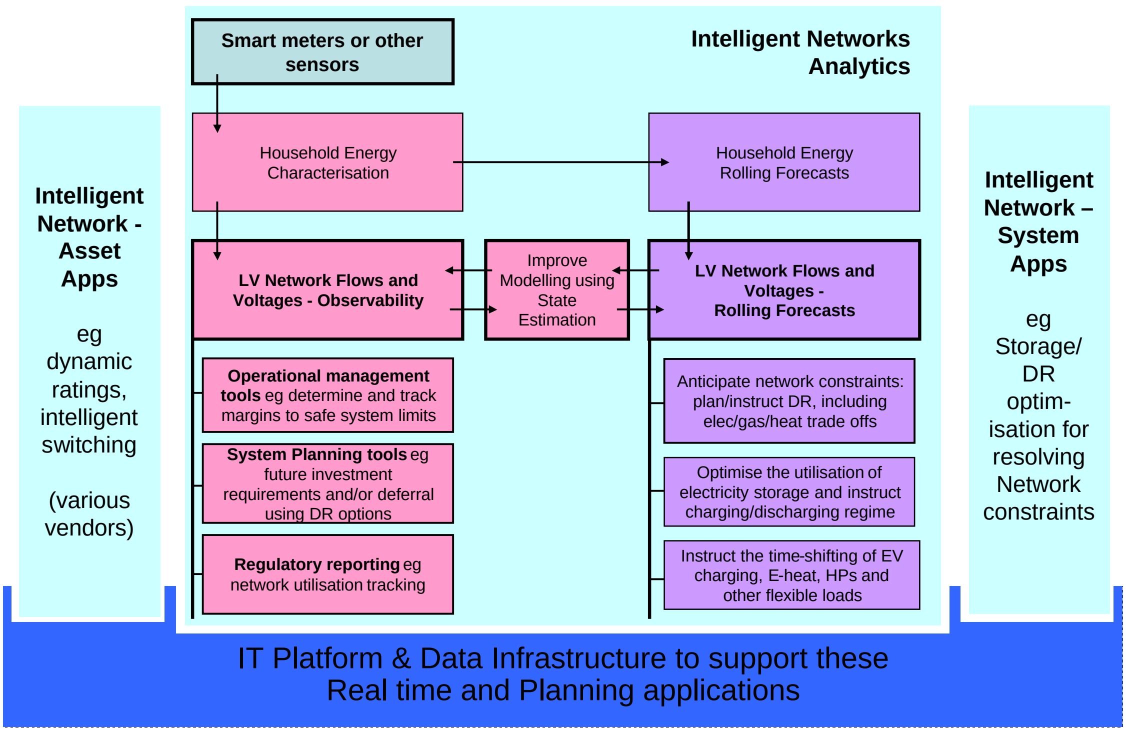
Scottish and Southern Energy Power Distribution	TVV Appendix 16.1	
	UoR Active Demand Modelling	
	Ver 1	

Thames Valley Vision – LCNF project submission

(draft dated 7 August 2010)

University of Reading contribution

Advanced Demand Modelling: Tracking & Inferencing of customer demand



The TVV project incorporates advanced customer modelling which is a major step in creating the essential elements of a truly smart grid. This innovative modelling is being led by Prof. Peter Grindrod, CBE of the Department of Mathematics at the University of Reading and utilises Agent Based Modelling, drawing on successful developments in the retail sector, combined with lessons from SSE's EDRP smart meter trials.

This work is of importance to the TVV project but is likely to have wide application across the electrical power sector in operational, investment planning and regulatory contexts. The traditional yardsticks used for estimating the maximum demand on low voltage networks will soon become unusable as penetrations rise in the use of micro-generation and new demands such as Heat Pumps and Electric Vehicle charging. Today's ADMD approach (After Diversity Maximum Demand) will be superseded by dynamic modelling that characterises demand types, using advanced algorithms and a Bayesian learning process. This work should enable traditional, static, demand profiles to be replaced by dynamic models that have direct application for operational planning of the networks, the scheduling of distributed storage charging/discharging, and demand response interventions. In the investment planning timescale it can be used to make informed decisions about capital expenditure on future networks and how this can be minimised through intelligent networks and customer demand response solutions. These techniques will be powerful tools to assist effective regulatory decision making.

The diagram shows the main elements of work proposed: these can be grouped under Household Energy Characterisation and Household Rolling Forecasts, supported by Network State Estimation. The boxes below show the principal practical applications which, as can be seen, are all germane to intelligent energy solutions.

The work is divided into a number of parts which exploit the available smart meters and the project design, yet infill for missing information from unmetered houses, and also foresee the interaction between future (active) smart grids controls in a world where smart meters are universal. There are thus long and short term aims. The modelling will demonstrate the role and assess the value of polling daily information from all households, in managing and prolonging the life of LV networks. Three forecasts will provide estimates, down to half hour resolution, for metered, unmetered and partly metered LV zones: these forecasts are (i) a 24-120 hour short term rolling forecast, (ii) an operational forecast (6-12months ahead), and (iii) a long term investment forecast (5 years, typically) to facilitate improved capital investment planning and the accuracy of regulatory submissions. The long term forecast will include scenario-driven options (eg for projected EV penetrations) applied adaptively in the light of the local behavioural typolgies. The project will determine forecasting accuracies in the differing applications And, in particular, assess the benefits of moving away from traditional static demand profiles. While developed for the TVV project these forecasting methods are seen to have application across SSE networks and GB more widely.

Behavioural energy usage pattern typology. Work undertaken with SSE (EDRP project) to date at the University of Reading has shown how varied household consumption is, and how poorly it is predicted by location, housing stock, assets, or socio-demographic information. There are many distinctive behavioural patterns evident in 24/7 smart meter data. In the TVV project all users will have their behaviour classified directly form their meter information or else inferred (by being “buddied” in an algorithmically suitable way). Moreover the numbers of users on the LV networks is insufficient to provide a group smoothing effect. This forecast for LV network demands (down to half hourly) requires methods that will deal directly with volatile and peaked behaviour. For this reason the modelling has already produced recommendations used in the selection of the LV assessment zones in Bracknell to be intensively monitored: (i) a relatively homogeneous group of homes with similar external patterns (school hours, employment hours)and similar housing assets (these demands may be highly co-dependent with aggregation producing a large co-dependent demand and little mutual mollification/smoothing); (ii) a heterogeneous group, with a mix of housing stock and other external factors; and (iii) a block of flats with electric heating and a range of occupants old and young for example).

Forecasting: we will adopt a dynamical simulation approach to produce rolling (as live) forecast for all meters. The aim is to have 24-120 hour forecast for all meters that can be used to flag up any network or supply quality violations and/or drive smart control algorithms (for example optimising the charging/discharging regimes for local storage). The forecasts must be simulations and must not smooth out usage peaks. So dynamic simulations, including ABM (agent based model) methods that have been deployed in a number of behaviour based sectors are to be preferred. Classical generalised linear modelling (ARMA, econometric, for example) simply fit terms within noisy data (making assumptions about the noise): here as in other sectors , the data isn’t noisy, it is stochastic, and the peaks are genuine and need to be inferred when making forecasts (typical peaks for users and groups of users). Staff at UoR have expertise in such problems in retail demands and supply (for large retailers such at Carrefour, Tesco, Sainsbury, Waitrose) and in climatology and insurance (claims and losses sector). Longer term forecasts will require biases to be imposed on a event based nature and impacts due to take-up scenarios of new customer assets (EVs HPs, PVs for example). Temperature and seasonal variability and volatility will also be considered. The ABM approach naturally allows us to “buddy” non-metered households with metered ones or surrogates based on the metered users. It also allows the users to influence each other: users/agents may change behaviour and acquire new technology in clusters (not independently). There are a number of forecasting tasks at different time scales, of increasing complexity and uncertainty.

Intelligent control within smart networks can also deploy the ABM approach. The dispatchable assets or storage employed physically or virtually can be modelled as agents with strategies for deployment: these can know the local LV demand forecasts and thus make decisions based on a future expected peaks. This ABM approach to these Hamiltonian control systems can be investigate both virtually as a test and live on the LV networks. Of course control algorithms are dependent upon the nature of the forecast and the uncertainties in those forecast. Ensemble forecasts (demand envelopes) will be investigated. UoR have expertise in this field from a number of mechanical and electrical control system sectors and this will be applied in the project.