Consulting with Experts

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Simon Feraday.
Central Modelling Team
Department of Energy and Climate Change
Area 6B,
3 Whitehall Place,
London SW1A 2AW

06 February 2015

Dear Mr. Feraday,

Tender: "Identification of superfluous Energy Demand Model variables" (Tender Reference Number: TRN949/12/2014)

UCL Consultants Ltd (UCLC) is pleased to provide its proposal in response to the Department of Energy and Climate Change's Invitation to Tender for Identification of superfluous Energy Demand Model variables (Tender Reference Number: TRN949/12/2014) on behalf of University College London (UCL), The Bartlett School for Environment, Energy and Resources.

UCLC has been established as a wholly owned subsidiary company of UCL to administer the contractual and financial arrangements for consultancy services undertaken by UCL staff. UCLC is thus authorised by UCL to enter into contracts with external clients for the provision of consultancy services on behalf of UCL staff undertaking consultancy work. Should the proposal be successful, the contracting party would be UCL Consultants Ltd acting on behalf of the UCL, The Bartlett School for Environment, Energy and Resources.

All technical correspondence should be addressed to Mr Baltazar Solano Rodriguez (b.solano@ucl.ac.uk), The Bartlett School for Environment, Energy and Resources, Central House, 14 Upper Woburn Place, London, WC1H 0NN.

Pricing

Please note that all our prices are quoted exclusive of VAT which will be charged at the prevailing rate.

[redacted]

Please do not hesitate to contact my colleague Cameron Logan (c.logan@uclconsultants.com) if you have any queries or require any further details concerning UCL Consultants Ltd.

Yours sincerely,

Patricia Greenan
Director
UCL Consultants Ltd.

Response to Invitation to Tender:

Identification of superfluous Energy Demand Model variables

Department for Energy and Climate Change

TRN 949/12/2014
Issued: 20th January, 2015

UCL ENERGY INSTITUTE

Tendering company	UCL Consultants Ltd The Network Building 97 Tottenham Court Road, London W1T 4TP Company Number 03332258 VAT registration number GB 524 37111 68 UCL Consultants Ltd is a wholly-owned subsidiary of University College London

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EXECUTIVE SUMMARY

UCL is pleased to submit this proposal to identify superfluous variables in DECC's Energy Demand Model, in response to the invitation to tender issued by the Department of Energy and Climate Change on 20th January, 2015 (Ref. No. TRN949/12/2014).

DECC, like many government departments, has to address new complexities and pressures in evaluating their policies. A combination of limited resource capacity and increased accountability make increasing transparency and efficiency an institutional challenge. For DECC and other government departments with strong modelling elements in their activities, the added challenge of understanding the impacts of key variables in their models are non-trivial.

The Energy Demand Model (EDM) is at the heart of DECC's Energy and Emissions Projection (EEP) model suite. It can be used in isolation but for key forecasting work it is used in conjunction with other EEP models, particularly the Dynamic Dispatch Model (DDM) which forecasts wholesale electricity prices. The EDM is key to assessments of the UK's likely progress against legally established carbon budgets. DECC are seeking to simplify the EDM as part of an overall redevelopment programme to streamline and better integrate the EEP model suite. This will improve the overall efficiency of the modelling process by removing unnecessary model variables and will also aid understanding of the key variables in the model. This is the challenge DECC faces and this is the challenge UCL is uniquely placed to help address.

Our approach is based on the extensive experience of our team in the topics relevant to this tender. Will Usher is a doctoral researcher at UCL specialised in methodologies to evaluate uncertainty in energy systems modelling; Dr Steven Siller is a software developer and Statistics expert and Baltazar Solano specialises in Operational Research techniques and energy systems modelling. We can leverage this knowledge to make certain that the project is delivered on time and to budget. We are confident we can both meet and exceed DECC's expectations for this work and we hope that you will find our proposal both attractive and informative.

We are pleased to offer EDM's sensitivity analysis for a fixed price of £25,500 excluding VAT. The following proposal sets out our appreciation of your requirements, the proposed methodology to deliver the project, and details of our team and relevant track record. Should you have any questions about the content please do not hesitate to contact us.

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1 Introduction

DECC, like many government departments, has to address new complexities and pressures in evaluating their policies. A combination of limited resource capacity and increased accountability make increasing transparency and efficiency an institutional challenge. For DECC and other government departments with strong modelling elements in their activities, the added challenge of understanding the impacts of key variables in their models are non-trivial.

The Energy Demand Model (EDM) is at the heart of DECC's Energy and Emissions Projection (EEP) model suite. It can be used in isolation but for key forecasting work it is used in conjunction with other EEP models, particularly the Dynamic Dispatch Model (DDM) which forecasts wholesale electricity prices. The EDM is key to assessments of the UK's likely progress against legally established carbon budgets. The EDM is an MS Excel workbook containing around 4000 inter-related variables relating to energy use, price and emissions. Indicative analysis suggests that a number of these variables are not used to calculate any of the model's outputs and are therefore redundant. DECC would like to remove any such internal variables from the EDM and would also consider removing any variables which have only marginal impact on the model outputs. DECC would like the contractor to identify these two sets of variables. This will enable DECC to reduce the internal complexity of the model as well as any effort currently put into obtaining unnecessary input data.

2 UCL's Appreciation

DECC are seeking to simplify the EDM as part of an overall redevelopment programme to streamline and better integrate the EEP model suite. This will improve the overall efficiency of the modelling process by removing unnecessary model variables and will also aid understanding of the key variables in the model.

Sensitivity analyses study how the uncertainties in the model inputs affect the model's response, describing the relative importance of each input in determining this variability. For each one of this input variables, DECC wish to be informed whether it is:

- Redundant (having no effect on any regular output)
- Insignificant (making negligible difference to any regular output over the next 30 years)
- Significant

This study will evaluate the level of significance of all external and internal variables in order to identify those that may be redundant or insignificant.

3 An Overview of our approach

3.1 Methodology overview

Outline

We propose a three-stage process to classify the significance of internal variable and inputs on model outputs:

1) Identify internal variables and inputs that are not linked by formula chains to the model output. Such cell formula dependency trees can be automatically constructed by recursively applying the Excel VBA Range precedence property.
2) We will then apply, in parallel, a global sensitivity analysis technique and a deterministic technique to identify variable effects:
   a) Elementary effects approach (global sensitivity analysis);
   b) Linearized tangent space analysis (local deterministic technique).
3) The results of (2a) and (2b) will be cross correlated and any discrepancies will be investigated using ad hoc methods e.g. focussed simulation/Monte Carlo tests or direct analysis of equations by hand and/or using graphical technique detailed below.

Before beginning our sensitivity analysis, we will establish a regression testing framework to ensure that our adjustments to the model do not materially effect the result outputs. We will amend the model through removal of equations and variables deemed to be uninfluential by our sensitivity analysis, and demonstrate the effect of the change through comparison of models before-and-after our amendments.

Details

(1) The VBA Excel API provides a number of Range properties which, when applied recursively, allow the construction of the cell formula dependency trees. One of the team (Dr. Siller) has previously used this technique to programmatically detect data and formula unused/disconnected from output in complex Excel spreadsheets.

The VBA tools for this will be provided with sufficient internal and external documentation so that the software may be managed and extended easily by another developer, and will be written with industry best practice in mind. Variable notation will be Hungarian with scope prefixes unless another in-house style is preferred by DECC.

(2a) **Global Sensitivity Analysis**: Global sensitivity analysis techniques quantify the degree to which model inputs influence model results. The associated metrics are global, in that they are robust over all inputs for all combinations of possible values. Given the large number of input parameters to the EDM, we will first use a screening approach (based on elementary effects or fractional factorial design of experiments) to determine the subset of the parameters that are most influential. We will then use a more detailed variance-based sensitivity analysis technique, such as the method of Sobol[2], on these parameters, while fixing the others to their mean value to determine a Total Sensitivity Index (TSI). TSI is a global metric, giving the sum of main and interaction effects for each parameter. Further analysis can be performed to quantify 2nd and

higher order interactions between input parameters. Graphing of these sensitivity metrics provides an intuitive and visual means to assess which parameters are most influential. Interactions will be visualised through heat-map style plots.

It is likely that only a small subset of the input parameters account for the majority of variance in outputs. Therefore the initial screening analysis will identify inputs that are essentially redundant and can be fixed to their mean value (factor fixing) or replaced with a constant. The second phase, using the more powerful and computationally demanding technique, will allow us to rank the remaining input parameters in order of influence (factor prioritisation).

The main advantage of the global sensitivity analysis techniques we propose over alternatives is the allowance for models that are non-linear and formulations that are non-additive. Techniques based upon linear regression or other statistical approaches such as principal components analysis, make unrealistic assumptions regarding the relationships between variables, e.g. that the output values are a linear function of the input values. These assumptions can strongly bias the results of a sensitivity analysis, particularly for models which contain polynomial or quadratic components.

These techniques are also computationally efficient, with the elementary effects method requiring N(k+1) runs of the model, where k is the number of model input parameters. Typically, the screening analysis will use N=10, while a more comprehensive analysis, but of fewer input parameters, would use a higher value for N e.g. 500.

This methodology will involve the following development tasks:

• Module to generate input samples, based upon fractional factorial design-of-experiments, Method of Morris[1], or Sobol[2]. We could use the open source Python library SALib[3] exposed to Excel as an add-in using the commercial software PyXLL to do this or, if DECC preferred, a bespoke VBA library.

• VBA module to load input samples into input parameter sheets of the EDM, run the model, and export results for each result metric.

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[1] Campolongo, Francesca, Jessica Cariboni, and A. Saltelli. "An Effective Screening Design for Sensitivity Analysis of Large Models." *Environmental Modelling & Software* 22, no. 10 (October 2007): 1509–1518. doi:10.1016/j.envsoft.2006.10.004.

[2] Saltelli, A., Paola Annoni, Ivano Azzini, Francesca Campolongo, Marco Ratto, and Stefano Tarantola. "Variance Based Sensitivity Analysis of Model Output. Design and Estimator for the Total Sensitivity Index." *Computer Physics Communications* 181, no. 2 (February 2010): 259–270. doi:10.1016/j.cpc.2009.09.018.

[3] Herman, Jon, Chris Mutel, Will Usher, Matt Woodruff, Fernando Rios, Dan Hyams, and Xantares. "SALib: Sensitivity Analysis Library in Python (Numpy). Contains Sobol, Morris, and FAST Methods.," 2015. http://jdherman.github.io/SALib/.

• Module to analyse results of EDM sensitivity analysis and produce graphics. Again, SALib provides an expedient method of doing this or this could be implemented in VBA.

According to the call for tender, "the variance of the input data is unknown." However, the tender Q&A mentions that DECC "…will be able to supply the winning bidder with 'baseline' and 'reference' scenario input data giving an indication of the potential variance of the input data between high and low demand scenarios." The techniques we suggest, such as elementary effects (Method of Morris[1]), require only lower and upper bounds on input data, rather than full probability distributions.

At this point, we will also analyse the model running time to determine the balance between cruder screening approaches, and more detailed, but computationally demanding variance based sensitivity analysis approaches. With hundreds of input variables, a 3-minute model runtime would require 10*(201) = 2001 model runs which requires ~4 days of computational time.

(2b) **Tangent Space Analysis**: Tangent space analysis identifies the effects of internal variables and inputs deterministically by investigating the strength and form of their individual marginal effects on output variables.

We propose to develop in VBA a marginal effect analysis tool (MEAT) to perform the tangent space analysis. MEAT will detect the effect of small (in percentage terms) perturbations of inputs and internal variables on the output variables by automatically working through the EDM altering a single variable at a time and letting the model update the relevant output cells, before resetting and moving onto the next input cell. These will be identified automatically by detecting cell status in the used ranges if appropriate, or by user selected ranges if not. As well as input cells, if required by the structure of the model, this approach can also be applied to linearly perturbing the values of formulae in the worksheets provided cells with formulae can be unprotected.

The results of this analysis will be reported in a detailed log workbook together with a snap shot of the EDM workbook with redundant, insignificant and significant input/variables' cells colour coded with further details included in cell comments where appropriate.

MEAT will also attempt to automatically detect variables that have non-linear effects by looking at a range of deviations and calculating whether or not the effects of these deviations are linear in perturbation size. This information will also be graphically recorded (e.g. by fill effects) in the snap shot of the EDM workbook.

The sizes of marginal effects, however, are not sufficient to determine which variables and data provide significant effects; the magnitude of the potential effect requires some knowledge of the likely variation in the variable/data. Although the actual variance in the data is unknown, having 'baseline' and 'reference' scenario input data enough is enough to obtain pseudo relative "coefficients of variation" which in conjunction with the linearized analysis proposed gives a rough cut ranking of the variables/input data's importance.

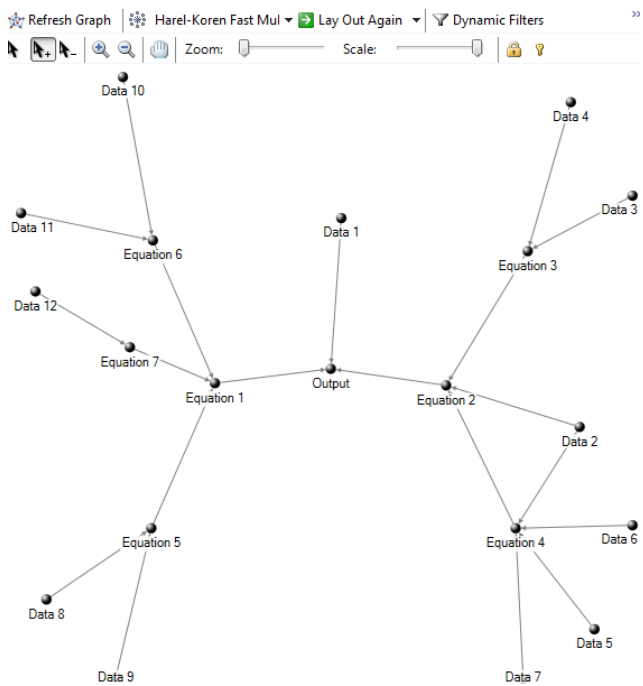
After the first order analysis detailed above, further analysis will be performed on second order interactions between inputs/variables that interact with variables that have a high coefficient of variation and strong independent effects. In particular, effort will be made to identify variables/inputs which, although they have only weak effect, have significant effect due to their interaction with variables/inputs with high coefficient of variation.

The precise approach taken will depend on the results previous stages and the number of variables with high coefficient of variation and large independent effect. An extension of MEAT to automatically identify significant second order effects is one possibility. Alternatively, if the number of high coefficient of variation variables is deemed to be relatively low or the formula dependency analysis indicates that sets of inputs affecting natural groupings of outputs are relatively disjoint, then Monte Carlo methods together with the application of multivariate polynomial regression/general linear models to the results could be used to identify significant variables/inputs.

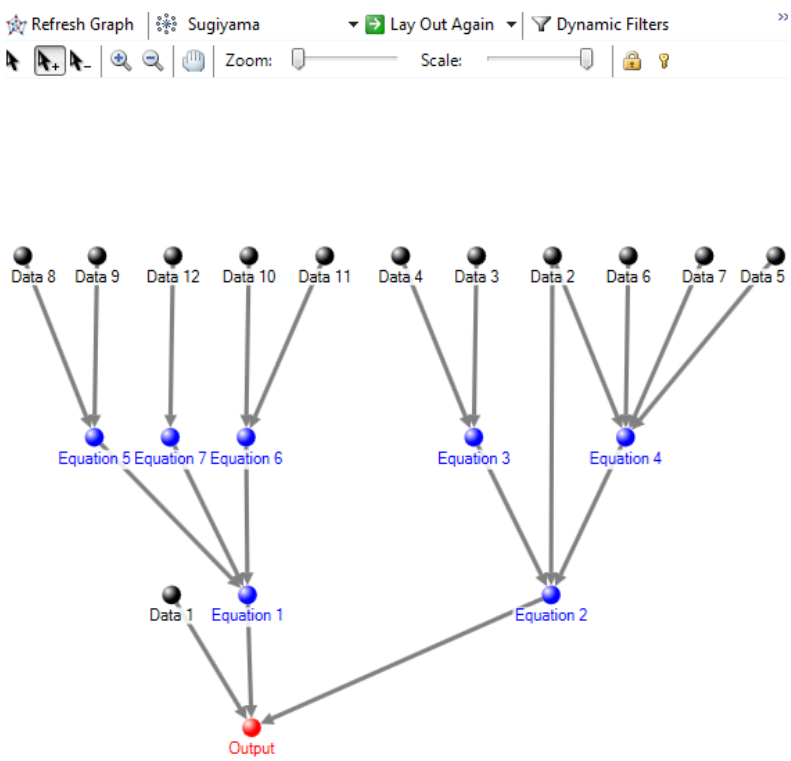
The MEAT tool will be documented to a level where DECC staff can easily repeat analyses performed, and will be general enough that it can be applied to workbook models other than the EDM.

(3) The results of the global probabilistic and the local deterministic analysis will be synthesized and any discrepancies investigated further using ad hoc methods. In particular we will be utilizing NodeXL, a free, open-source network graphing template for Excel (http://nodexl.codeplex.com/) in conjunction with an extension of the VBA formula precedence software discussed in (1) to generate formula network graphs to aid this stage of analysis. These graphs will be part of the deliverable, as well as the software used to generate them.

Please find examples of the graphing outputs below for the same set of equations.



Harel-Koren format



Sugiyama layout format

UCL is using standard commercial software tools, or tools that are open source and are accepted by the community, with good assurance of their future availability. Thus we do not believe that DECC will require any software licences – except for PyXLL if we agree on its use.

3.2 Timing and Deliverables

UCL propose to deliver the project on March 31st, 2015. This delivery date is subject to the timely receipt of all necessary models, signature of contract and an assumed start date of February 16th, 2015.

Communication: The first point of contact for DECC will be the Project Manager – Baltazar Solano. As per the schedule above, UCL proposes a comprehensive communication plan with DECC, including a kick-off meeting and presentation of final results at a location convenient to DECC. This will be complemented by regular updates of project activities provided to DECC via a written note and weekly teleconference with the DECC Project Manager which will allow feedback to be input by DECC throughout the project. These activities are detailed below:

- Kick-off Meeting. In order to proceed swiftly, UCL proposes a meeting with DECC members at the beginning of the project (preferably during the first week, but this is

subject to finding a mutually convenient date for all parties). This meeting will refine the scope of the project and ensure DECC's views are adequately incorporated.

- Email/Telephone updates of an agreed minimum frequency. To provide continuous engagement with DECC, UCL proposes a weekly update email or telephone call with a nominated DECC representative.
- One interim face-to-face project meetings (optional). During the course of the project, it may be useful to hold face-to-face project meetings with representatives from DECC to discuss progress and interim findings.
- Presentation of Final Results in person. To ensure a thorough understanding of the methodology and findings of the project among DECC representatives, we will present our results at the end of the project.

Deliverables: UCL proposes to provide DECC with the following deliverables by 31st March 2015:

- Full results of the analysis on all internal variables
- Documentation of the analytical methodology used; and
- Graphical 'logic maps' showing the relationships between all model variables and indicating what the effects would be on removing variables or groups of closely related variables deemed redundant or insignificant

Our team will deliver this project according to the timetable proposed by DECC.

Action	**Timing – completed by**
Inception steering group meeting for project (Baltazar Solano, Will Usher)	16th February 2015
Draft report with logic maps (responsible: Will Usher)	16th March 2015
Final report delivered to DECC (responsible: Baltazar Solano)	31st March 2015
Presentation of final results to DECC (Baltazar Solano, Will Usher)	31st March 2015

4 UCL's Team

Models can represent powerful tools, but their very complexity can lead to unexpected behaviour, and it can be difficult to separate the noise from the signal in model outputs. The team:

- Possess a strong foundation in the philosophy of model-based science and the theoretical constraints imposed by different modelling strategies

- Are experts in carrying out model structure and parameter tests for the validation of outputs
- Are experienced in accounting for uncertainty and advising on policy decisions in the face of uncertainty posed by the outputs of techno-economic and whole-energy system models
- Can uniquely exploit this underpinning experience to make a grounded estimate of the resources and skills required to deliver this project on-time and to the required standard, and have then the resources available so to do..

UCL proposes to provide an exceptional group of technical experts specialised in uncertainty and sensitivity analyses in energy systems modelling, Operational Research and energy systems modelling, supported by an external IT and Statistics specialist. CVs are presented in Annexe A.

Baltazar Solano (Project Manager) is a Research Associate in Energy Systems at the UCL Energy Institute. He specialises in the application and development of models to provide quantitative insights into energy and climate change issues. He is the lead developer of ETM-UCL, a European energy systems model that provides a basis for estimating EU energy dynamics to 2050. ETM-UCL is currently used in European Commission backed research to study the implications of different long-term techno-economic scenarios. Baltazar's current research interests revolve around energy-environment-economic modelling, low carbon transition pathways, carbon risk, risk dynamics and broader Operational Research applications in the energy industry.

Will Usher (Uncertainty in Energy Systems) is a graduate researcher specialising in energy modelling and uncertainty at University College London. His research interests in energy modelling include the application of computational methods to analyse and understand the influence of uncertainty upon model outputs. He has contributed modelling and analysis to key supporting research projects for Government and the private sector. Working primarily with the UK MARKAL model, he developed a stochastic variant, which he used with Neil Strachan in a project supporting the Committee on Climate Change 4th Budget Report in 2011. He also helped develop the UCL version of TIAM (the TIMES Integrated Assessment Model) and presented the results of both projects at several international conferences.

Dr Steven Siller (VBA Programming) is a freelance statistical consultant and software developer. He has been programming in VBA since 1997 and has 10 years commercial software development experience. Whilst consulting for Ricardo-AEA (formerly AEA Technology) he developed and maintained VBA software to generate, manage, and quality assure approximately 140 energy policy models for the DEFRA SPM/MTP project and consulted on experimental design for an EST/DECC experiment on chrono-proportional thermostats. He has also worked for the oil and telecommunications industries, has been a research fellow in zoology at Oxford University, and was lead designer and developer of the server side of a real time distributed financial exchange platform. Currently, when not consulting, he is writing a statistical and numerical library in C#.

5 UCL overview and experience

5.1 About UCL

The UCL Energy Institute delivers world-leading learning, research and policy support on the challenges of climate change and energy security. Our approach blends expertise from across UCL, to make a truly interdisciplinary contribution to the development of a globally sustainable energy system. The UCL Energy Institute is part of The Bartlett School of Energy, Environment and Resources (BSEER), a multi-disciplinary institute that incorporates researchers from mathematics, physics, engineering, economics, policy and social science backgrounds.

5.2 UCL's Team Track Record

5.2.1 Selected Microsoft Excel Modelling Experience

UK MARKAL and UK TIMES (UCL/DECC energy systems models). Development of comparison sheet to display model results.

UK Market Transformation Programme (MTP). Modelling and QA Management for the programme, providing modelling technical support to a large team of product analysts. MTP models are used by DEFRA to provide UK government with product policy insights through projections of energy and emissions savings over time under alternative scenarios.

Distribution of Bioenergy across Transport Modes. Co-development of a large Excel model for the Department for Transport to estimate the cost-effectiveness scenarios for biofuel deployment options across the UK transport sector to 2020 and 2050. This assessment was based on a variety of feedstock combinations and future availability as well as GHG emissions and demand from the automotive, aviation and marine transport sectors.

Fate of Clostridium Botulinum during compost and Anaerobic Digestion production and use. Development of a series of Excel models for DEFRA to support a semi-quantitative risk assessment of Clostridium Botulinum in the context of waste management of organic wastes and the use of composts and anaerobic digestates in agricultural land.

Decommissioning Control. Re-engineering of a spreadsheet model designated as "Significant" by a nuclear industry customer. A "Significant" spreadsheet provides data upon which safety or key process decisions are made which could place a demand on the safety system or cause a radiological event to occur which could lead to a hazard or prosecution. A system was developed to reduce time spent on data entry, ensure data integrity and develop flexible and valuable reports for Decommissioning Strategy support teams and coordinators.

Safkeg Loading Throughput Dose Model . Development of a spreadsheet model for a nuclear industry client to evaluate three Safkeg loading options in order to provide an analysis framework and support the decision making process for the Safkeg loading strategy. This optioneering analysis was undertaken looking at the impact of increasing the throughput capacity in terms of radiation dosage and labour required to comply with given annual dose limits.

5.2.2 Selected Microsoft Visual Basic for Applications Experience

UK Market Transformation Programme (MTP). Development of a VBA based framework to improve the productivity and efficiency of this high value UK Governmental Energy Efficiency Policy programme.

- Legacy Excel models were causing massive delays and budget overruns, jeopardising the continuance of the project. Standardised and automated model creation and alteration thus reducing expenditure and reliance on expensive and sometimes unreliable external contractors by improving turnaround time from several weeks to minutes per model.
- Improved QA, and thus client confidence, by eliminating manual intervention in model structure allowing necessary checks to be automated. This also improved efficiency by removing the necessity for individual checking of each of the **140+** models and reducing the models' memory footprints by 90%.

TIAM-UCL and ETM-UCL (UCL global and European energy systems models). VBA based development of complex base-year templates to automate the generation of regional energy consumption figures.

VantagePoint model. Development of a prototype for decarbonisation scenarios model called VantagePoint based on VBA.

Cost-effective Implementation of Anaerobic Digestion in England and Wales. Co-development of a multi-decision analysis Excel/VBA tool to inform DEFRA of the most attractive locations for Anaerobic Digestion plants based on economic, environmental and social factors. Available at http://warrr.org/1219/1/Implementation_of_AD_in_England_%26_Wales_Balancing_optimal_outputs_with_minimal_environmental_impacts_-_Impact_of_using_purpose_grown_crops.pdf

Field production control. Development of a VBA model for an oil and gas exploration company to identify variations in recorded seismic data in order to observe production trends and prevent project delivery delays under strict contractual conditions in the Gulf of Mexico.

5.2.3 Selected Publications related to Energy and Climate Change

Solano, B., Drummond, P. 2014. Techno-economic scenarios for Reaching Europe's Long-Term Climate Targets. Available at: http://cecilia2050.eu/publications/214

McDowall, W., Solano, B., Usubiaga A., Acosta, J. 2014. Incorporating indirect emissions into a TIMES model.

Hawkes A., Narkeviciute R., Morris S., Solano B. 2011. Pathways to 2050 – Detailed analyses: MARKAL Model Review and Scenarios for DECC's 4th Carbon Budget Evidence Base, London, UK

Available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48073/2270-pathways-to-2050-detailed-analyses.pdf

Pye, Steve, Will Usher, and Neil Strachan. "The Uncertain but Critical Role of Demand Reduction in Meeting Long-Term Energy Decarbonisation Targets." *Energy Policy* 73, no. 2000 (October 2014): 575–586. doi:10.1016/j.enpol.2014.05.025.

Strachan, Neil, and Will Usher. "Failure to Achieve Stringent Carbon Reduction Targets in a Second-Best Policy World." *Climatic Change* 113, no. 2 (October 11, 2011): 121–139. doi:10.1007/s10584-011-0267-6.

Usher, Will, and Neil Strachan. "An Expert Elicitation of Climate, Energy and Economic Uncertainties." *Energy Policy* 61 (July 2013): 811–821. doi:10.1016/j.enpol.2013.06.110.

Usher, Will, and Neil Strachan. "Critical Mid-Term Uncertainties in Long-Term Decarbonisation Pathways." *Energy Policy* 41 (February 2012): 433–444. doi:10.1016/j.enpol.2011.11.004.

Usher, Will, and Neil Strachan. *UK MARKAL Modelling - Examining Decarbonisation Pathways in the 2020s on the Way to Meeting the 2050 Emissions Target*. London, UK, 2010. http://downloads.theccc.org.uk.s3.amazonaws.com/4th Budget/CCC MARKAL Final Report - UCL Nov10.pdf.

5.2.4 Selected Work Experience with HM Government

2050 Global Calculator model. Provision of technology costs for the global calculator project. August 2014-February 2015. Client: DECC.

Energy system modelling and report entitled "*UK MARKAL Modelling - Examining Decarbonisation Pathways in the 2020s on the Way to Meeting the 2050 Emissions Target*". http://downloads.theccc.org.uk.s3.amazonaws.com/4th Budget/CCC MARKAL Final Report - UCL Nov10.pdf. January 2010. Client: Committee on Climate Change

Global energy system modelling using TIAM-UCL: Valuing carbon for long run policy appraisal, November 2011. Client: DECC

*Please see Excel (5.2.1) and VBA (5.2.2) experience for additional projects carried out for HM Government.

6 Management and delivery

6.1 Conceptual Framework

The operational and legal framework for UCL activities will be established by using the existing business model of UCL Consultants. This model has been in place for 10 years, and provides a robust contractual framework by which UCL academic staff, and external subcontractors, can perform work for external clients. UCLC has in place teams to manage finances, invoices etc, and also to negotiate any required contracts or variances.

We have completed the required Compulsory Declarations as requested by DECC in Annexe B.

6.2 Governance and Quality Assurance

6.2.1 Information security

A key aspect of the project management is how we handle data and models passed to us from DECC to carry out sensitivity analysis work arising from this tender. It is vital that information is kept secure from accidental or deliberate loss, destruction or disclosure. At the same time it is also essential that information is accurate, complete and available when it is needed. UCL has put in place appropriate information security policies, procedures and processes. Details can be found at http://www.ucl.ac.uk/privacy/data-protection . The team bidding for this project have extensive experience of engaging with consultancies as part of consortia and able to match the strictest information security requirements demanded by their clients.

UCLC have established a secure IT infrastructure which cannot be accessed through normal academic channels, and will maintain the key project information within this environment

6.2.2 Quality Management and Quality Assurance Plan

UCL is committed to the highest quality standards and to stringent **quality management**, in line with its worldwide reputation of academic excellence. As part of our strive to maintain excellence, UCL adopts and pursues an explicit Quality Management and Enhancement process. UCL sees quality assurance and quality enhancement as two aspects of the same process and believes that both must be embedded not only in our structures and processes but also our institutional culture. More information is available at http://www.ucl.ac.uk/srs/governance-and-committees/qme

The quality management process is as follows:-

Objective	**Implemented through**	**Metric**
Deliver work meeting our clients' requirements	Project management, set-up and scoping meetings; providing draft material whenever possible and several opportunities for feedback.	Analysis of clients' feedback
Communications and feedback loops with clients	Agreeing management and communication processes with	Analysis of clients' feedback

	the client; providing one point of contact for each contract	
Deliver work meeting any legal, contractual and regulatory requirements	Identifying requirements at the start of projects and including them as project objectives; Creation of quality assurance checklist. Involve required specialist UCL or UCLC teams as required.	Meeting project objectives and satisfying quality assurance checklist
Produce well presented, free from error, and appropriately written work	Internal proof-reading; formal sign-off by senior members of staff; external peer-review if arranged with client	Results of annual quality review and client feedback forms
Ensure that members of staff understand and are committed to our quality policy and objectives	Quality approach being reflected in the contracts of our member of staff and in the internal culture (which provides many opportunities for self-development and skills enhancement)	Analysis of clients' feedback. Analysis of UCL staff feedback upon completion of work.

Although we have our own established UCL QA processes for testing models and software, we propose to follow DECC's QA guidelines for models (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/384595/decc_qa_guidance_for_models.pdf). We will QA the work carried out thoroughly and document it in accordance to the guidance. Will Usher will supervise the implementation of the sensitivity analysis methodology and Baltazar Solano will be responsible for the final QA.

6.2.3 Possible conflict of Interest and Unfair Advantage situations

Given the extent of UCL current engagement with a number of governmental departments and other related stakeholders, we have to assume that conflicts of interest, or the perception of a possible conflict of interest, will arise during the course of the project. We propose to deal with these actual or perceived conflicts in three ways:

1) We will maintain the highest level of confidentiality regarding the client information, and the work being done, in order that there should be no "leakage" of information that could give an outside body (and even one of the UCL collaborators in related work) any potential advantage. Such ways of working are well established for all the UCL staff who work for external clients through UCL Consultants
2) We will establish the UCLC Point of Contact as monitor of any potential Conflicts or Unfair Advantages, communicating with the Project Manager, and

a. advising UCL staff working on the project of the potential for perceived conflict,
b. will advise the Project Manager of remedial actions that should be taken, and
c. will monitor compliance.

Such remedial actions could range from a formal communication to DECC of the conflict through to declining to make use of a particular staff member for a Project entirely. This process is consistent with the UCL Policy on Conflict of Interest.

3) We will seek to maintain the highest levels of transparency and openness with DECC. As academics with existing working relationships with several governmental departments, and many other stakeholders both private and public, we are committed not only to the DECC technical expertise process but also to maintaining the long-term relationships we have established as well as our reputation of integrity and independence.

6.2.4 Challenges and risks

We appreciate that these are associated challenges and risks with the project. We assess them, and our proposed mitigation measures as below.

Challenge	Likelihood	Impact	Our mitigation approach
Team challenges			
Unanticipated change in a project team (team members falling ill, leaving, having urgent commitments etc)	Unlikely	Low	Overlapping of competencies within the team will ensure that the team is not overly dependent on any single individual. We can also arrange for any short term replacement to be agreed with. We have a large pool (150+) of experienced researchers within the core Institutes supporting this proposal who can be drawn on if necessary, and a wider pool within UCL can also be called upon as the need arises. We will also ensure that the Project Management team is aware of their commitment timescales as early as possible, so they can be either rescheduled or a mitigation plan developed at an early stage.
Not adhering to Quality Standards	Very unlikely	High	UCL will ensure that the work undertaken is to the quality standards which are expected by a world-leading university. We have an established relationship with several governmental departments which are familiar with the high standards of our work. We will strictly implement our quality assurance procedures.
Relationship challenges			
Lack of communication between experts	Very unlikely	Medium	We have established working relationships, having worked together in projects in the past. The routine communication between Project Manager and experts will avoid communication challenges.

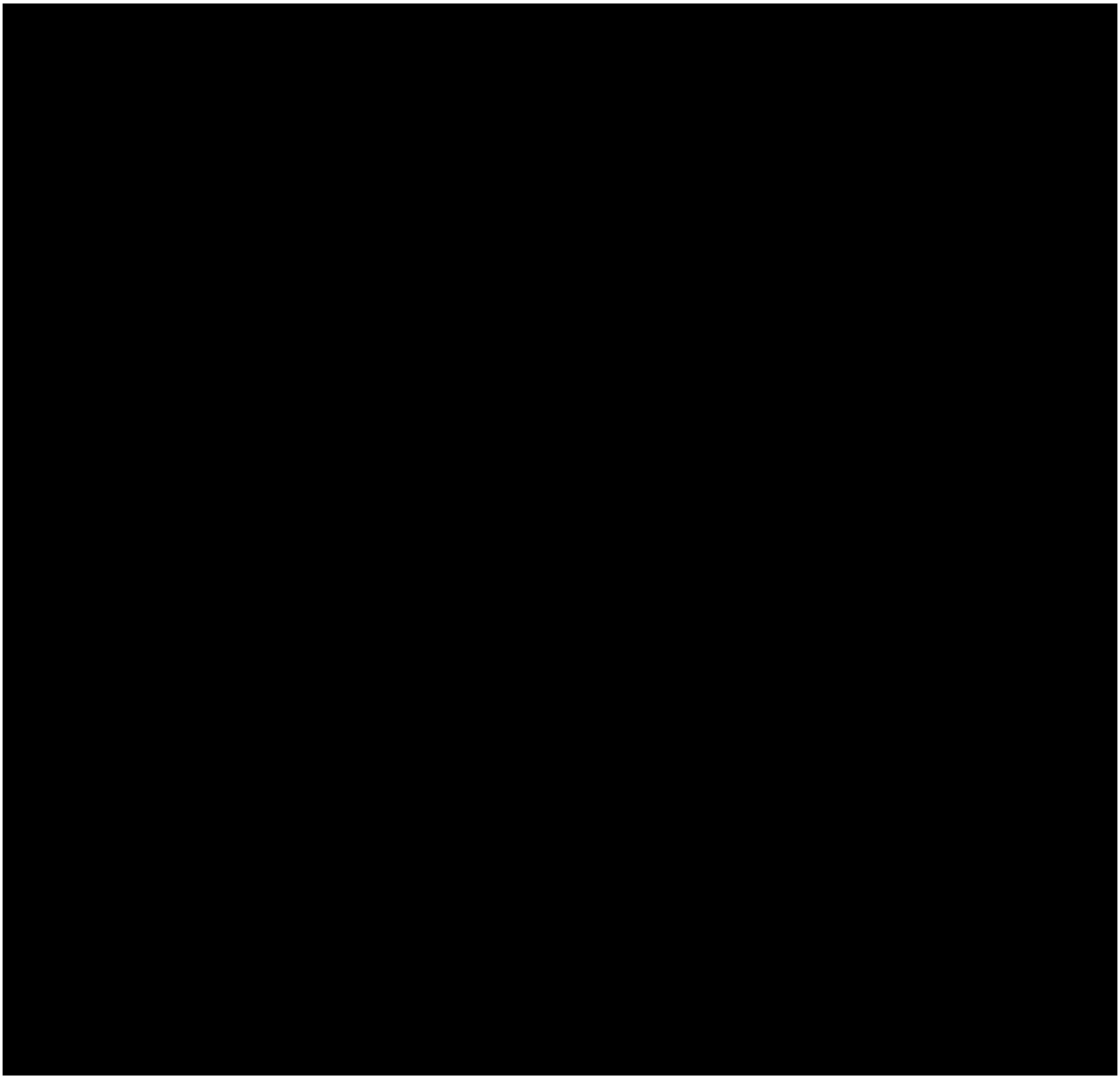
Modelling challenges			
Integration with other models in the EPP suite	Likely	Medium	We will remain in close contact with DECC and ask for advice if there is potential for feedback effects from other EEP models.
Skills and knowledge challenges			
The team is not able to be responsive to the technical demands of the project	Very unlikely	High	The particular set of skills in our team puts UCL in a very good position to implement the service required. However, should we need any additional specialist knowledge, we have the privilege of having access to a large pool of experts at UCL.

7 Financial and Commercial Proposal

7.1 Price

Our fixed price for completing the work detailed in this proposal is £25,500 exc. VAT. Please find the breakdown of our pricing below.

Part A – Staff/project team charges



7.2 Commercial Terms

Validity

This proposal is valid for 60 days from date of submission, 6th February 2015.

Annex A – Team CVs

Baltazar Solano Rodriguez, MSc, MPhil

RESEARCH INTERESTS

Baltazar is a Research Associate in Energy Systems at the UCL Energy Institute. He specialises in the application and development of models to provide quantitative insights into energy and climate change issues. He is the lead developer of ETM-UCL, a European energy systems model that provides a basis for estimating EU energy dynamics to 2050. ETM-UCL is currently used in European Commission backed research to study the implications of different long-term techno-economic scenarios. Baltazar's current research interests revolve around energy-environment-economic modelling, low carbon transition pathways, carbon risk, risk dynamics and broader Operational Research applications in the energy industry.

ACADEMIC, CONSULTANCY AND INDUSTRIAL POSITIONS

June 2012 – Present	**University College London**, UK. Research Associate in Energy Systems Modelling, UCL Energy Institute
May 2010 – May 2012	**AEA Technology** (now Ricardo-AEA), UK. Modelling Consultant, Energy & Climate Change Practice
June 2008 – April 2010	**UK's National Nuclear Laboratory** (NNL), UK. Operational Research Consultant, Strategic and Operational Analysis Team
Oct 2001 – April 2005	**Schlumberger**, various locations (Mexico, US, Chad, Argentina). Senior Engineer, Oil & Gas Exploration

EDUCATION

Sep 2006 – Aug 2007	MSc in Operational Research. University of Edinburgh, UK
Aug 2005 – June 2006	MPhil in Industrial Systems, Manufacture and Management. University of Cambridge, UK
Aug 1996 – June 2001	BSc in Industrial Physics Engineering. Instituto Tecnológico y de Estudios Superiores de Monterrey, México

SELECTION OF REPORTS

- Solano, B., Drummond, P. 2014. Techno-economic scenarios for Reaching Europe's Long-Term Climate Targets. Available at: http://cecilia2050.eu/publications/214
- Hawkes A., Narkeviciute R., Morris S., Solano B. 2011. Pathways to 2050 – Detailed analyses: MARKAL Model Review and Scenarios for DECC's 4th Carbon Budget Evidence Base, London, UK
  Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48073/2270-pathways-to-2050-detailed-analyses.pdf
- Mistry P., Procter C., Narkeviciute R., Webb J., Wilson L., Metcalfe P., Twining S., Solano B. 2011. Implementation of Anaerobic Digestion in England & Wales: Balancing optimal outputs with minimal environmental impacts – Impact of using purpose grown crops. Harwell, UK. Available at
  http://warrr.org/1219/1/Implementation_of_AD_in_England_%26_Wales_Balancing_optimal_outputs_with_minimal_environmental_impacts_-_Impact_of_using_purpose_grown_crops.pdf

CONFERENCE PAPERS

- Solano B., McGlade C. 2014. Long-term European strategies to enhance gas supply security.
  Paper for the IAEE Conference 2014, October 28-31, 2014. Rome, Italy

- Solano B., McGlade C., Pye S. 2014. Cost-effectively meeting EU's 2030 climate and energy targets.
  Paper for the Energy Systems Conference 2014, June 24-25, London, UK

- Solano B., Strachan N., Anandarajah G. 2013. Long-term dynamics of European decarbonisation without nuclear.
  Paper for the IAEE Conference 2013, August 18-21, 2013. Dusseldorf, Germany

WILLIAM USHER

OVERVIEW

William Usher is a graduate researcher specialising in energy modelling and uncertainty at University College London. His research interests in energy modelling include the application of computational methods to analyse and understand the influence of uncertainty upon model outputs. He has contributed modelling and analysis to key supporting research projects for Government and the private sector.

EDUCATION

2012-Present: University College London
PhD, Energy and Modelling
Ongoing

2008-2009: Imperial College London
Master of Science, Environmental Technology
- Pass with Distinction
- Thesis: Frequency Regulation from Electric Vehicles in the UK
- Specialisation: Energy Policy

2007-2008: Open University
Short Courses: Energy for a Sustainable Future; Technology for a Sustainable Future
- Pass with Distinction

2001-2003: Middlesex University, UK
Bachelor of Arts, Recording Arts

EXPERIENCE

2009-2012 : Research Associate in Energy and Modelling, **University College London**, UK
2007-2009 : Software Developer and Energy Consultant, **Carbon Descent**, London UK
2005-2007 : Transmission Operator, **Ascent Media**, London UK
2004-2006 : Technician, Assistant Engineer, **Metropolis Studios**, London UK

SELECTED PROJECTS

- 2010 UK MARKAL Modelling - Examining Decarbonisation Pathways in the 2020s on the Way to Meeting the 2050 Emissions Target (for the Committee on Climate Change 4th Budget Report)
- 2010 Failure To Meet Long-Term UK Carbon Reduction Targets – A Systematic Assessment
- 2010 Investment Uncertainty Under Stringent UK Decarbonisation Targets
- 2009 Policies To Develop A Recharging Infrastructure For Electric Vehicles
- 2009 Pre-Treatment Methods For Cellulosic Ethanol Production
- 2008 Energy Transitions And The Multi-Level Perspective

Awards
- Industrial Case PhD Studentship joint award from EPSRC/EDF Energy -18k per annum + fees for 3.5 years
- Andrew Holmes Memorial Award, British Institute of Energy Economics 2012, Best Student Poster - 1st Prize worth £500
- Winter School 2014: Stochastic Programming with applications in Energy, Finance and Insurance - Full fees and board

Peer Reviewed Journal Publications

- Pye, S., Usher, W. & Strachan, N., 2014. The uncertain but critical role of demand reduction in meeting long-term energy decarbonisation targets. Energy Policy, 73(2000), pp.575–586.
- Usher, W. & Strachan, N., 2013. An expert elicitation of climate, energy and economic uncertainties. Energy Policy, 61, pp.811–821.
- Usher, W. & Strachan, N., 2012. Critical mid-term uncertainties in long-term decarbonisation pathways. Energy Policy, 41, pp.433–444.
- Strachan, N. & Usher, W., 2011. Failure to achieve stringent carbon reduction targets in a second-best policy world. Climatic Change, 113(2), pp.121–139.

Reports

- Anandarajah, G. et al., 2010. TIAM-UCL Global Model Documentation
- Ekins, P. et al., 2013. The UK energy system in 2050 : Comparing Low-Carbon, Resilient Scenarios, London, United Kingdom.
- Usher, W. & Strachan, N., 2010. UK MARKAL Modelling - Examining Decarbonisation Pathways in the 2020s on the Way to Meeting the 2050 Emissions Target, London, UK.

Conference Presentations

- Usher, Will. Using Approximate Dynamic Programming to Assess Investment Options in Long-term Energy Transitions, EURO/INFORMS, Rome, Italy, 2013
- Usher, Will, and Neil Strachan. A Comparison of Key Energy Policy Uncertainties: Expert Beliefs versus Model Parameters. International Energy Workshop, Cape Town, South Africa, 2012.
- Pye, Steve, Neil Strachan, Gabrial Anandarajah, and Will Usher. The UK Energy System in an Uncertain World: Insights from Different Modelling Scales. International Energy Workshop, Stockholm, Sweden, 2010.
- Usher, Will. Investment Uncertainty under Stringent UK Decarbonisation Targets. 11th IAEE European Conference, Vilnius, Lithuania, 2010.
- Strachan, N. & Usher, W., 2010. Failure To Meet Long-Term UK Carbon Reduction Targets – A Systematic Assessment. 11th IAEE European Conference, Vilnius, Lithuania

Software

- git_diff_xlsx - Author. Allows version control of Microsoft Excel spreadsheets
- SALib - Contributed. Powerful sensitivity analysis library.
- See www.github.com/willu47 for a full list

STEVEN SILLER, B.Sc.(Hons I) M.Sc. D.Phil.

Employment History

Personal Software Project **Jan 12 - Present**

I am presently involved in a statistical software development project.

Ricardo-AEA **Mar 09-Dec 12**
(formerly AEA Technology)

AEA is a leading UK environmental consultancy, the majority of whose work is government based.

Q.A. & Statistical Consultant

Brought in as consultant to advise on and implement measures to improve the productivity and efficiency of a high value UK Governmental Energy Efficiency Policy project.

- Legacy Excel models were causing massive delays and budget overruns, jeopardising the continuance of the project. Standardised and automated model creation and alteration thus reducing expenditure and reliance on expensive and sometimes unreliable external contractors by improving turnaround time from several weeks to minutes per model.
- Improved QA, and thus client confidence, by eliminating manual intervention in model structure allowing necessary checks to be automated. This also improved efficiency by removing the necessity for individual checking of each of the 140+ models and reducing the models' memory footprints by 90%.

Experimental Design Advisor

Advised on experimental design correction for multi-million £ experimental project attempting to measure the effect of chrono-proportional thermostats on energy use. The data were incomplete and badly organised; the experiment itself sufficiently disorganised that the results could not be considered viable.

- Provided improved experimental design, increasing statistical power of final analyses, increasing the likelihood of a significant result for the multimillion £ experiment.
- Coached project team through design and statistical techniques for client meetings.
- Identified suspect data and provided detailed instructions for future information that needed to be collected and checked for a final analysis to be viable.
- Designed and mentored the implementation of a database approach to data organisation and collation reducing input error and time taken.

Oxford Virtual Markets (OVM) **Aug 04-Dec 08**

OVM is a small Oxford based start-up developing a novel financial exchange and arbitrage platform.

Senior Developer

Developed liquidity and arbitrage models for a real time financial exchange platform. Responsible for the ISO27000 compliance of the Matchbet betting exchange, holding a personal UK Gambling Commission License. The version of the platform extant when I joined the company was not fit for purpose, being slow and unreliable.

- Personally redesigned and coded the back end of the OVM financial platform as an extremely robust, multithreaded and distributed system, significantly increasing stability and improving order handling from *circa* one order per second to tens of thousands per second.
- Successfully managed and brought up to speed a team of 5 external contractors for a project with an immovable two month deadline.
- Identified and proved at an early stage a serious breach of a £500,000 contract by a supplier, enabling OVM's managing director to take action.

Oxford Risk (ORRA) **Jun 02-Jun 04**

ORRA is a start-up providing innovative solutions to clients based on research that addresses risk.

Risk Consultant & Developer

- Conceived, designed, project managed and contributed to development of interactive portfolio and visualisation software for Amerada Hess, a client US oil company. Work sponsored at highest level and I presented to the CFO in New York. This product opened up a second tranche of funding from Amerada Hess, allowing ORRA to expand.
- Contributed to project to understand systematic errors in estimates of reserve distributions. This rôle involved interviewing staff at Amerada Hess at all levels.

Oxford University **Sep 98-Jun 04**

Research Fellow (Department of Zoology, from Jun 02)

Junior Research Fellow (Christ Church)

- Independent research into game theory and biology, publishing in leading journals, e.g.: S. Siller. "Sexual selection, and the maintenance of sex." *Nature* 411: 689-692 (2001).
- Statistical and experimental design support for empirical researchers.
- Invited (i.e. funded) speaker at a number of international biology, finance and economics conferences (e.g. The Royal Economic Society Easter School 2003 and The Swiss Stock Exchange Conference on Evolutionary Finance 2002), as well as top ranked university departments (e.g. Zoology Departments of Cambridge, Oxford, and the Economics Department of University College London.)
- I was continually involved in teaching at the tertiary level from 1988 as a second year undergraduate until 2004. I have taught the following subject areas: physics, mathematics, statistics, behavioural ecology, evolution, and theoretical biology in departments and colleges.

BT (British Telecom)

Aug97-Mar 99

Business Analyst

- BT needed to understand the impact of various factors and work practices on the quality of service of its engineering workforce for its customers. They had been using labour intensive simulation software applied to limited real world data sets. I developed more flexible, less labour intensive queuing theory based models and simulation software, validating them with previous results. This saved significant time in evaluating scenarios as well as allowing a much greater range of factors and practices to be investigated.
- Retained as external consultant after leaving permanent employment with BT.

Education

Oxford University (Balliol College) **Sep 92-Jun 97**

- **D.Phil.** (Mathematical Biology)

University of Queensland **Jan 87-Sep 92**

- **M.Sc.** (Pure Mathematics) by research.
- Awarded **The University Medal,** May 1992.
- **B.Sc. (Hons I)**, (Mathematics) **GPA. 7.0/7.0**
- **B.Sc.**, (Mathematics and Physics) **GPA 6.9/7.0**
- **Awarded 17** academic prizes and scholarships, including Devourguilla Scholarship (Balliol), The University of Queensland Travelling Scholarship, and The University Medal (UQ)

Technology

- I have been developing software in a professional context since 2003, though have been coding on and off as part of other jobs since 1983.
- Programming: Java, VBA and C#. Some C, Fortran, various BASICs, 6502 machine code.
- Data: Excel (95 to 2010), Minitab, Mathematica, SPSS, Mathcad.
- IDE: Visual Studio, Eclipse.

Annex B DECC compulsory declarations

Declaration 1: Statement of non-collusion

To: The Department of Energy and Climate Change

1. We recognise that the essence of competitive tendering is that the Department will receive a bona fide competitive tender from all persons tendering. We therefore certify that this is a bona fide tender and that we have not fixed or adjusted the amount of the tender or our rates and prices included therein by or in accordance with any agreement or arrangement with any other person.

2. We also certify that we have not done and undertake not to do at any time before the hour and date specified for the return of this tender any of the following acts:

(a) communicate to any person other than the Department the amount or approximate amount of our proposed tender, except where the disclosure, in confidence, of the approximate amount is necessary to obtain any insurance premium quotation required for the preparation of the tender;

(b) enter into any agreement or arrangement with any other person that he shall refrain for submitting a tender or as to the amount included in the tender;

(c) offer or pay or give or agree to pay or give any sum of money, inducement or valuable consideration directly or indirectly to any person doing or having done or causing or having caused to be done, in relation to any other actual or proposed tender for the contract any act, omission or thing of the kind described above.

3. In this certificate, the word "person" shall include any person, body or association, corporate or unincorporated; and "any agreement or arrangement" includes any such information, formal or informal, whether legally binding or not.

.....
Signature (duly authorised on behalf of the tenderer)

PATRICIA GREENAN
Print name

UCL CONSULTANTS LTD
On behalf of (organisation name)

5.2.15
Date

Declaration 2: Form of Tender

To: The Department of Energy and Climate Change

1. Having considered the invitation to tender and all accompanying documents (including without limitation, the terms and conditions of contract and the Specification) we confirm that we are fully satisfied as to our experience and ability to deliver the goods/services in all respects in accordance with the requirements of this invitation to tender.

2. We hereby tender and undertake to provide and complete all the services required to be performed in accordance with the terms and conditions of contract and the Specification for the amount set out in the Pricing Schedule.

3. We agree that any insertion by us of any conditions qualifying this tender or any unauthorised alteration to any of the terms and conditions of contract made by us may result in the rejection of this tender.

4. We agree that this tender shall remain open to be accepted by the Department for 8 weeks from the date below.

5. We understand that if we are a subsidiary (within the meaning of section 1159 of (and schedule 6 to) the Companies Act 2006) if requested by the Department we may be required to secure a Deed of Guarantee in favour of the Department from our holding company or ultimate holding company, as determined by the Department in their discretion.

6. We understand that the Department is not bound to accept the lowest or any tender it may receive.

7. We certify that this is a bona fide tender.

.....
Signature (duly authorised on behalf of the tenderer)

PATRICIA GREENAN
Print name

UCLC CONSULTANTS
On behalf of (organisation name)

5.2.15.
Date

Declaration 3: Conflict of Interest

I have nothing to declare with respect to any current or potential interest or conflict in relation to this research (or any potential providers who may be subcontracted to deliver this work, their advisers or other related parties). By conflict of interest, I mean, anything which could be reasonably perceived to affect the impartiality of this research, or to indicate a professional or personal interest in the outcomes from this research.

I wish to declare the following with respect to personal or professional interests related to relevant organisations*;

- Baltazar Solano and Will Usher are both Researchers at the UCL Energy Institute. As such , in the normal course of academic work, and in the course of consultancy work, they have extensive involvement with projects and players (academic, commercial and third-sector) with an interest in DECC's models.

Where a potential conflict of interest has been declared for an individual or organisation within a consortia, please clearly outline the role which this individual or organisation will play in the proposed project and how any conflict of interest has or will be mitigated.

- Normal UCL management processes for Conflict of Interest and Unfair Advantage are in place (as per UCL policy attached as decribed in the proposal), and we do not believe that any additional mitigations need to be imposed..

Signed .....

Name Patricia Greenan

Position Director, UCL Consultants Ltd

5th February 2015

Declaration 4: Questions for tenderers

In some circumstances the Department is required by law to exclude you from participating further in a procurement. If you cannot answer 'no' to every question in this section it is very unlikely that your application will be accepted, and you should contact us for advice before completing this form.

Please state 'Yes' or 'No' to each question.

Has your organisation or any directors or partner or any other person who has powers of representation, decision or control been convicted of any of the following offences?	**Answer**
(a) conspiracy within the meaning of section 1 or 1A of the Criminal Law Act 1977 or article 9 or 9A of the Criminal Attempts and Conspiracy (Northern Ireland) Order 1983 where that conspiracy relates to participation in a criminal organisation as defined in Article 2 of Council Framework Decision 2008/841/JHA;	No
(b) corruption within the meaning of section 1(2) of the Public Bodies Corrupt Practices Act 1889 or section 1 of the Prevention of Corruption Act 1906; where the offence relates to active corruption;	No
(c) the offence of bribery, where the offence relates to active corruption;	No
(d) bribery within the meaning of section 1 or 6 of the Bribery Act 2010;	No
(e) fraud, where the offence relates to fraud affecting the European Communities' financial interests as defined by Article 1 of the Convention on the protection of the financial interests of the European Communities, within the meaning of:	No
(i) the offence of cheating the Revenue;	No
(ii) the offence of conspiracy to defraud;	No
(iii) fraud or theft within the meaning of the Theft Act 1968, the Theft Act (Northern Ireland) 1969, the Theft Act 1978 or the Theft (Northern Ireland) Order 1978;	No
(iv) fraudulent trading within the meaning of section 458 of the Companies Act 1985, article 451 of the Companies (Northern Ireland) Order 1986 or section 993 of the Companies Act 2006;	No
(v) fraudulent evasion within the meaning of section 170 of the Customs and Excise Management Act 1979 or section 72 of the Value Added Tax Act 1994;	No
(vi) an offence in connection with taxation in the European Union within the meaning of section 71 of the Criminal Justice Act 1993;	No

	(vii) destroying, defacing or concealing of documents or procuring the execution of a valuable security within the meaning of section 20 of the Theft Act 1968 or section 19 of the Theft Act (Northern Ireland) 1969;	No
	(viii) fraud within the meaning of section 2, 3 or 4 of the Fraud Act 2006; or	No
	(ix) making, adapting, supplying or offering to supply articles for use in frauds within the meaning of section 7 of the Fraud Act 2006;	No
(f)	money laundering within the meaning of section 340(11) of the Proceeds of Crime Act 2002;	No
(g)	an offence in connection with the proceeds of criminal conduct within the meaning of section 93A, 93B or 93C of the Criminal Justice Act 1988 or article 45, 46 or 47 of the Proceeds of Crime (Northern Ireland) Order 1996; or	No
(h)	an offence in connection with the proceeds of drug trafficking within the meaning of section 49, 50 or 51 of the Drug Trafficking Act 1994; or	No
(i)	any other offence within the meaning of Article 45(1) of Directive 2004/18/EC as defined by the national law of any relevant State.	No

Declaration 5: Code of Practice[1]

I confirm that I am aware of the requirements of the DECC Code of Practice[2] for Research and, in the proposed project, I will use my best efforts to ensure that the procedures used conform to those requirements under the following headings[3]:

- ☐ Responsibilities
- ☐ Competence
- ☐ Project planning
- ☐ Quality Control
- ☐ Handling of samples and materials
- ☐ Facilities and equipment
- ☐ Documentation of procedures and methods
- ☐ Research/work records

I understand that DECC has the right to inspect our procedures and practices against the requirements of the Code of Practice, and that I may be asked to provide documentary evidence of our working practices or provide access and assistance to auditors appointed by DECC.

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[1] Please note that this declaration applies to individuals, single organisations and consortia.
[2] The Code of Practice is attached to this ITT as Annex C
[3] Please delete as appropriate