Additions and Revisions to the prior "EV/ Transformer Discussion Points"

I. Managed Charging

The standard approach to addressing the "*Last Mile*" challenge has been so-called "*Managed Charging*", pursuant to which EV chargers cede control to a third-party agent of the exact timing and charging rate, subject to their EV being suitably charged by the morning. This is of course a very sensible approach, which would allow the overall charging profile to be greatly smoothed out in a highly beneficial manner. Moreover, sudden bursts in generation from Wind Energy could be advantageously accommodated. More broadly, Wind Energy is notoriously volatile, and requires highly inefficient back-up from low-efficiency simple-cycle gas turbines ramping up and down, with a carbon footprint that can actually exceed that of a coal-fired power plant. Charging intermittently can obviate the need for such a costly back-up, and its benefits are widely appreciated. There have been over the last ten years numerous academic papers on this topic of *Managed Charging*, with increasingly sophisticated refinements. Moreover, two companies eMotorWerks and Fleetcarma (www.emotorwerks.com and www.fleetcarma.com) were launched specifically to offer *Managed Charging* to EV owners. However, the unfortunate truth is that *Managed Charging* has not yet been widely adopted, and both of these companies were, after reportedly struggling to survive for some time, acquired by much larger companies with deeper pockets and longer time horizons.

Moreover, electric utilities may be cautious to let such companies become too powerful, as their interests may not be congruent with those of the utilities. For example, eMotorWerk on their website advertises *"Charge up to 13*x *faster with a JuiceBox! Powerful and portable, our smart EV charging stations make it easy to charge at home and on the go".* This type of fast charging would likely exacerbate the *Last Mile* problem, and could burden utilities with large costs. Nowhere does eMotorWerks explicitly mention that its algorithms even take into account local distribution networks, and anyway, utilities may not wish to share this confidential information until matters get clarified. For example, might electric utilities wish to avoid possible conflicts of interest and provide the *Managed Charging* themselves, if they could attract the (expensive?) technical talent to get the job done? One may note that most of the utilities that have associated with eMotorWerks already have AMI-type Smart Meters capable of two-way communication, and may therefore be well-positioned to implement a form of *Managed Charging* on their own in the future.

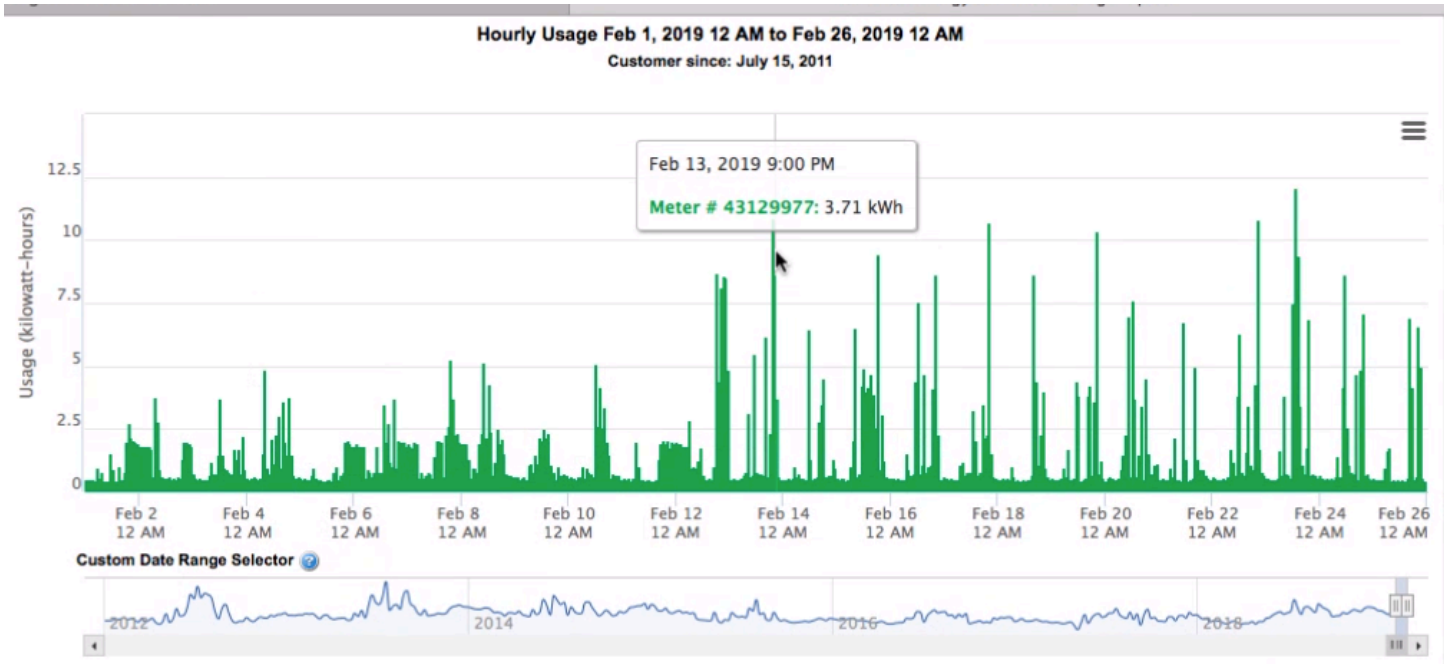
As a somewhat broad generalization, most individuals (especially in America?) seem to like to make their own decisions. They do not seem eager to pay for an expensive specialized two-way communications meter that does not actually offer them lower electricity rates in return (although a generous array of credits and other benefits are currently offered to defray the initial cost). So even though in California wholesale electricity prices in the middle of the night are demonstrably on average only half the level at the onset of PG&E's EV Off-Peak period, EV owners gain no benefit from deferring their charging to this later time (although an intermediary such as eMotorWerks might instead benefit by simply purchasing power in the wholesale or real-time market, and reselling it at a profit). Moreover, the cost of clusters of EV chargers choosing to charge at the onset of the Off-Peak period is that a mini-load-peak is created, which may expensively shorten the lives of the nearby pole-mounted local distribution transformers.

II. An Intermediate Approach

The algorithmic approach outlined in the earlier "*EV/ Transformer Discussion Points*" is in not as optimal as *Managed Charging* could be. Rather, the goal was merely to informationally assist an electric utility in acting in sensible ways in the context of an imperfect world, and to minimize potentially avoidable costs. This starts with the surprising fact that most utilities do not know which of their customers have EV's, and which of their local distribution transformers are most likely to be thermally degraded, with a consequent expensive shortening of their remaining life. Specifically, more than a dozen sensible measures were enumerated that would appear to be constructive in avoiding unnecessary costs, whose confluence could easily render EV charging unprofitable for an electric utility. In the long term, *Managed Charging* would be better, but its prospects are quite uncertain.

III. A Case Study: Corn Belt Energy

The chart below shows the hourly kwh consumption of a fellow data scientist who lives in Illinois and has recently acquired a Tesla. The electricity provider is Corn Belt Energy, a not-for-profit co-op, which is the sixth largest utility in Illinois, with more than 30,000 households and 34,000 Automated Meter Reading ("AMR") type meters, which record electricity consumption on an hourly basis, as indicated in the chart below. A simple visual inspection suggests the date of the acquisition was around February 13th, as after this date the daily peaks now regularly exceed 5kwh, while this was a rarity with just a single occurrence before. The construction of a synthetic variables, such as moving averages of respectively 3-hours, 5-hours, and 24-days would likely be quite revealing.



Nationwide, a statistical analysis of 2017 data reveals that there are over 300 utilities with more relevant meters (one-way AMR, and two-way AMI, or Smart Meters) than Corn Belt: although some of these could relate exclusively to natural gas. The five larger utilities in Illinois are described in the table below:

utility	state	grid	amr	ami	smeters
Commonwealth Edison Co	IL	PJM	0	3394474	3394474
Ameren Illinois Company	IL	MISO	441222	615409	1056631
MidAmerican Energy Co	IL	MISO	74043	0	74043
City of Springfield - (IL)	IL	MISO	59912	0	59912
City of Naperville - (IL)	IL	PJM	0	53398	53398
Corn Belt Energy Corporation	IL	MISO	33778	0	33778

Perhaps the takeaway from the foregoing is that although there is much dismay among utility analysts that Smart Meters (type AMI, with two-way communication) are not as common as would be ideal, nevertheless if the goal is the pro-active detection of EV's, and the inference of whether they are charging at Level 1 or Level 2, ***the AMR data may well be sufficient***. The key issue is to detect EV's, and most specifically clusters of Level 2 EV chargers, <u>before</u> the cumulative thermal load of the cluster severely shortens the remaining life of nearby pole-mounted transformers, with an associated cost of thousands of dollars per transformer. If this cost is imputed to the kwh sold for EV charging for a given cluster, the cost may exceed $0.15/kwh: this is more than the <u>total</u> hourly rate, and a multiple of the "*Distribution Component*" of the total hourly charge when it is broken out. For example, for the Salt River Project example provided (in Section VII below), the *Distribution Component* of the

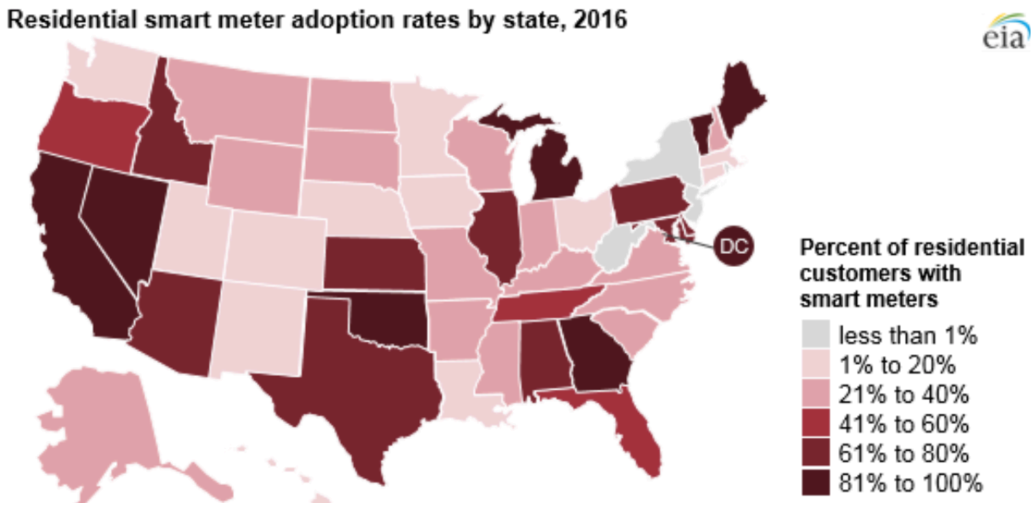
Summer Peak rate is $0.0725, while for the Off-Peak and Super-Off-Peak rates the *Distribution Component* is in each case $0.0102.

Con Ed Case Study: the importance of the AMR/AMI distinction is especially clear for Con Ed, which has relatively few genuine Smart Meters, but more than a million AMR meters. Con Ed might think "an algorithm" is not feasible, because *Managed Charging* requires two-way communication. But Con Ed could use the *Intermediate Approach* above to identify the small percent of households with EV's, and then give them a discounted deal on a Smart Meter. That way every new Smart Meter could be profitable, rather than a cost burden.

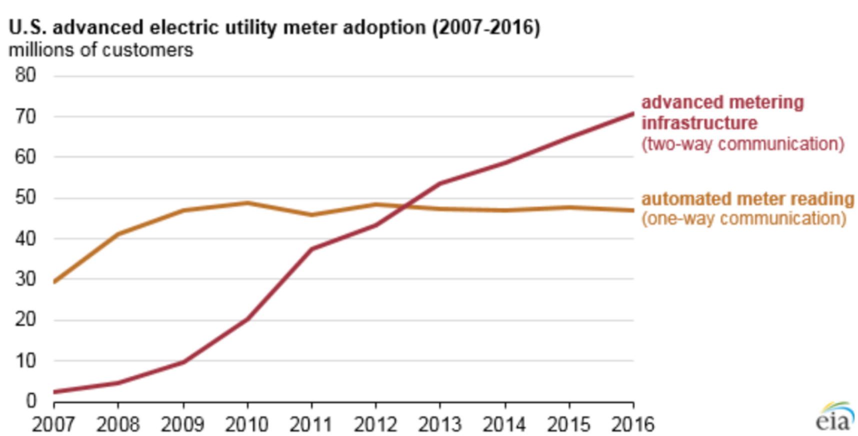
Accounting Considerations: generally accepted accounting principles (GAAP) require that the value of a given asset be amortized over its remaining life. In the prior example chart, the life of a transformer was shortened due to thermal stress from 20-30 years to just four years. In this case, the annual amortization charges should properly be increased by a factor of 5-7x. It is unclear if this is in fact being done, or if this cost is being covered up. Eventually it will of course become transparent, as the transformers will need to be actually replaced. But that may be a different management team, when the utility's current team has happily retired.

IV.National Perspective

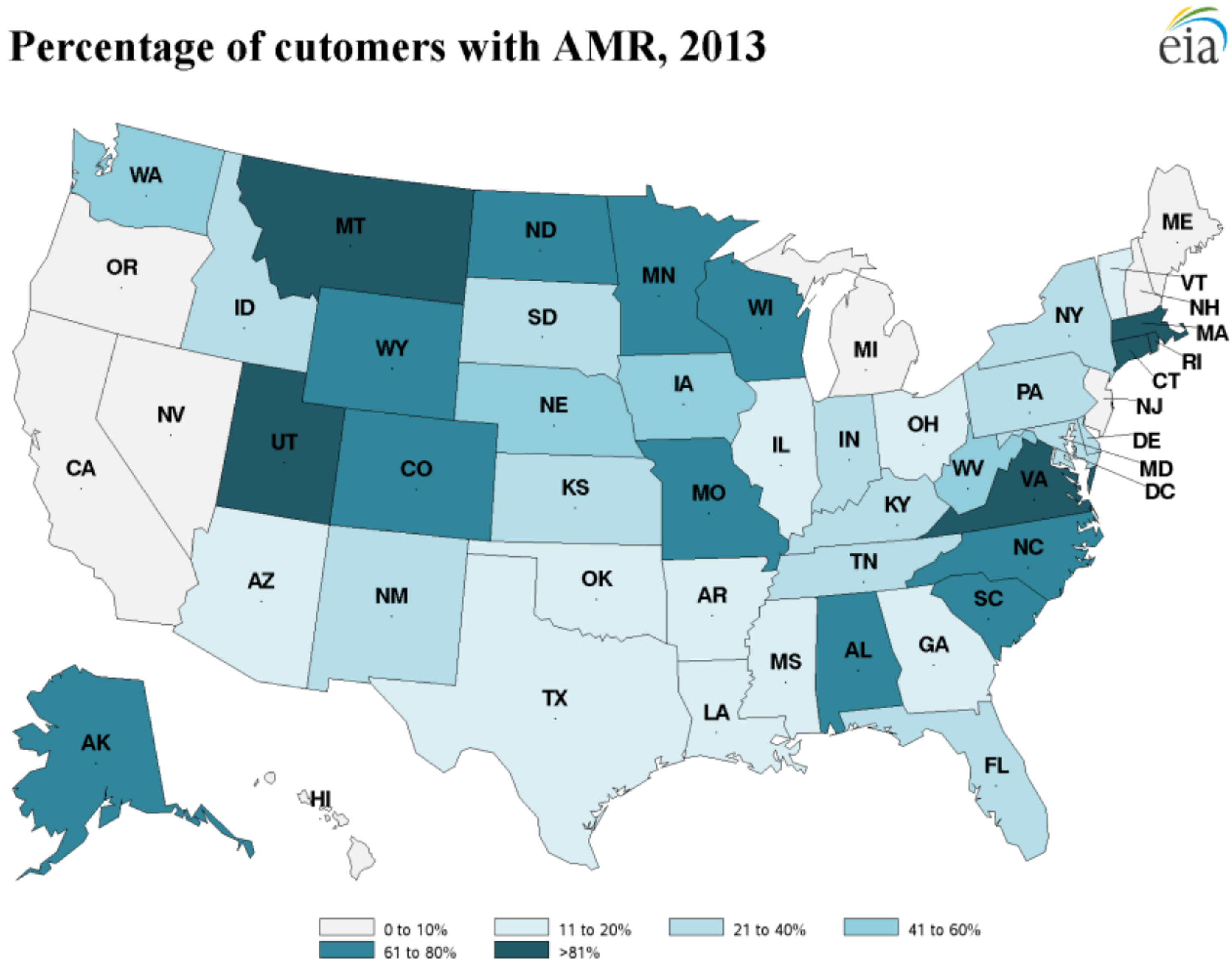
Residential smart meter penetration rates vary widely by state. Washington, DC, has the highest AMI penetration rate at 97%, followed by Nevada at 96%. Six other states had a residential AMI penetration rate higher than 80% in 2016: Maine, Georgia, Michigan, Oklahoma, California, and Vermont. In 2016, Texas added the most residential AMI meters of any state, installing smart meters on more than 200,000 customer accounts.



Two-Way Smart Metering has grown rapidly: however, Automated Meter Reading (AMR) is at almost 50% nationwide, and this hourly data appears to be valuable, and sufficient for EV detection and monitoring.



In the context of an Algorithm, states (such as New York and Connecticut) with low AMI penetration but high AMR penetration are especially interesting: because there is no two-way communication that could facilitate a temporary intervention, it is especially important that pole-mounted residential distribution transformers are configured in advance to avoid expensive permanent damage. Nationwide, almost 50% of residences have AMR-type meters. Moreover, to the extent that the installations of AMR-type meters are positively correlated with the higher income areas more likely to purchase EV's, they could potentially represent 70% of the EV's and 90% of the EV clusters that are of most interest. This however is a purely personal and speculative conjecture.



Smart Meters have two-way communication, and therefore potentially offer the possibility of a Utility intervening in the context of EV charging that may be damaging to local transformers. The two-way meters provided by eMotorWerks are tailored to EV charging and are highly sophisticated.

Perspective: suppose we arbitrarily take as a cut-off the 33,778 relevant meters that Corn Belt Energy has. With two vehicles per household, and an overall 1% EV penetration, that would yield a sample of 675 EV's to analyze at the bottom of the range. This cut-off would yield about 300 utilities, encompassing respectively an aggregate of x AMR and y AMI meters (respectively p & q percent of the total).

V. Largest Utilities in Terms of Suitable Metering

A. More than one million relevant meters (30 utilities, as set forth below)
B. More than 400,000 relevant meters. (33 utilities, as set forth below)
C. More than 150,000 relevant meters. (39 utilities, as set forth below)

The thirty electric utilities which each have more than one million relevant meters combined are listed below. AMR is Automated Meter Readings (one-way communication) and (AMI) is Advanced Metering Infrastructure (two-way communication is enabled). If we have 1% EV penetration of the cumulative stock of vehicles, then each utility would have more than 20,000 EV's (since two vehicles per household). The number of EV's may be expected to be higher as one of the motivations for installing such Meters in the first place may well have been to assist in future EV management.

NB: the variable '*smeters*' here denotes the ***Sum*** of the two relevant meter types, and does NOT denote two-way communication Smart meters, which are exclusively of the AMI-type.

utility	state	grid	amr	ami	smeters
Pacific Gas & Electric Co.	CA	CISO	0	4665973	4665973
Southern California Edison Co	CA	CISO	8460	4463243	4471703
Florida Power & Light Co	FL	FPL	544	4406460	4407004
Commonwealth Edison Co	IL	PJM	0	3394474	3394474
Oncor Electric Delivery Company LLC	TX	ERCO	0	3023661	3023661
DTE Electric Company	MI	MISO	0	2324285	2324285
Virginia Electric & Power Co	VA	PJM	1861891	339583	2201474
Georgia Power Co	GA	SOCO	0	2177917	2177917
CenterPoint Energy	TX	ERCO	0	2163953	2163953
Consumers Energy Co	MI	MISO	0	1605327	1605327
Niagara Mohawk Power Corp.	NY	NYIS	1603887	268	1604155
Duke Energy Carolinas, LLC	NC	DUK	718561	857135	1575696
Duke Energy Florida, LLC	FL	FPC	1571192	1459	1572651
PECO Energy Co	PA	PJM	900	1522805	1523705
San Diego Gas & Electric Co	CA	CISO	8	1281737	1281745
Alabama Power Co	AL	SOCO	0	1264327	1264327
PPL Electric Utilities Corp	PA	PJM	0	1246636	1246636
Massachusetts Electric Co	MA	ISNE	1223966	14998	1238964
Baltimore Gas & Electric Co	MD	PJM	49950	1141826	1191776
Duke Energy Progress - (NC)	NC	CPLE	1177640	0	1177640
Consolidated Edison Co-NY Inc	NY	NYIS	1174296	0	1174296
Connecticut Light & Power Co	CT	ISNE	1151987	0	1151987
Arizona Public Service Co	AZ	AZPS	334	1088451	1088785
Public Service Co of Colorado	CO	PSCO	1048874	11988	1060862
Ameren Illinois Company	IL	MISO	441222	615409	1056631
Union Electric Co - (MO)	MO	MISO	1056167	0	1056167
NSTAR Electric Company	MA	ISNE	1054428	0	1054428
Puget Sound Energy Inc	WA	PSEI	1018842	1167	1020009
Wisconsin Electric Power Co	WI	MISO	605288	411498	1016786
Northern States Power Co - Minnesota	MN	MISO	1016277	0	1016277

Another 33 electric utilities have between 400,000 and 1,000,000 relevant (AMR & AMI) meters, and these are as set forth below:

utility	state	grid	amr	ami	smeters
Salt River Project	AZ	SRP	3	935205	935208
Nevada Power Co	NV	NEVP	3	804486	804489
PacifiCorp	UT	PACE	796118	0	796118
Portland General Electric Co	OR	PGE	0	762211	762211
City of San Antonio - (TX)	TX	ERCO	101731	642749	744480
Duke Energy Indiana, LLC	IN	MISO	490421	236293	726714
AEP Texas Central Company	TX	ERCO	32	719226	719258
Tampa Electric Co	FL	TEC	681836	4885	686721
Oklahoma Gas & Electric Co	OK	SWPP	1	679619	679620
Ohio Power Co	OH	PJM	546488	130538	677026
Duke Energy Ohio Inc	OH	PJM	3677	639093	642770
South Carolina Electric&Gas Company	SC	SCEG	608980	8764	617744
MidAmerican Energy Co	IA	MISO	587285	0	587285
Central Maine Power Co	ME	ISNE	0	561692	561692
Sacramento Municipal Util Dist	CA	BANC	0	553695	553695
Duquesne Light Co	PA	PJM	71894	461026	532920
Potomac Electric Power Co	MD	PJM	119	507384	507503
The Narragansett Electric Co	RI	ISNE	483011	0	483011
Public Service Co of Oklahoma	OK	SWPP	273	475108	475381
Duke Energy Carolinas, LLC	SC	DUK	23291	441062	464353
Indianapolis Power & Light Co	IN	MISO	362987	85319	448306
Appalachian Power Co	VA	PJM	395847	48902	444749
Public Service Co of NH	NH	ISNE	443074	0	443074
Pennsylvania Electric Co	PA	PJM	2	439160	439162
Idaho Power Co	ID	IPCO	1167	433530	434697
Austin Energy	TX	ERCO	118	424436	424554
Wisconsin Power & Light Co	WI	MISO	0	414765	414765
JEA	FL	JEA	200198	214237	414435
Los Angeles Department of Water & Power	CA	LDWP	359234	50048	409282
Northern Indiana Pub Serv Co	IN	MISO	408500	0	408500
Indiana Michigan Power Co	IN	PJM	396461	9980	406441
Wisconsin Public Service Corp	WI	MISO	404186	0	404186
Gulf Power Co	FL	SOCO	0	404178	404178

An additional 39 electric utilities have between 150,000 and 400,000 relevant (AMR & AMI) meters, as set forth below:

utility	state	grid	amr	ami	smeters
Tucson Electric Power Co	AZ	TEPC	392592	0	392592
Appalachian Power Co	WV	PJM	358698	1159	359857
West Penn Power Co	PA	PJM	11826	331683	343509
Omaha Public Power District	NE	SWPP	330349	0	330349
City of Memphis - (TN)	TN	TVA	0	314603	314603
United Illuminating Co	CT	ISNE	90798	223221	314019
Dayton Power & Light Co	OH	PJM	309878	0	309878
Sierra Pacific Power Co	NV	NEVP	2	296551	296553
El Paso Electric Co	TX	EPE	294989	0	294989
NorthWestern Energy LLC - (MT)	MT	NWMT	292247	0	292247
Pedernales Electric Coop, Inc	TX	ERCO	0	290119	290119
Metropolitan Edison Co	PA	PJM	2820	284836	287656
Westar Energy Inc	KS	SWPP	6307	279498	285805
Nashville Electric Service	TN	TVA	12924	262716	275640
Delmarva Power	DE	PJM	57	262535	262592
Kansas Gas & Electric Co	KS	SWPP	3313	256776	260089
Kansas City Power & Light Co	MO	SWPP	24	253662	253686
Potomac Electric Power Co	DC	PJM	935	252040	252975
Cleco Power LLC	LA	MISO	0	244250	244250
Green Mountain Power Corp	VT	ISNE	2	224585	224587
Orlando Utilities Comm	FL	FMPP	211609	0	211609
Kansas City Power & Light Co	KS	SWPP	6	211165	211171
Texas-New Mexico Power Co	TX	ERCO	0	206366	206366
Jackson Electric Member Corp - (GA)	GA	SOCO	0	204445	204445
Denton County Elec Coop, Inc	TX	ERCO	0	203709	203709
Southwestern Electric Power Co	LA	SWPP	202040	0	202040
Lee County Electric Coop, Inc	FL	FPL	197805	0	197805
Western Massachusetts Electric Company	MA	ISNE	196586	0	196586
City of Colorado Springs - (CO)	CO	WACM	179189	14739	193928
Withlacoochee River Elec Coop	FL	SEC	191614	1383	192997
Middle Tennessee E M C	TN	TVA	0	191504	191504
PUD No 1 of Clark County - (WA)	WA	BPAT	186102	0	186102
Northern States Power Co - Wisconsin	WI	MISO	180691	0	180691
Cobb Electric Membership Corp	GA	SOCO	0	180495	180495
KCP&L Greater Missouri Operations Co.	MO	SWPP	0	168567	168567
Northern Virginia Elec Coop	VA	PJM	159554	968	160522
Sawnee Electric Membership Corporation	GA	SOCO	0	157982	157982
AEP Texas North Company	TX	ERCO	6	150188	150194
Southwestern Electric Power Co	TX	SWPP	150139	0	150139

VI. New York

utility	state	grid	amr	ami	smeters
Niagara Mohawk Power Corp.	NY	NYIS	1603887	268	1604155
Consolidated Edison Co-NY Inc	NY	NYIS	1174296	0	1174296
Central Hudson Gas & Elec Corp	NY	NYIS	127665	139	127804
Orange & Rockland Utils Inc	NY	NYIS	83229	40047	123276
Long Island Power Authority	NY	NYIS	15671	46365	62036
Village of Fairport - (NY)	NY	NYIS	15618	0	15618

Long Island Power Authority (aka PSEG Long Island??), commonly abbreviated as LIPA, is a municipal subdivision of the State of New York that owns the electric transmission and electric distribution system serving all Long Island and a portion of New York City known as the Rockaways. *May have a high concentration of (several thousand?) Tesla's in the Hamptons??*

An EV Working Group has been formed: *On April 24, 2018, the Public Service Commission issued an Order Instituting Proceeding, establishing the PSC EV Proceeding and defining its purpose as considering the role of electric utilities in providing infrastructure and rate design to accommodate the needs and electricity demand of EVs and EVSE. The proceeding will explore cost-effective ways to build such infrastructure and equipment, and determine whether utility tariff changes will be needed in addition to those already being considered for residential customers to accommodate and promote the deployment of EVs. The proceeding will also investigate the characteristics of EV charging systems and how those systems may facilitate EV participation as a distributed energy resource ("DER") in a manner not yet captured by the Reforming the Energy Vision ("REV") Initiative. The PSC EV Proceeding is open to all interested stakeholders. The DPS Staff will file a white paper in the proceeding for formal public comment. When public comment hearings on topics related to the EV Proceeding are scheduled by the DPS, notice of the hearings will be posted on the DPS' Document and Matter Management System.2 Additional public comment hearings will be held by the Authority in Nassau and Suffolk Counties. The dates and locations of the Authority's hearings will be posted on the Authority's website as they are scheduled*

VII. Connecticut

utility	state	grid	amr	ami	smeters
Connecticut Light & Power Co	CT	ISNE	1151987	0	1151987
United Illuminating Co	CT	ISNE	90798	223221	314019
City of Norwich - (CT)	CT	ISNE	0	16836	16836
Groton Dept of Utilities - (CT)	CT	ISNE	12645	0	12645
Town of Wallingford - (CT)	CT	ISNE	8841	0	8841

VIII. Vermont

utility	state	grid	amr	ami	smeters
Green Mountain Power Corp	VT	ISNE	2	224585	224587
Vermont Electric Cooperative, Inc.	VT	ISNE	36896	0	36896
City of Burlington Electric - (VT)	VT	ISNE	470	16241	16711
Washington Electric Coop - (VT)	VT	ISNE	0	10418	10418

IX. Breakout of the Distribution Component of Time-Of-Use Tariffs for Salt River Project

"On-peak hours from May 1 through October 31 consist of those hours from 1 p.m. to 8 p.m., Monday through Friday, Mountain Standard Time, excluding the holidays listed in Condition C below. On-peak hours from November 1 through April 30 consist of those hours from 5 a.m. to 9 a.m. and from 5 p.m. to 9 p.m., Monday through Friday, Mountain Standard Time, excluding the holidays listed in Condition C below.

Super off-peak hours year-round consist of those hours from 11 p.m. to 5 a.m., Mountain Standard Time, on weekdays, weekends, and holidays. All hours that are not on-peak or super off-peak are off-peak."

For Salt River's Time-Of-Use plan announced in 2015, the On-Peak "Distribution Delivery" charge increases sevenfold in the Summer, while the 'Generation Charge' increases 2.3x.

SUMMER PEAK	On-Peak All kWh	Off-Peak All kWh	Super Off-Peak All kWh
Distribution Delivery	$0.0725	$0.0102	$0.0102
Transmission Delivery	$0.0476	$0.0051	$0.0051
Transmission Cost Adjustment	$0.0000	$0.0000	$0.0000
Ancillary Services 1-2	$0.0024	$0.0003	$0.0003
Ancillary Services 3-6	$0.0026	$0.0003	$0.0003
System Benefits	$0.0007	$0.0007	$0.0007
Environmental Programs Adjustment	$0.0055	$0.0055	$0.0055
Competitive Customer Service	$0.0000	$0.0000	$0.0000
Energy (Generation)	$0.0618	$0.0265	$0.0114
Fuel and Purchased Power	$0.0295	$0.0295	$0.0295
Total	$0.2226	$0.0781	$0.0630

X. <u>"Adopt the European (averaging) approach of larger (100 kVa) transformers serving more households"</u>

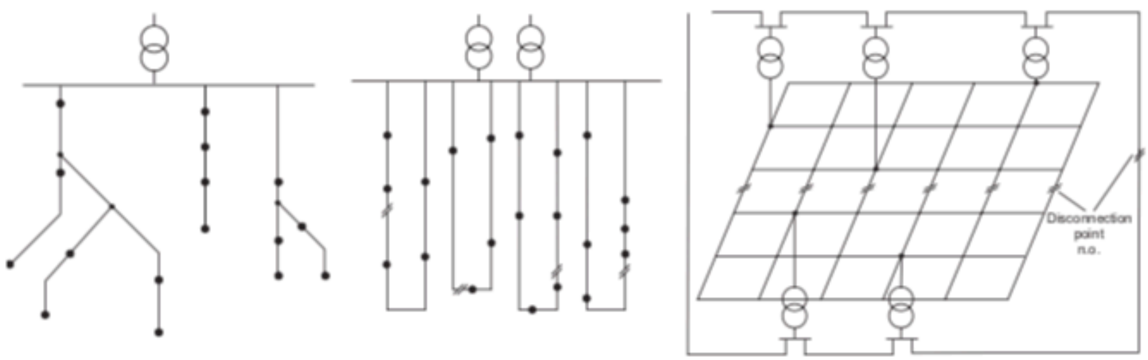
Toronto, Canada seems to have a similar approach to Europe, with 100 kVa transformers being more common, relative to the 25 kVa transformers most popular in the US. In a 2016 study of a suburb of Toronto with relatively high EV ownership, two 100 kVa pole-mounted transformers serve 19 and 16 households respectively. Interestingly, the *emergency capacity* of these transformers during Winter and Summer is 150 kVa and 125 kVa respectively (these values are based on assumed ambient temperatures of 33F & 88F respectively). Of course, in Summer the air-conditioning load is high, so an overload is more probable.

XI. <u>Radial and Meshed Distribution Networks</u>

The "Meshed" distribution networks appear to offer superior reliability, but seem rare in the US, but more common in Germany and Switzerland.

Radial configuration

The simplest structure is the radial configuration which is characterized by having only one path for power to flow from the source (SSt) to each customer (TSt). The main feeders are connected via circuit breakers to the bus-bar on the 10 kV-MV-winding of a 110 kV to 10 kV substation. Each of these feeders exclusively feeds several TSts (connected via load break switches). Figure 2.1 a) shows a radial structure.



a) radial configuration b) open-ring configuration c) meshed configuration

Figure 2.1: Examples of a) radial, b) ring and c) meshed configuration [12]

Open-ring configuration (one substation)

Distribution networks in open-ring configuration increase the reliability of supply by the option to connect two main feeders from one substation (now called half-rings) with each other, see Figure 2.1 b). During normal operation the switch connecting the half-rings is open, in case of a disturbance the affected device or conductor section is disconnected and the connection switch is closed to ensure supply of all operable TSts. This configuration is useful for areas with high load density and a centrally placed SSt.

Open-ring configuration (two substations)

In the cases of elongated areas, long straight cable routes or outlying SSts it is recommended to construct an open ring structure between two different SSts. In this configuration the two half-rings start at two different neighboring SSt (which are connected via the HV grid). The switching procedure is similar to switching with only one SSt.

2.1.3 Low voltage distribution networks

German local low voltage grids (secondary distribution) operate at 400 V and spread out from a single TSt (MV/LV).
A TSt's supply radius is between 250 m to 500 m depending on its rated apparent power S_r (100 kVA to 630 kVA). This corresponds to 30 to 500 residential units, the radius of the supply area is limited by voltage drop limits along the lines.
In addition to the transformer, cable distribution cabinets with 4 to 8 outlets are placed at crossroads. This allows an individual disconnection of malfunctioning sub-feeders while the main feeder maintains normal operation.
Although the reliability level decreases from meshed[1] over open-ring to radial configuration [11] the radial configuration is because of its easy and clear operation the most practical configuration [13, 1].

An Important Development in the Peak-to-Average Ratio: since the 2014 report mentioned below, EV's with larger batteries (which tend to be charged with the faster Level 2 chargers) have become more common. The *Peak-to-Average* ratio for a normal household might be c.2x, and transformers appear to be optimally configured for this profile. A Level 1 charger might charge for eight hours overnight (equivalent to about 50 miles of driving range), and therefore has a *Peak-to-Average* ratio of 3x. However, this is equivalent to just two hours at the higher Level 2 charging rate. The *Peak-to-Average* ratio for such a Level 2 charger is 12x. This changes a lot of things in quite a fundamental way.

XII. <u>Other [Nancy Ryan is a former colleague of Colleen's]</u>

Dr. Nancy Ryan is an economist who focuses on GHG mitigation policy, electricity regulation, and transportation electrification at E3, and handles much of its regulatory and business strategy work. She has spent her career working for effective, data-driven energy solutions as a consultant, a regulator, an academic, and an environmental advocate—personifying the 360-degree industry perspective that guides all of E3's work. Nancy's multifaceted career honed her ability to synthesize and translate complex information into plain English, a talent she puts to work for E3 clients and the energy stakeholders E3 works with. She also educates leaders in other industries, such as transportation, that experience the effects of changes in the energy landscape, and she has taught regulatory policy and cost-benefit analysis at the University of California and the University of British Columbia.

Nancy joined E3 in 2013 after working for seven years with the California Public Utilities Commission. She was appointed a commissioner by Gov. Arnold Schwarzenegger, serving from 2010 to 2011. She also served as deputy executive director for policy and external relations and chief of staff to the president, working closely with policy makers, regulators, and stakeholders in areas such as renewable energy, the smart grid, electric transportation, and the implementation of cap and trade for the electric sector. Her career also includes five years at the Environmental Defense Fund, where she focused on energy and climate policy and dabbled in water. She also held positions at several consulting firms.

Nancy finds E3 a natural fit for her background, and she respects the intelligence and integrity of her colleagues. She likes working at E3 because the firm is making a difference, helping clients make informed decisions that matter to the public, investors, and the environment. nancy.ryan@ethree.com

Education: PhD, economics, University of California, Berkeley; BA, economics, Yale University

E3 assisted Southern California Edison (SCE) in developing the policy case for its successful application to the California Public Utilities Commission to pilot a ratepayer-funded plug-in electric vehicle (PEV) infrastructure program and education effort. Envisioned as the first phase of a five-year program, the Charge Ready initiative will accelerate the buildout of charging infrastructure by preparing host sites and providing rebates to defray the cost of charging equipment. SCE will recruit hosts in multifamily buildings, workplaces, and disadvantaged communities to ensure that charging is available to a broad spectrum of potential PEV owners. E3 provided supporting analysis, which showed that increasing PEV adoption by 2030 is essential to achieving California's long-term GHG mitigation goals. SCE also relied on E3's cost-benefit analysis to show that PEV adoption yields net economic and ratepayer benefits. In January 2016, the CPUC authorized SCE to proceed with the pilot program.

Transportation electrification assessment | CalETC, 2014–16

E3 analyzed the grid impacts of charging light-, medium-, and heavy-duty electric vehicles (EVs) for the California Electric Transportation Coalition (CalETC), a consortium of automakers and utilities. To quantify the distribution system upgrades needed to accommodate residential charging of light-duty EVs, we mapped vehicle registration data with utility distribution system and load data for more than 81,000 circuits and feeders and 2,200 substations; we then modeled costs under different rate and charging scenarios. Even with clustered EV adoption, distribution impacts were modest, and we found that managed charging reduced distribution upgrade costs by 60 percent. For most technologies studied, we showed that EV adoption can actually reduce rates for utility customers while providing net economic, environmental, and societal benefits for California. CalETC's member utilities used our study to educate regulators and stakeholders about the benefits of EV adoption prior to seeking authorization to invest ratepayer funds in charging infrastructure and customer outreach.

2014 Energy and Environmental Economics, Inc. **PEV Phase 2 2014 pdf Report 80p**
Nancyryan@ethree.com

4.3. Mapping PEV Clusters to Distribution System

The final step in the clustering analysis is mapping each ZIP+4 cluster of PEVs to circuits and feeders on the utility distribution systems. Geographic Information System (GIS) analysis mapped each ZIP+4 area to the closest utility circuit or feeder according to its latitude and longitude information. In nearly all cases, there is a one to one mapping of PEV ZIP+4 clusters to a single circuit (for SMUD) or feeder (for the IOUs).

4.7. Distribution System Costs

4.7.1. DISTRIBUTION COSTS FOR AT HOME CHARGING

Recall that the scenarios assume the 80 percent or more of vehicle charging will occur at home. Under these scenarios studies, we find that the incremental feeder and substation upgrades driven specifically by incremental PEV charging to be relatively small. In the non-TOU rate scenarios, the present value costs are just under $400 million in the ZEV Most

Likely adoption case (Figure 12). TOU Rates shift charging off-peak and reduce upgrade costs by over 40% to under $150 million. Under the more aggressive ZEV x 3 adoption case, the present value distribution costs increase to $910 million (Figure 13). Note that the distribution upgrade costs do not increase linearly between the ZEV Most Likely and ZEV x 3 case. At higher levels of adoption, the available capacity of the existing system is exhausted more quickly, and the PEV related upgrades are larger in both number and size. Nevertheless, even at the ZEV x 3 adoption case, annual distribution costs are roughly $9 million per year - less than 1% of the 2012 distribution revenue requirement of $9 billion for the four utilities.

==