Use of an Electric Vehicle Greatly Reduces the Return on Investment Period for a Solar Array

John F. Hedge Jr., FAIA
DesignGroup
515 East Main Street
Columbus, OH 43215
Email: jhedge@designgroup.us.com

ABSTRACT

Because of relatively lower electricity costs in Ohio and the mid-west, the return on investment for a residential solar array is in the range of 10- 15 years. For all but the most environmentally conscientious, this is too long of a period to consider installing a solar array. A little published fact is that if the power from a solar array is used to charge an electric vehicle the return on investment period is greatly reduced if the savings over the cost of gasoline is used as the criteria. Electric vehicles, (EV) are 3 times as efficient as gasoline powered vehicles. While there are a growing number of EVs on the market there are only 3 readily available in the mid-west. They are the Nissan Leaf, the Chevrolet Volt and the Tesla. Using the EPA ratings for watts hours/mile of the electric vehicle and comparing it to the ratings for miles/ gallon of the comparable gasoline powered vehicle the amount of gasoline saved can be calculated. This multiplied times the cost of gasoline gives annual cost of gasoline that can be allied to offset the cost of the solar array. With the calculated annual power consumption of the EV, the required size and cost of the required solar array can calculated. If the cost of gasoline is $3.50/ gallon the solar array return on investment for a Nisan Leaf is 6.12 years. The Chevy Volt is 5.46 years and a Tesla S is 3.99 years. If the cost of gasoline is reduced to $2.50/ gallon the return is 8.5 years for the Leaf, 7.6 years for the Volt and 5.58 years for the Tesla. When gasoline is at $2,50/ gallon the payback period for a solar array is about one half the time as compared to the payback time of using the generated electricity for use in a building and with higher gasoline costs, which are inevitable, the return time is even shorter. Another benefit of powering an electric vehicle from electricity generated from the sun is the reduction carbon released into the atmosphere.

The annual carbon reduction per year for the 3 vehicles considered is 3.37 ton of carbon per year for the Nissan Leaf, 4.53 tons of carbon for the Chevy Volt and 6.55 tons of carbon for the Tesla S. This results from the fact that according to US DOE gasoline emits 8.91 kg of carbon per gallon. Currently most electric vehicles are significantly more expensive than the equivalent gasoline powered vehicles. This difference is currently reduced by the $7500 federal income tax rebate. This paper contains the tables and calculations to back up the conclusions.

1. INDRODUCTION

Over last ten years the installation of photo voltaic arrays has increased exponentially. During that time grants and subsidies have reduced the costs to incentivize new installations. The federal government currently still offers a 30% income tax rebate that is available through 2016. However, as the cost of systems decrease many other subsidies have been removed. In Ohio the payback time for a photo voltaic system can be 10-15 years. This is based on using the electricity to power the building or home it is connected to. One little publicized fact is that if the electricity generated by a photo voltaic system is used to power an electric vehicle (EV), the payback time is greatly reduced. This is a result of the fact that gasoline is more expensive than electricity to operate a motor vehicle.

2. BACKGROUND

2.1Electric Vehicle Characteristics

In an electric vehicle electricity stored in a battery powers electric motors that power the wheels. EV's are more efficient than fossil fuel powered vehicles. They convert 59 to 62 percent of the electrical energy to power the wheels while gasoline-powered vehicles convert 17 to 21 percent of the fuel to power at the wheels. Electric motors provide smoother and stronger acceleration and require less maintenance than internal combustion engines.

The current EV drawbacks are range, charge time, and cost. The current driving range of an EV is 38 to 265 miles on a charge, and a charging time of 4-16 hours. Batteries are expensive which makes the vehicle cost generally more than gasoline-powered vehicles without incentives. If the vehicle is driven daily within the range of the charge and there is adequate charging time between uses, an EV is a very efficient alternative to a fossil fuel powered vehicle.

2.2 Extended Range Electric Vehicle

A variation of an EV is the Extended-Range Electric Vehicle (EREV), With a much smaller battery, these vehicles have range of 38-50 miles on a charge When the charge is depleted, a small gasoline engine powers a generator which sends an electrical current to run the wheels, much like diesel locomotives used on railroads. These vehicles provide the versatility of indefinitely extending the range of the vehicle, while still offering all electric propulsion for shorter trips such as commuting to work.

Government Incentives

In the US, the federal government and many states offer incentives to reduce the purchase price of qualified EVs. In Ohio only the federal government income tax rebate of $7,500 is available for purchase of a new EV. To qualify for this rebate the vehicle must have a battery capacity of 16 kilowatt hours or more. Hybrid and most plug-in hybrid vehicles do not qualify for this rebate because of their battery capacity. While these vehicles do get very good gas mileage they can only go up to 19 mile on a charge.

3. CALCULATION METHOD

The following table gives the 2013 DOE watt hour per mile ratings for electric passenger vehicles and EPA miles per gallon ratings for comparable gasoline powered vehicles. The Nissan Leaf, Chevy Volt and Tesla S were selected for case studies because they are the top selling EVs and the only ones readily available in Ohio. (figure 1)

3.1 Case Study Vehicle Selection

Figure 1

EV/EREV VEHICLE COMPARISONS

Electric Vehicle	watt hours/mile (US DOE)	Gasoline Vehicle	miles/gallon (US EPA)
Chevy Spark EV	280	Chevy Spark	34
Fiat 500 EV	290	Fiat 500	30
Nissan Leaf	**300**	**Nissan Versa**	**35**
Mitsubishi Mi EV	300	Mitsubishi Mirage	40
Ford Focus EV	320	Ford Focus	31
Ford Fusion EV	340	Ford Fusion	29
Chevy Volt EREV	**360**	**Chevy Malibu**	**26**
Tesla Model S	**380**	**Jaguar XJ Sedan**	**18**
Cadillac ELR EREV	370	Cadillac V Coupe	16

3.2 Assumptions

Solar Array Cost

$3.50/ watt (average cost for small residential array installed in Ohio)

Annual Solar Array Production (average in Ohio**)**

Array size in KW X 1.2 = output in KWH (use .83333 conversion factor for converting required output to array size)

Federal Rebate

30% off of total cost of array (use .7 conversion factor for cost after rebate)

Gasoline Cost

$2.50/ gallon ;$3.00/gallon;$3.50/gallon

Miles Driven / Year

12,000

3.3 Equation

The equation first calculates the size of the required solar array to power the electric vehicle for one year and then the cost of that array. The third equation determines the cost of gasoline to drive the equivalent vehicle for one year. The array cost is then divided by the gasoline cost per year to determine the return on investment period for the solar array.

EQUATION

Size of required solar array

miles / year driven X KWH / mile (rating of vehicle) X .833 = ____ KW, size of required solar array

Cost of required solar array

___KW, (size of array) X $3500 / KW X .7 (federal rebate factor) = $___(cost of required solar array)

Cost of equivalent gasoline per year

$$\frac{\text{\_\_\_\_ miles / year driven}}{\text{\_\_\_\_miles / gallon rating}} \times \text{\_\_\_cost of gasoline / gallon} = \$\text{\_\_\_ (cost of equivalent gasoline per year)}$$

Years for simple return on investment

$$\frac{\$\text{\_\_\_cost of solar array}}{\$\text{\_\_\_cost of gasoline /year}} = \text{\_\_\_ years for simple return on investment}$$

4. RESULTS

In the following case studies, the annual miles driven are 12,000 and the cost of gasoline is $2.50 / gallon,(figure 2) $3.00 /gallon,(figure 3) $3.50/ gallon.(figure 4)

Figure 2

RESULTS @ $2.50/GALLON

Electric Vehicle	Array Size	Array Cost	Gasoline Cost	ROI
Nissan Leaf	2.95 KW	$7,232	$857.00	**8.5 years**
Chevy Volt	3.54 KW	$8,673	$1153.83	**7.6 years**
Tesla S	3.74 KW	$9,163	$1667.50	**5.58 years**

Figure 3

RESULTS @ $3.00/GALLON

Electric Vehicle	Array Size	Array Cost	Gasoline Cost	ROI
Nissan Leaf	2.95 KW	$7232	$1029.00	**7.11 years**
Chevy Volt	3.54 KW	$8,673	$1383.16	**6.37 years**
Tesla S	3.74 KW	$9,163	$1667.50	**4.65 years**

Figure 4

RESULTS @ $3.50/GALLON

Electric Vehicle	Array Size	Array Cost	Gasoline Cost	ROI
Nissan Leaf	2.95 KW	$7232	$1200.50	**6.12 years**
Chevy Volt	3.54 KW	$8,673	$1615.36	**5.46 years**
Tesla S	3.75 KW	$9,163	$2334.50	**3.99 years**

The following table shows reduction of carbon in the atmosphere because of not using gasoline to power the vehicle based on DOE 1605b☹figure5)

Figure 5

CARBON REDUCTION

US DOE 1605b GASOLINE EMITTS 8.91 KG OF CARBON/GALLON

VEHICLE	GALLONS/12,000 MILES	CARBON SAVED/12,000 MILES
LEAF	343 GALLONS SAVED	3.37 TONS
VOLT	461.5 GALLONS SAVED	4.53 TONS
TESLA	667 GALLONS SAVED	6.55 TONS

The following table shows cost savings in driving and electric vehicle using utility generated electricity at $.12 per KWH over equivalent gasoline powered vehicle.(figure 6)

Figure 6

SAVINGS @$2.50/GAL & $.12/KWH

Electric Vehicle	Electricity Use	Electricity Cost	Gasoline Cost	Savings
Nissan Leaf	3.6 KWH	$432.00	$857.00	**$425/year**
Chevy Volt	4.32 KWH	$518.40	$1153.83	**$635.43/year**
Tesla S	4.56 KWH	$547.72	$1667.50	**$1120.30 year**

5. CONCLUSION

I operating a vehicle on power generated from a photo voltaic solar array can greatly reduce the payback period for the solar array. With a mid and higher priced model vehicles the payback period is between 4.65 and 6.37 years if gasoline averages $3.00 per gallon. After this period the fuel for the electric vehicle is free for the next 15-20 years. All the while effecting a significant reduction in carbon added to the atmosphere and giving the driver the enhanced driver experience of operating a more responsive, efficient and lower maintenance vehicle. If more automobile buyers where aware of this fact they may opt for buying an electric vehicle and a solar array to provide the electricity to charge it.

6. REFERENCES

(1) DOE 1605b
(2) EPA 2013 auto mileage ratings
(3) www.energy.gov