MARKETS

SUSTAINABILITY

BUSINESS PLANNING

CHANGE MANAGEMENT

RESOURCE PLANNING

INNOVATION

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Planning Energy
for a Sustainable World

Ofgem LCNF Tier 2 Evaluations

PATHS - Powering Agriculture, Transport and Heat Sustainability

SSEPD

Final Report

Submitted to: Ofgem

Date: 2 November 2012

CONTENTS

Explanatory Note

This report, including the "traffic light" indicators that reflect issues of concern identified during the evaluation process, (other than Section 9) is based on:-

- the original full submissions that were received from the DNOs in August 2012;
- subsequent question responses through the formal written question process; and
- discussions held at meetings between the DNOs and the Expert Panel and/or PPA Energy.

In October 2012 the DNOs were given an opportunity to submit revised proposals. The traffic light indicators and the metrics shown in Sections 1 to 8 have not been changed to reflect any changes made by the DNOs in these revised submissions.

Section 9 of this report contains an addendum, which summarises changes made between the original and revised submissions, and the impact this has on the evaluation of the project against the criteria. Any significant changes to figures/metrics are noted in this addendum.

Project Summary

Full name:	Powering Agriculture, Transport and Heat Sustainability	Short name:	PATHS
		Total cost:	£24.336 million
DNO group:	SSEPD	LCNF funding request:	£15.588 million

The Problem(s): The project is attempting to address a number of problems:-

- the additional costs of connection resulting from renewable generation being required to connect at higher voltage levels (such as 132kV) rather than at lower distribution voltages such as 33 or 11 kV
- the loss of opportunities to use distributed generation close to where electricity is generated
- how to bring sustainable low carbon benefits to sectors such as transport, heat and agriculture
- the challenge of providing an evaluation of hydrogen production as an alternative energy storage and constraint management tool.

The Method(s):

- Identify, test and address the technical, commercial and operational issues associated with the electrolysis and production of hydrogen, including the interaction with renewable generation
- Develop and test commercial arrangements and technical solutions required for distribution network operators to use an energy vector (hydrogen produced by electrolysis)
- Develop and test robust economic arrangements for the integration of energy networks by the transfer of energy between multiple systems
- Provide full life cycle cost models to inform further implementation of similar solutions on other networks under RIIO ED1
- Create a blueprint for integrating multiple energy networks,

applicable anywhere in the UK

The Trial(s):

Method 1

Improve access for renewable generation on the distribution network by active local energy management and energy transfer

Method 2

Un-constrain highly congested electricity networks by the transfer of energy to the gas networks

Method 3

Un-constrain highly congested electricity networks by the transfer of energy to the transport sector

The Solution(s): PATHS aims to develop the following solutions to the problem of accommodating peak outputs from intermittent renewable generation sources:-

- Introduce active local energy management and energy transfer which improves access for renewable generation to the distribution network
- Transfer energy from the highly constrained electricity networks to less constrained networks
- Partially decarbonised the heat and transport sectors by the provision of a sustainable fuel
- Develop models to optimise the value of integrated energy systems

In Phase 1 of the project, the first electrolyser will be installed and will connect to a small wind farm. A simple Active Network Management (ANM) system will be developed to connect the wind farm to the grid, and to the electrolyser. The renewably generated hydrogen produced by this electrolyser will be used to power a fleet of 10 fuel cell buses.

In Phase 2 of the project, electrolysers coupled with an ANM system will facilitate the connection to the distribution network of a wind farm which is being developed offshore from Aberdeen.

An initial study suggests that a 3MW electrolyser is the optimum size to help manage the output of the windfarm and provide hydrogen for the likely demands from the gas grid and merchant hydrogen. The 1MW system from Phase 1 will be moved to the site of the Phase 2 electrolyser, with 2MW of electrolysis being added in Phase 2. Phase 2 will trial the injection of hydrogen into the local gas distribution system.

Key strengths and weaknesses against the criteria

Strengths:

- This project is an opportunity to trial an innovative approach to the delivery of projects aimed at deploying new technology on and around distribution networks focused on encouraging low carbon solutions.

- It is intending to use an active network management system and hydrogen electrolysers to facilitate a lower cost and more timely connection for a large off-shore wind farm. The suitability of the electrolysers to operate as controllable load will be examined. It is intended to use the hydrogen produced to power a fleet of buses and to inject it into the gas pipeline distribution system. The commercial and technical issues surrounding this will be examined. The project has the potential to take forward the use of hydrogen in the energy sector but there are a number of concerns which are examined (in "Weaknesses" below).

- The partners come from many of the most important stakeholders – including Aberdeen City and Aberdeenshire Councils; Aberdeen Renewable Energy Group; Scotia Gas Networks; Stagecoach; First Group; Wood Group; BOC Linde; Element Energy; Robert Gordon University. External funders include the Scottish Government; Scottish Enterprise; the Technology Strategy Board.

- A diverse range of funding has been identified – some of it covering items that are only indirectly related to the distribution system.

Weaknesses:

- There is considerable doubt about the rate of growth of the hydrogen market.

- It is not clear the hydrogen produced from electrolysis will necessarily be an economic production method.

- Some activities being undertaken in the project have a limited, or

even tenuous connection to the distribution system. Whilst it is recognised that there is a significant external funding amounting to more than £6 million or about a quarter of the costs, the LCNF is still being asked to provide more than £15 million. There is some concern that some of the activities funded from this may not be sufficiently closely aligned to the distribution business and if the project were successful large benefits would flow to other parties.

- Not all of the funding for the project is in place. In particular some of that related to the injection of hydrogen into the gas pipeline network is still subject to application and approval. There would be a risk to the project if that funding were not obtained.

- It is not yet clear whether any significant issues may arise (for example from the HSE) from the injection of hydrogen into the gas pipeline network. This again represents a risk to the project although SSE assert that there are no major issues associated with injecting small concentrations of hydrogen into natural gas streams.

- The largest component of cost to be funded by the LCNF is the labour costs of SSE which amount to £5.331 million (including the DNO compulsory contribution). The number of person days allocated to various tasks and the associated charge rate per person day is high and perhaps excessive. SSE have indicated their intention to resubmit a revised proposal and that this will reduce the level of the funding request by £1.5 - £2 million as a result of reduced labour costs and contingencies.

- The project proposal does not seem to fully recognise the project management challenge of dealing with such a complex multi-party innovative project. It mentions the application of SSE's "Large Capital Project Governance" Framework, which is helpful but does not test whether a project of the type of PATHS raises new issues that need the standard approach to be refined. However SSE believes that their framework is adaptable to a wide range of projects although this has not really been demonstrated. In view of the range and diversity of the partners in this project a strong, appropriate and responsive project management approach will be required.

1 Summary of Assessment against Evaluation Criteria

Criteria	Overall Assessment	
(a) Low carbon and benefits		The project claims that very large carbon and financial benefits would result from the wide scale application of the PATHS approach, although it is recognised and explained that on some occasions PATHS is an enabler and it would not be appropriate to claim all of the apparent benefits. Inevitably in view of the uncertainties surrounding this topic there are many assumptions that need to be made and there is a very large range of potential outcomes that could occur. Whilst the benefits indicated in the proposal document are positive this may not always be the case. SSE have indicated their intention to include in their resubmission further information and clarification on the robustness of the financial benefits of the project. Some of the significant uncertainties should be reviewed. For example these concern the rate of growth in the number of hydrogen fuelled vehicles and, even if the suggested growth rates are achieved, will the hydrogen used to power such vehicles be sourced from electrolysers powered by renewable generation? This is questionable and is likely to be dependent on the costs of alternative methods of hydrogen generation. During the meeting between the PATHS project team and Ofgem's consultants on 4th September it was stated that it was expected that the cost of hydrogen produced by electrolysis in 2020 would be one and a half to twice the cost of that produced by conventional means which raises further questions about the scale of the carbon benefits suggested from the PATHS approach. However SSE have contended that they have utilised independent forecasts of the rate of growth of hydrogen fuelled vehicles, hydrogen demand and the use of renewable energy to produce a significant

		proportion of the required hydrogen which, they suggest, in respect of the latter will be needed to hit emission reduction targets. Nevertheless considerable uncertainty remains.
(b) Value for money		Some very large benefits are claimed for the distribution system (although as mentioned previously these are subject to some significant risks) but it is recognised that substantial benefits also accrue to gas networks, transport systems and agricultural energy systems (and related areas) from this project, although this is not quantified. The project claims that for those learning outcomes that do not directly relate to the distribution business, funding is not being sought from the LCNF. Elements of the learning from the project have the potential to relate to the distribution system including distribution network utilisation, the total cost of providing connections, and the total time for provision of connections although there are other aspects of the learning where the link is far more indirect, or even tenuous. Overall there is a sense that the costs to be funded by the LCNF are high and there may be opportunities for more cost effective approaches to be used and that this may be an area for further scrutiny. Examples of this include (although this is not intended to be a comprehensive list) the quantity of labour and the daily charge out rate and certain elements of the contractor costs. For example, the total estimated SSE labour (in person-days) that it is claimed is needed to successfully deliver the PATHS project seems excessive, as does the cost per day (including overheads). This suggests that there may be a risk that SSE may well be recovering costs in excess of those directly applicable to the project and that the overhead charge-out rate may be disproportionate. SSE have indicated their intention to resubmit a revised proposal and that this will reduce the level of the funding request

		by £1.5 - £2 million as a result of reduced labour costs and contingencies. The large charge rate and the very high level of resources raises serious questions about the value for money provided by the project although SSE have argued that the level of costs is appropriate in view of the project management approach required and comparable with those used in other projects such as Thames Valley Vision and Nines which they claim have been previously subject to a high degree of scrutiny from Ofgem.
(c) Generates knowledge		The project has the potential to generate considerable knowledge relating to the interconnection of gas and electricity networks and the utilisation of electrolysers to balance electricity demand and generation. This is potentially widely applicable in DNO regions where there are large quantities of intermittent DG and where there is availability of gas network connections. The learning outcomes should, if successful: • Provide a clearer understanding of the applicability and costs of alternatives to traditional network reinforcement; and • allow decisions to be made on broader terms, considering other energy systems. It should also be recognised that learning outcomes more relevant to other parts of the value chain may result from the project.
(d) Partners and Funding		This project has a large and diverse group of partners which is likely to be appropriate in view of the wide breadth of activity that it is anticipated will be undertaken. Around a quarter of the costs of the project are to be met by others. This amounts to in excess

		of £6 million. It also needs to be recognised that other funding has been obtained that whilst necessary for the project to be undertaken falls outside the costs that have been reported. In particular this covers funding for 10 hydrogen buses for the city of Aberdeen and to deliver the initial hydrogen production and storage elements of the project. This amounts to almost £20 million of external funding and meets the full cost of the provision of the buses and associated hydrogen station. Some of this funding is also covering the costs of developing the 1MW electrolyser. In addition funding is not being sought from the LCNF for the gas injection parts of the project. It should be noted that whilst some possible sources of such funding have been identified this has not yet been confirmed and thus represents a risk to the project.
(f) Relevance and timing		The timing for this project appears to be linked to the need to connect a large wind trial project (a wind-farm is being developed offshore from Aberdeen by a consortium led by Vattenfall), support from other funders (such as the European Union and the Technology Strategy Board), and parallel projects on gas injection. Whilst much of the learning would be relevant for the distribution network the PATHS solution is critically dependent on the use of an electrolyser to produce hydrogen and to operate as managed demand which, in turn, is dependent on the increased use of hydrogen as an energy vector and on the emergence of the approach suggested here as an economic method of production. It is debatable whether this is going to occur in the relatively near future and as outlined in the proposal. The question that arises is whether hydrogen supply for vehicles represents a "current" obstacle or is it a much longer time frame?

(g) Methodology		There are some concerns about whether the PATHS solution is one that would really be attractive to developers. This is a complex and wide ranging project which involves integrating many aspects. Whilst this does not make the project infeasible it does mean that there are significant risks that will need to be addressed. SSE suggests a number of steps that have already been put in place to mitigate this. Whilst most of the important risks appear to have been identified some of these may be difficult for the project team to manage. There is little reference to or explanation of the active network management (ANM) component of the project. The commercial arrangements in this project are key. SSE state that a focus of the project is in "developing and understanding the commercial models and markets which will support the effective transfer of energy...". However there is little in the methodology about this. In general, neither the methodology nor the project plan appears to be very detailed. The project proposal does not seem to fully recognise the project management challenge of dealing with such a complex multi-party innovative project. It mentions the application of SSE's "Large Capital Project Governance" Framework, which is helpful but does not test whether a project of the type of PATHS raises new issues that need the standard approach to be refined. However SSE believes that their framework is adaptable to a wide range of projects although this has not really been demonstrated. In view of the range and diversity of the partners in this project a strong, appropriate and responsive project management approach will be required.

Successful Delivery Reward Criteria		There are a large number of SDRCs provided – these are clear and specific and have dates associated with them. However in almost all cases they relate to the publication of guides, other reports, academic papers, presentations at events etc. None of these relate to the operation of the systems. It should be possible to derive some quantified key performance indicators (KPIs) that relate to the actual operation of the systems. SSE indicate that whilst in their view there is an adequate balance between physical delivery and knowledge creation they would be happy to discuss the issue with Ofgem or the Expert Panel.

The "traffic light" system used in the table above gives an indication of PPA Energy's assessment of the information provided by the DNO in support of the project in respect of its detail, alignment with the LCNF evaluation criteria, identification and management of project risks and other aspects for each of the criteria. This is not intended to suggest whether projects should be funded or not but to point out those areas which PPA Energy believes merit particular scrutiny or consideration. Thus:-

	• Seems to be generally in line with the objectives and requirements of the LCN Fund evaluation criteria, • Whilst there are some areas where additional information would be useful, that provided is generally comprehensive and provides no immediate cause for concern.
	• Some indication that the project is in line with the objectives and requirements of the LCN Fund evaluation criteria. However further scrutiny is required to ensure this, • There are some gaps in the information provided, • Further assurance is needed to confirm that the project is viable and that risks are appropriately managed.
	• Significantly more assurance is required that the project is in line with the objectives and requirements of the LCN Fund evaluation criteria, • There are some major gaps in the information provided, • Considerable scrutiny is needed to confirm that that the project is viable and that risks are appropriately managed,

	• Potential major risks to the viability of the project.

In the following evaluations against the criteria, if the project is addressing various problems and/or trialling several methods and solutions, separate analysis of metrics and sub-criteria will be provided, if appropriate, for relevant criteria.

2 Criterion (a) Low Carbon and Benefits

Criterion:	Accelerates the development of the low carbon energy sector and has the potential to deliver net financial benefits to future and/or existing consumers
Overall assessment:	The project claims that very large carbon and financial benefits would result from the wide scale application of the PATHS approach, although it is recognised and explained that on some occasions PATHS is an enabler and it would not be appropriate to claim all of the apparent benefits. Inevitably in view of the uncertainties surrounding this topic there are many assumptions that need to be made and there is a very large range of potential outcomes that could occur. Whilst the benefits indicated in the proposal document are positive this may not always be the case. SSE have indicated their intention to include in their resubmission further information and clarification on the robustness of the financial benefits of the project. Some of the significant uncertainties should be reviewed. For example these concern the rate of growth in the number of hydrogen fuelled vehicles and, even if the suggested growth rates are achieved, will the hydrogen used to power such vehicles be sourced from electrolysers powered by renewable generation. This is questionable and is likely to be dependent on the costs of alternative methods of hydrogen generation. During the meeting between the PATHS project team and Ofgem's consultants on 4th September it was stated that it was expected that the cost of hydrogen produced by electrolysis in 2020 would be one and a half to twice the cost of that produced by conventional means which raises further questions about the scale of the carbon benefits suggested from the PATHS approach. However SSE have contended that they have utilised independent forecasts of the rate of growth of hydrogen fuelled vehicles, hydrogen demand and the use of renewable energy to produce a significant proportion of the required hydrogen which, they suggest, in respect of the latter will be needed to hit emission reduction targets. Nevertheless considerable uncertainty remains.

Metrics (where available):			
Net financial benefit (£)[1]:	£3.624 million	Network capacity released (kW)[2]:	44,000 kW
Base case time to release capacity (months)[3]:	36 months	Method time to release capacity (months)[4]:	24 months
Potential for replication[5]:	Claims potential to replicate the solution in up to 23% of all onshore wind connections ("67% by MW capacity by 2030"?)		

Sub-criteria	Assessment
Carbon claims (including quantitative, if provided)	It is claimed that the initial phase of PATHS will fuel the replacement of 10 conventional diesel buses with hydrogen fuel cell buses, saving over 800tCO_2/year. Additionally it is asserted that replacing 5% of the methane in the medium pressure gas grid close to the electrolyser site with hydrogen provides savings of 125tCO_2/year. If, under PATHS, the connection of the offshore wind farm

[1] The financial benefit of each method (at the trial scale) compared to the most efficient existing method; **Net financial benefit = Base case costs** (the lowest cost of delivering the Solution (on the scale outlined as part of the project) which has been proven on the GB Distribution Systems) **– Method costs** (the costs of replicating the method at the trial scale once it has been proven successful)

[2] The network capacity released by each method (the additional headroom released on the distribution system following implementation of the Method)

[3] The time it would take in months to deliver the capacity shown in "Network capacity released" under the Base Case

[4] The time it would take in months to deliver the capacity shown in "Network capacity released" using the replicated Method

[5] The estimated number of sites or % of the GB Distribution System where the method could be rolled out, up to 2040

	could be made one year earlier than with a traditional connection this would facilitate one year's worth of early wind farm generation, equivalent to carbon savings of approximately 74,000tCO_2. On a wider basis it is suggested that the PATHS solution could avoid up to 40,000 heat pump installations if it were replicated across GB by 2030. The carbon savings associated with this could amount to 57,000t CO_2/annum from 2020. In regard to transport it is argued that if vehicle numbers reach the anticipated levels and it is assumed that up to fifty per cent of these vehicles could be fuelled from wind powered electrolysers then this could see carbon savings rise to 420,000tCO_2/annum in 2030 - part of this could be attributed to the PATHS solution. There are some significant uncertainties in respect of the above analysis. For example these concern the rate of growth in the number of hydrogen fuelled vehicles and, even if the suggested growth rates are achieved, will the hydrogen used to power such vehicles be sourced from electrolysers powered by renewable generation? This is questionable and is likely to be dependent on the costs of alternative methods of hydrogen generation. During the meeting between the PATHS project team and Ofgem's consultants on 4th September it was stated that it was expected that the cost of hydrogen produced by electrolysis in 2020 would be one and a half to twice the cost of that produced by conventional means which raises further questions about the scale of the carbon benefits suggested from the PATHS approach. However SSE have contended that they have utilised independent forecasts of the rate of growth of hydrogen fuelled vehicles, hydrogen demand and the use of renewable energy to produce a significant proportion of the required hydrogen which, they suggest, in respect of the latter will be needed to hit emission reduction targets. Nevertheless considerable uncertainty remains.
Quantitative analysis	See "Carbon claims" above
Robustness of financial benefits	Limited financial information about the actual differences in cost between the conventional 132 kV connection of the generation and that proposed for the trial are provided. Most of the information relates to financial details which it is asserted would result from the wide scale application of the PATHS

	approach. This is summarised and discussed below <u>Method 1</u> The project proposal document states that if PATHS were replicated across GB, the net direct benefit of deploying Method 1 (improving access for renewable generation on the distribution network by active local energy management and energy transfer) by 2020 could be about £304 million - with a sensitivity range of benefits from £176 million to £498 million. The wide range indicates the level of uncertainty in the underlying assumptions – and, in reality, it may well be that the range is somewhat higher than this if the doubts about the rate of growth of the hydrogen fuelled vehicle market and the economics of hydrogen produced by electrolysis are fully taken into account. It is also not wholly clear what the additional benefits of the hydrogen electrolyser are - on top of those provided by the active network management scheme alone. <u>Method 2</u> It is argued that PATHS, by introducing a renewable fuel into the gas system leading to the partial decarbonisation of gas, can contribute to the offsetting of the number of heat-pump systems installed. This, it is asserted, can access the value of avoiding heat pump systems in terms of avoided network reinforcement, of £558 million by 2050. As previously it is likely that there is a wide sensitivity range to this figure <u>Method 3</u> The project has considered the potential benefits of having increased numbers of hydrogen fuelled vehicles as against electric vehicles (EVs) to support Method 3. It is argued that an increase in the number of electrolysers could be advantageous in helping to drive such an increase in hydrogen-fuelled vehicles and could be a second order benefit to PATHS-type solutions being deployed more widely. It is claimed that the analysis (in terms of the reduction in network investment required to allow the connection of an appropriate number of EVs) is shown to be £187 million by 2030 and upwards of £2.3 billion by 2050. Clearly this is extremely

	speculative at this stage. SSE have indicated their intention to include in their resubmission further information and clarification on the robustness of the financial benefits of the project.
Capacity released (and how quickly)	The capacity released has been defined by the project as 44 MW which is defined as the "average wind-farm capacity associated with the method". It is assumed that this is suggesting the application of the method would allow wind-farms to be constructed and connected that otherwise would not be implemented and that the 44MW represents one such case. There does not seem to be an indication of the wider implications in terms of the amount or speed of capacity release.
Replication (applicability of technology, dependence on specific network characteristics)	In order to determine the replication potential for a PATHS-style solution to facilitate the connection of distributed generation, a sample of real cases has been examined by the project. This has identified that the attractiveness varies with wind farm size and headroom capacity in the network and suggests that up to around 23% of the cases were suitable. There is no reason to challenge this conclusion.

3 Criterion (b) Value for Money

Criterion:	Provides value for money to distribution customers
Overall assessment:	Some very large benefits are claimed for the distribution system (although as mentioned previously these are subject to some significant risks) but it is recognised that substantial benefits also accrue to gas networks, transport systems and agricultural energy systems (and related areas) from this project, although this is not quantified. The project claims that for those learning outcomes that do not directly relate to the distribution business, funding is not being sought from the LCNF. Elements of the learning from the project have the potential to relate to the distribution system including distribution network utilisation, the total cost of providing connections, and the total time for provision of connections although there are other aspects of the learning where the link is far more indirect, or even tenuous. Overall there is a sense that the costs to be funded by the LCNF are high and there may be opportunities for more cost effective approaches to be used and that this may be an area for further scrutiny. Examples of this include (although this is not intended to be a comprehensive list) the quantity of labour and the daily charge out rate and certain elements of the contractor costs. For example, the total estimated SSE labour (in person-days) that it is claimed is needed to successfully deliver the PATHS project seems excessive, as does the cost per day (including overheads). This suggests that there may be a risk that SSE may well be recovering costs in excess of those directly applicable to the project and that the overhead charge-out rate may be disproportionate. SSE have indicated their intention to resubmit a revised proposal and that this will reduce the level of the funding request by £1.5 - £2 million as a result of reduced labour costs and contingencies The large charge rate and the very high level of resources raises serious questions about the value for money provided by the project although SSE have argued that the level of costs is appropriate in view of the project management approach required and comparable with those used in other projects such

	as Thames Valley Vision and Nines which they claim have been previously subject to a high degree of scrutiny from Ofgem.
Metrics (where available):	
Size of benefits to distribution system[6]	See "Proportion of benefits attributable to distribution system (as opposed to elsewhere on supply chain)" below

Sub-criteria	**Assessment**
Proportion of benefits attributable to distribution system (as opposed to elsewhere on supply chain)	Some very large benefits are claimed for the distribution system (see previous criteria). However it is also asserted that as a result of the integrated nature of the project that substantial benefits accrue to gas networks, transport systems and agricultural energy system (and related areas) from this project. These are not quantified so it is not possible, at this stage to assess their size or proportionalities. However it would be reasonable to assume that they would amount to at least a similar size to those of the distribution system or indeed substantially larger. This assessment is made more complex by the external funding to the project both directly and indirectly – for example, the funding of the hydrogen powered buses is outside the scope of this project. The project claims that for those learning outcomes that do not directly relate to the distribution business, funding is not being sought from the LCFN. This is difficult to assess in practice as both the operation of the project and the learning outcomes are integrated together meaning that it is wholly clear which is related to which.
How learning relates to the distribution system	Elements of the learning from the project have the potential to relate to the distribution system including distribution network utilisation, the total cost of providing connections, and the total time for provision of connections. In addition knowledge of the impact of the use of hydrogen as an energy vector will help understanding which, from various technologies will be

[6] Size of benefits attributable or applicable to the Distribution System versus elsewhere

	relevant to solving specific grid constraints. However it should be noted that there are other aspects of the learning where the link to the distribution network is far more indirect, or even tenuous. Examples of this include a feasibility study of methanisation, certain activities related to the agricultural sector and others.
Approach to ensuring best value for money in delivering projects	The project claims that "PATHS aims to provide the maximum possible learning for the lowest possible cost. Accordingly, where it is feasible to conduct a competitive tender process, we will do so." However, in reality, the use of such processes seems to apply to a relatively small proportion of the overall costs. This raises questions about the extent to which real best value has been obtained.
Identify and review major cost items, examine justification for relevant costs, assess choice of discount rates	The largest component of cost to be funded by the LCNF is the labour costs of SSE which amount to £5.331 million (including the DNO compulsory contribution). The number of person days allocated to various tasks and the associated charge rate per person day are high and perhaps excessive. For example significant time is attributed to programme management, governance, document control, contract placements, project board, legal and regulatory requirements. Similar comments can be made about other categories of work. In response to questions SSE provided more details about the methods and assumptions used to calculate these costs. These suggest that both the labour and overhead rates are high and that there may be a risk that SSE may well be recovering costs in excess of those directly applicable to the project. Total estimated SSE labour (in person-days) that it is claimed is needed to successfully deliver the PATHS project seems excessive, as does the cost per day (including overheads). This again suggests that the overhead charge-out rate may be disproportionate. SSE have indicated their intention to resubmit a revised proposal and that this will reduce the level of the funding request by £1.5 - £2 million as a result of reduced labour costs and contingencies. The large charge rate and the very high level of resources raises serious questions about the value for money provided by the project although SSE have argued that the level of costs is appropriate in view of the project management approach required and comparable with those used in other projects such as Thames Valley Vision and Nines which they claim have been previously subject to a high degree of scrutiny from

	Ofgem Other major costs are those of contractors (some £4.309 million, on the same basis as above) and payments to users and contingency (about £4.601 million). For the former around half of the costs result from the supply and installation of power and communication cabling to connect the electrolysers to the network and civil costs in respect of the costs of design and construction works for the phase 2 electrolysers site. The project does not seem to have revealed the contingency rate that it has used and hence it is difficult to assess payments to users and contingency categories. Overall there is a sense that the costs to be funded by the LCNF are quite high and there may be opportunities for more cost effective approaches to be used and that this may be an area for further scrutiny.

4 Criterion (c) Generates Knowledge

Criterion:	Generates knowledge that can be shared amongst all DNOs
Overall assessment:	The project has the potential to generate considerable knowledge relating to the interconnection of gas and electricity networks and the utilisation of electrolysers to balance electricity demand and generation. This is potentially widely applicable in DNO regions where there are large quantities of intermittent DG and where there is availability of gas network connections. The learning outcomes should, if successful: • Provide a clearer understanding of the applicability and costs of alternatives to traditional network reinforcement; and • allow decisions to be made on broader terms, considering other energy systems. It should also be recognised that learning outcomes more relevant to other parts of the value chain may result from the project.
Metrics (where available):	
Conforming to default IPR arrangements:	Yes

Sub-criteria	**Assessment**
Potential for new/incremental learning to be generated by the project	There is likely to be considerable incremental learning generated by the project in relation to the interface between electricity generation from intermittent sources and hydrogen production, storage and injection into the gas network. The degree of such incremental learning associated with the control of the electricity network itself is likely to be more limited - in that this is focused on the use of active network management techniques to control the balance of power generation and electrolyser demand. The performance of the electrolyser is

	heavily influenced by the hydrogen load to which it is connected, and its impact on the distribution network will be dependent on a wide range of factors beyond the operation of the distribution network itself. SSE has identified four learning outcomes: 1. What are the network benefits of actively managed loads? 2. What services can the dispatch of electrolyser systems provide to electricity networks? 3. What is the potential for energy transfer to supply transport, heat and agricultural energy demand? 4. How can the integration of multiple energy networks be replicated across GB? These are categorised as "broad learning" applicable to many types of energy storage (1, 2 and 4) and PATHS specific learning.
Applicability of learning to other DNOs	The Solutions include: • improving access for generation connections (by active local energy management and energy transfer); • addressing constraints for peak export from generation; • de-carbonising heat and transport. The first two are very relevant to DNOs, less so the latter (in terms of hydrogen fuelled transport). SSE believes the PATHS methods are transferable to all DNOs. Generally the learning outcomes (above) sound like they would be applicable to all DNOs, although some learning outcomes are more relevant to other parties (e.g. the extent to which hydrogen can be injected into the gas network).
Proposed IP management and any deviations from	The project will conform with the default IP principles. SSE does not anticipate that the project will develop foreground IPR

default IP principles	that will fall outside the default IPR arrangements. It is not clear how IP related to the parallel gas injection project will be handled
Credibility of proposed methodology for capturing learning from the trial and plans for disseminating	PATHS will create an "Energy Network Integration Toolkit", to include guidelines on dealing with issues such as safety, technical, contractual, etc. Stakeholder groups, and their specific interests in PATHS, have been identified. Dissemination media are discussed, which include conferences, a project website, videos, publications, using "appropriate social media". There is a reflection on an interactive learning event run by SSEPD (on Orkney Smart Grid) as an effective way of disseminating learning. Generators are key stakeholders in this project, but there are only two taking part in the trials – one relatively small and one quite large wind farms). This is not a large sample size to canvas views from and SSE recognise this within their proposal. There are some references to interactive events, but the emphasis is on disseminating knowledge; there is not much reference to gathering views / experiences of stakeholders. Key roles include a "Communications Manager" and a "Knowledge Manager".

5 Criterion (d) Partners and Funding

Criterion:	Involvement of other partners and external funding
Overall assessment:	This project has a large and diverse group of partners which is likely to be appropriate in view of the wide breadth of activity that it is anticipated will be undertaken. Around a quarter of the costs of the project are to be met by others. This amounts to in excess of £6 million. It also needs to be recognised that other funding has been obtained that whilst necessary for the project to be undertaken falls outside the costs that have been reported. In particular this covers funding for 10 hydrogen buses for the city of Aberdeen and to deliver the initial hydrogen production and storage elements of the project. This amounts to almost £20 million of external funding and meets the full cost of the provision of the buses and associated hydrogen station. Some of this funding is also covering the costs of developing the 1MW electrolyser. In addition funding is not being sought from the LCNF for the gas injection parts of the project. It should be noted that whilst some possible sources of such funding have been identified this has not yet been confirmed and thus represents a risk to the project.

Metrics (where available):

Total cost of project (£):	£24.336 million	LCNF support (£):	£15.588 million
Costs met by DNO (£):	£1.792 million	Costs met by others (£):	£6.415 million
LCNF support (% of total cost):	64.1%	Costs met by DNO (% of total cost):	7.4%
Costs met by others (% of total cost):	26.4%	Number of consortium members:	9 Project partners 3 External funders

<table>
<tr><th>Sub-criteria</th><th>Assessment</th></tr>
<tr><td>Appropriateness of collaborators (including experience, expertise and robustness of commitments)</td><td>This project has a large and diverse group of partners which is likely to be appropriate in view of the wide breadth of activity that it is anticipated will be undertaken. The partners in this project include Aberdeen City and Aberdeenshire Councils, Aberdeen Renewable Energy Group, Scotia Gas Networks, Stagecoach, First Group, Wood Group, BOC Linde, Element Energy, Robert Gordon University.

External funders include the Scottish Government, Scottish Enterprise and the Technology Strategy Board.</td></tr>
<tr><td>Level of external funding (presented on a comparable basis with other Projects)</td><td>Around a quarter of the costs of the project are to be met by others. This amounts to in excess of £6 million from across the energy system from generation to end use. In particular this comes from:-

<table><tr><td>BOC Linde</td><td>the hydrogen generation, delivery and fuel retail equipment</td></tr><tr><td>Wood Group</td><td>overall project management for the H_2 system</td></tr><tr><td>Element Energy and Aberdeen Renewable Energy Group (AREG)</td><td>reporting and disseminating project results focussing on the transport and supply chain development elements of the project</td></tr></table>
It also needs to be recognised that other funding has been obtained that whilst necessary for the project to be undertaken falls outside the costs that have been reported. In particular the project proposal states that one of the key roles of PATHS is to help provide low carbon transport fuel which is to be utilised by hydrogen buses. Aberdeen City Council has secured a combination of funding from two EU Projects, First Group, Stagecoach and BOC Linde to provide up to 10 hydrogen buses for the City. This has been supported by funding from Scottish Government, Aberdeen City Council, Scottish Enterprise, Scotia Gas Networks and the Technology Strategy Board to deliver the initial hydrogen production and storage elements of the project. This amounts to almost £20 million of external funding and meets the full cost of the provision of the buses and associated hydrogen</td></tr>
</table>

	station. Some of this funding is also covering the costs of developing the 1MW electrolyser. In addition funding is not being sought from the LCNF for the gas injection parts of the project. It should be noted that whilst some possible sources of such funding have been identified this has not yet been confirmed and thus represents a risk to the project. SSE have indicated that in their resubmission they will include a statement that the agreement with Scotia Gas Networks, a partner in the project, will be revised to include a commitment from them to fully investigate and pursue all potential funding sources and to introduce a break point in the project such that a commitment to the physical delivery of the second phase will be made only when external funding for the mains gas injection element has been secured.
Effectiveness of process for seeking and identifying new project partners and ideas	The initiation of this project seems to have been somewhat opportunistic and has resulted from the coming together of the ambitions of Aberdeen City Council to reduce the city's carbon footprint and its reliance on the oil and gas sector, the need of the wind-farm to access a cost effective connection to the electricity grid and SSE's own low carbon activities. It is not clear that there has been a comprehensive attempt or process to access new project partners and ideas. SSE argues that the project has been developed directly in response to the demands of stakeholders.

6 Criterion (f) Relevance and Timing

Criterion:	Relevance and timing		
Overall assessment:	The timing for this project appears to be linked to the need to connect a large wind trial project (a wind-farm is being developed offshore from Aberdeen by a consortium led by Vattenfall), support from other funders (such as the European Union and the Technology Strategy Board), and parallel projects on gas injection. Whilst much of the learning would be relevant for the distribution network the PATHS solution is critically dependent on the use of an electrolyser to produce hydrogen and to operate as managed demand which, in turn, is dependent on the increased use of hydrogen as an energy vector and on the emergence of the approach suggested here as an economic method of production. It is debatable whether this is going to occur in the relatively near future and as outlined in the proposal. The question that arises is whether hydrogen supply for vehicles represents a "current" obstacle or is it a much longer time frame?		
Metrics (where available):			
Start date:	December 2012	Elapsed time of project:	5 years

Sub-criteria	**Assessment**
Significance in the project in: (a) overcoming current obstacles to a low carbon future	The current problem is that networks are designed to cater for the peak demand that is expected to occur on them. As a result of the standards associated with this, renewable generation may need to be connected at quite high voltages (including transmission voltages). This can lead to higher costs and significant lead times (and issues with the community, planning permission, disruption of build etc.) compared to connection at lower distribution voltages. The outcome of this is delay, expensive connections for low carbon generation, and, in the worst case, projects that may not proceed. The project proposal document states that in summary, PATHS

	aims to demonstrate how integrated network solutions can: • Facilitate the timely and efficient connection of large scale renewable generation on the electricity distribution network • Reduce the cost of connection to the electricity network in the UK • Reduce reinforcement costs for the electricity distribution network operator • Provide a cost effective means of dealing with constraints on the electricity distribution network • Reduce downstream network losses by capturing and utilising energy locally, where and when it is needed • Bring sustainable low carbon benefits to other sectors such as transport, heat and agriculture • Provide an evaluation of hydrogen production as an alternative energy storage and constraint management tool Whilst many of these do represent obstacles to a low carbon future the PATHS solution is critically dependent on the use of an electrolyser to produce hydrogen and to operate as managed demand which, in turn, is dependent on the increased use of hydrogen as an energy vector and on the emergence of the approach suggested here as an economic method of production. It is debatable whether this is going to occur in the relatively near future and as outlined in the proposal. The question that arises is whether hydrogen supply for vehicles represents a "current" obstacle or is it a much longer time frame? In terms of the scale of the problem SSE claim that PATHS is likely to be applicable to one in five new generation developments with a capacity of greater than 15MW up to 2020. Note that the need for a PATHS solution depends on the generation development size and location.
(b) trialling new technologies that could have a major	Whilst there continues to be controversy about the rate at which renewable generation will be constructed and connected to electricity network systems, this project is based on the

low carbon impact	assumption that this continue to significantly grow. The project proposal argues that the electrolyser technology is "mature and proven", with a number of trials linked to wind farms. However it is the first time an electrolyser will be used to facilitate the connection of a large wind farm to the distribution network (rather than to the transmission one) and also the first where it is being used as a managed demand to facilitate the increased utilisation factor of the wind farm (whilst reducing the investment in the electricity network). Whilst not wholly directly funded by this project the injection of hydrogen into gas networks represents an important aspect of it with potentially important benefits. There are important safety issues related to this and it is not clear that all of these have yet been addressed or that all the relevant stakeholders have indicated that they are likely to consent to this. However SSE assert that there are no major issues associated with injecting small concentrations of hydrogen into natural gas streams. As mentioned above the potential benefits outlined here are dependent on the economic use of the resulting hydrogen.
(c) demonstrating new system approaches that could have widespread application	The project offers the opportunity to test as an integrated system individual components that have so far been utilised or tested in isolation. The control of the electrolyser via an ANM system is cited by SSE as a significant novel element that could have widespread application, and this is a reasonable assertion for those situations in which an electrolyser is a viable demand to connect to the network.
Applicability of the project to future business plans, regardless of uptake of Low Carbon Technologies (LCTs)	PATHS appears to be driven by the increased application of Low Carbon Technologies – specifically renewable generation and the emergence of hydrogen as an energy vector. In fact it is claimed that this will displace the need for other LCTs - reducing the need for heat pumps (decarbonise heat by injecting hydrogen into the gas network) and electric vehicles (use hydrogen fuel cell vehicles instead). Since it is so critically dependent on the use of the hydrogen electrolyser as a managed demand it is not clear that there would be significant benefit in the absence of a large uptake of LCTs.

7 Criterion (g) Methodology

Criterion:	Demonstration of a robust methodology and that the project is ready to implement
Overall assessment:	There are some concerns about whether the PATHS solution is one that would really be attractive to developers. This is a complex and wide ranging project which involves integrating many aspects. Whilst this does not make the project infeasible it does mean that there are significant risks that will need to be addressed. SSE suggests a number of steps that have already been put in place to mitigate this. Whilst most of the important risks appear to have been identified some of these may be difficult for the project team to manage. There is little reference to or explanation of the active network management (ANM) component of the project. The commercial arrangements in this project are key. SSE state that a focus of the project is in "developing and understanding the commercial models and markets which will support the effective transfer of energy...". However there is little in the methodology about this. In general, neither the methodology nor the project plan appears to be very detailed. The project proposal does not seem to fully recognise the project management challenge of dealing with such a complex multi-party innovative project. It mentions the application of SSE's "Large Capital Project Governance" Framework, which is helpful but does not test whether a project of the type of PATHS raises new issues that need the standard approach to be refined. However SSE believes that their framework is adaptable to a wide range of projects although this has not really been demonstrated. In view of the range and diversity of the partners in this project a strong, appropriate and responsive project management approach will be required.

Metrics (where available):			
Requested level of protection against cost over runs (default 5%) (%):	5%	Requested level of protection against direct benefits (default 50%) (%):	0%
Level of resources committed to the project (person-months):			

Sub-criteria	Assessment
Feasibility of project proposal	There are some concerns about whether the PATHS solution is one that would really be attractive to developers. Whilst there may be benefits in reducing the costs of connection this approach raises a range of other questions. For example what residual constraints would remain, are there increased risks from being a party to the hydrogen value chain as well as to electricity, what are the economics of hydrogen and how might the bankability of a renewable energy project be affected? This is a complex and wide ranging project which involves integrating many aspects. Whilst this does not make the project infeasible it does mean that there are significant risks that will need to be addressed. SSE suggests a number of steps that have already been put in place to mitigate this. These include • the indication that the project has support at "every level" • "Key roles" have already been filled • a number of existing projects have been listed and it is stated that these have providing learning which has been used in the preparation of this one.
All risks, including customer impact, exceeding forecast costs and missing	Whilst most of the important risks appear to have been identified some of these may be difficult for the project team to manage. For example should the generation developer withdraw from

delivery date	the project or select a conventional higher voltage connection suitable mitigating actions are difficult to identify. Similarly should the electrolyser not perform as expected, this could result in network constraints, and there is a risk that the available control actions might not address these adequately. SSE seek to provide reassurance regarding the project by suggesting that electrolysers could be commercially viable by 2020 and have provided some further evidence of this in response to questioning. However this appears dependent on a number of assumptions which, at this stage, remain questionable. As previously mentioned the funding regarding for the injection of hydrogen into gas networks is not yet fully in place and is to be sought from other sources. There is a risk that such funding may not be achieved. SSE argues that further re-assurance can be gained from the fact that this project would be managed under its "Large Capital Project Governance" Framework, which is a project management tool, with "gates" at decision points, including stage gate reviews.
Whether items within project budget provide value for money	See Criterion (b) and in particular Sub-Criterion "Identify and review major cost items..."
Project methodology (including depth and robustness of project management plan)	The project has been divided into two phases. Phase 1: Active Network Management (ANM) and 1 MW electrolyser for a "small" wind farm. Hydrogen used for buses. Phase 2: ANM and 3 MW electrolyser for bigger wind farm (70 MW). Hydrogen used for gas network. It is claimed that this de-risks the project - the end of phase 1 will allow a break point to make a decision about phase 2. There is little reference to or explanation of the active network management (ANM) component of the project. The commercial arrangements in this project are key – for example, who purchases the hydrogen, will the price be

	comparable to ROCs, and who is responsible for selling the hydrogen? SSE state that a focus of the project is in "developing and understanding the commercial models and markets which will support the effective transfer of energy...". However there is little in the methodology about this. How will they develop models? Are there any initial ideas? Is this a solution that developers would want? In general, neither the methodology nor the project plan appears to be very detailed. The project proposal does not seem to fully recognise the project management challenge of dealing with such a complex multi-party innovative project. It mentions the application of SSE's "Large Capital Project Governance" Framework, which is helpful but does not test whether a project of the type of PATHS raises new issues that need the standard approach to be refined. However SSE believes that their framework is adaptable to a wide range of projects although this has not really been demonstrated. In view of the range and diversity of the partners in this project a strong appropriate and responsive project management approach will be required.
Appropriateness of Successful Delivery Award Criteria (SDRC)	See Section 8 below

8 Successful Delivery Reward Criteria

Criterion:	Appropriateness of the SDRC definitions and timing and adequacy of links to key project milestones.
Overall assessment:	There are a large number of SDRCs provided – these are clear and specific and have dates associated with them. However in almost all cases they relate to the publication of guides, other reports, academic papers, presentations at events etc. None of these relate to the operation of the systems. It should be possible to derive some quantified key performance indicators (KPIs) that relate to the actual operation of the systems. SSE indicate that whilst in their view there is an adequate balance between physical delivery and knowledge creation they would be happy to discuss the issue with Ofgem or the Expert Panel.
Detailed assessment:	There are a large number of SDRC's provided – these are clear and specific and have dates associated with them. However in almost all cases they relate to the publication of guides, other reports, academic papers, presentations at events etc. None of these relate to the operation of the systems. It should be possible to derive some quantified key performance indicators (KPIs) that relate to the actual operation of the systems. For example there could be KPIs on • achieving a specified amount of time that the wind-farm is not constrained off as a result of the (a) active network management system and (b) the electrolysers; • defining the amount of hydrogen to be produced and the amount to be used (a) to power the buses (b) to be injected into the gas pipeline system. SSE indicate that whilst in their view there is an adequate balance between physical delivery and knowledge creation they would be happy to discuss the issue with Ofgem.

9 Addendum: Changes made in resubmission

9.1 Summary of Changes

SSE submitted a revised project proposal in mid-October 2012 following meetings and discussions with the Expert Panel and PPA Energy, and after receiving and responding to written questions.

SSE has made a number of changes to their proposal in the resubmission. Some of these resulted from requests from the Expert Panel during one of the bilateral meetings. The most significant changes made by SSE are listed below.

9.1.1 Project benefits

The project summary and some of the project description section have been rewritten to emphasise the claimed direct benefits of the project to distribution customers. However this did not represent additional information as it repeated material that had effectively been embedded in the original submission.

9.1.2 LCNF Tier 2 Funding Request

The amount of LCNF Tier 2 funding requested for the project has reduced from £15.587 million to £13.998 million. It was stated that this had resulted from the identification of synergies from managing multiple LCNF projects simultaneously.

9.1.3 Images

Two of the images used in the business case section have been changed. SSE state that this is intended to clarify firstly, the direct benefits of the project to distribution customers and, secondly, which parties are responsible for the ownership and operation of the electrolysers and the nature of payments made for the service that they provide to the network. However it is not clear how these diagrams contribute to the understanding of the nature of such payments.

9.1.4 Business Case

The project business case section has been amended and, in parts, rewritten from some additional information and arguments provided. This is, primarily, a clarification of the information previously provided.

A number of changes have been made to the "Evaluation Criteria" section. In each case the intention has been to clarify the direct benefits of the project to distribution customers although, as previously, this seems to be based on the previously provided information.

It has been clarified that SSE estimate that the cost to customers of the Base Case is £8.5 million.

9.2 Impact on LCNF Funding Request

In this section the impact of the additional material provided during the project review process and the changes made by SSE to the proposal are considered for each criterion.

9.2.1 Criterion (a) Low Carbon and Benefits

In their re-submission SSE has sought to emphasise the potential benefits of the project to the distribution customer. However there remain considerable concerns about the robustness of these benefits. These stem from the scale and timing of the demand for hydrogen and the commercial attractiveness of the use of a renewable powered electrolyser as a source for it. In addition, although SSE has presented a range for the level of these potential benefits, it is still not clear that the underlying assumptions of the low case are sufficiently pessimistic to fully represent the lowest level of such benefits.

This is exacerbated by concerns about the claimed indirect savings from PATHS resulting from the decarbonisation of gas and savings from transport. These both continue to seem highly speculative and tenuous.

9.2.2 Criterion (b) Value for Money

In assessing the initial PATHS submission considerable concerns were expressed regarding value for money. Some of these related to the nature of the potential benefits from the project and these have been discussed under the previous criteria. However others related to the costs of the project and the level of LCNF Tier 2 funding being sought. These seemed high.

In their resubmission SSE has reduced the level of funding requested from £15.587 million to £13.998 million (or some £1.589 million or 10.2%) as a result, it is claimed, from managing multiple LCNF projects simultaneously. The estimated total project cost has reduced from £24.336 million to £22.42 million (a reduction of some £1.916 million or 7.9%) with the biggest falls being in labour costs (over £0.8 million or 15.5%), contractor costs (£0.45 million or 5.9%), and payments to users and contingency (again £0.45 million or 5.9%).

Most of the labour cost reduction results from reducing the number of days allocated to certain tasks, e.g. programme management reduction – nearly £0.4 million. The proposed level of resource still seems to be excessive. Despite previous references to the high level of the person day rates these have, in fact, slightly increased in the resubmission. The concerns previously expressed about the excessive level of the person day rates have not been alleviated.

Much of the reduction in contractor costs seems to result from lower costs to supply and install power and communications cabling to connect the electrolysers to the network, civil engineering costs for the Phase 1 electrolyser site, and costs of design and construction works for the Phase 2 electrolyser site. SSE has stated that as the locations of the sites for Phase 1 and Phase 2 of the project have been refined, it has been possible to make reductions in the budget for civil works for both of these sites, as well as the cabling. These are all contracting costs, and whilst the length of the contract has not been reduced, the total cost of the contract has been reduced. When the project commences, a detailed procurement exercise will be undertaken to formally secure these services.

9.2.3 Criterion (c) Generates Knowledge

It is accepted that, if successful, the project has the potential to generate considerable knowledge relating to the interconnection of gas and electricity networks and the utilisation of electrolysers to balance electricity demand and generation.

9.2.4 Criterion (d) Partners and Funding

The project has a large and diverse group of partners which, should the project be funded, would be likely to be appropriate in view of the wide breadth of activity that it is anticipated will be undertaken.

9.2.5 Criterion (f) Relevance and Timing

Comments made above in response to SSE's original PATHS submission raised concerns about the timing of this work and the relevance of it to distribution customers. The latter has already been covered above in this section. As far as timing is concerned SSE has not include any additional arguments in its resubmission regarding the need to undertake this project now.

9.2.6 Criterion (g) Methodology

No additional information is included in the SSE resubmission regarding methodology.

9.2.7 Successful Delivery Reward Criteria

SSE have not amended the SDRCs that they included in their original submission despite the comments made above. However they have indicated that they are willing to discuss possible amendments with Ofgem.