# REVIEW OF KEY ASSUMPTIONS UNDERLYING DR. FARUQUI ESTIMATE OF INCREMENTAL IMPACT OF AMI ON SALES OF PLUG-IN ELECTRIC VEHICLES (PEV)

Dr. Faruqui presents his quantification of societal benefits and costs associated with PEV's in his Direct Testimony on Rehearing, Ameren Exhibit 5.6RH. His quantification rests upon a number of assumptions. This exhibit reviews those assumptions.

There are two categories of plug-in electric vehicles (PEVs), Plug-in Hybrid Electric Vehicles (PHEV) and Battery Electric Vehicle (BEV). Dr. Faruqui limits his analyses to Plug-in Hybrid Electric Vehicles.

Dr. Faruqui asserts that implementation of the AMI Plan will cause incremental sales of plug-in electric vehicles to residential customers of Ameren Illinois, and are therefore a source of societal benefits and costs. His position is that implementation of AMI will allow Ameren to offer time-of-use (TOU) pricing, which in turn will cause incremental purchases/sales of PEV because a residential customer could charge a PEV at less cost using that pricing as opposed to charging under typical flat pricing.

Dr. Faruqui's estimate rests upon a number of assumptions including:

1. Ameren must implement AMI in order to enable or support TOU pricing for residential customers;
2. The availability of TOU pricing enabled by AMI will cause incremental annual sales of PEVs to residential customers;
3. Annual sales of PEVs to residential customers in the absence of TOU pricing;
4. Societal costs of incremental annual sales of PEVs to residential customers
5. Societal benefits of incremental annual sales of PEVs to residential customers, including reduction in gasoline consumption and carbon emissions

Following is our review of these assumptions.

**Assumption 1. Ameren must implement AMI in order to enable or support time-of-use rates for residential customers**

Dr. Faruqui assumes that "… a small set of residential customers will buy electric vehicles in response to the incentives created by a TOU rate and smart charging enabled by a Home Energy Management System" (Faruqui, p.9, line 195). He then estimates the benefits and costs of those incremental purchases of PEVs, and attributes those benefits and costs to implementation of the AMI Plan.

It is not reasonable to attribute any benefits or costs of PEVs to the AMI Plan because Ameren could offer TOU pricing without implementing AMI. For example:

- in response to AG Data Request 6.04 a Dr. Faruqui confirmed that a residential customer could choose a time-of-use (TOU) rate if he or she had an interval meter and if Ameren or other third party supplier offered a residential TOU rate;
- in response to AG Data Request 3.17 h Dr. Faruqui responded that many utilities now offer TOU rates for PEVs, however in response to AG Data Request 6.04 b he responded that the Brattle Group does not have and has not researched information about the specific technologies that utilities are using to implement their TOU rates;
- As of July 2011 Union Electric Company d/b/a Ameren Missouri was offering a Time-of-Day rate to its residential customers.

**Assumption 2. The availability of TOU pricing enabled by AMI will cause incremental annual sales of PEVs to residential customers**

Dr. Faruqui begins by estimating the rate at which residential customers would make incremental purchases of PEVs. His position is that those incremental purchases would be solely a function of the cost savings a residential customer would realize by charging a PEV under TOU pricing relative to charging it under typical flat pricing. Economists refer to the sensitivity of demand for one good due to the price of another as the "cross-price elasticity of demand." This elasticity represents the percentage change in demand for every 1% change in the price of another good (e.g. an elasticity of 0.5 would mean demand for Good 1 would increase by 0.5% for every 1% increase in price of Good 2). As discussed below, Dr. Faruqui's estimate of the extent to which

the availability of TOU pricing will cause incremental annual sales of PEV to residential customers is developed in the following steps:

- He assumes that TOU pricing will save PEV owners 23% when compared to typical flat rates over the twenty year time horizon Ameren uses to evaluate its AMI Plan. In his testimony and in Data Response AG 6.08, Dr. Faruqui cites his own article on estimating electricity cost savings from dynamic pricing for PEV owners as his justification for this methodology.
- He assumes the price elasticity for PEV adoption by Ameren residential customers will be equal to the price elasticity of hybrid electric vehicle (HEV) sales with respect to gasoline prices over the period 2000 to 2006 identified in one academic research paper published in 2009. That one paper found that "as the price of gasoline increased by 1%, the quantity of fuel efficient hybrid vehicles increased by 0.86%" (Dr. Faruqui, p.13, lines 290-291). He then applies this price elasticity (0.86) to his estimated 23% electricity cost savings from dynamic pricing to arrive at a 20% increase in PEV sales (.86 * 23%) (Dr. Faruqui, p.13-14, lines 292-294).

The inconsistencies and pproblems with these assumptions are discussed below:

- Ameren compares the costs of charging to gasoline on their website entitled "Charging Time & Fuel Cost Comparison" (attached) but this is based on flat rates and makes no mention of TOU rates.[1]
- The price of electricity is not the only determinant of a PEV purchase. In their analysis in the 2012 Connecticut IRP, the Brattle Group listed several barriers to increased PEV adoption including: "initial cost of the vehicle," "unfamiliarity and range anxiety" and "availability of charging infrastructure."[2]
- Customers may resist switching from flat rates to TOU rates. In their 2010 PEV assessment, Ameren Illinois stated that, "customers may perceive a small benefit under TOU, but find such benefits do not outweigh the convenience of a standard rate." A

[1] http://www.ameren.com/Environment/ElectricVehicles/Pages/ChargingTimesEstimatedCost.aspx. Downloaded on August 24, 2012.
[2] Brattle Group. 2012. 2012 Integrated Resource Plan for Connecticut. Connecticut Department of Energy and Environmental Protection.

recent EPRI report discusses the different effects of TOU pricing on both BEV's and PHEV's, claiming that "if a flat rate comparable to current prices is available, PHEV drivers will be much more likely to choose the flat rate, even if they have to forgo the benefit of the nighttime rate."[3]

- Dr. Faruqui provides no evidence for applying the price elasticity of hybrids with respect to gasoline in order to predict PEV sales. When asked to provide "all the research on the major drivers of residential PEV sales and residential hybrid vehicles sales that Dr. Faruqui reviewed" his response was "we are unaware of any existing data showing how sensitive PEV sales are to electricity prices" (Data Response AG 6.07 b).
- When asked to provide "all analyses of actual residential electricity prices and actual annual residential PEV sales" that he reviewed, Dr. Faruqui responds by saying that "it is premature to undertake this type of analysis due to the nascent nature of the implementation of PEV and AMI technology" (Data Response AG 6.08 c).
- There are several issues with Dr. Faruqui's previous research that he used to justify the savings from dynamic pricing for PEV owners:
    - The article cited claimed that "if the price elasticity is consistent with what has been observed in whole-house applications of time-of-use (TOU) pricing, then the outcome might be disappointing." In fact, the article refers to another previous study that "suggested that wholesale electricity prices could even increase with TOU rates for PEVs."[4]
    - The article also measured the cost savings of a Nissan Leaf which is a Battery Electric Vehicle (BEV) whereas Brattle only modeled Plug-in Hybrid Electric Vehicles in this filing (PHEV) (Data Response AG6.05 a and 6.05 b). PHEV's rely on both electricity and gas, however, Dr. Faruqui applies the effect of electricity cost savings on BEV adoption to that of a PHEV.
    - The article estimated savings from TOU for PEV 's assuming Level 2 charging for the Nissan Leaf whereas Dr. Faruqui is assuming that Ameren's PEV owners will all have Level 1 charging which is much cheaper to install but requires longer charging times (Data Response AG 6.21 i). Therefore, due to the differences in

[3] EPRI. 2011. Transportation Electrification: A Technology Overview. July 2011.
[4] Faruqui, Ahmad, Ryan Hledik, Armando Levy and Alan Madian. 2011. Smart Pricing, Can time-of-use rates drive the behavior of electric vehicle owners? Public Utilities Fortnightly, October 2011, 38-45.

costs and electricity usage between charging types, it is not reasonable to include the lower costs of Level 1 charging with the higher benefits of Level 2 charging.

**Assumption 3. Annual sales of PEV to residential customers in the absence of TOU pricing**

Dr. Faruqui applies the previous assumption to estimate new PEV sales due to AMI in the following way:

- He starts with the assumption of PEV adoption based on a "Becker, Sindu & Tendrich estimate that PEV's will constitute 24% of the light vehicle fleet in 2030" (Dr. Faruqui, p. 14, lines 298-299).
- He then halves this number to "better reflect PEV penetration predictions filed with the ICC in 2010 in Ameren Illinois" to get 12% adoption (Dr. Faruqui, p. 14, lines 299-300).
- Then, applying the portion of vehicle miles traveled by light vehicles (90%) to this he arrives at an estimate of 11% adoption.
- He then applies the 20% increase in PEV sales due to electricity cost savings and more reductions ("we halve this number again, and then reduce it by one-third to get to the baseline case") to match Ameren's assumption of 0.8% of TOU, HEMS and PEV participation (Dr. Faruqui, p. 14, lines 303-306; Exhibit 5.3RH, page 1). If, as Faruqui claims, 20% of PEV sales are due to AMI then this means that effectively the PEV fleet would be 4% of all vehicles (0.8% / 20%).

Problems with these assumptions are discussed below:

- The study that Dr. Faruqui refers to estimates PEV market share is based on Energy Information Administration (EIA) gas prices applied to a technology adoption model from 1969.[5] When asked he did not simply use the EIA's forecasts for electric vehicle adoption, Faruqui responded that "Becker et al. provide cumulative market shares. The AEO reports only offer the market share in terms of new vehicle sales for a given reference year" (Data Response AG 6.10 b). In fact, the EIA does provide sales and stock of electric vehicles for every future year so this response is incorrect. The EIA's Annual

[5] Becker, Thomas, Ikhlaq Sidhu and Burghardt Tenderich. 2009. Electric Vehicles in the United States: A New Model with Forecasts to 2030. Center for Entrepreneurship & Technology (CET) Technical Brief. See Exhibit 5.

Energy Outlook forecasts that PEV's will comprise 1.3% of the light vehicle fleet in 2030 (3.4 million PEV's of the 264 million in the fleet).[6]

- When asked "how does the assumption that PEV's will represent 11% of the total fleet compare with more recent projections of PEV adoption?" Dr. Faruqui responded that "the Brattle Group is unaware of any more recent studies" (Data Response AG 6.11 c). This claim is unfortunate since the Becker et al study is from 2009 and much research (in addition to the AEO forecasts discussed above) has been made available since including a study by MIT and National Research Council (which includes a "probable" scenario that PEV's will make up 4.5% of the fleet in 2030).[7,8]

**Assumption 4. Societal costs of incremental annual sales of PEV to residential customers**

Dr. Faruqui assumes that the premium for PEV's (i.e. the cost over and above conventional vehicles) is $9,500 in 2012 but declines over time (Dr. Faruqui p.12, line 271). To arrive at this assumption, he cited several sources including "informal conversations with experts as well as a review of automotive literature" and "prices of the Chevy Volt electric vehicle and the Toyota Prius PHEV were compared to similar models of vehicles made by their respective manufacturers" (Data Response AG 6.21 b).

Problems with this assumption are discussed below:

- The 2013 Chevy Volt currently costs $39,145 and even adjusting for the eligible $7,500 tax credit, this is nearly $15,000 more than the Chevy Malibu.
- The Toyota Prius Plug-in Hybrid costs $32,000 at minimum and even adjusting for the eligible $2,500 tax credit, this is over $13,000 more than the Toyota Corolla.

[6] EIA AEO 2012. Table 58: Light-Duty Vehicle Stock by Technology Type, Reference case. Available here: http://www.eia.gov/forecasts/aeo/tables_ref.cfm

[7] MIT. 2011. The Future of the Electric Grid. An MIT Interdisciplinary Study.

[8] National Research Council. 2010. Transitions to Alternative Transportation Technologies-Plug-in Hybrid Electric Vehicles. See: http://www.nap.edu/catalog.php?record_id=12826

- While Dr. Faruqui assumes that Level 1 charging will be included, if customers require Level 2 charging (i.e. higher voltage for charging in less time) then the installation costs would increase the premium by an additional $2,000 or more.[9]
- Currently, the tax credits are partly making up for the cost differences between PEV's and conventional vehicles yet these incentives are likely to decrease or vanish in the future.

**Assumption 5. Societal benefits of incremental annual sales of PEV to residential customers, including reduction in gasoline consumption and carbon emissions**

Dr. Faruqui estimates fuel savings from PEV adoption based on gas mileage from a July 2007 EPRI report documented in Data Response DAB 3.02 and Data Response AG 7.10 Attachment 1. This study assumes that conventional (i.e. gas-powered) vehicles get 30 miles per gallon in 2050 from Table 5.1 and 5.2 of the EPRI report.

The problem with this assumption is that the EPRI report is five years old and, therefore, does not account for more stringent CAFE (Corporate Average Fuel Economy) Standards that have been implemented or proposed. The current CAFE Standards for 2011 are 30.2 miles per gallon for passenger cars. However, President Obama has proposed increases in fuel economy up to 49.6 miles per gallon by 2025 for light vehicles.[10] A more realistic gas mileage assumption would decrease the estimated gasoline savings to PEV owners in Dr. Faruqui's analysis. Also, a more recent EPRI report also points out that "owners of plug-in hybrid vehicles that choose to delay charging may end up consuming more gasoline, possibly increasing their energy costs."[11]

[9] See: http://www.autobytel.com/chevrolet/volt/2011/car-buying-guides/gm-sets-pricing-for-2011-chevrolet-volt-home-charging-station-106968/

[10] Environmental Protection Agency and National Highway Traffic Safety Administration (EPA and NHTSA). 2011. Proposed Rule: 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards. Federal Register, Volume 76, No. 231. December 1, 2011.

[11] EPRI. 2011. Transportation Electrification: A Technology Overview. July 2011.

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- Know the Basics
- Discover the Benefits
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- Get Plug-in Ready
- FAQs
- Free Service Assessment
- Learn More
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Renewable Energy
Solar Energy
Sustainability
Wildlife Protection

# Charging Time & Fuel Cost Comparison

Charging times and costs have more to do with your daily commute and personal driving habits than with the electric vehicle you own. For this reason, it's best to talk about these in terms of the commute miles you are looking to recover with each recharge.

The following table summarizes average charging times and costs per day based on various daily commute miles. Actual daily charging costs may differ based on customer classification, the time of year, and rate structure differences between Ameren Illinois and Ameren Missouri.

**Charging Times and Costs**

| Miles Driven Daily | Charging Times: Level 1 (120V) | Charging Times: Level 2 (240V) | Charging Times: Level 3 (480V) | Daily Charging Cost[2] | Equivalent Gasoline Costs[3]: $3 per gallon | $4 per gallon | $5 per gallon |
|---|---|---|---|---|---|---|---|
| 20 | 4-5 hours | 1-2 hours | 10 minutes | $0.50 | $2.00 | $2.65 | $3.35 |
| 30 | 6-8 hours | 2-3 hours | 15 minutes | $0.75 | $3.00 | $4.00 | $5.00 |
| 40 | 8-10 hours | 4-5 hours | 20 minutes | $1.00 | $4.00 | $5.35 | $6.65 |
| 50[1] | 10-13 hours | 5-6 hours | 25 minutes | $1.25 | $5.00 | $6.65 | $8.35 |
| 75[1] | 15-19 hours | 7-8 hours | 30 minutes | $1.90 | $7.50 | $10.00 | $12.50 |

[1] Data only applies to an electric vehicle that can provide this many "electric only" miles.
[2] Based on Ameren's blended residential rate of 8¢ per kilowatt-hour.
[3] Based on a conventional vehicle rated at 30 MPG.