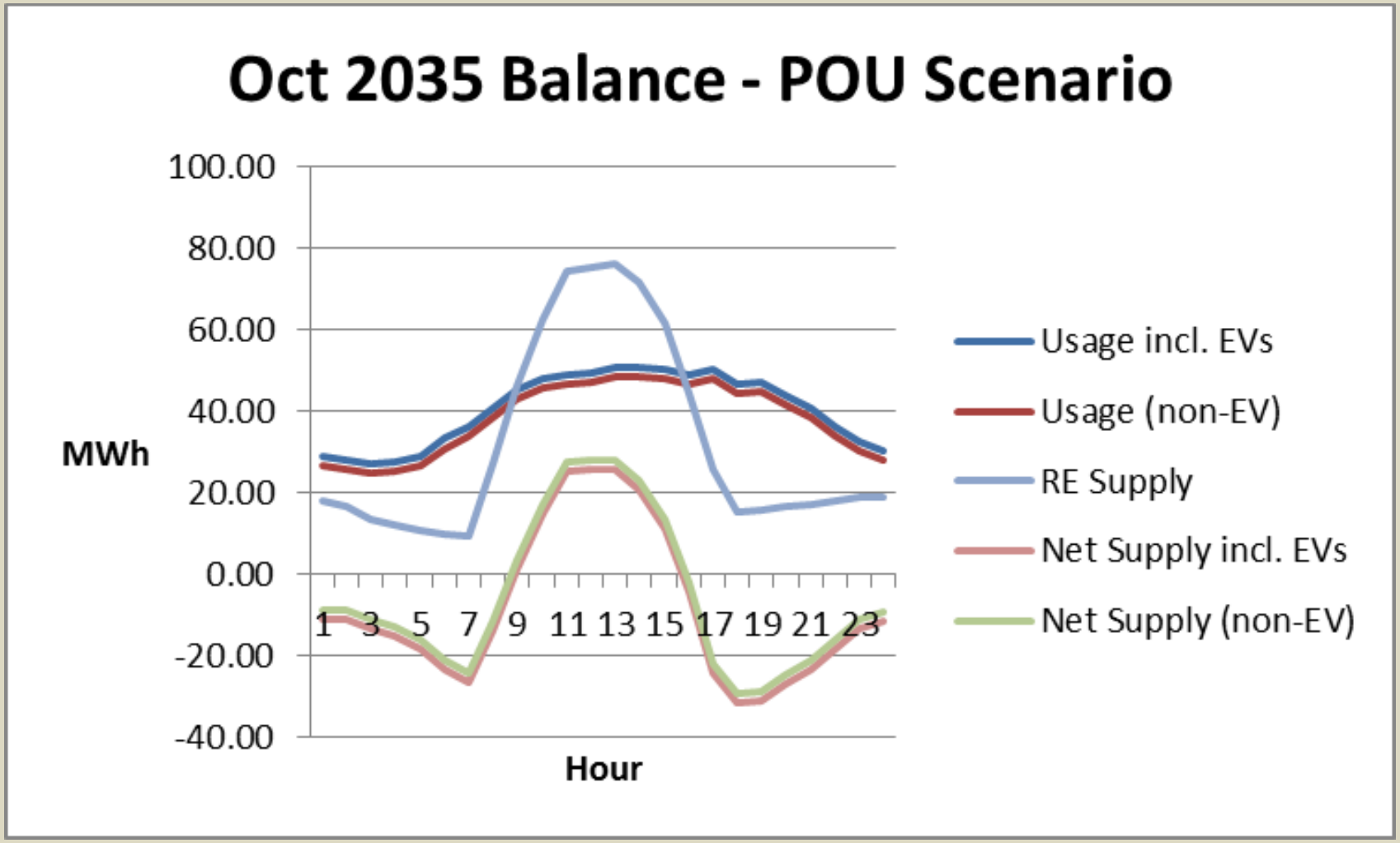
EV Demand Response Potential



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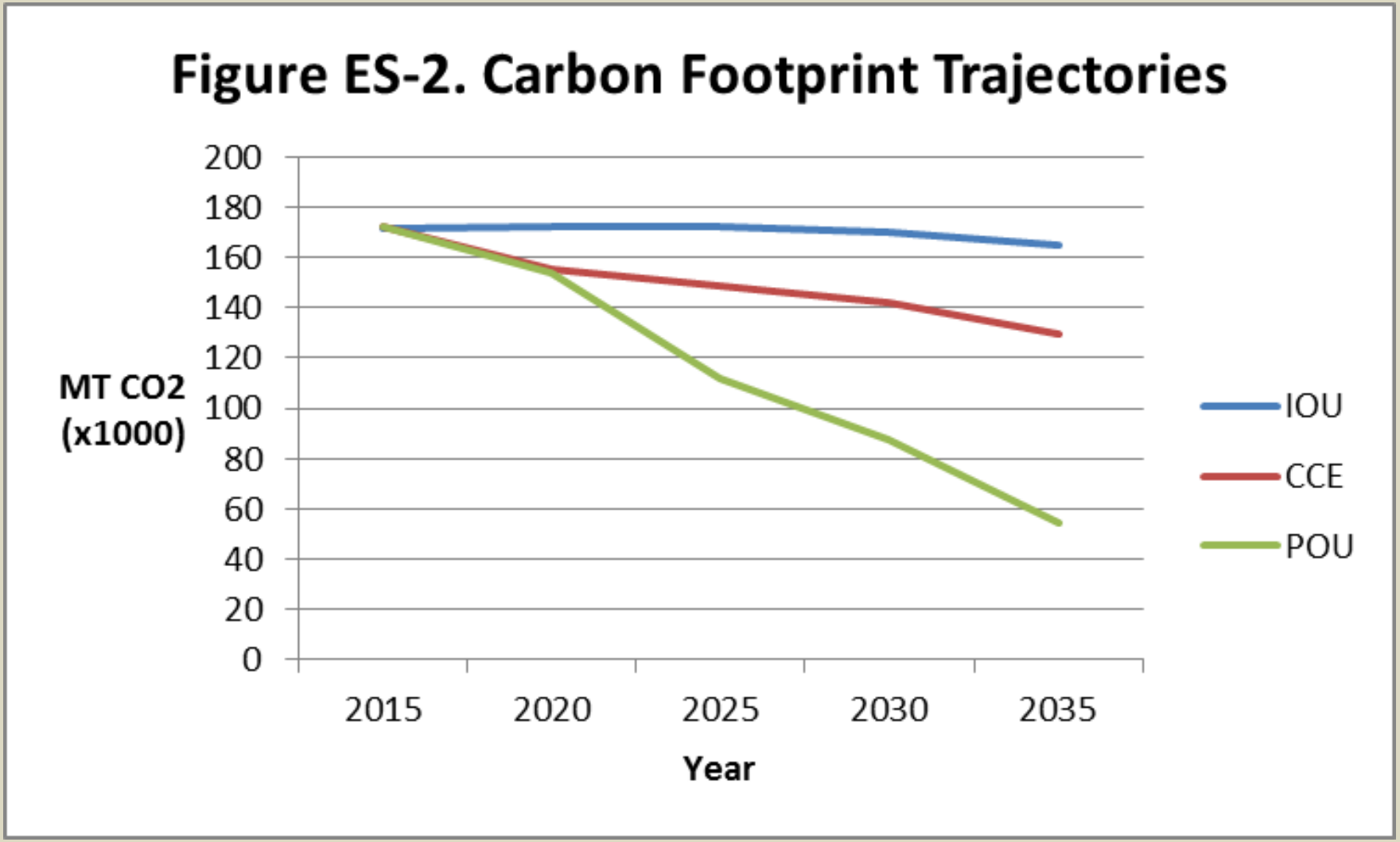
Energy Storage? How Much?

- In 2035 in the POU scenario:
  - 550 MWh average net daily over-supply in July 2035
  - 200 MWh average net daily over-supply in April 2035
- 6000 local EVs averaging 33kWh of storage capacity each = 200MWh of storage capacity capable of multiple daily charge/discharge cycles.
- Combined with an investment in stationary storage, this may suffice, assuming some excess generation can be sold to other small grids.

Carbon Footprint Comparison



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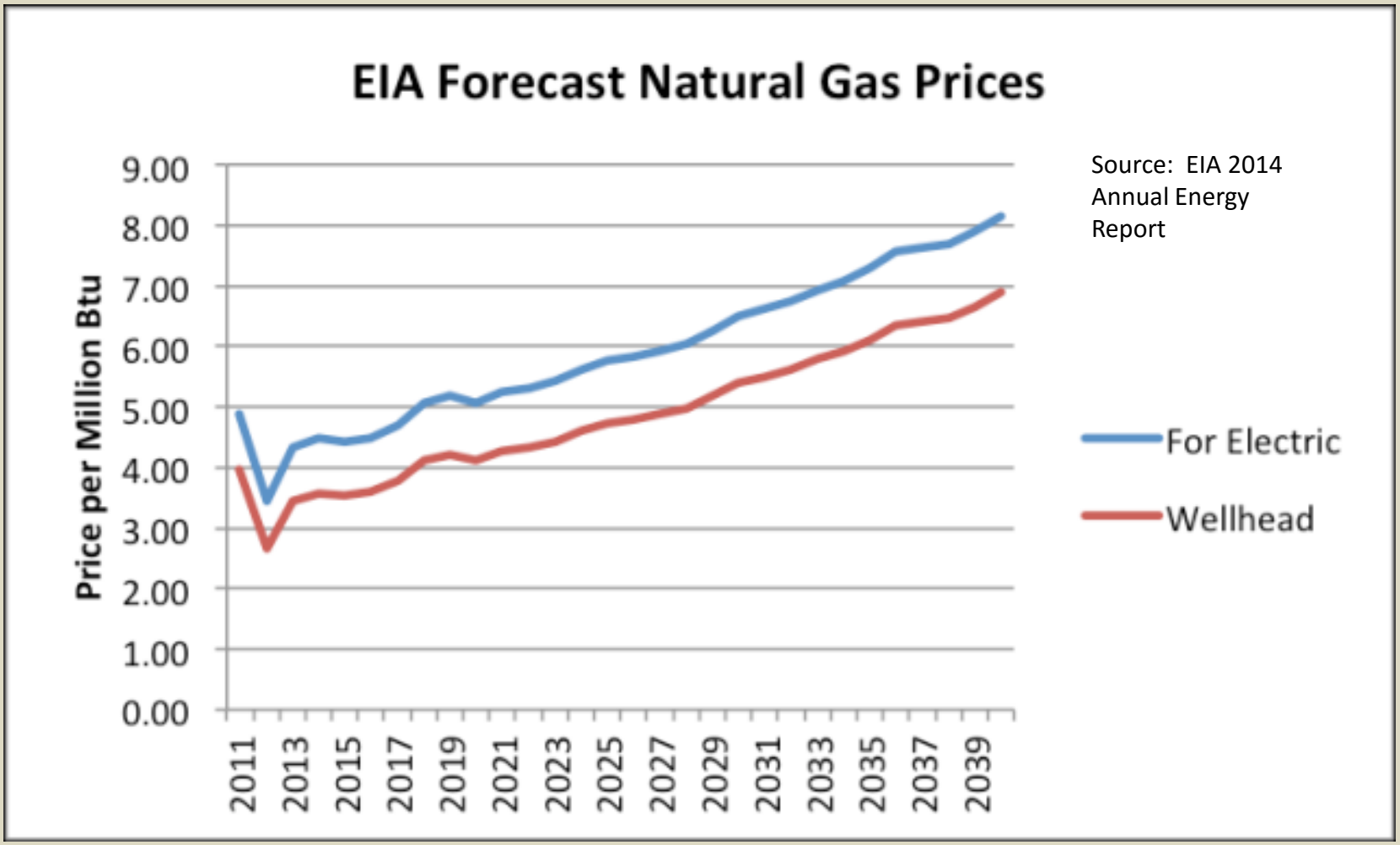
Comparative Economics



Source: EIA 2014 Annual Energy Report

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General Conclusions

- Crunching the numbers for a specific small city based on realistic assumptions and pragmatic scenarios confirms, calibrates and in some cases refutes intuitively reasonable expectations.
- Most importantly, it points to an emerging need increasing numbers of small cities will face in the next decade for locally specific and detailed integrated renewable deployment planning and analysis.
- Locally accountable energy service will be a necessary condition for locally integrated energy planning and deployment, especially where local economic and environmental improvements are targeted.

Specific Conclusions

- Most of Davis, California's energy usage can, realistically and economically, be supplied by a mix of local solar and wind resources, resulting in a near zero local carbon footprint within two decades.
- Some other small cities in northern California are even better positioned to achieve a comparable result, because they plan and operate local electricity infrastructure.
- In the near term, community choice energy frameworks enable development of local solar and wind resources that would not otherwise be developed. The increasing need for integration of regional utility and local planning may become a limiting factor in these cases unless community choice market frameworks become more flexible.

Uncharted Territory

Further analysis should address:

- The non-residential segment of Davis electricity and natural gas usage and on site electricity and heat supply, including combined heat and power deployment goals and strategies.
- Options for long term finance and ownership of on site power supply and grid infrastructure.
- Preferred evolution of the city's capacity to provide integrated local energy service.
- Infrastructure integration for fuel cell electric vehicle fleets and local solar hydrogen production/distribution.
- Potential for thermal (hot and cold) storage for supply/demand balancing, esp. storage coupled solar plants.
- Impacts of energy storage round trip inefficiencies.

Thank you!

Questions?

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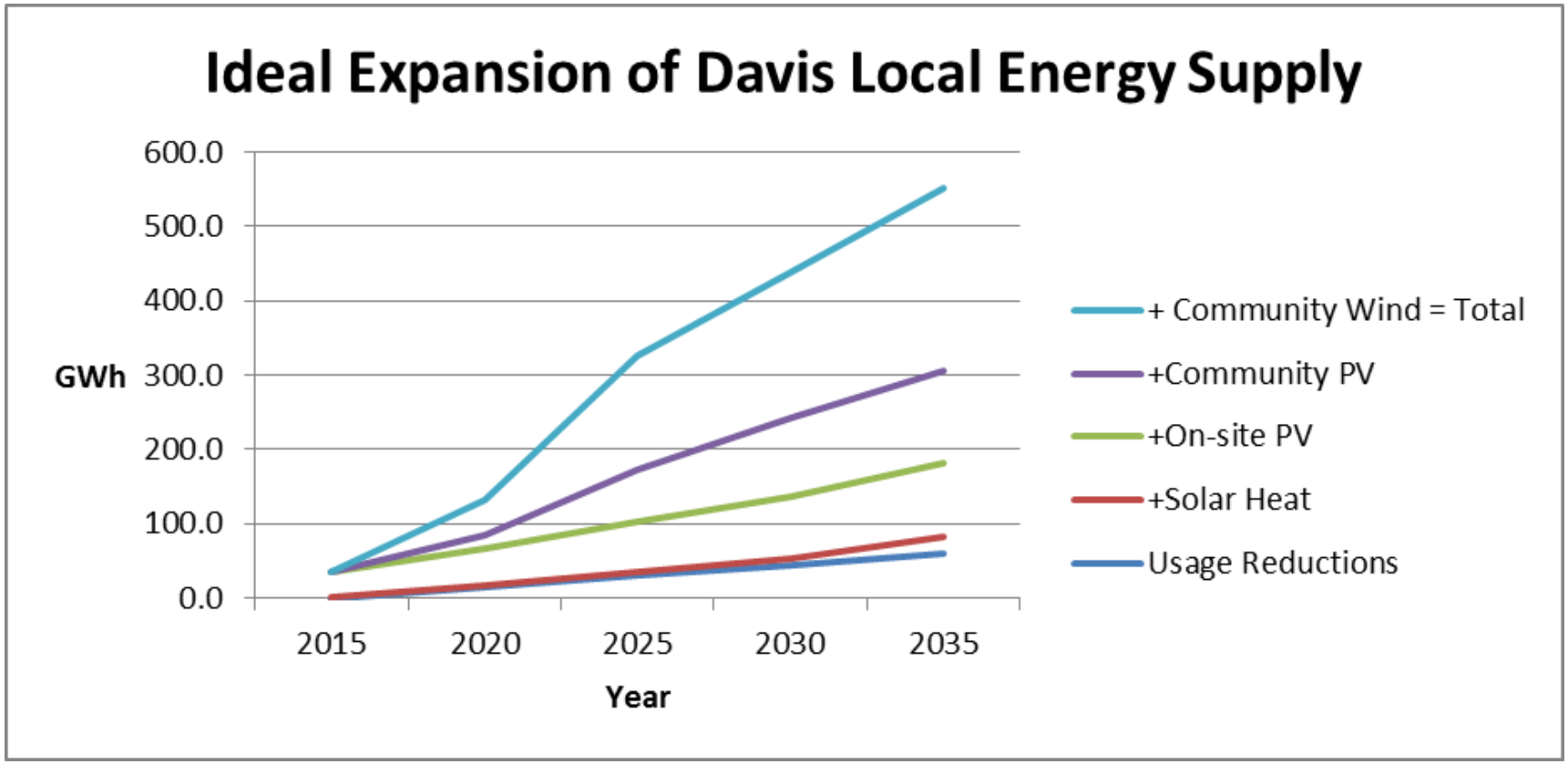
General Renewable Deployment Roadmap



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Energy Balance – Buildings plus Transportation

Ideal Davis Energy Usage/Supply Balance - 2015 to 2035					
	2015	**2020**	**2025**	**2030**	**2035**
	Annual GWh				
Unrestrained Usage	503.9	524.9	550.1	581.7	626.8
Usage Reductions	0.0	-15.5	-30.0	-44.3	-60.4
Reduced Usage	**503.9**	**509.3**	**520.1**	**537.4**	**566.4**
Local Supply Sources					
Solar Heat	0.5	1.0	4.7	10.0	21.2
On-site PV	35.2	51.0	67.1	83.2	99.3
Community PV	0.0	18.0	72.0	104.4	126.2
Community Wind	0.0	46.7	151.6	198.3	245.0
Total Local Supply	**35.7**	**116.7**	**295.5**	**395.9**	**491.6**
Imports	**468.2**	**392.6**	**224.6**	**141.5**	**74.8**
Total Supply	**503.9**	**509.3**	**520.1**	**537.4**	**566.4**

Integrated Resources Network