Homes as Power Stations – Economic Appraisal

Economic Case Part 2: Cost Benefit Analysis

Project Elements

To meet the project objectives, the Homes as Power Stations project comprises is planned to include 5 key elements:

- Financial Incentives to increase the adoption of renewable technologies for a target number of new build and retrofit homes
- Monitoring and Evaluation programme
- Marketing to disseminate the results of the monitoring and evaluation programme
- Regional Supply Chain development including an associated fund
- Project Management

Potential Impacts and Approach to the Cost Benefit Analysis (CBA)

The HAPS project is unique in that only a relatively small amount of funding is available for financial incentives for renewable technologies vis a vis the target number of homes. Rather than solely funding renewable technologies in new build or retrofit homes, the HAPS project seeks to fill gaps in the funding of other housing programmes with the various HAPS elements working together aim to produce positive outcomes and benefits far beyond direct spending on homes.

It is recognised that the funding for financial incentives for renewable technologies forms only a proportion of the cost of the renewable technologies, as well as of the overall budget for either a new build or a retrofit home. Rather, the intention of the project is to use financial incentives to encourage the target number of homes to adopt renewable technologies i.e. adopting the HAPS concept which generally cannot be funded under other housing programmes.

The monitoring and evaluation programme is intended to be used to help provide evidence of benefits of investment in new technologies at a scale not done before and through a marketing / dissemination programme and

so influence greater use of renewable technologies through adopting the HAPS approach.

Through developing a regional supply chain, the project aims to minimise leakage and retain much of the economic development impacts within the area including business opportunities, jobs, training and skills development. In this way the various elements of the HAPS project work with other ongoing investments in homes to achieve objectives.

The HAPS project is also unique in that the precise investment technologies, the programme of monitoring and evaluation and the precise actions to be undertaken to develop the supply chain will be further refined in the early stages of implementation. The identified alternatives and approach to the CBA recognises these essential features.

These unique features are challenging for the purpose of CBA which generally requires specific spending plans so pathways to impact and measurement can be identified and evaluated. A project specific approach to the CBA has been developed which best reflects the various elements of the project and reflects these unique features.

In implementation, a number of the target houses would be used to develop an evidence base to demonstrate the viability of the HAPS approach and used as the sample for the monitoring and evaluation exercise. For the purpose of CBA, which needs to compare options against a counterfactual, the project options focus on the costs and benefits associated with living test-bed example homes (test-beds). If the test-bed homes show positive NPV then scaling-up of the number of homes should also yield positive NPV. If there are differences in NPV between the options, then scaling up of the number of homes should yield similar relative results. This focus on a number of living-test-bed homes and undertaking a valuation of the energy saving impact at the margin i.e. only of the marginal technology likely to be funded under HAPS is considered a more appropriate approach than including all spending of the housing programmes on the target homes, of which HAPS would only be a very small component.

The CBA therefore considers the costs and benefits from energy savings and energy production to ascertain the economic outcome of the test-bed homes, as if all the financial incentives are spent on test-bed homes recognising that this will not be the practice but that it is the best approach to defining options and costs and benefits for the purpose of CBA. In this

way, the approach is like selecting a number of projects to demonstrate the economic outcome of a programme of similar small projects. The NPV calculation includes the costs and benefits of energy saving and energy production.

Developing the Options for Cost Benefit Analysis (CBA)

The Counterfactual

Under the requirements of CBA, all options are compared to a counterfactual, the 'as is' situation. Under the counterfactual for HAPS, other funding programmes will go ahead and the same number of homes will be built/retrofitted. However, the energy efficient technologies adopted will be limited, particularly the more experimental technologies that may be funded under HAPS to enable homes to be net exporters of energy. The regional supply chain will not adapt to supply and commission/maintain energy efficient technologies and what is adopted will likely come from outside the Swansea Bay region. There would not be a consistent, at-scale, coordinated monitoring and evaluation programme to review the findings and disseminate across all sections. The counterfactual is referred to as Option 1.

Three alternative options, direction of travel and focus

Drawing on the direction of travel presented in Part 1 of this Economic Case, three alternative options are identified. The options vary primarily in their focus on different housing sectors, and the number of target homes:

- **Option 2** – focus on Local Authority (LA properties), which are under public sector direct control, the target number of homes is 1000 new units and 1200 retrofits under pathfinder development
- **Option 3** – focus on LA properties plus Registered Social Landlord (RSL) properties, the target number of homes is larger, at 2100 new units and 3350 retrofits under intermediate development.
- **Option 4** – includes LA properties, RSL properties and private sector properties. The target number of homes is 3300 new units and 7000 retrofits under maximum development.

Options, five key elements expanded

As discussed above, the Homes as Power Stations project is planned to include five key elements:

1. **Financial Incentives** to adopt energy efficient and clean technology in undertaking new build housing and retrofit housing. The financial incentives will cover a proportion of the cost of these technologies, with the remainder to be funded by the developer/owner/other in compliance with State aid funding requirements. The technologies adopted through financial incentives will provide additional energy saving applications. Under each of the options, a number of **test-bed homes** will be undertaken first with the technologies included at an average cost of £15,000. These homes will have different types and scale of technology (as well as any needed for control purpose) that will be included in the monitoring and evaluation programme. The **target homes** will be the focus of the marketing and dissemination exercise and encouraged to take up the financial incentives to adopt the HAPS approach through renewable technologies. For the purpose of the CBA, funding is assumed for the test-bed projects with 'top up' funding from RSL and private sector under options 3 and 4 as explained in the approach section.
2. **Monitoring and Evaluation** of the HAPS project to provide robust and evidence-based analysis and guidance on the most effective and suitable energy efficient technologies for housing. No such guidance currently exists. The intention is that this evaluation will provide a benchmark to the housing industry and act as a catalyst changing behaviours towards more energy efficient and demand-side management solutions in all future public and private housing programmes. The scope of the monitoring and evaluation differs between the options with limited funding under option 2, moderate in option 3 and maximum in option 4.
3. **Marketing** to disseminate the outcome of the evaluation and guidance to support the further take-up of energy efficient and demand-side management technology. This is only included in options 3 and 4 where RSL and private sector are targets to take up the financial incentives, in option 2, there is no marketing as the properties are all LA owned.
4. **Regional Supply Chain Development** through a range of measures including financial incentives, inward investment advice, accreditation of businesses etc, to encourage the regional supply and servicing of energy technologies, most of which are not available within the region and are currently imported or sourced from outside Swansea Bay region. The supply chain does not vary between options.

5. **Project Management** to cover the operational delivery of the overall project and co-ordinate with the other public and private agencies involved. The project management does not vary between options.

Options: Living test-bed Homes and Target Homes

The number of test-bed and target homes for each option are set out in Table 2.1. Under option 2, all of the test-bed homes are LA owned, under option 3 there is a split of LA and RSL properties and in option 4, a split between LA, RSL and private sector properties. The total number of test-bed homes in each option is determined by the level of funding available.

Table 2.1: Number of Test-bed and Target Homes

	Option 1	**Option 2**	**Option 3**	**Option 4**
	Counterfactual	LA properties	LA & RSL only	LA, RSL & Private Sector
New build **test-bed homes**	-	200	200	235
Retrofit **test-bed homes**	-	250	300	348
Subtotal test-bed homes		*450*	*500*	*583*
New build targets	-	800	1,900	3,065
Retrofit targets	-	950	3,050	6,652
Subtotal investment targets		*1,750*	*4,950*	*9,717*
New Build	-	1,000	2,100	3,300
Retrofit	-	1,200	3,350	7,000
Total	**-**	**2,200**	**5,450**	**10,300**

Differences between the Options

In addition to the differences in the number of test-bed and target homes, there are differences in the cost allocations for the various options, including different levels of contributions from RSL and private sector. See Table 2.

The total project cost for HAPS is £15 million under each option. Under options 3 and 4 more homes are included but there is a top up from RSL

and private sector[1], whilst public sector funding remains the same, the overall project costs are higher – up to £18 million in option 4.

Table 2.2: Options, Cost Allocation

	Option 1	Option 2	Option 3	Option 4
Financial Incentives - HAPS funded	-	*6,750,000*	*6,250,000*	*5,750,000*
Financial Incentives - Top up by third party (RSL and Private sector)	-		*1,250,000*	3,000,000
Monitoring & evaluation	-	250,000	600,000	1,000,000
Marketing	-	-	150,000	250,000
Supply Chain Development	-	7,000,000	7,000,000	7,000,000
Project Management	-	1,000,000	1,000,000	1,000,000
Subtotal HAPS direct cost	**-**	**15,000,000**	**15,000,000**	**15,000,000**
Total Project Cost	-	**15,000,000**	**16,250,000**	**18,000,000**

Benefits

Identification of Benefits

There are six main project benefits identified. Three of these apply to HAPS project homes only and 3 to all future housing programmes.

Table 2.3: Types of Benefit and their Application

Type of Benefit	Relevant Application	Included in CBA BCR Calculation
Marginal reduction in energy use as a result of the additional technologies funded by the HAPS project for new build and retrofit homes and production of energy by HAPS homes	New Build and Retrofit HAPS project test-bed homes	Converted to economic values and included in CBA BCR calculation. Estimated income to households from energy production included as a benefit in the BCR calculation.
Reduction in greenhouse gas (GHG) emissions as a result of reduction in energy use	New Build and Retrofit HAPS project test-bed homes	Converted to economic values and included in CBA BCR calculation

[1] RSL are assumed to contribute one third 33% of investment costs under financial incentives. Private sector is assumed to contribute 50% of investment costs. Due to this funding 'top up' a larger number of homes can be included as test-bed homes.

Reduction in fuel poverty from energy savings	New Build and Retrofit HAPS project test-bed homes	Reduction in overall energy bill estimated (excluding income earned) included in BCR calculation. Health benefits discussed qualitatively but direct impacts not included in BCR calculation
Additional economic activity in Swansea Bay region, manufacturing, construction, maintenance servicing from developing supply chain activities	Target three technologies, as identified under the Supply Chain 3	Discussed as a benefit, and estimated number of additional jobs estimated based on the 3 focus technologies for the HAPS period and considering future demand for technologies for a further 5 years. The additional jobs valued using uplift in salaries and included in the BCR calculation
Greater take up of investment in energy efficient technology as a result of dissemination programme on outcome of monitoring and evaluation. Leaning and avoidance of mistakes. Associated energy and GHG emission savings and fuel poverty impacts	Target homes and potentially all future housing programmes	Discussed as a benefit and estimated % resource cost savings in identified future housing programmes over 5 year period included in BCR calculation.
Potential increase in value of retrofit homes	All test-bed homes and those retrofitted as a result of learnings from the HAPS programme	Discussed qualitatively but not included in BCR calculation

These benefits are further discussed, below.

Benefits: Reduction in Energy Use, Greenhouse Gas Emissions, and Energy Production

Supplementary Guidance on Valuation of Energy Use and Greenhouse Gas (Supplementary Guidance) was published in April 2019. The

Valuing Changes in Energy Use

Supplementary Guidance on Valuation if Energy Use and Greenhouse Gas

$V_u = \Delta (EU)_{it} \times (VC)_{it}$

V_u = *Value of change in use of fuel I in year t (£)*

$\Delta (EU)_{it}$ = *Change in use of fuel i in year t*

$(VC)_{it}$ = *Year t Long Run Variable Supply of fuel I (£/KwH*

Guidance sets out the process and formula for valuation of changes in energy use, as well as providing data tables for different fuel types.

To value energy savings from HAPS funded technologies, research case studies undertaken by the Welsh School of Architecture (WSA), Cardiff University were adopted[2].

Key findings from a case study on a 'typical' 1970s semi-detached house were used as the basis for energy savings for the retrofit test-bed homes and findings from a case study on a new build were used for the new build test-bed homes.

For the purpose of the valuation exercise, the rebound effect, the increase in energy consumption as a result of reduced energy bills, was incorporated into the energy reduction amounts estimated. The research and analysis undertaken, and the basis of the estimates draw on technologies that together cost in the order of over £30,000. These costs in the case studies amount to about two times the average assumed for the test-bed homes of £15,000. As such, the estimated energy reduction/production benefit adopted for the purpose of the CBA is factored at 50% of the energy savings arising in the reference case studies.

The net change in reduced energy use is valued at the Long Run Variable Cost (LRVC) for the relevant fuel source and the national electricity grid. For both New Build and Retrofit, the energy saving is assumed to remain constant over the life of the project, whilst the long run variable cost changes over time.

For energy produced, the sale price to the grid is adopted as the value per KwH revenue since this is a direct cash releasing benefit to the household and the source of production is the home, through solar photovoltaic cells, rather than other conventional energy sources.

Reduction in GHG as a result of reduction in energy use is also included in the case studies undertaken by Cardiff University in terms of the

[2] The work by the Welsh School of Architecture, Cardiff University was undertaken as part of the Low Carbon Research Institute (LCRI) Programme part-funded by the European Regional Development Fund through the Wales European Funding Office together and the Low Carbon Built Environment team at Cardiff University funded through SPECIFIC which is part-funded by the European Regional Development Fund (ERDF) through the Welsh Government, and also by InnovateUK and the Engineering and Physical Sciences Research Council (EPSRC).

reduction in CO2. The reduction in CO2 is divided into traded and non-traded sectors with direct fuel used by households in our case, oil or gas being non-traded and any grid electricity use being traded.

The key assumptions adopted from the case studies undertaken by the Cardiff University are shown in Table 4 along with the key values adopted for a new build or retrofit, occurring in 2020. The total value is the sum of the value of each type of fuel saving plus the income from producing electricity. For example, for new build the total value in 2020 per home is: the value of gas saving (£149) plus value of electricity saving (£337) plus income from electricity production (£641) = £1,127 x 50% = £564.

Table 2.4: Energy Saving Value/house HAPS Project Test-bed Homes

New Build (per house)		**Retrofit (per house)**	
Technologies adopted include: Mechanical Ventilation with Heat Recovery (MVHR) Air Source Heat Pump (ASHP) Solar PhotoVoltaics and Batteries		Technologies adopted include: Mechanical Ventilation with Heat Recovery (MVHR) Ground Source Heat Pump (GSHP) Solar PhotoVoltaics and Batteries	
Energy saving gas	8249 kWh/year	Energy saving oil	9737 kWh/year
LRVC gas (2020)	1.81p/KwH	LRVC oil (2020)	4p /kWh
Value saving gas	£149	Value saving oil	£393
Energy saving electricity	3230 kWh/Year	Energy saving electricity KwH	680
LRVC electricity (2020)	10.42p/KwH	LRVC electricity (2020)	10.42p/KwH
Value saving electricity	£337	Value saving electricity	£71
Income from electricity production	£641	Income from electricity production	£1051
Cost adjustment factor	50%	Cost adjustment factor	50%
Total value per home (2020)	**£564**	Total value per home (2020)	**£758**

Note: this table refers to 2020 for ease of presentation, all values incorporated into the CBA are adapted for the number of new builds and retrofits over time, as well as changes in LRVC[3]

[3] For simplicity and transparency, the CBA adopts the same prices for 2020 as those in the case studies, which were undertaken in 2017 for new build and 2019 for retrofit. This is proportionate and appropriate for the CBA since the technologies adopted in the case studies would have also used 2017 and 2019 price points and the average investment under HAPS is roughly half of the estimated investment cost in the case studies.

*converted from LRVC price/litre to KwH using 10.122 as per Supplementary Guidance

Table 2.5: Reduction in Greenhouse Gases, HAPS Project Test-bed Homes

New Build (per house)		**Retrofit (per house)**	
Non-traded CO2 reduction	1179 CO2	Non-traded CO2 reduction	2068 CO2
Non-traded carbon price	£69/tCO2	Non-traded carbon price	£69/tCO2
Non-traded value	£81	Non-traded value	£144
Traded CO2 reduction	4366 CO2	Traded CO2 reduction	2501 CO2
Traded carbon price	£14/tCO2	Traded carbon price	£14/tCO2
Traded carbon value	£61	Traded carbon value	£53
Cost adjustment factor	50%	Cost adjustment factor	50%
Total value per home (2020)	**£71**	Total value per home (2020)	**£99**

Note: Whilst the carbon price of traded and non-traded is very different in 2020, in the long run the 2 prices merge and are the same by 2030.

Benefit: Reduction in Fuel Poverty

A household is regarded as being in fuel poverty if the home cannot be kept warm at a reasonable cost. In Wales, this is measured as any household that would have to spend more than 10% of their income on maintaining a satisfactory heating regime, as recommended by the World Health Organisation (WHO). This requires a minimum indoor temperature of 21 degrees centigrade in living rooms and 18 degrees centigrade in other areas. Any household having to spend more than 20% of their income on maintaining a satisfactory heating regime is defined as being in severe fuel poverty. Households in fuel poverty in the Swansea Bay City Region based on the 10% of income method are shown in Table 6.

Table 2.6: Fuel Poor Households in Swansea Bay City Region, 2018

Local authority area	Total households	Fuel poor households	Fuel poor %
Pembrokeshire	51,761	12,083	23%
Carmarthenshire	76,771	18,934	24%
Swansea	100,787	24,394	24%
Neath Port Talbot	58,780	14,450	24%
Total	**288,099**	**69,861**	**24%**
All Wales	**1,265,000**	**291,000**	**23%**

The Swansea Bay City Region has a slightly higher percentage of fuel poor households than the Welsh average which is about 23% [4]. This is

[4] http://www.nea.org.uk/the-challenge/fuel-poverty-statistics/

exacerbated by lower household incomes and higher energy prices in Wales.

England adopts a different method, the Low Income High Cost (LIHC) method of estimating fuel poverty. Under this method, fewer households in Wales are estimated to be in poverty, about 10%[5]. Under this definition, the estimated average fuel poverty gap for Wales 2018 was approximately £431, this is the average reduction in annual fuel bill that was needed to move these households out of fuel poverty[6].

The Cardiff University analysis of reduction in energy use enables the calculation of the approximate amount saved per household on energy bills. Comparing the £ savings to total gross disposable household income the saving is 5% for new build and 6% retrofit respectively. Based on estimates for Wales' fuel poverty of £431, the HAPS project, assuming the householder doesn't have to pay for the improvements, would lift 100% out of fuel poverty.

Table 2.7: Reduction in Fuel Bills, Household Income & Fuel Poverty

	New Build Home	**Retrofit Home**
Reduction in fuel bill	£898	£619
Income from electricity production	£641	£1050
Cost factor (only part of benefit allocated)	50%	50%
Net saving /income	£770	£835
Household gross disposable income Swansea (HHI)*	£15,003	£15,003
Net saving as % of HHI	5%	6%
Fuel poverty gap Wales	£431	£431
Do HAPS expected savings exceed the estimated fuel poverty gap Wales?	Yes Exceed by 339	Yes Exceed by £404
Reduction in fuel bill included in **BCR****	£449	£309.50

*Source: https://gov.wales/statistics-and-research

** Income from electricity production included under benefit of reduction in energy use and energy production described above and so not included here. 50% of the reduction in fuel bill included to reflect the proportion attributable to HAPS. Values in BCR calculation include those for test-bed homes, both new and retrofit homes

Reductions in fuel poverty will also have potential benefits to local health services in reducing the number of health issues arising from poorly heated homes. Whilst there is little empirical evidence about the specific linkages between fuel poverty and health, there are common links between substandard housing and associated health issues. Most

[5] http://www.nea.org.uk/the-challenge/fuel-poverty-statistics/

[6] Source: https://gov.wales/sites/default/files/statistics-and-research/2019-12/fuel-poverty-estimates-wales-2018.pdf

notably, evidence from evaluation of the Warm Homes Nest scheme, suggested there was a 14% difference in respiratory illnesses recorded (between those homes in the scheme or not, whilst for asthma the difference was 19%.

There are clear health benefits of HAPS. However, their quantum and monetisation in terms of including £ values in the BCR calculation is more difficult to support with evidence that can attribute healthcare resource savings or monetised improvements to the energy cost savings under HAPS. These benefits are thus treated qualitatively.

Substandard housing, which is often hard to heat, is estimated to cost the National Health Service (NHS) some £2.5 billion a year through building-associated health-related issues (National Housing Federation/ECOTEC, 2010).

Source: Jones, Phillip, Li, Xiaojun, Perisoglou, Emmanouil and Patterson, Joanne 2017. Five energy retrofit houses in South Wales. Energy and Buildings 154 , pp. 335-342. 0.1016/j.enbuild.2017.08.032 file

Benefit: Regional Supply Chain Economic Development

The proposals for regional supply chain development include two phases.

Phase 1 (Yr 1) will include:

- Mapping of existing supply chain and identification of gaps
- Analysis of kit in terms of imported kit and scope for market in region to reshore (based on Bill of Materials)

Lessons learned from developments e.g. Hafod development in terms of costs developments

- Focus on 2 or 3 technologies of technologies, in particular, what worked, and what didn't work

This initial work will build on the supply chain development exercise currently being undertaken by Cardiff University and City and County of Swansea. The proposed measures will also draw on other supply chain development programmes for renewables, such as that being undertaken in Scotland[7].

Phase 2 (Yr 2 – 4) will include:

[7] https://energysavingtrust.org.uk/scotland/businesses-organisations/supply-chain

Assessment of aggregate demand for incremental technologies
HAPS has pipeline demand with 10,300 homes over 5 years – HAPS will share the pipeline of an anchor in the region such as heat pumps, powerwall and control systems

The aim is to embed the supply chain in the region and enable both public and private housebuilding programmes to source technologies from the region, rather than importing from abroad, which for most technologies is currently the only choice.

The plan for supply chain development includes activities to raise the awareness of local businesses of the demand for technologies, including those not normally the target of public funded programmes. The intention is to identify as wide a potential supply chain as possible, through an competitive open call for proposals focused on 2 or 3 technologies to include:

- Start-up companies. To encourage start-ups in investing in these technologies
- Existing companies. To enable small businesses to build capacity and/or larger more established companies to diversify to include these technologies in their suite of products offered to the market

Appraisal of bids is planned to include Industry Wales amongst the selection panel.

The initiatives involved could include accreditation schemes, incentives for manufacturing companies to develop new processes and equipment, company search and facilitating site finding for inward investment, skills upgrading schemes, information and events. Whilst the number of test-bed homes and indeed target homes is fairly limited, the regional supply chain development component of HAPS could be applied to all local housing programmes and will therefore have an aggregation effect to stimulate demand.

The current situation is that there is no coordinated supply chain and skills specifically linked to energy efficient homes. The implications of a fragmented supply chain are higher transactions costs which affects purchasing decisions and ultimately acts as a barrier for local firms and trades to enter the market. A recent report by Regen on the South West of the UK indicated that the current supply chain does not have the capacity to deliver domestic retrofit on the scale required to meet 2020 carbon emissions targets and even at current levels of activity, there are supply chain constraints. The situation is likely to be similar for Wales.

Whilst the proposals for specific activities under the supply chain development component of HAPS are to be defined as part of the first

phase of the project, there are a number of positive factors which suggest that the supply chain development could be successful and lead to positive economic benefits, which involves a combination of demand and supply factors which under HAPS, through implementation of the living test-bed homes, monitoring and evaluation and marketing look to influence demand – and through supply chain measures, enable the regional supply chain to respond.

Learning from other supply chain development schemes elsewhere, a number of factors are important:

- the purchasing power of public sector bodies – some £115 million is planned to be spent by the public sector on housing programmes over the next 5 years[8]
- through accreditation and other incentives, influencing the decision makers in purchasing for the private sector is likely to involve a mix of house developers and architects; some £375 million is planned to be spent by the private sector over the next 5 years. Supply chain development will need to consider how decisions are made and enable local companies and trades to be able to adequately respond to changes in demand

The valuation of benefits included in the BCR calculation, relies on evidence provided by NPT, drawing on an ongoing project to support the establishment of a heat-pump manufacturer in the area.

The valuation draws on the following assumptions:

- Evidence from the ongoing NPT project suggests that production of around 12,000 heat pumps requires a workforce of about 160 staff, the average salary of which is about £46,000
- HAPS homes total about 10,300 over the 5 year programme, although for supply chain development most of the benefit is likely to be in after say 2 years, as the investment requires time to take effect
- Given companies impacted by supply chain investment can supply technologies to HAPS or other housing programmes, it is assumed that one third of the 162 jobs in the example, (say 3,400 heat pumps a year is supported). This benefit is assumed to accrue over the latter 3 years of HAPS plus an additional five years, supporting other

[8] These figures for housing programmes include a range of costs for new build and retrofit but energy technologies will be a significant proportion of the investment

housing programmes. Beyond 5 years is less certain. Jobs are valued as additional using the salary uplift between average salary in NPT, about £27,000 and the £46,000 in the example

- The same assumptions are adopted for 2 other technologies, as recommended by NPT based on the example case

The benefits of supply chain improvements and provision are not limited to current or planned housing programmes, of course and the businesses could supply technologies throughout the UK and abroad. The impacts and values assumed are thus considered to be reasonable and achievable.

Benefit: Greater Investment in Energy Efficient Technology, Target Homes under HAPS and other Future Housing Programmes

The investment in monitoring and evaluation, and the dissemination of its outcomes through the marketing component will enable the HAPS living test-bed homes, which include energy efficient technologies to inform and encourage future housing investment programmes and potentially avoid mistakes and wasted investment.

What is clear to date, is that whilst there has been attempts at case studies and example homes to showcase renewable technologies, a comprehensive and definitive study has not been undertaken. The proposed number of test-bed homes under HAPS provides great potential to require participants to agree to comprehensive monitoring and evaluation and to undertake analysis, not just of a few homes but a sample in the order of over 100 for new build and retrofit. This would enable the study and its results to be far more comprehensive and potentially compelling than any analysis to date. The intention is that several technologies are tested and under different circumstances to facilitate comprehensive recommendations.

Whilst it is not possible to accurately judge the magnitude of this benefit, some comparisons are made to help understand the potential scale of the impacts relative to the investment. Under option 4, the number of target homes is much higher.

Table 2.8: Scenarios of Scaling up the Investment in Energy Efficient Technology

	Option 1	Option 2	Option 3	Option 4
New Build target homes under HAPS	-	1,000	2,100	3,300

Retrofit target homes under HAPS	-	1,200	3,350	7,000
Total target homes under HAPS	**-**	**2,200**	**5,450**	**10,300**

That said, successful dissemination programmes are not exclusive to the initiating project and if done well could reach a wide audience, influencing not just the target homes in the Swansea Bay region but have much wider and further reach, geographically and beyond the HAPS project timeframe. There is also a risk, that if the results are not compelling and/or the analysis or the dissemination outcomes are weak then anticipated take up of technologies will also be weak and benefits will not occur.

Compelling evidence on the benefits of efficiencies gained through better understanding of what technologies work where, best and how, has been collated by NPT in conjunction with a RSL. Their experience on a site developed in partnership with NPT and Specific suggests that lessons learned from the project may be able to reduce the costs of technology by about half, from some £40,000 above the Acceptable Cost Guidance to about £15-20,000. Evidence suggests there has been a strong learning curve and a private engineering company are monitoring the development through funding from BEIS. The results are not yet available but could be used to support HAPS and act as a building block for the HAPS project to further develop and so provide evidence for the market – and gain efficiencies in both public and private housing programmes.

For the purpose of the BCR calculation, reference to the cost of housing and the cost reduction of some 50% for technologies is taken into account, also bearing in mind, that only a proportion of future housing will take these learnings into account. As discussed the expenditure under HAPS will help to facilitate wide dissemination and learning to facilitate widest benefits as possible. Assumptions for the valuation include:

- For RSL, the saving on new housing is around 9% of the overall cost of the house (reference to RSL developments in NPT), and assuming that for a five year housing programme of some £23 million a year (reference the current £115 million 5 year programme), savings of about £520,000 a year, over five years
- Similar savings for private sector housing programmes but at a lower take up rate (reference private sector housing programme of £375 million a year), savings of about £850 a year, over five years

Whilst these learnings may impact housing programmes over longer period, for prudency, the savings assumed in the valuation and used in the BCR are limited to five years.

Value of Properties Retrofitted under HAPS

There is compelling evidence that properties retrofitted with new technologies under HAPS will have lower heating costs and may thus be cheaper to run and have a higher market value. Specific research into this uplift to provide evidence for economic valuation has not been undertaken and thus is discussed here as a positive benefit, but not included in the BCR calculation.

Risk Assessment

With reference to HMT Green Book (Annex 5) a preliminary risk assessment has been undertaken. The focus of the assessment is on the financial incentives component of the HAPS project, rather than regional supply chain, monitoring and evaluation, marketing and project management, as these components are allocations and their specific scope will be defined at a future date.

The project is considered to be a non-standard building project, for which the capital cost optimism bias is estimated to be between 4% and 51%. The HAPS project and the type of renewable energy technologies adopted will vary from home to home and could be adjusted to accommodate increases or decreases in cost. For this reason, a slightly lower than mean value is taken at 20% of financial incentive costs.

Project Costs

Costs are developed in 2020 prices and are exclusive of VAT. Costs do not include additional lifecycle costs of replacement etc, rather a suitable 30 year of operations project evaluation period is used.

For project management, it is assumed that there is no subsequent liability to the public sector of hiring staff to manage and run the project, such that any contracts would be terminated at the end of the project term. Costs include the top up contributions from the RSL and the private sector.

Costs are phased, assuming that spending on the test-bed homes occurs within the first two years, as per the monitoring and evaluation programme, with the marketing spent in the second year. Supply chain developments are spread out over the five-year project, relatively small in

the first year as the project is developed and then building up over subsequent years. Project management is assumed to be spread equally over the five-year project.

Table 2.9 shows the costs of the various options, including optimism bias, in NPV 2020.

Table 2.9: Option Cost Estimates, NPV 2020

	Option 1	Option 2	Option 3	Option 4
Direct Costs (to Project proponent)				
Financial Incentives	-	6,399,216	5,916,124	5,433,032
Monitoring & Evaluation	-	238,279	569,908	949,847
Marketing	-	-	140,027	233,378
Supply Chain	-	6,272,101	6,272,101	6,272,101
Project Management	-	903,010	903,010	903,010
Subtotal	-	13,579,029	13,579,029	13,579,029
Third party 'top up'	-	-	1,191,393	2,801,637
Optimism Bias	-	1,279,843	1,421,503	1,646,934
TOTAL	-	14,858,873	16,191,926	18,027,600

Results of the CBA

CBA Monetary NPV Calculation

The monetary NPV and BCR calculation is undertaken using the costs and benefits described in the previous sections.

Summary results are shown in Table 2.10 along with reference to benefits that are either not able to be quantified or monetised.

The results of the monetised valuation show that all of the options have a positive NPV and deliver a benefit cost ratio, against public sector costs of greater than 2. As discussed health benefits and uplift in

property values are not included; neither are very long term benefits as they are more uncertain.

Option 4, which leverages the highest amount of private funding, delivers the greatest NPV and also the greatest BCR. Benefits that cannot be monetised and/or any sensitivities in the analysis are not considered to change this outcome. Rather any sensitivities in assumptions, is likely to reinforce the relative performance of the options. Option 4 is thus considered to be the preferred option and is taken forward.

Table 2.10: Appraisal Summary Table

	Option 1	Option 2	Option 3	Option 4
A Net Present Social Value (£million)	-	15.13	16.35	16.63
B Public sector cost (or appropriate value for cost) (£million)	-	14.86	14.76	14.67
C Appropriate BCR	-	2.05	2.15	2.50
D Significant unmonetisable costs/benefits	-	Health impacts attributable to reduction in fuel poverty and increase in value of retrofit homes	Health impacts attributable to reduction in fuel poverty and increase in value of retrofit homes	Health impacts attributable to reduction in fuel poverty and increase in value of retrofit homes
E Significant unquantifiable factors	-	Longer term (greater than 5 year after HAPS programme, impacts on future programmes and supply chain)	Longer term (greater than 5 year after HAPS programme, impacts on future programmes and supply chain)	Longer term (greater than 5 year after HAPS programme, impacts on future programmes and supply chain)
F Risk costs by type and residual optimism bias £million	-	1.28	1.42	1.65
G Switching values (for the preferred option only)	-			81%
H Time horizon and reason	5 year programme + 30 years after, lifecycle of technologies	5 year programme + 30 years after, lifecycle of technologies	5 year programme + 30 years after, lifecycle of technologies	5 year programme + 30 years after, lifecycle of technologies

Summary of the Preferred Option

Drawing on the business needs identified in the Strategic Case, and the results of the above CBA, the preferred option to be taken forward to the Commercial, Financial and Management cases is set out below.

This will be a regional pioneering project to facilitate the adoption of the 'HAPS approach' i.e. the integration of energy efficient design and renewable technologies in new build and existing housing stock across the public, private and third sectors in the Swansea Bay City Region. Importantly, the HAPS project is about the approach to delivering energy positive homes, not developing new technologies. The technologies to be used in the design solutions are already known. The innovative aspect to this project will be:

- The coordinated approach to combining design and technologies at scale
- Ongoing monitoring and evaluation to maximise the benefits of the approach
- Developing a sustainable, skilled regional supply chain

The recommended scope of activity of the HAPS preferred option is as follows:

Activity	**Details**
Facilitate the adoption of the HAPS approach in new build and retrofit developments	A targeted regional financial incentives fund will be created to provide gap funding to facilitate the adoption of the HAPS approach in new build and retrofit developments. The funding will not act as a subsidy for every development. Rather, it will provide incentives at the start of the project to incentivise the adoption of the HAPS approach (similar to WG Innovative Housing Programme (IHP)) for a target number of properties. The fund will be State aid compliant. The aim will be to facilitate the adoption of energy positive, low carbon and renewable technologies and design in new-build and retrofit developments, to create an evidence base at scale to develop a cost effective, flexible design approach.

	A phased approach will be adopted so as to de-risk the project. Roll-out will initially focus on the Local Authority and Regional Social Landlord (RSL) sectors. Once benefits in the public sector have been demonstrated, the project will then look to incentivise private sector housebuilders to adopt the HAPS approach. Delivery at scale like this should help to reduce the cost of the technologies, thereby facilitating further take-up.
Develop a sustainable, skilled regional supply chain	The HAPS project includes funding for developing a sustainable regional supply chain. The project team will work with key partners, including Welsh Government and industry, including Industry Wales to develop a sustainable, indigenous regional supply chain. The project activity will lead to an aggregation of technologies creating demand for technologies. The HAPS project will work with the Skills and Talent project to ensure the workforce is appropriately skilled. The HAPS project has already established links with FE and HE, together with the Skills and Talent City Deal project. The Renewable Energy Skills Forum (Wales) is currently mapping the skills and experience currently available in renewable technologies to develop a competency and skills matrix, for a qualification routeway in Wales. It is looking at existing work through SPECIFIC and RSLs, in particular, as well as taking account of UK and local companies, developing an expertise in renewables. This would allow the Skills Matrix to reflect the broad nature of the renewables sector.
Establish a coordinated monitoring and	The HAPS project will include funding to properly monitor and evaluate the project.

evaluation programme	Through ongoing monitoring and evaluation, the project will provide the evidence for using a variety of renewable technologies and to demonstrate the viability of adopting the homes as power stations approach at scale, moving away from one off demonstrators in both new build and retrofit programmes. The monitoring and evaluation will focus on three key areas: ▪ Energy efficiency (to provide evidence of costs and benefits of a range of design solutions for a range of tenures and site locations) ▪ Health and wellbeing (in partnership with Public Health Wales) ▪ Social science (in partnership with academia to consider how people interact with the technologies across a wide demographic)
Develop a flexible design approach	The aim of the regional HAPS project is to coordinate the approach to delivering smart, low carbon, energy efficient homes by encouraging the use of a range of renewable technologies incorporated with a design approach appropriate to local circumstances e.g. site location, tenure etc. It is not a 'one size fits all' technology solution, it is a flexible and adaptable design strategy offering a range of technology and design solutions based on a number of factors including site location and tenure. The design and technology solutions will be tested and refined during the five-year project, allowing the design solutions to adapt to technological advances. The flexible design strategy will be developed to allow the HAPS approach to be adapted to a variety of challenges and constraints associated with sites and tenure across the region. A few examples of this flexible, design approach are detailed below: Hafod site, Neath – this is an example of solar alignment where the topography of the site has determined the use of technologies

	Another example is of homes which have been installed with east and west facing photovoltaic panels (PVs) to capture the morning and evening sun The HAPs regional project shares the same ambition as the Active Building Centre focus i.e. to accelerate market adoption of energy positive homes to provide cleaner, cheaper and more resilient energy supply. **Design approach** The fundamental design principles underpinning the HAPS approach are: • Whole house approach • Fabric first approach • Passive design where feasible • Electrical and heat generation • Storage (electrical and heat) • Optimisation of energy performance **Overview of current technologies** The following technologies will be incorporated into the flexible design solutions: • SIPs panels (Structural Insulated Panels) • Solar PVs • Transpired Solar Collector (TSC) cladding • Integrated photovoltaic roof covering • Air source heat pumps • Ground water source heat pumps • Mechanical Ventilation with Heat Recovery (MVHR) • High levels of Insulation • PV / Solar water heating • Voltage optimisation • Battery storage (allowing the solar energy to be collected, stored and released to meet the energy demands of the dwellings and their occupants)

The figure below presents a simple overview diagram of the project's different components and how each fits together.

Figure 2.3: Overview of the HAPS Project