Technical Note

Project:	**Investigating the Effects of Insulated Conservatory Roofs**	Job No:	**60270677**
Subject:	**Results from IES Dynamic Thermal Modelling**		
Prepared by:	**Elizabeth Ward**	Date:	**20th June 2012**
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The installation of insulation systems to reduce heat loss from conservatories and similar spaces provides a number of benefits. These include reduced heating requirements for both the conservatory and the adjacent dwelling as well as improved comfort levels due to the effects of radiant heat loss.

AECOM have undertaken a dynamic thermal modelling analysis to investigate the impact of installing an insulated roof compared with a standard conservatory roof. The effect of the insulation on a number of key variables has been assessed, particularly relating to energy requirements and carbon dioxide emissions.

1.1 Dynamic Thermal Modelling

AECOM uses the IES Virtual Environment dynamic thermal modelling software which is widely accepted to be one of the leading building simulation packages. AECOM originally wrote the APACHE engine at the heart of the IES thermal modelling package and therefore is well placed to undertake detailed analysis of this nature.

Dynamic thermal modelling is a powerful design tool that is routinely used for a range of building types to optimise building designs in terms of a wide range of variables including energy use, thermal comfort of building occupants and daylight levels. This process works by creating a model of the proposed building taking account of geometry, building fabric properties, building services such as heating and lighting systems and building usage in terms of heating temperatures and occupancy patterns. The building is then simulated using weather data for the relevant location and orientation.

1.2 Modelling Methodology and Key Modelling Inputs

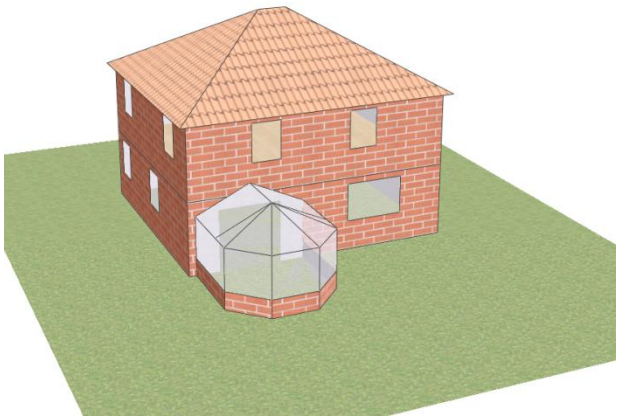

Figure 1: IES Thermal Model of Typical House with Conservatory

AECOM modelled a typical house with a standard “Victorian 12’x12’” conservatory type attached. Further work may be undertaken to investigate the effects of the insulated roof on conservatories of different shapes and sizes.

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Dimensions of the house modelled have been designed so as to be representative of typical housing stock in the UK. The house measures 8m by 9m, with a floor to ceiling height of 2.5m. The total floor area of the house modelled is 144m².

Details and dimensions of the conservatory modelled have been taken from the drawing provided by Celuplast Conservatory Roofs, see Figure 2. The height of the conservatory to the bottom of the pitched roof has been assumed to be 2m.

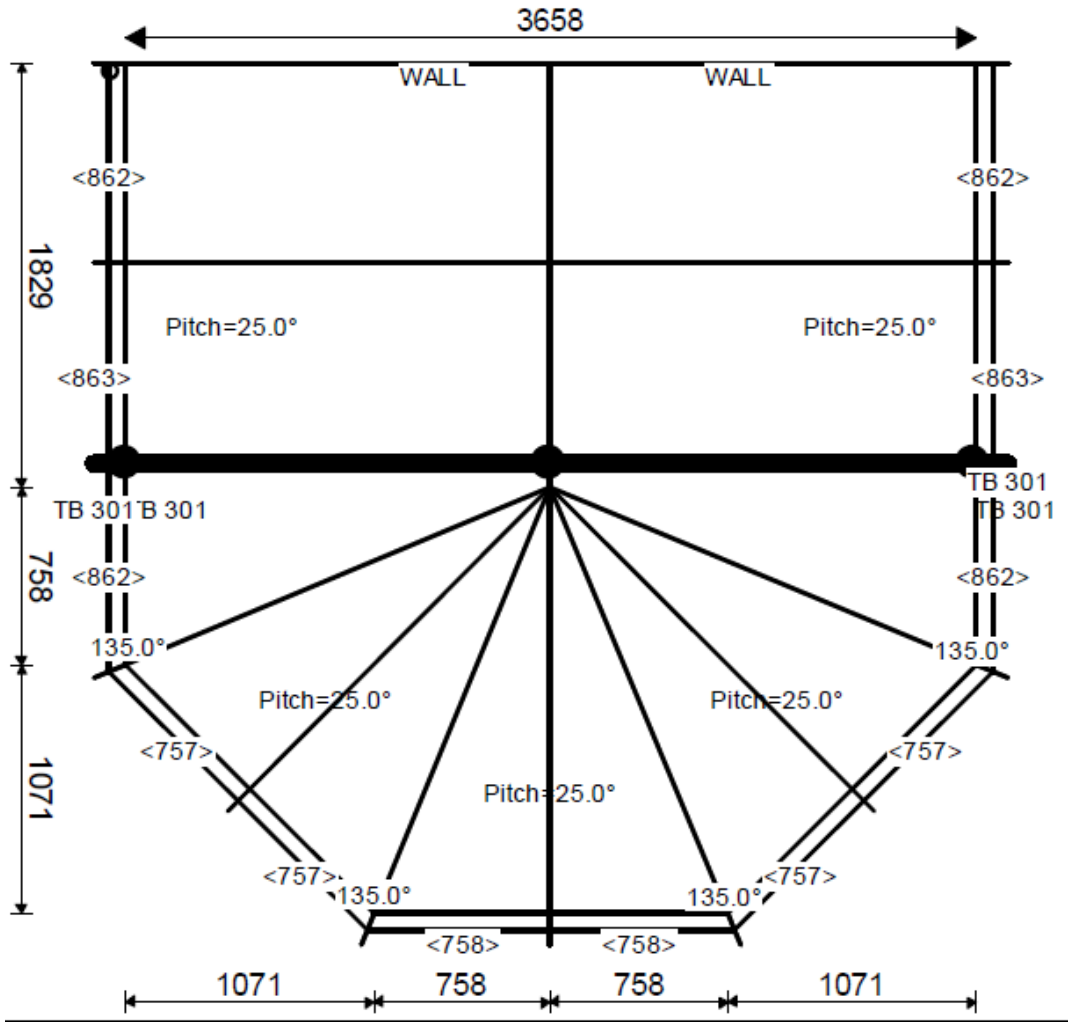

Figure 2: Details and Dimensions of the Standard Victorian 12'x12' Conservatory Type Modelled

The conservatory has been modelled as being directly connected to the ground floor of the house by means of a permanent opening. This represents the condition when a conservatory is added as an extension to the living accommodation and is used, and serviced, in a way that make this possible. This has been represented in the model by applying the Living Room thermal template to the conservatory.

The dwelling has been modelled using the standard National Calculation Methodology (NCM) templates for room occupancy, heating temperature set points and incidental heat gains. The heating variation profile has been modified for the heating to be on from 7am until 11pm everyday with a night-time setback temperature of 12°C.

For both conservatory roof types, the building has been tested for all 4 cardinal directions. In each case, the orientation of the building has been defined as the direction in which the conservatory projects.

The simulation provides energy consumption and carbon emission figures for the dwelling with a standard conservatory roof and with an insulated conservatory roof. These simulations take account of the energy savings for heating the conservatory, and also the reduction in heating demand of the dwelling connected to it.

Three distinct construction conditions have been modelled, to account for differing construction periods and legislation. These are summarised as follows:

Scenario	U Value (W/m²K)								
	House				Conservatory				
	Wall	Floor	Roof	Window	Wall	Floor	Glazed Roof	Window	New Roof
House and Conservatory Built between 1995 -2002	0.45	0.60	0.45	3.30	0.45	0.60	3.30	3.30	0.18
House and Conservatory Built between 2002- 2010	0.35	0.25	0.25	2.20	0.28	0.22	2.20	2.20	0.18
House and Conservatory Built after 2010	0.35	0.25	0.25	2.20	0.28	0.22	1.60	1.60	0.18

Table 1: Summary of Key Modelling Inputs for Cases Tested.

There are two key differences between the original glazed conservatory roof and the new “Guardian” roof installation. Primarily the U-value of the new installation is significantly better than the original roofing types, and secondly the “Guardian” roofing system is opaque rather than transparent. Therefore, the differences in performance between the conservatories with each roof type are a complex combination of reduced solar heat gains along with reduced heat loss.

1.3 Locations Investigated

The dwelling has been modelled as being located in Manchester. Further analyses may be carried out to investigate the effects of the insulated roof product on conservatories located elsewhere. AECOM have access to weather data for a wide range of locations both in the UK and around the world. Therefore alternative locations can be simulated upon request.

1.4 Energy prices

One of the key technical outputs of this analysis is the predicted financial benefit of the insulated roof product. Energy cost savings have been calculated based on current average energy prices and predicted future changes to energy costs.

Future energy cost savings have been calculated using four different future energy price forecasts. These forecasts have been taken from Ofgem's Project Discovery Energy Market Scenarios[1].

Project Discovery models the predicted effect of two levels of economic recovery and their interaction with the possibility that a global agreement on tackling climate change is reached or not; this produces the four scenarios shown in Table 2:

	Global Agreement to Tackle Climate Change	No Global Agreement to Tackle Climate Change
Strong Economic Recovery	**Green Transition**	**Dash for Energy**
Weak Economic Recovery	**Green Stimulus**	**Slow Growth**

Table 2: The four energy price forecast scenarios from Ofgem's Project Discovery.

The variations in gas and electricity prices taken from Project Discovery are shown in Figure 3 and Figure 4 respectively.

For the purposes of this study the energy price forecasts have been adjusted so that all four scenarios start from the current energy prices as recorded by the European Energy Portal website[2]. The Project Discovery energy cost forecasts only extend until 2025; therefore energy prices have been extrapolated based on the forecast trend between 2010 and 2025 to extend the projected costs to 2037 (i.e. a 25 year period).

[1] http://www.ofgem.gov.uk/Markets/WhlMkts/monitoring-energy-security/Discovery/Documents1/Discovery_Scenarios_ConDoc_FINAL.pdf

[2] http://www.energy.eu/#prices Data taken on 20th June 2012:
Gas = 0.0374 £/kWh
Electricity = 0.1348 £/kWh

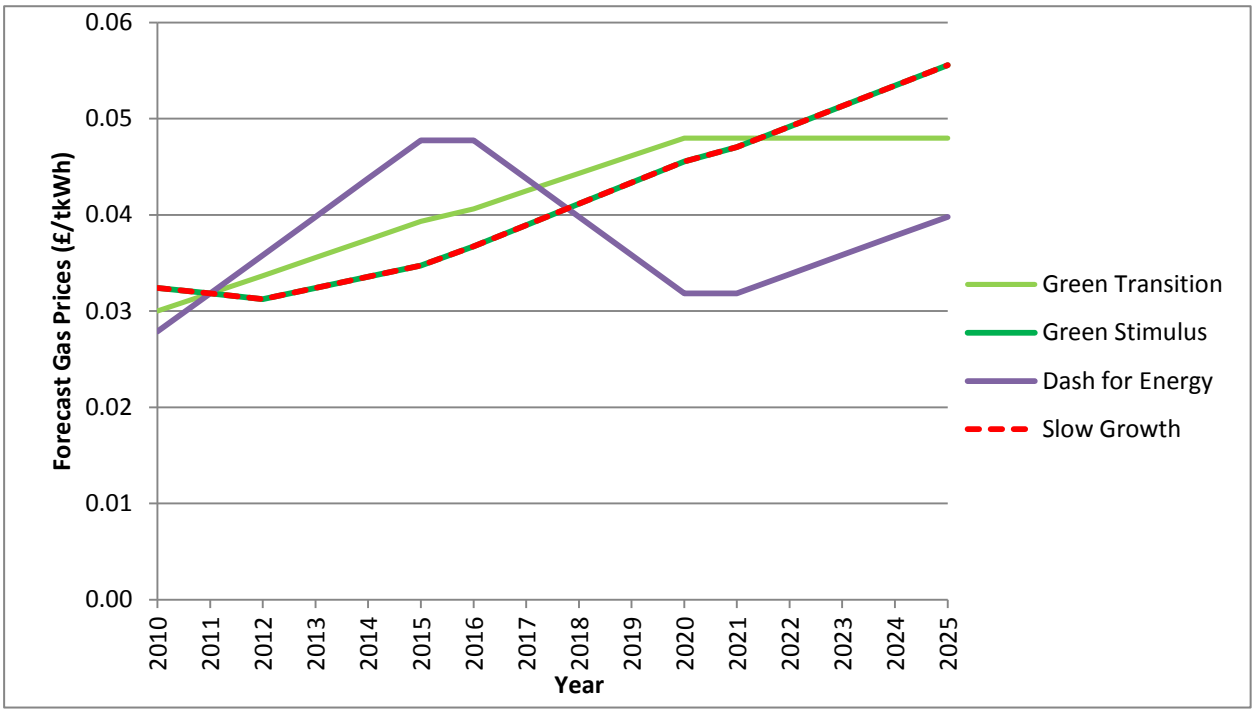

Figure 3: Forecast gas prices taken from Ofgem's Project Discovery.

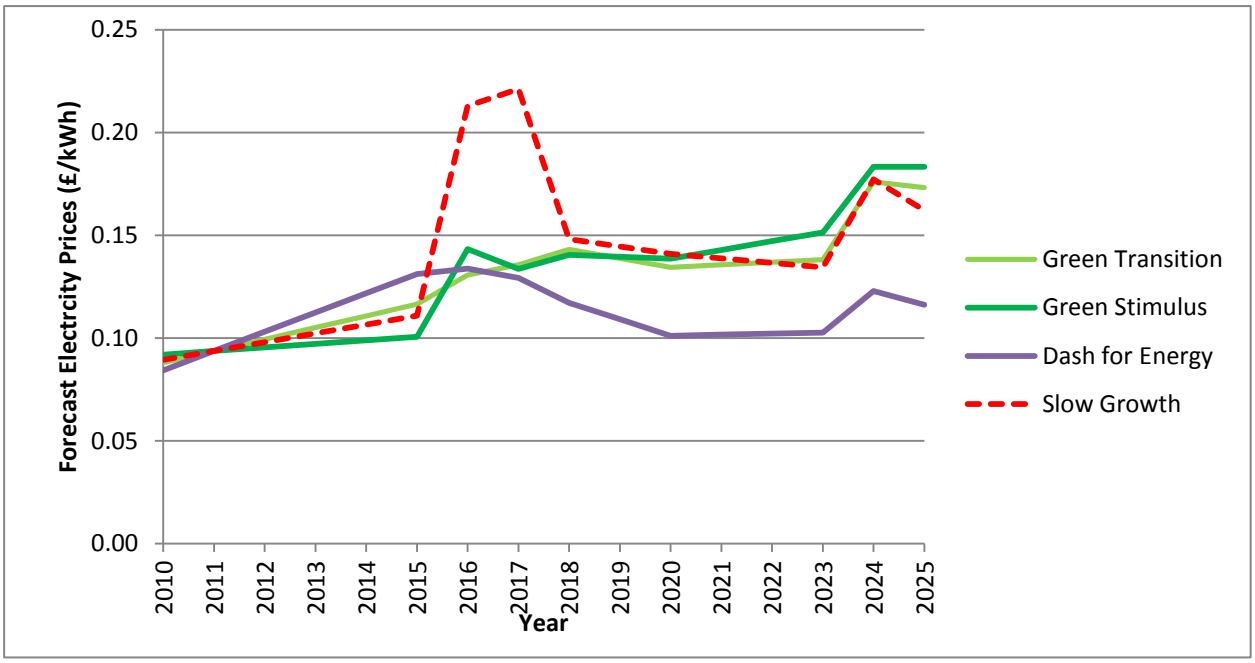

Figure 4: Forecast electricity prices taken from Ofgem's Project Discovery.

1.5 Technical Outputs

The key technical outputs from this analysis are split into two categories: energy and carbon dioxide emissions savings, and cumulative Net Present Value.

1.5.1 Energy Demand Savings and Carbon Dioxide Savings

House Age	Direction in which Conservatory Projects	Annual Energy Savings due to Retrofitted Roof (kWh)	Annual Energy Cost Saving		Annual Carbon Dioxide Emissions Saving	
			for Gas Heating for 85% efficiency (£)	for Electric Heating for 100% efficiency (£)	for Gas Heating for 85% efficiency ($kgCO_2$)	for Electric Heating for 100% efficiency ($kgCO_2$)
House and Conservatory Built between 1995 -2002	North	1,309.5	57.62	176.52	305.04	677.01
	East	1,125.1	49.50	151.66	262.08	581.68
	South	961.9	42.32	129.66	224.07	497.30
	West	1,161.9	51.12	156.62	270.65	600.70
House and Conservatory Built between 2002- 2010	North	852.3	37.50	114.89	198.54	440.64
	East	702.5	30.91	94.70	163.64	363.19
	South	552.0	24.29	74.41	128.58	285.38
	West	738.1	32.48	99.50	171.93	381.60
House and Conservatory Built after 2010	North	532.4	23.43	71.77	124.02	275.25
	East	397.8	17.50	53.62	92.66	205.66
	South	257.6	11.33	34.72	60.01	133.18
	West	428.0	18.83	57.69	99.70	221.28

Table 3: Summary of Heating Energy Demands and Carbon Dioxide Emissions Savings

1.5.2 Net Present Value

The Net Present Value has been calculated based on the amount of energy saved by changing the roof from a standard conservatory roof to the “Guardian Hybrid” option.

There has been assumed to be no maintenance costs involved with the installation of the new “Guardian” roof, as it has been deemed reasonable to believe that once the roof has been installed that there will be no further associated costs.

The efficiencies of each heating system have been accounted for in the following Cumulative Net Present Value curves. The efficiency of the gas heating system has been assumed to be 85%, with the efficiency of the electric resistance heating assumed to be 100%.

1.5.2.1 Net Present Value for House and Conservatory Built Between 1995 and 2002

1.5.2.1.1. Gas Fired Heating

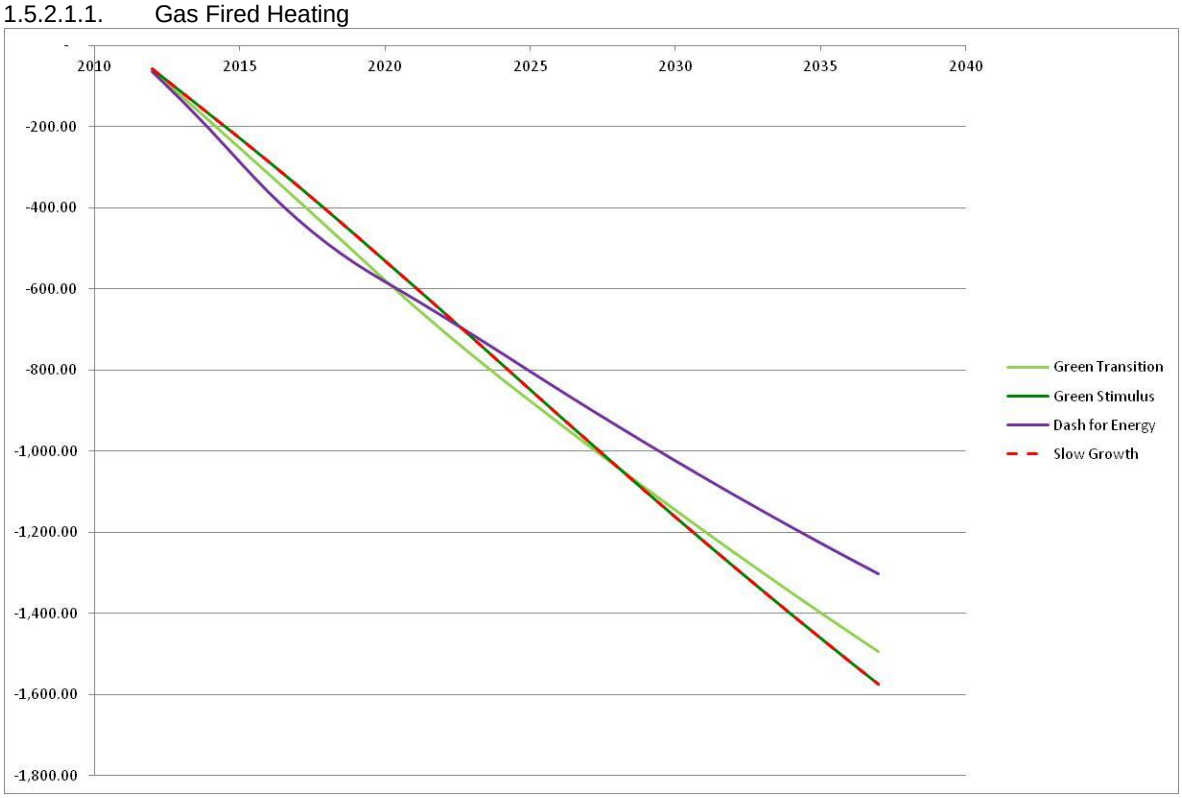

Figure 5: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **North** Facing Conservatory and Gas Fired Heating

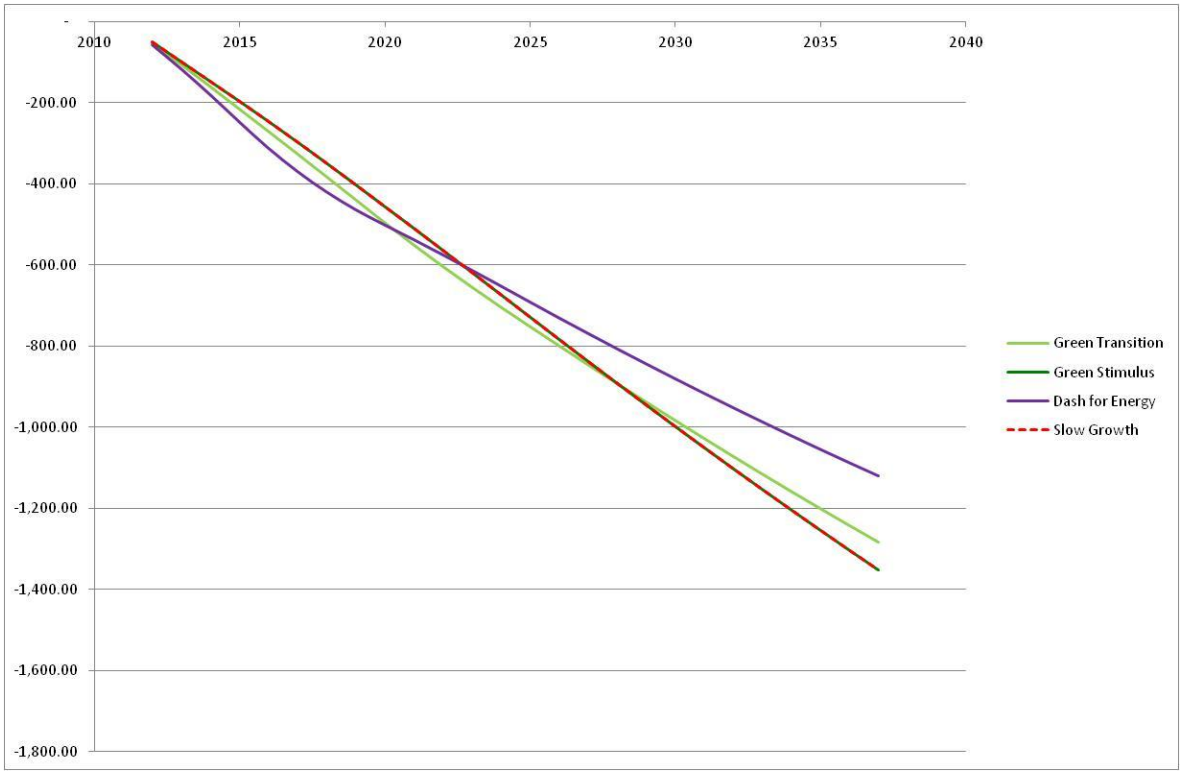

Figure 6: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **East** Facing Conservatory and Gas Fired Heating

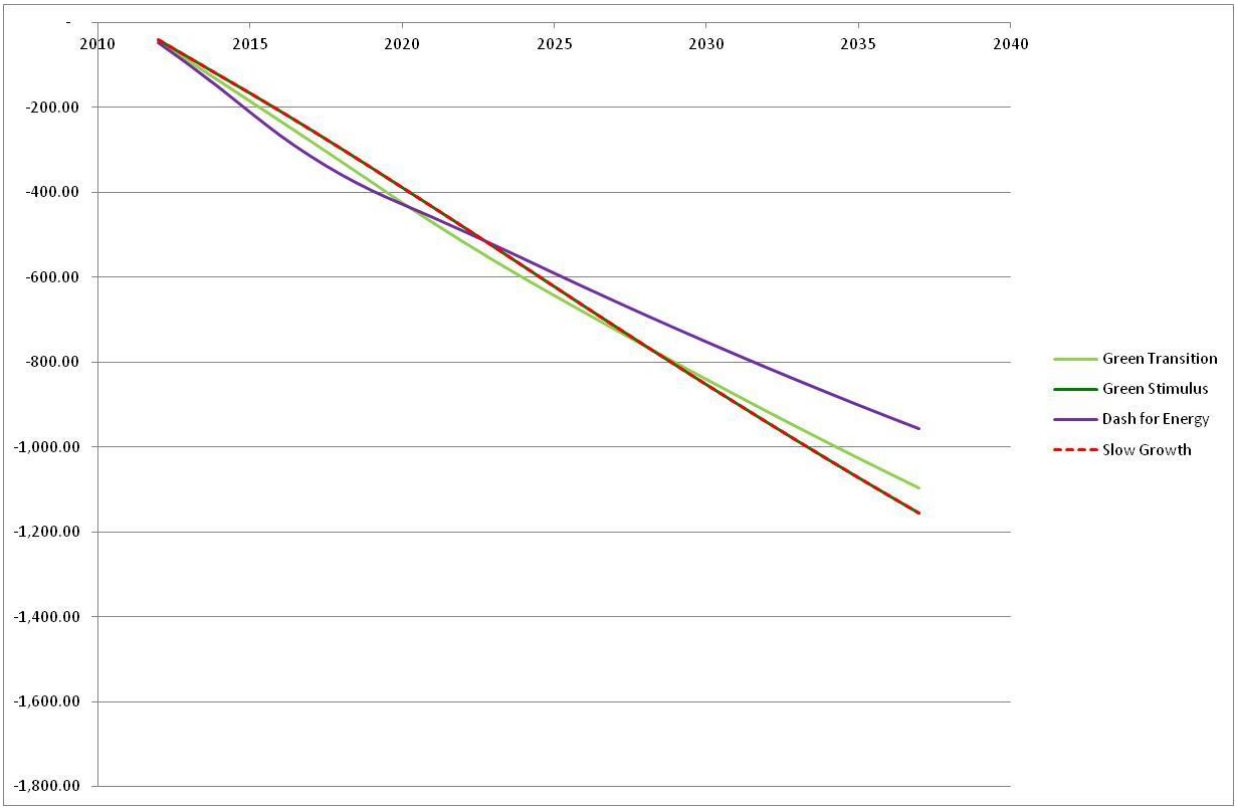

Figure 7: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **South** Facing Conservatory and Gas Fired Heating

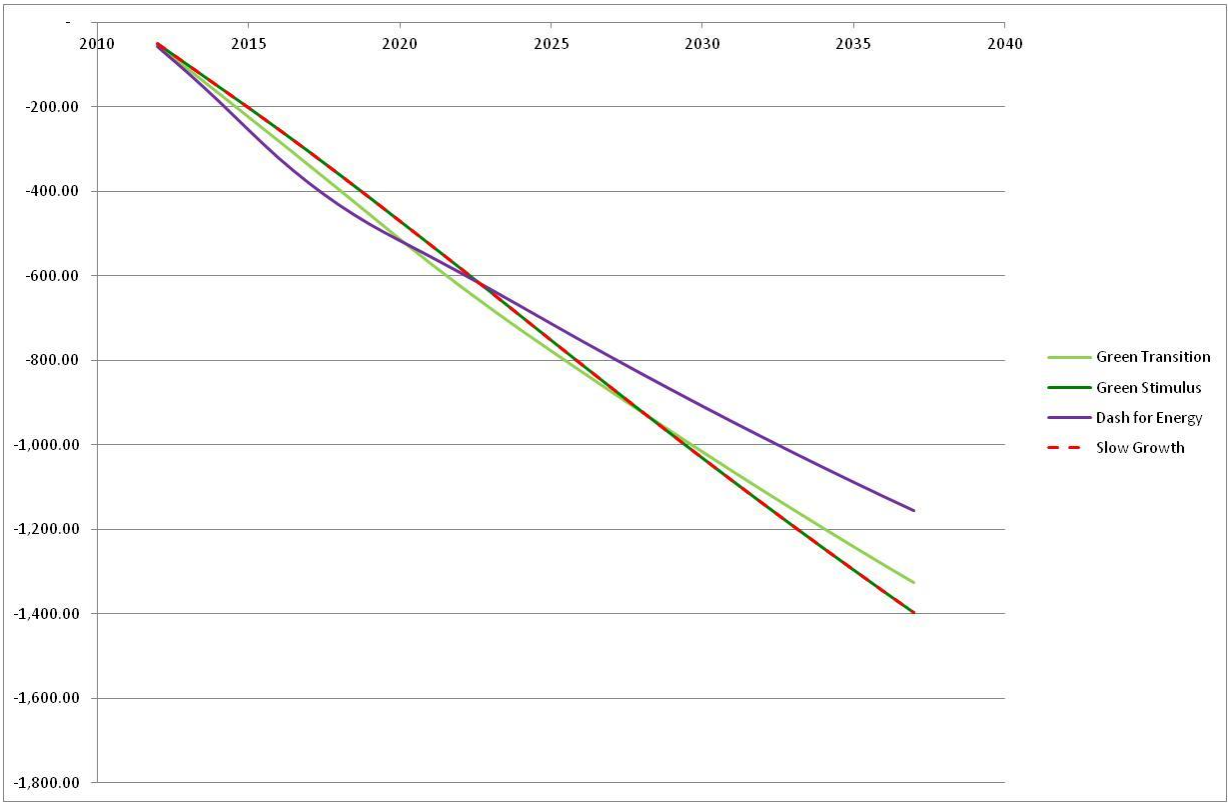

Figure 8: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **West** Facing Conservatory and Gas Fired Heating

1.5.2.1.2. Electric Resistance Heating

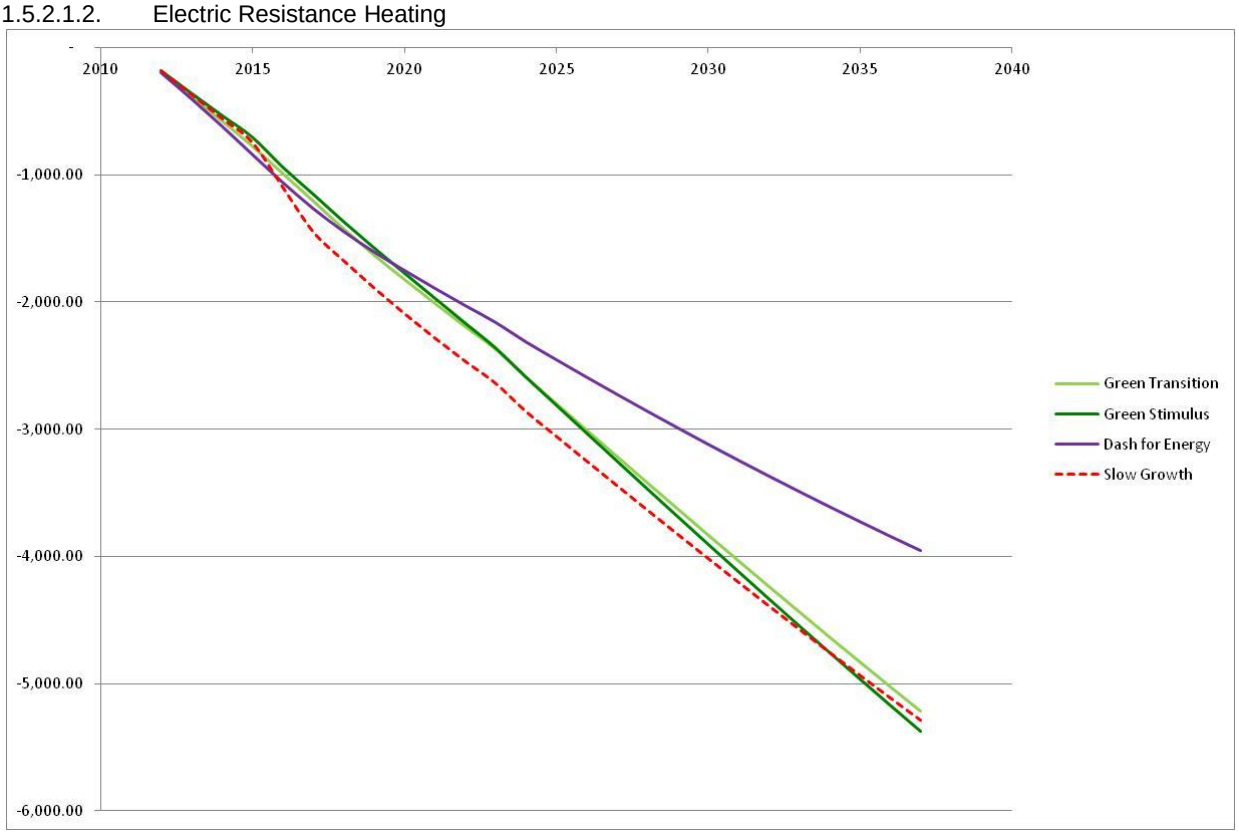

Figure 9: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **North** Facing Conservatory and Electric Resistance Heating

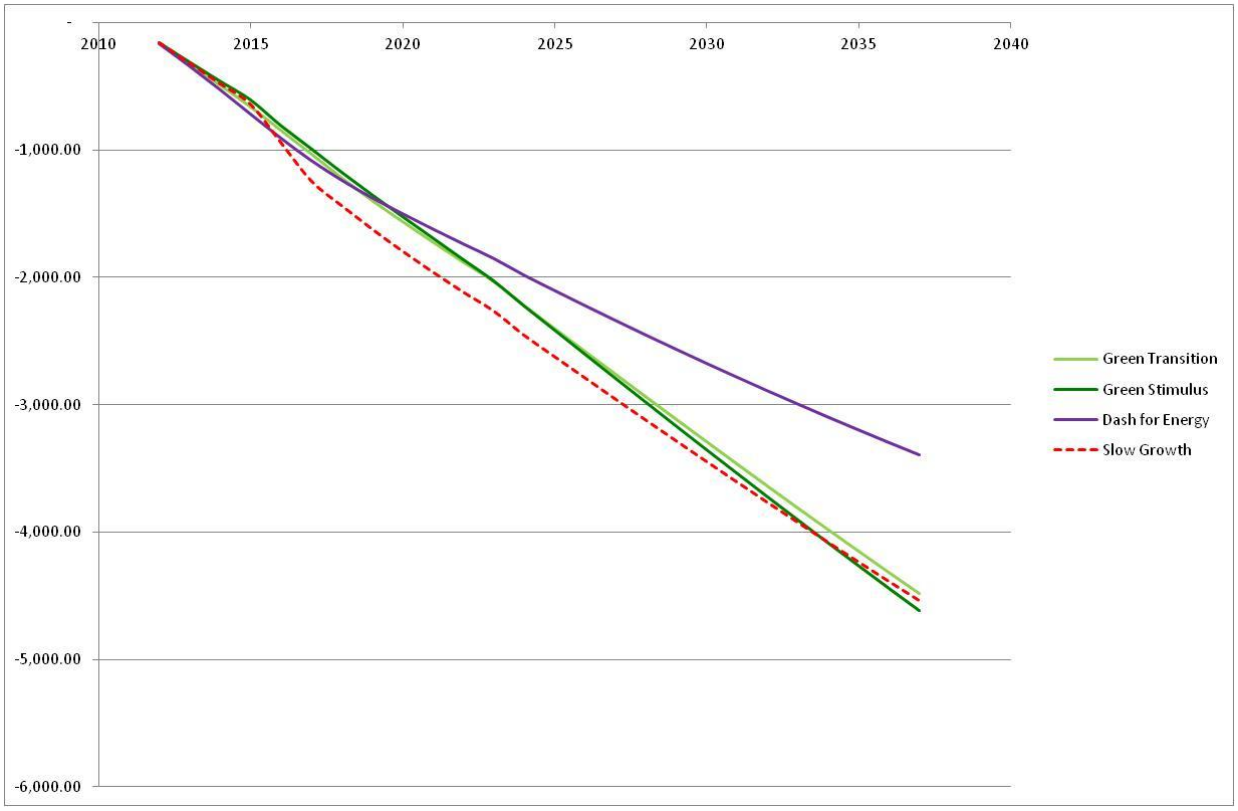

Figure 10: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **East** Facing Conservatory and Electric Resistance Heating

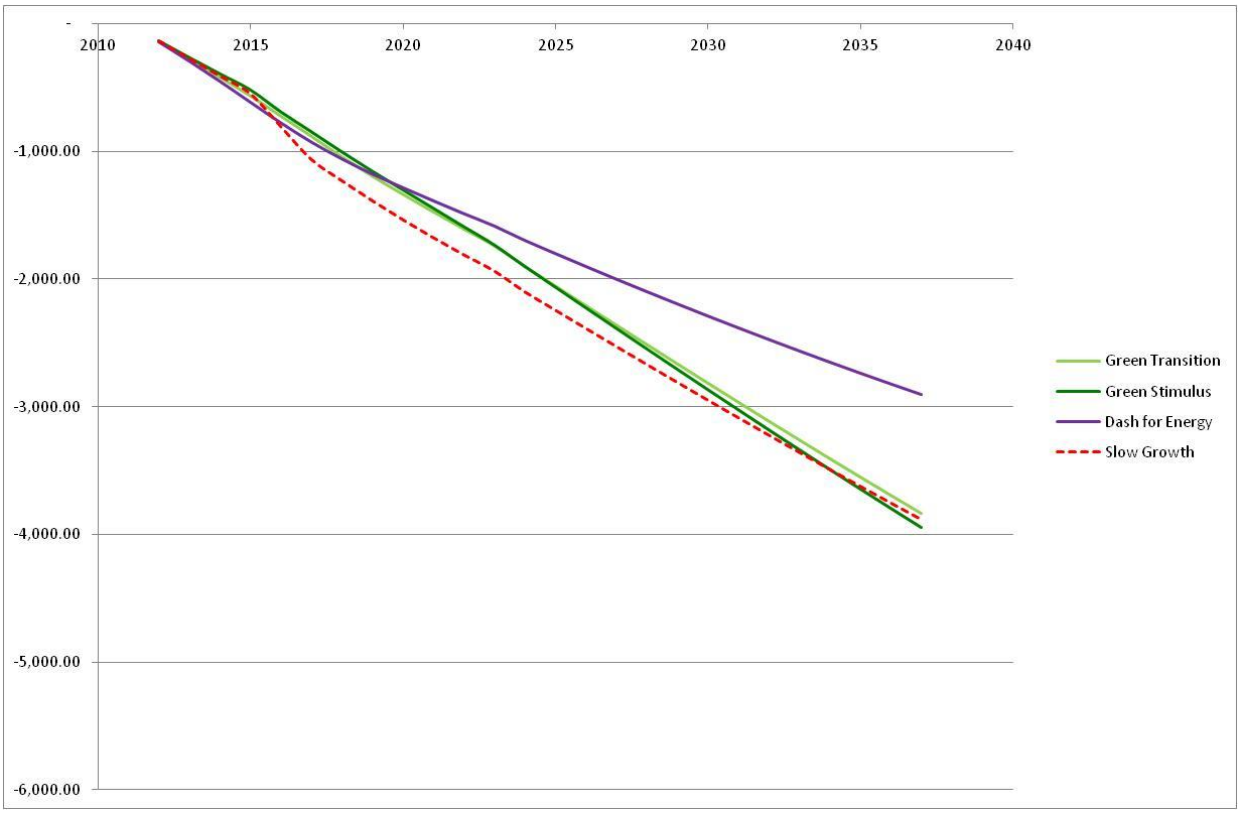

Figure 11: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **South** Facing Conservatory and Electric Resistance Heating

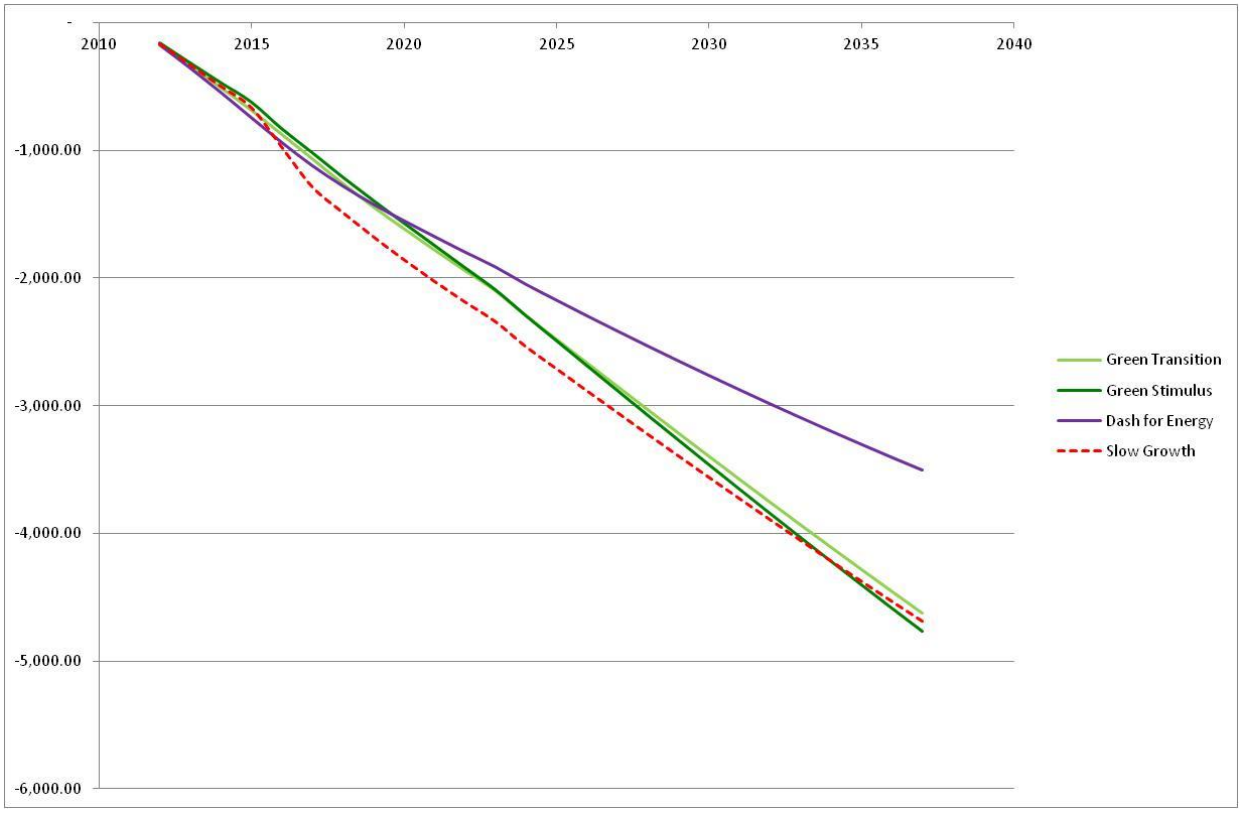

Figure 12: Cumulative Net Present Value for House and Conservatory Built Between 1995 and 2002 with **West** Facing Conservatory and Electric Resistance Heating

1.5.2.2 Net Present Value for House and Conservatory Built Between 2002 and 2010

1.5.2.2.1. Gas Fired Heating

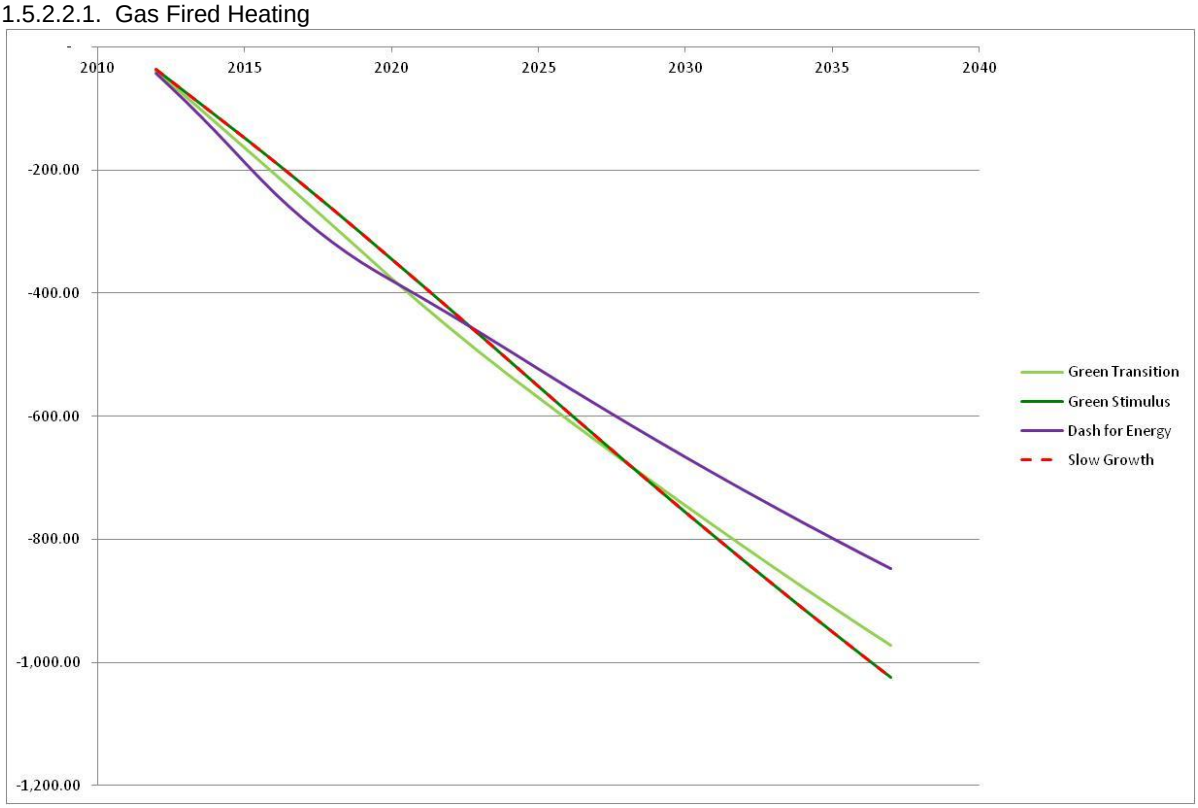

Figure 13: Cumulative Net Present Value for House and Conservatory Built between 2002 and 2010 with **North** Facing Conservatory and Gas Fired Heating

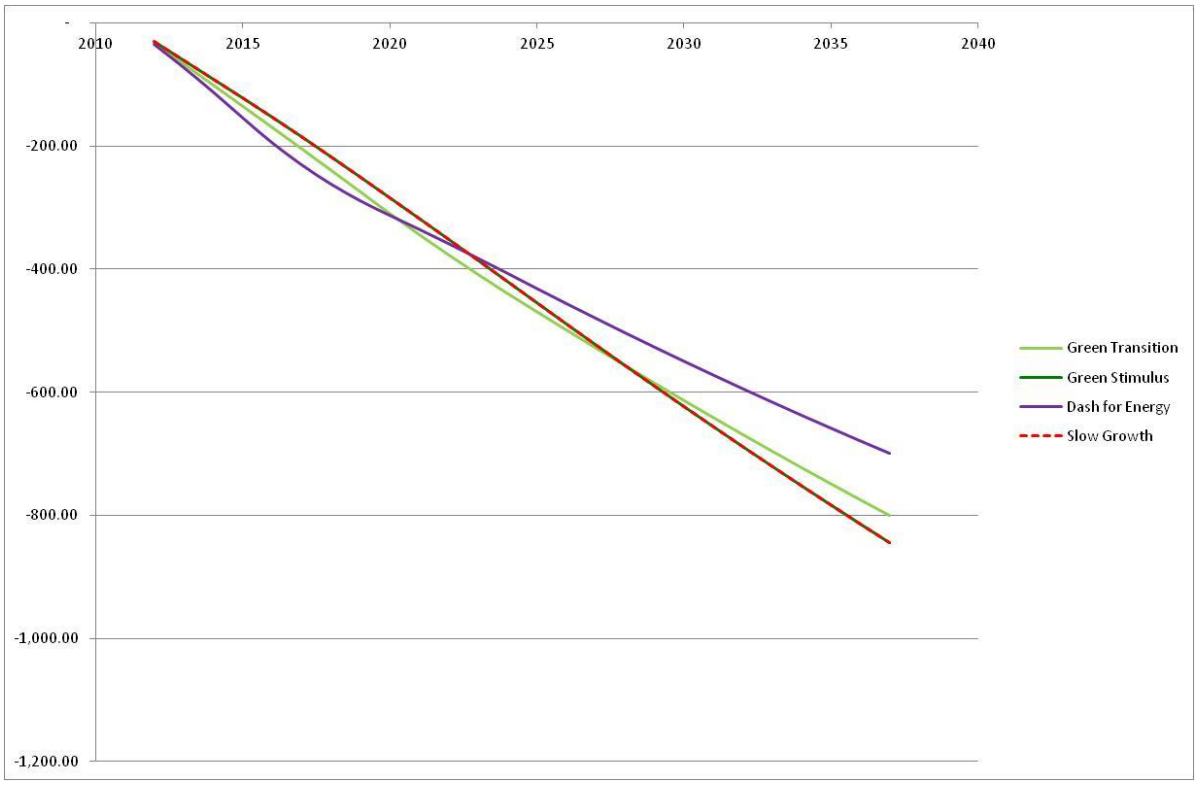

Figure 14: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **East** Facing Conservatory and Gas Fired Heating

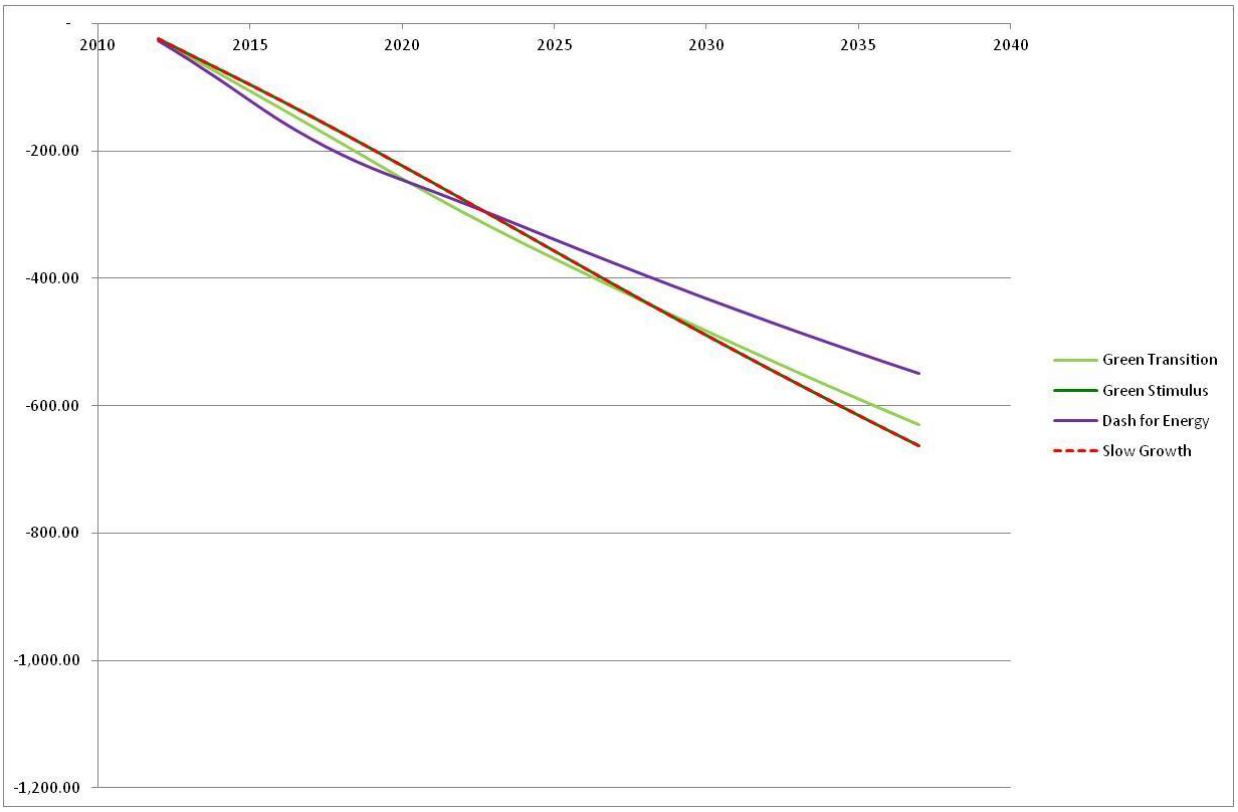

Figure 15: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **South** Facing Conservatory

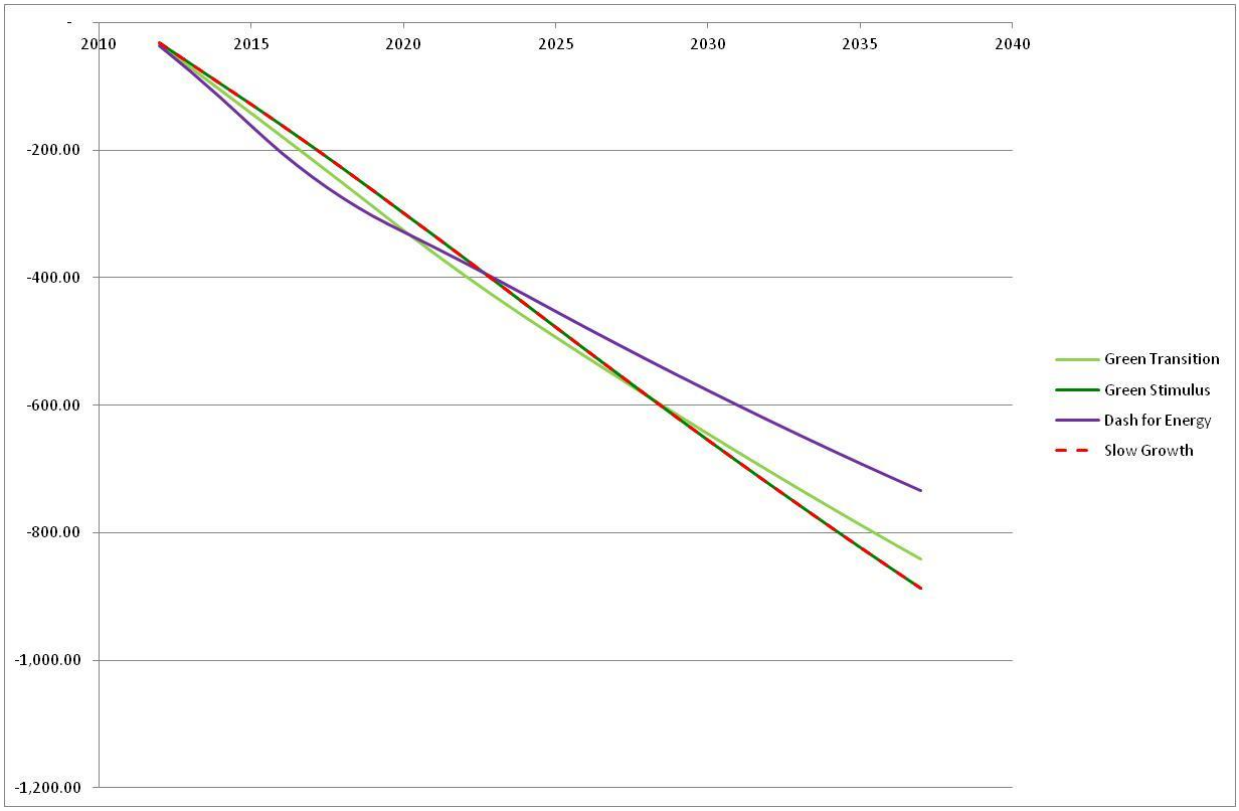

Figure 16: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **West** Facing Conservatory and Gas Fired Heating

1.5.2.2.2. Electric Resistance Heating

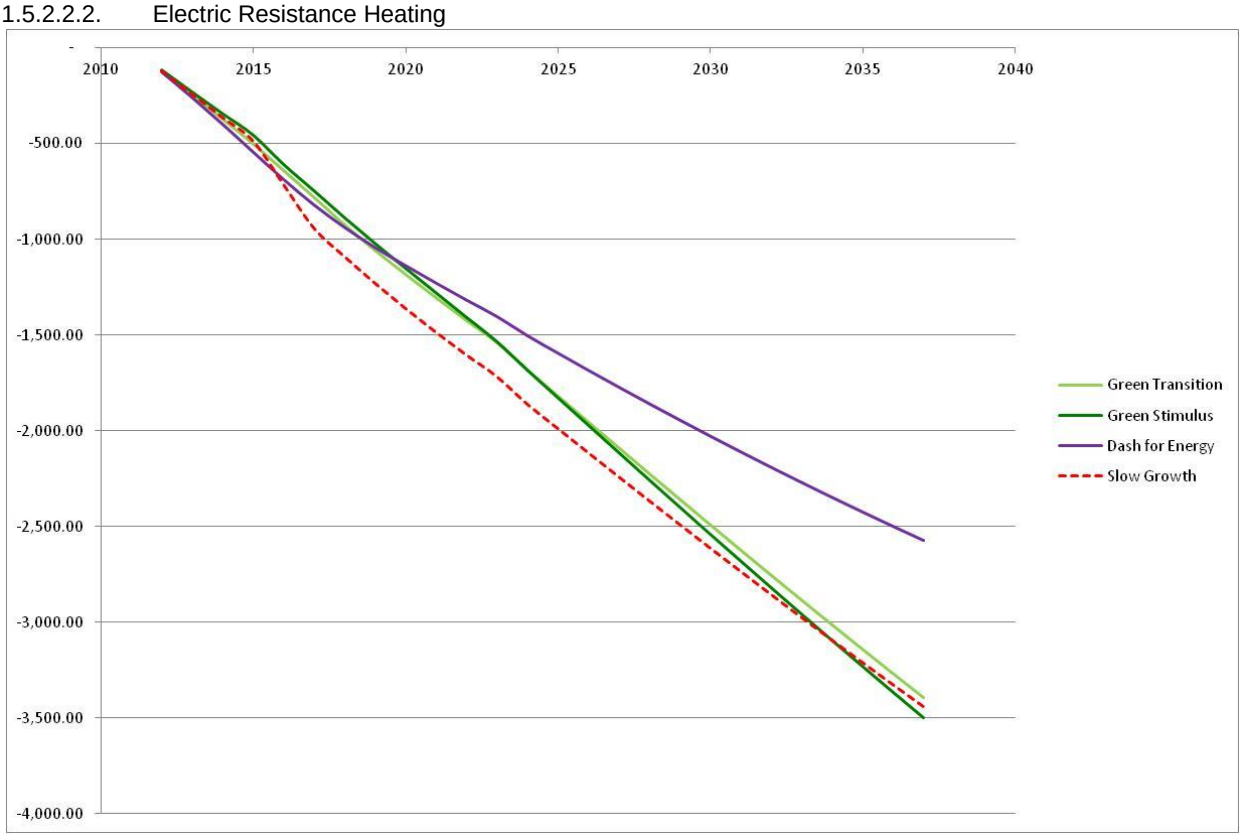

Figure 17: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **North** Facing Conservatory and Electric Resistance Heating

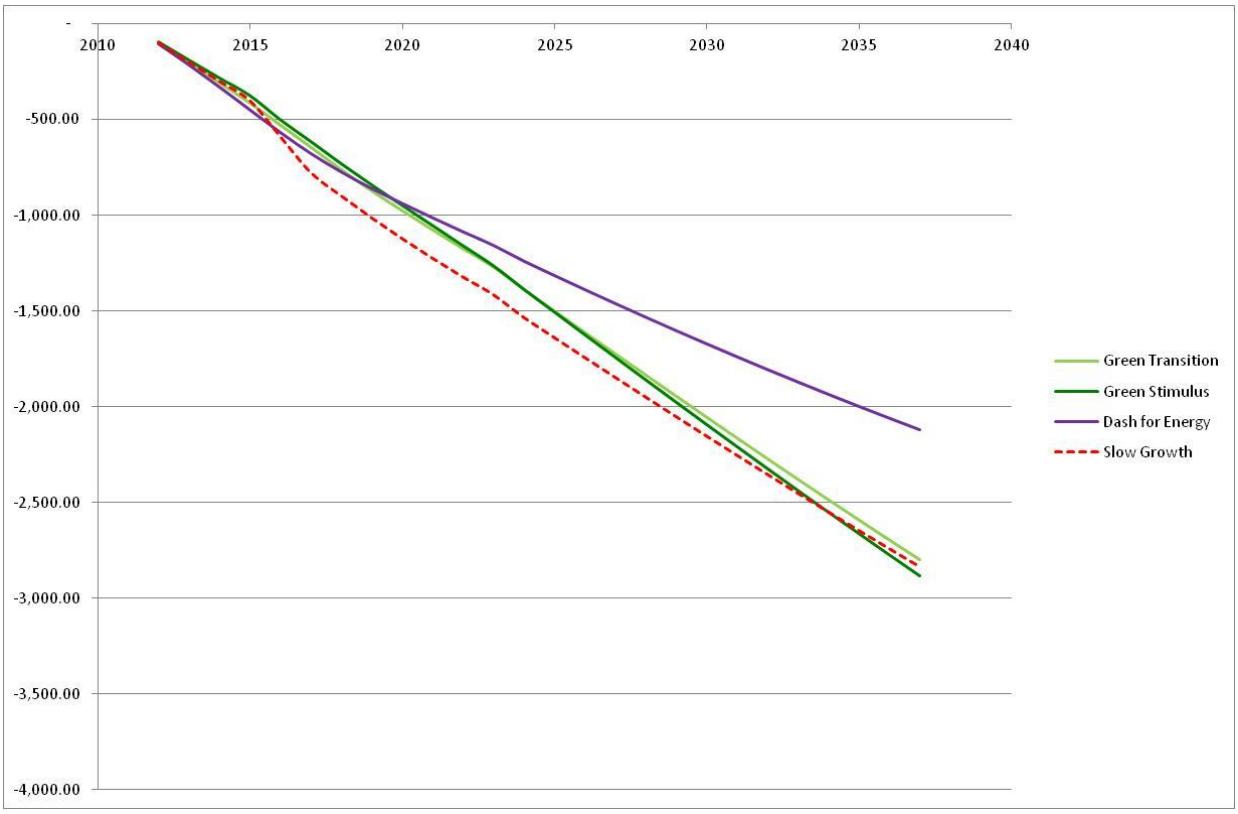

Figure 18: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **East** Facing Conservatory and Electric Resistance Heating

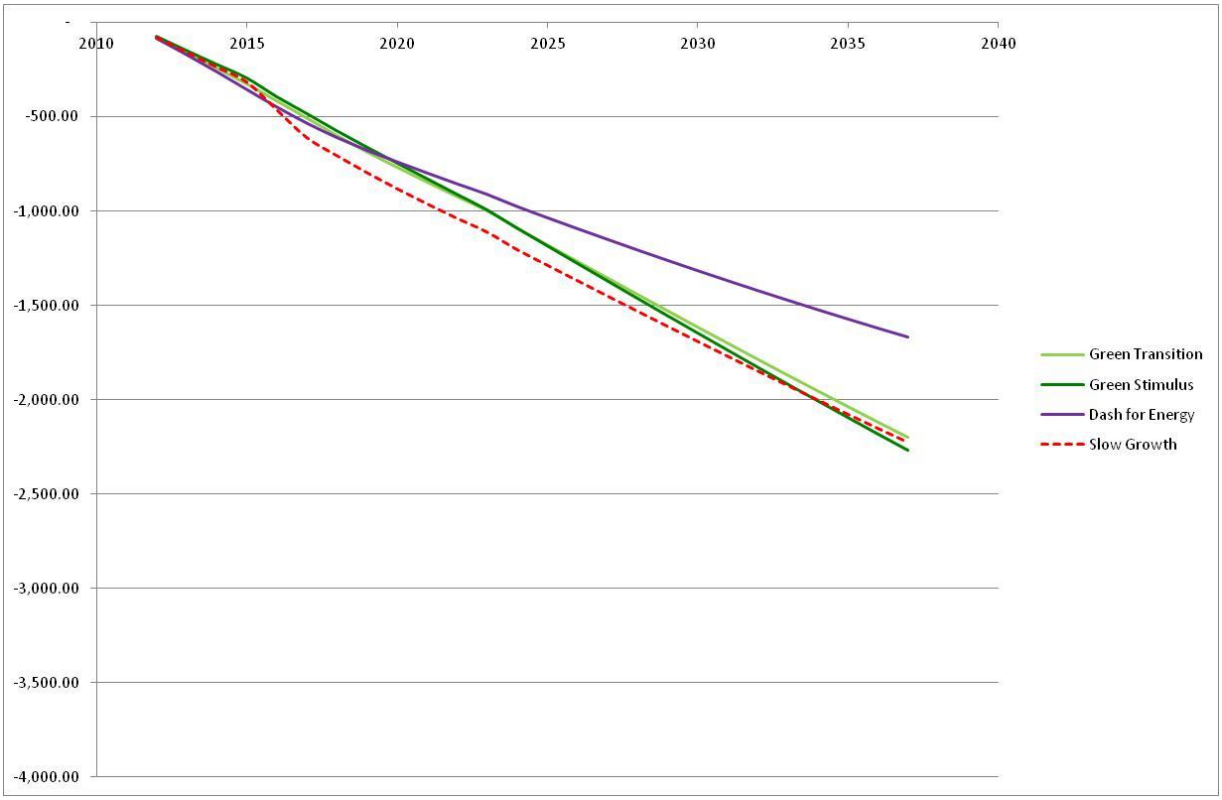

Figure 19: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **South** Facing Conservatory with Electric Resistance Heating

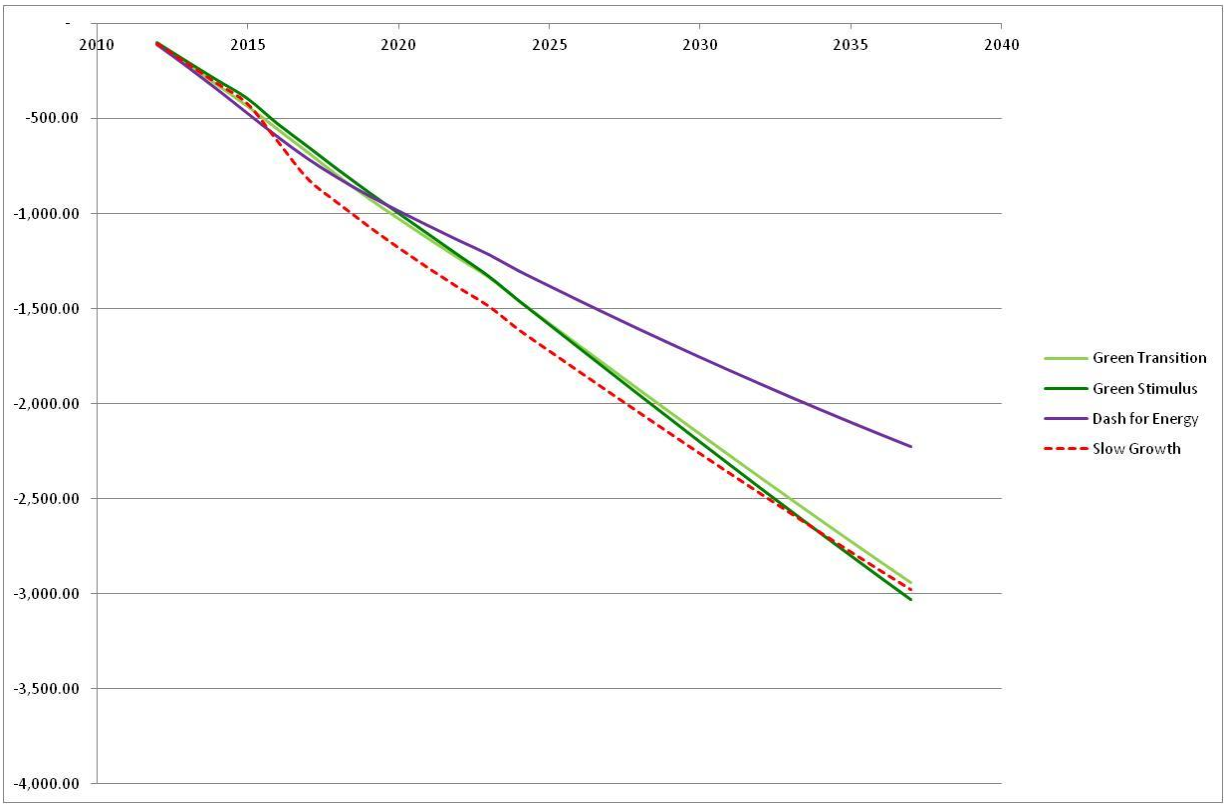

Figure 20: Cumulative Net Present Value for House and Conservatory Built Between 2002 and 2010 with **West** Facing Conservatory and Electric Resistance Heating

1.5.2.3 Net Present Value for House and Conservatory Built After 2010

1.5.2.3.1. Gas Fired Heating

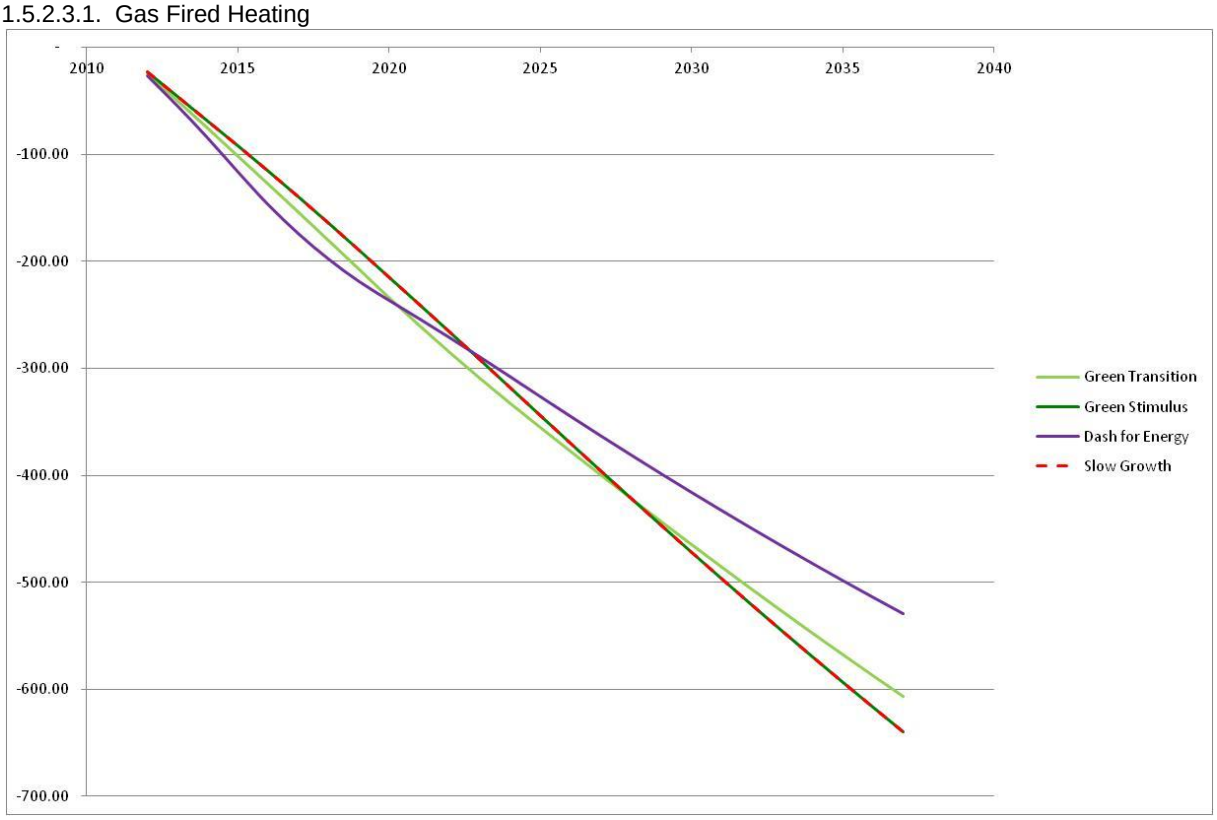

Figure 21: Cumulative Net Present Value for House and Conservatory Built After 2010 with **North** Facing Conservatory and Gas Fired Heating

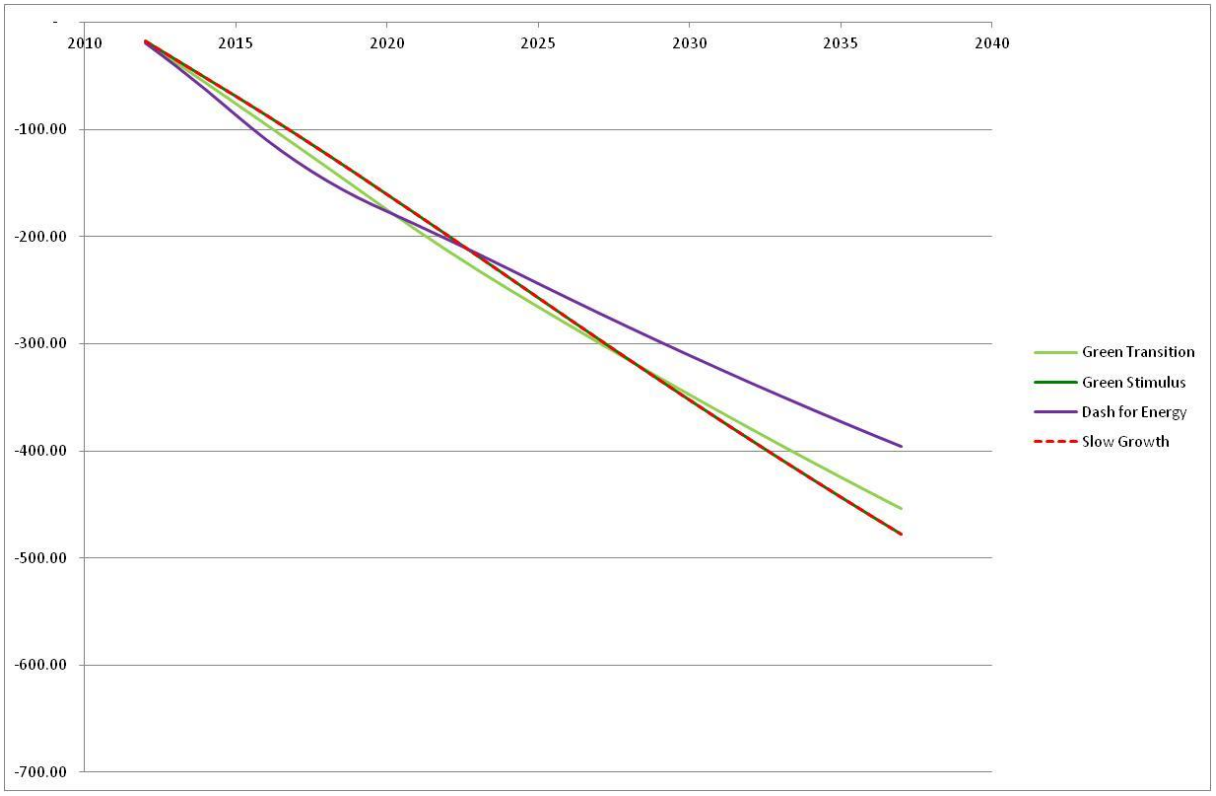

Figure 22: Cumulative Net Present Value for House and Conservatory Built After 2010 with **East** Facing Conservatory and Gas Fired Heating

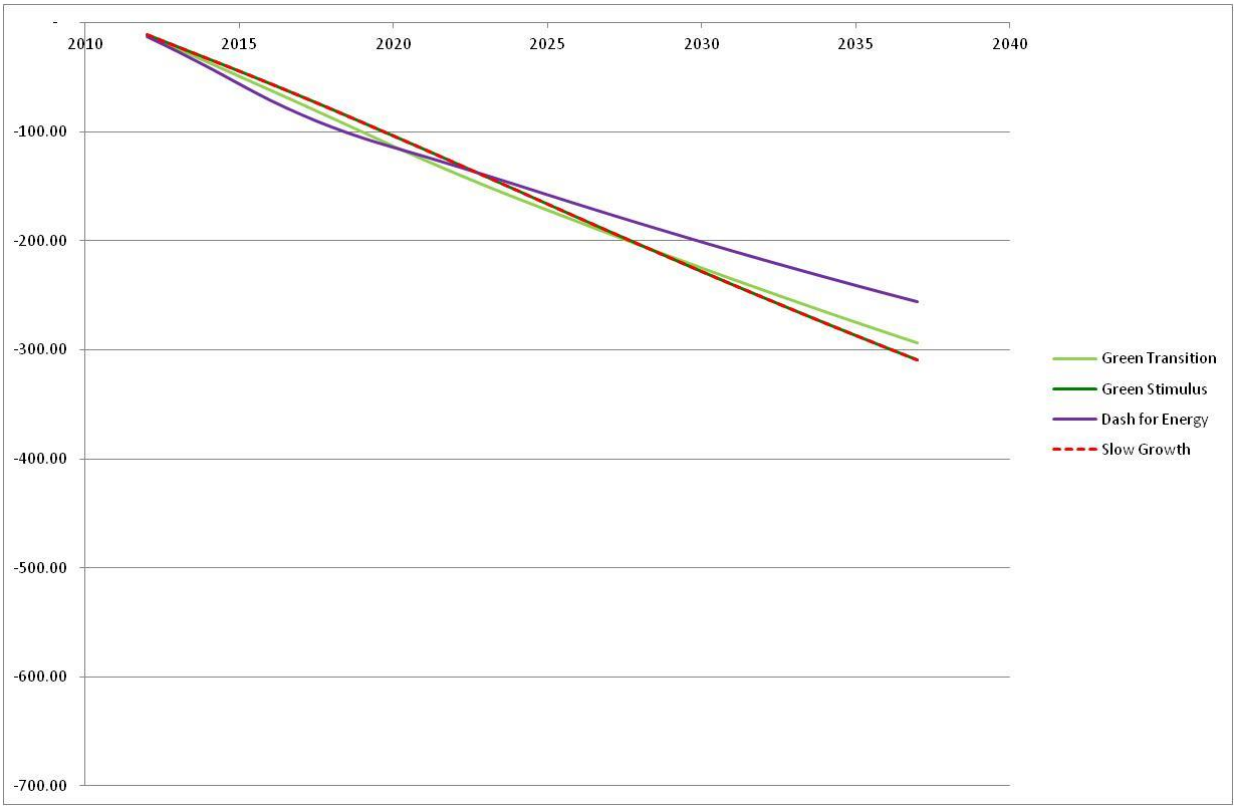

Figure 23: Cumulative Net Present Value for House and Conservatory Built After 2010 with **South** Facing Conservatory and Gas Fired Heating

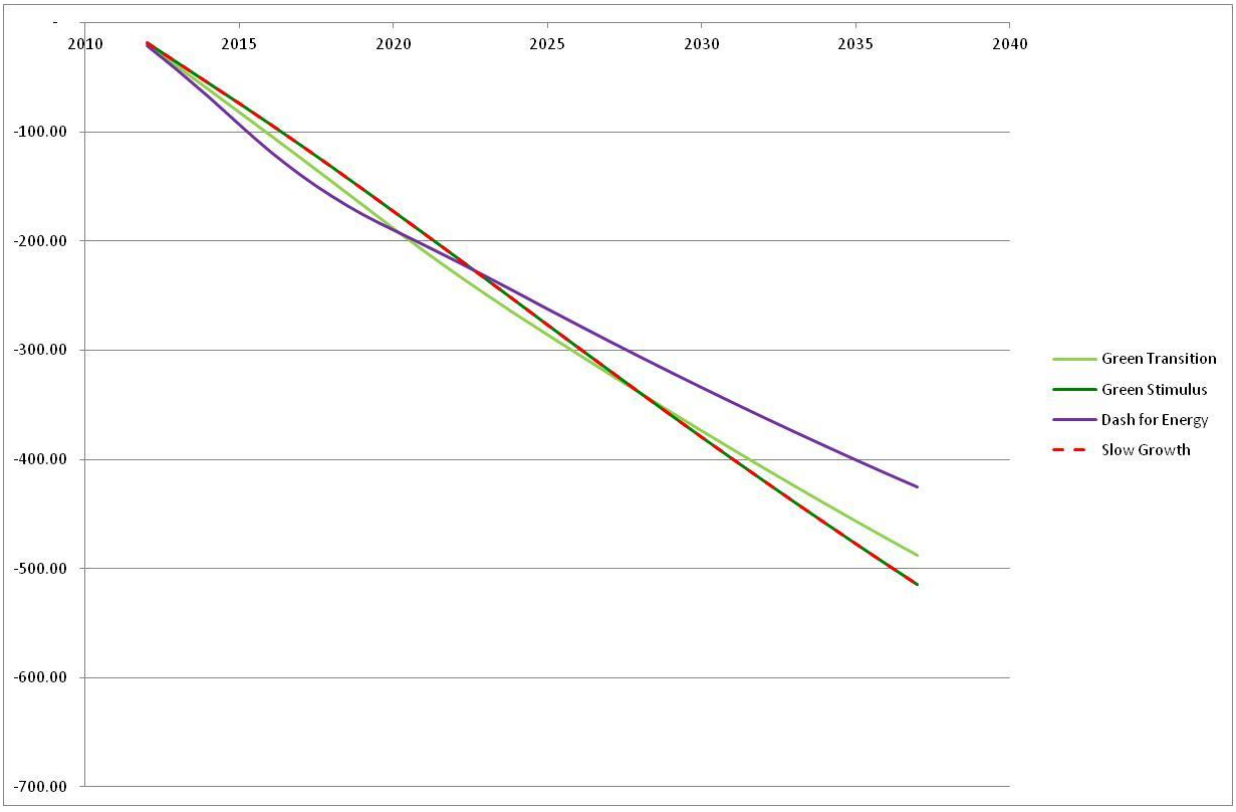

Figure 24: Cumulative Net Present Value for House and Conservatory Built After 2010 with **West** Facing Conservatory and Gas Fired Heating

1.5.2.3.2. Electric Resistance Heating

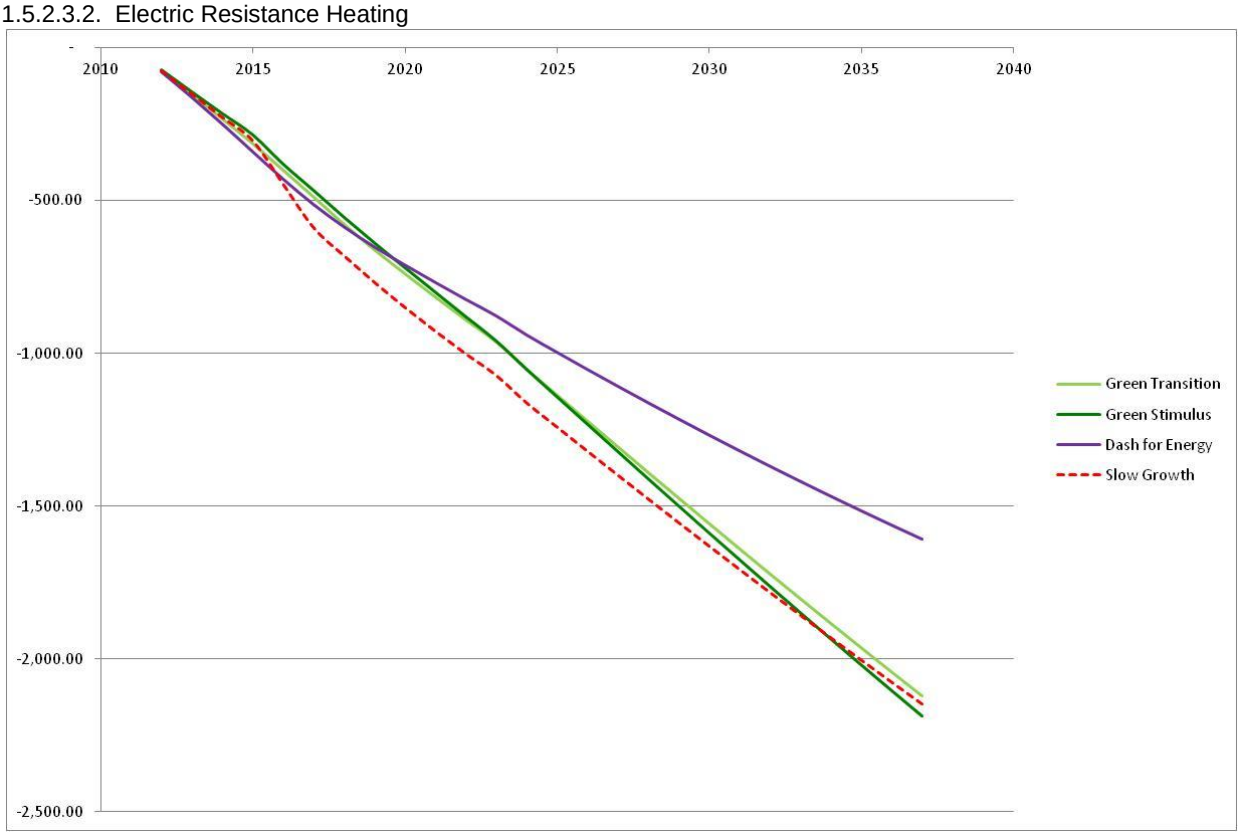

Figure 25: Cumulative Net Present Value for House and Conservatory Built After 2010 with **North** Facing Conservatory and Electric Resistance Heating

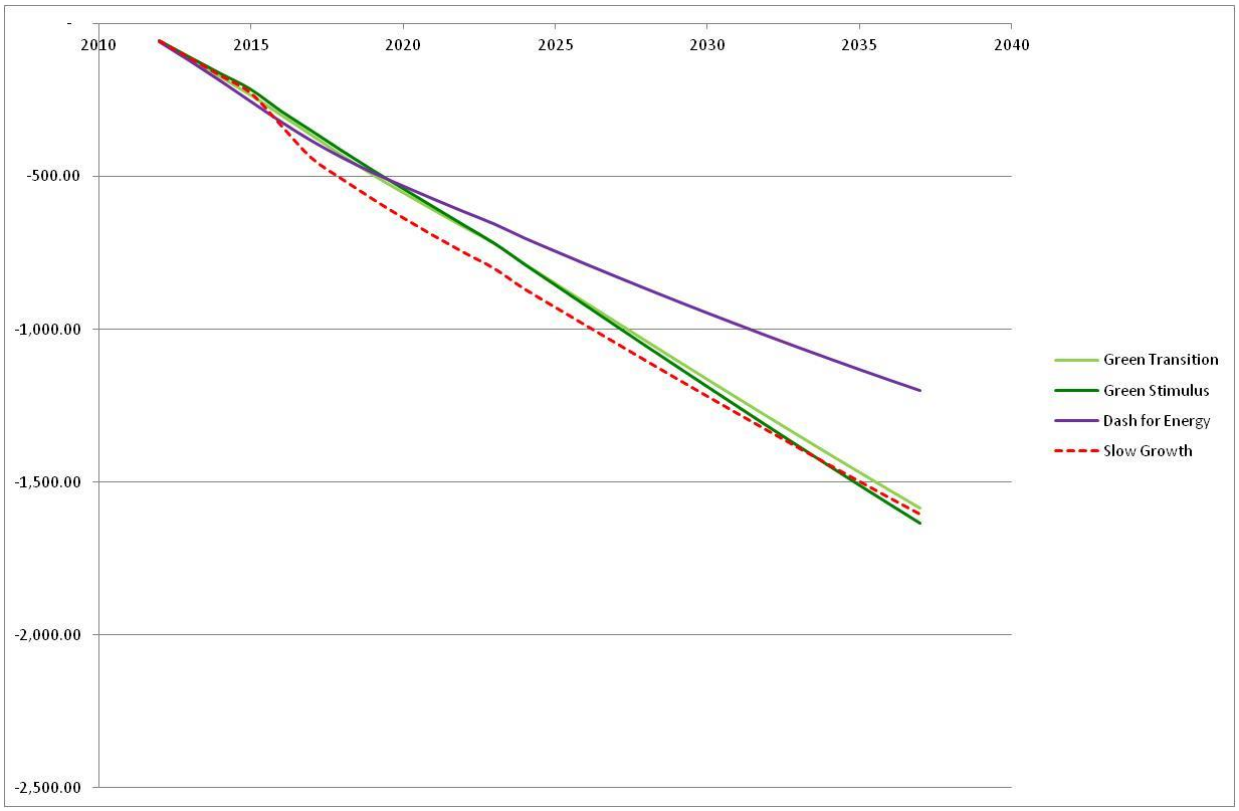

Figure 26: Cumulative Net Present Value for House and Conservatory Built After 2010 with **East** Facing Conservatory and Electric Resistance Heating

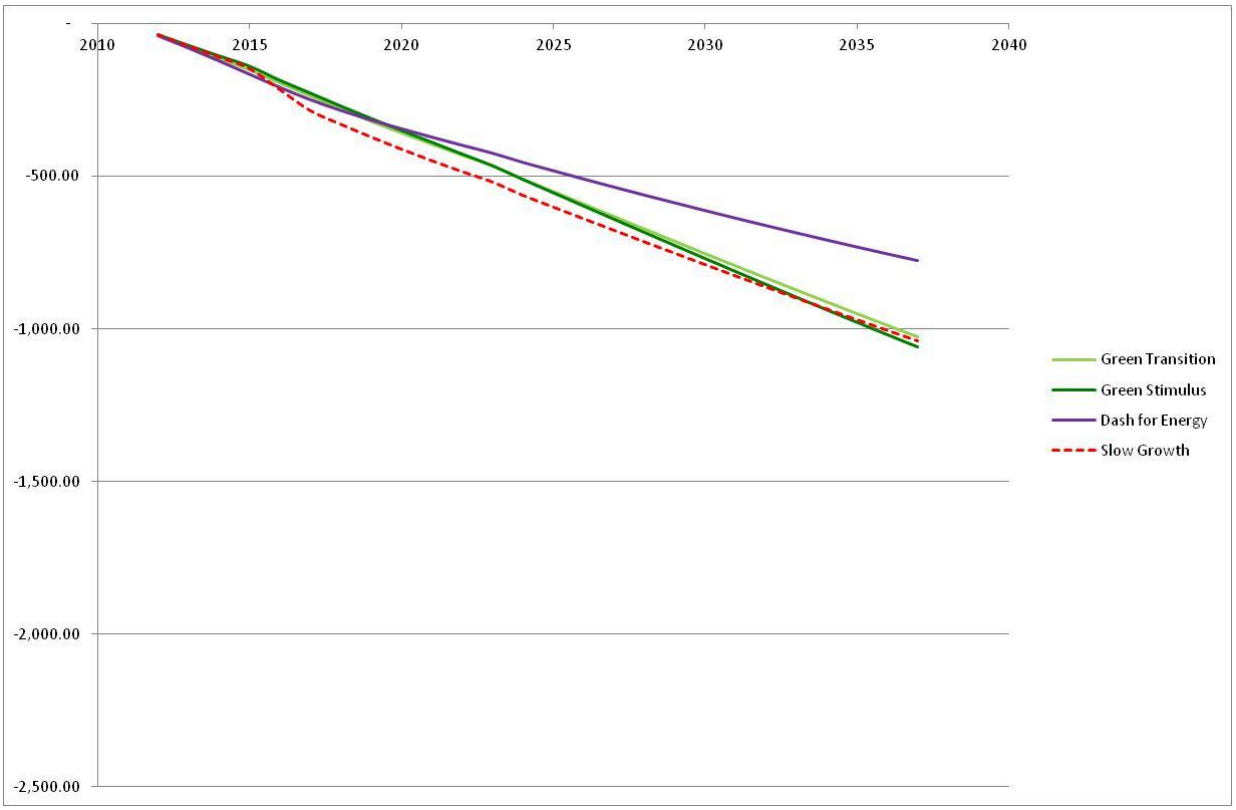

Figure 27: Net Present Value for House and Conservatory Built After 2010 with **South** Facing Conservatory and Electric Resistance Heating

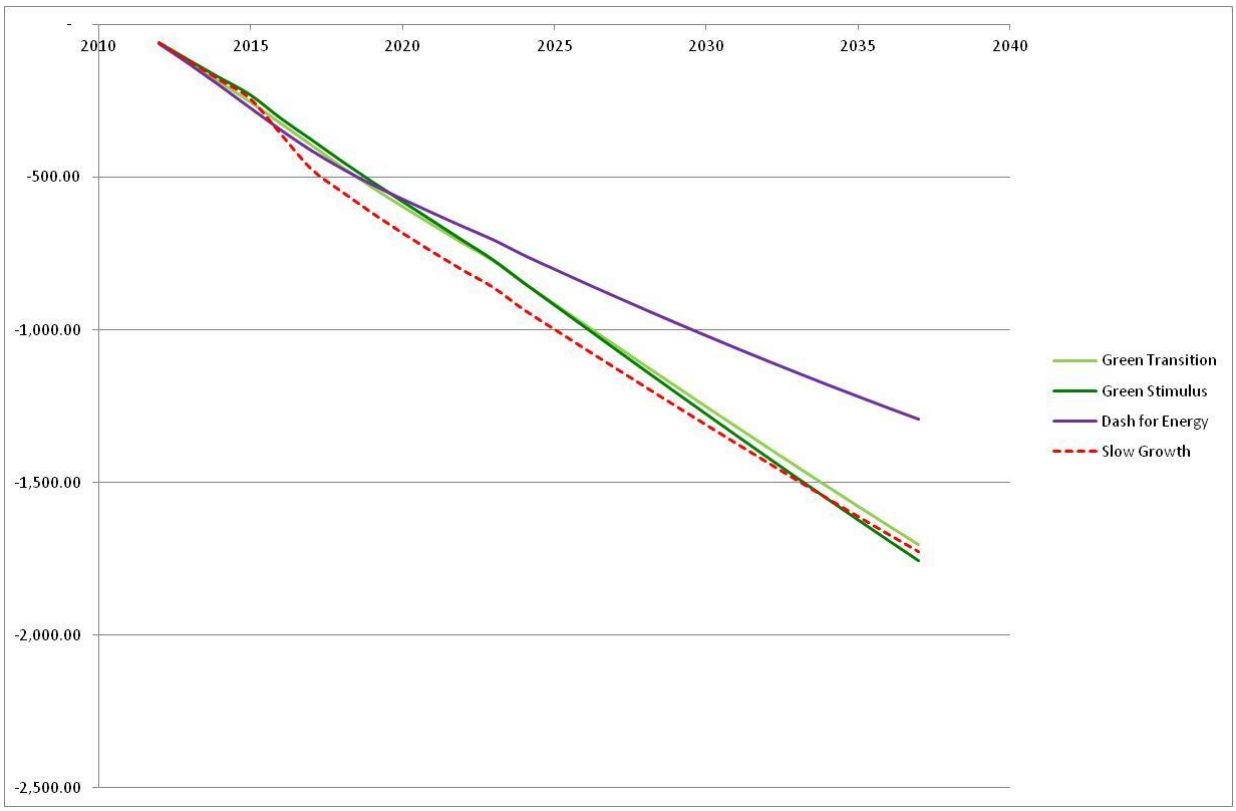

Figure 28: Cumulative Net Present Value for House and Conservatory Built After 2010 with **West** Facing Conservatory and Electric Resistance Heating

1.6 Analysis

1.6.1 Energy Demand and Carbon Dioxide Savings

The largest energy savings are reaped for the oldest house type modelled, in this case the house representative of housing stock built between 1995 and 2002. This is due to the fact that the difference between the U-value of the original conservatory roof and that of the retrofitted “Guardian” roof is greatest.

For all of the three construction ages modelled, the largest energy savings are seen for dwellings where the conservatory projects to the north. This is due to the reduced effect of solar heat gains for this orientation.

The largest Carbon Dioxide emissions savings are achieved by houses with electric heating, because the Carbon Factor and per-unit energy cost associated with electricity are higher than those of Gas.

1.6.1.1 Net Present Value

The greatest Net Present Value benefit is achieved by the oldest house type, for a northward projecting conservatory with an electric heating system. Due to the different future energy price forecasts accounted for, this has given 4 different NPVs for each situation. The highest NPV is achieved under the “Green Stimulus” price forecast, with an NPV of £5,376, and the lowest under the “Dash for Energy” forecast where the NPV reached after 25 years is calculated to be £4,952.

The lowest NPV is seen for the newest house and conservatory type with gas fired heating. The lowest NPV is under the “Dash for Energy” price forecast and is £256 after 25 years. The highest NPV for this house and heating type is £309 under both the “Green Stimulus” and “Slow Growth” forecasts.

1.7 Conclusions

The key conclusion drawn from this evaluation is that the greatest benefits from installing the “Guardian” roof are made when it is retrofitted to an old house and conservatory, as a result of the greater difference between the U-values of the original roof and the new roof type.