Future Power Systems 22 - Strategy and Value

Background

I spent many years with the CEGB then National Grid, working in the fields of generation, system operation and the development of models for Generation Economics - Commitment, Scheduling, Dispatch and Ancillary services with the associated representation of Demand, Fuel, Market, Interconnection flows and Transmission security constraints.

I retired in 2003, then got into Renewables and Distributed Energy Resources and produced these documents on Future Power Systems (FPS), covering the principles and characteristics of main power plant and future developments. The ideas on the Smart Enterprise (FPS20) and Customer engagement (FPS21) seemed to have much support on the Linkedin professional forums.

As part of Linkedin forum discussions on Electric Vehicle integration, we managed to develop workable strategies using exchangeable vehicle batteries, for systems with different types of large scale renewables penetration (Distributed PV or Centralised Big Wind).

Rewards for Renewables - ROCs, FITs, CfDs and time

The Feed in Tariffs, Renewables Obligations, Contracts for Differences and other such schemes are designed to reward this class of plant by an extra payment for their Gross generation output.

However these schemes do not recognise that the output from such generation differs in value depending on when it is available.

It seems incredible that, while we are persuading the customer under Smart that 'time matters', the Feed In Tariff, the ROC scheme (GB only) and CfDs under the Electricity Market Review have no time variation (or even seek to remove such) in the renewables incentive prices. These really are 'blunt instrument s in the sharpest industry' and give the wrong message. You cannot claim that the same p/kWh 'reward' should be paid for generation at @0600hrs on the first Sunday in August (GB annual min demand @23000MW) as against that supplied at the annual maximum (GB winter weekday 1730hrs @60000MW). Even if we had some form of preset 'Period of day by Weekday/Weekend by Season' variation, it would certainly encourage the 'controllable' embedded generation (CHP etc) to consider using thermal or electrical storage to allow them to vary their output. This would to be to their benefit and would also allow them to assist in reducing fuel burn/emissions on central main power plant and to help maximise the use of distribution assets.

Future Power Systems - what does it look like

The Power System of the Future will be radically different, with penetration of unpredictable variable output renewables. We have a lot of potential new technology and control mechanisms to utilise.

We need to determine what combination of Generation (Big+Little), Storage, Distributed Resources management, Interconnection trading, Ancillary services provision and Transmission/Distribution management will deliver the goods as regards safe, secure, efficient, and economic operation with reduced fossil fuel burn. All parts of the electricity business are involved; generation, supply, transmission, distribution, system operation and the market, together with the customer, in a commercial/technical framework in which the target can be hit while maintaining system security, quality of supply and accuracy of settlement. Better commercial and technical interfaces are required between member states and across Interconnectors between Electricity Pools. This forms the 'Smart Enterprise', incorporating Smart Grid and Smart Meter initiatives.

Future Power and other Energy sector Technology - What's it worth?

The main issue is the need to evaluate the various scenarios correctly; full nested time series simulations (Commitment-Schedule-Dispatch-Outturn) in respect of the Power System, with Fuel supply allocation and emissions calculations. As we move through time, predictive and forecast data will change within the forward models and the actual conditions will be applied to give the outturn, including reserve delivery. This needs to cover prediction of generation and demand (in total and by location), the matching of the totals and the overlaid actions to maintain Transmission and Distribution security (static/dynamic stability, pre/post fault overload and voltage risk). The system will be more 'volatile' than at present, especially where variable renewables and counterbalancing storage, interconnection and/or customer action cause power flow swings .

We also need to run the full simulation of GB heat/cooling provision, again back to the fuel inputs and with emissions calculations, with the various proposed changes to energy sources (boilers vs heat pumps vs CHP etc) covered.

To cover the proposed large scale introduction of Electric vehicles, we need to also have the full GB Vehicle Internal Combustion model (Well to Exhaust), again to produce fuel burn and emissions data.

Obviously, each scenario will represent different data exchanges between the three main energy sector simulations.

This whole exercise will determine the value of each scenario and thus allow the correct judgements to be made as regards practicability, impact and cost.

Future Energy - the really Big Picture

It is the 'Sustainable Transformation' of all three energy sectors; Power, Heat and Transport, which is the big target for Energy Security, Emissions reduction and Cost. We have a lot of different technology which tries to approach this, but which combination will deliver the goods??. We can only work out the Smart Customer and Grid requirements if we have a view of where the Smart Enterprise is going.

We need to model the three energy sectors with different combinations of technology to see which is the best approach. To cover increased variability and unpredictability of renewables, the 'Future Power' simulation is especially difficult. It requires sequential overlapping simulations for commitment through to outturn, including reserve delivery and with specific modelling of prediction changes. The problem as regards distributed energy resources is to model customer participation; what will the Smart Customer do in response to more dynamic price signals??.. This is an iterative problem; each modelling solution will produce the prices which will influence different customer actions, which in turn change the solution... But, we have awesome levels of computing power available for modelling; just need to formulate the problems.

And there will be a large number of different solutions around the world; one size certainly don't fit all. Out of the solution you get the 'worth' of each 'Smart Enterprise'.

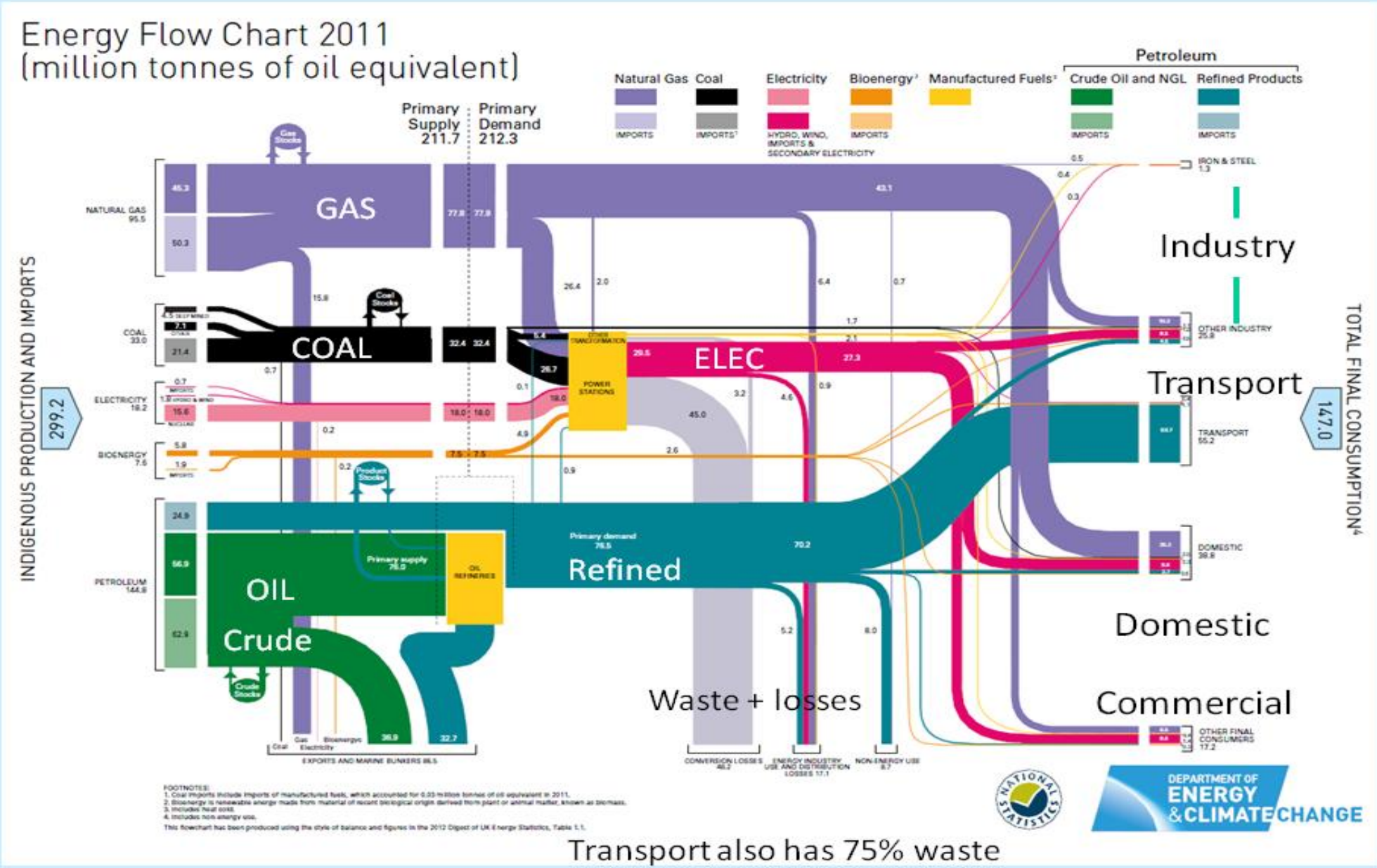
As regards the level of dramatic changes which might be indicated for energy systems, here is another example of what GB might need to do (60GW Peak dmd, 375TWh annual energy). If we put up the proposed 33GW of wind, we are going to get severe variations in the 'demand less wind' curve. For example, the current winter weekday morning pickup is @37GW up to @52GW from 0600 to 0800. Various studies have used actual wind speed data to calculate the 'Big wind output' and superimpose that on the load curve. In the worst case (wind dropoff) the pickup can end up as @8GW (below base Nuclear output) at 0600 to @36GW at 0800. No way is conventional generation and the customer base going be Smart enough to handle all that. So, we need big storage, and over long periods. Now, we do have big storage and lots of capacity in our existing gas network. Annual Thermal Energy handled is 1000+TWh, inc 350TWh to Power Generation, and max energy demand on one day (winter) is 5+Twh. But we are running out of indigenous National gas supplies. So, there is a proposal to convert the lot to H2 and buffer the Electricity variations that way. Just one example of a potential big Energy change; but will the losses of the Elec-H2-Elec cycle make it unattractive??. Or will fuel cells be able to improve the H2 energy delivery with both Heat and Electricity?? All needs studying properly and we still need prediction accuracy and the Smart customer. There is also

another interesting mechanism which could enable the existing Gas system to provide large Power/Volume storage support for electricity.

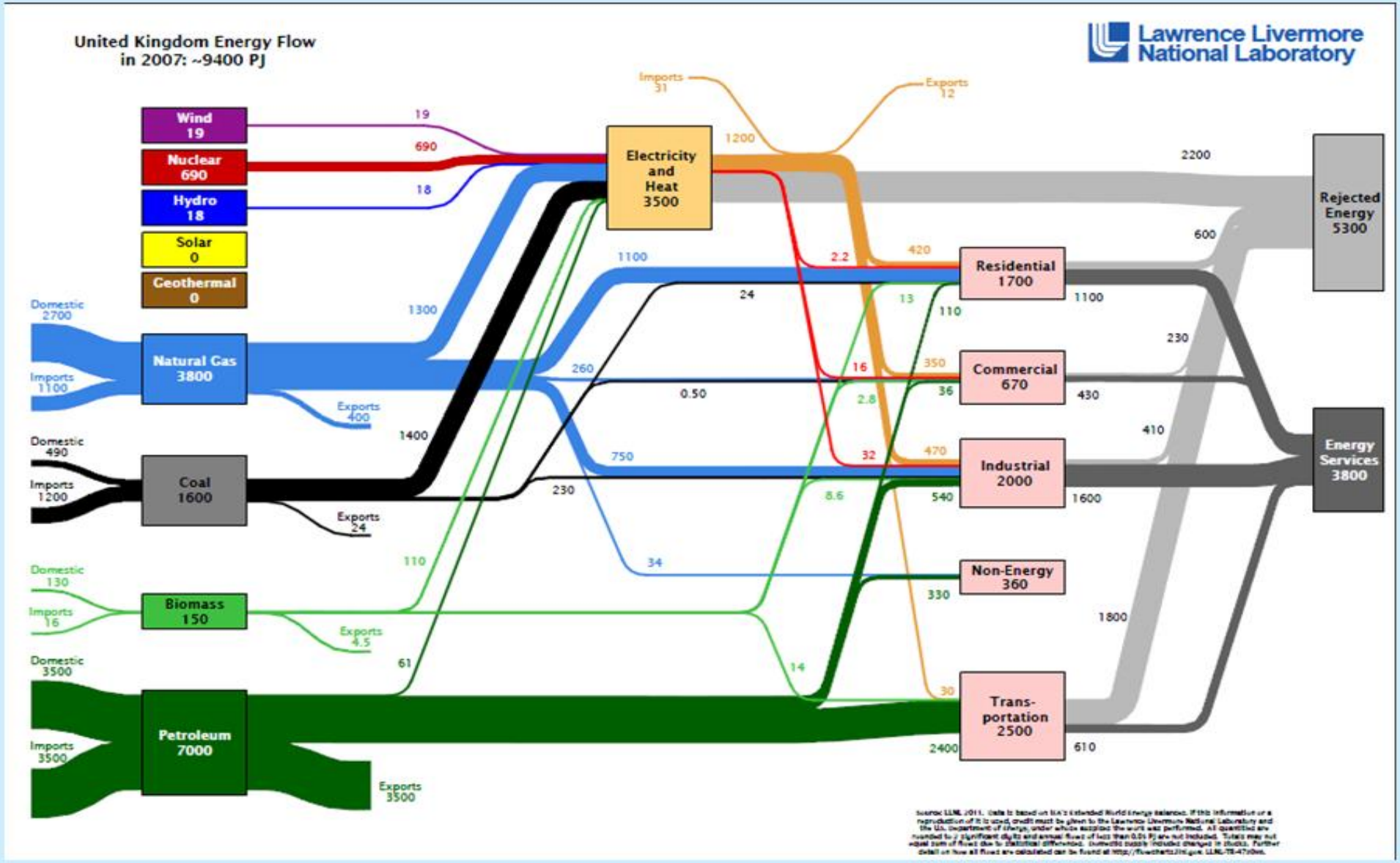
Future Energy - How do you run it

The Energy Systems of the Future will be more volatile to operate and the three sectors (Power, Heat, Transport) will interact to a far greater extent than currently.

As I wrote in FPS 20, the basis for customer power demand forecasting may have to change completely. It may no longer be possible to run the Power System manually, due to the increased need for more frequent trading and operational instruction, at all levels. In GB, the interface between Generating plant and the Operator (data submission and instructions) have been electronic for over 10 years. Full automation of the Market and Operator internal processes (Generation-Demand matching and Transmission/Distribution Security) is now required. This looks like the 'rise of the machines' in the Information Age.



Transport also has 75% waste


United Kingdom Energy Flow
in 2007: ~9400 PJ
Lawrence Livermore National Laboratory
Wind 19
Nuclear 690
Hydro 18
Solar 0
Geothermal 0
Domestic 2700
Imports 1100
Natural Gas 3800
Exports 400
Domestic 490
Imports 1200
Coal 1600
Exports 24
Domestic 130
Imports 16
Biomass 150
Exports 4.5
Domestic 3500
Imports 3500
Petroleum 7000
Exports 3500
Imports 31
Exports 12
Electricity and Heat 3500
Rejected Energy 5300
Residential 1700
Commercial 670
Industrial 2000
Non-Energy 360
Trans-portation 2500
Energy Services 3800
19
690
18
1300
1400
110
61
1200
1100
24
260
0.50
750
230
34
2.2
16
32
420
350
470
330
30
2200
600
1100
230
430
410
1600
1800
610
2400
540
110
13
2.8
8.6
14
36