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Appraisal of Costs & Benefits of Smart Meter Roll Out Options

Final Report

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Glossary

AMM – Automated Meter Management

AMO – Association of Meter Operators

AMR – Automated Meter Reading

BCR – Benefit Cost Ratio

BEAMA – British Electro Technical and Allied Manufacturers Association

BERR – (Department for) Business Enterprise and Regulatory Reform

BRE – Buildings Research Establishment

COMMS – (Tele) Communications

CDU – Customer Display Unit (also known as clip-on)

DEFRA – Department for Environment, Food and Rural Affairs

DNO – Distribution Network Operators

EDD – Electricity Display Device (also known as clip-on)

EIRR – Economic Internal Rate of Return

ERA– Energy Retail Association

ESD – EU Energy Services Directive

EWP – Energy White Paper

GPRS – General Packetised Radio System

GSM – Group Special Mobile

HAN – Home Area Network

IT – Information Technology

LAN – Local Area Network

MAP – Meter Asset Provision

MID – Metering Industries Directive

MML - Mott MacDonald Limited

MOP – Meter Operators

MPF – Metallic Path Facility

NG – National Grid

NPV – Net Present Value

OFGEM – Office of Gas and Electricity Markets

O & M – Operation & Maintenance

OTA – Over The Air

PLC – Power Line Carrier

PPM – Prepayment Meter

PSTN – Public Switched Telephone Network

RTD – Real Time Display

SIM – Subscriber Identity Module

SM – Smart Meter

SMOF – Smart Meter Operational Framework

SMPF – Shared Metallic Path Facility

SMS – Short Message Service

SPC – Shadow Price of Carbon

SRSM – Supplier Requirements for Smart Meters

TOU – Time of Use (tariff)

VPN – Virtual Private Network

WAN – Wide Area Network

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Summary

MML has been appointed by the Department of Business, Enterprise and Regulatory Reform (BERR) to conduct an independent appraisal of the costs and benefits for various smart meter (SM) roll out options.

In conducting this assessment and guided by BERR we have included a range of technologies that offer various attributes of a smart metering system that provides real time feedback to customers, consumption analytics, automated (remote) meter reading (AMR) and full automated meter management (AMM) using two way communications.

There is a wide range of metering technologies and communications technologies available that is broadening all the time. This study reviews the following metering technologies:

- Clip-on customer display units (CDU) or electricity display devices (EDD) are simple devices comprising a portable real time display which receives data from a clip-on current transformer that is attached externally to the meter. They are low cost and easy to fit but inaccurate.

- Comms enabled standard meters can be specifically designed standard meters with internal comms built in. These meters can provide an alternative to clip-ons; however there are external devices in the market that can be attached to existing meters, retrofitted with a reading device and transmitter. There are three retrofit technologies that can provide accurate reads: pulse reader, optical readers and magnetic field sensors. Any electricity, gas and water meter could be retrofitted using the appropriate devices, however for the purpose of this report we have only examined local comms enabled standard meters.

- Dumb meter /smart box. This combines a comms enabled standard “dumb” meter with an external comms link embedded within a separate “smart box” or home hub. Various devices are available for non-residential customers today and equipment companies are now seeking to target the domestic market. These devices offer potentially very high functionality, including some AMM functions and are likely to be comparatively low cost.

- Suppliers Requirements for Smart Meters specification. This provides what the Energy Retail Association calls a minimum spec for a smart meter, but is seen by many others as a state-of-the-art meter, based on integrating a 2-way comms interface into the electricity meter. These meters have the highest AMM functionality.

- A SM specification suugested by BEAMA-the meter manufacturers’ trade body. This specification has lower functionality than the ERA spec above, with many of the additional features as optional.

For the comms technologies there is also a wide range of options. These comprise wireless and fixed line and include existing technologies like PSTN, 2G and new technologies like 3G and WiMax. There are two ways of getting data from meter to suppliers, either using a direct end-to-end comms link (such as Broadband, GSM, WiMax, etc) or else via an intermediate local area network.

The costs of the various devices varies considerably, with the clip-on device being the cheapest and the ERA smart meter the most expensive. The difference in costs largely relates to functionality and robustness. However, the dumb meter smart box option offers a lower price for a given spec since it is cheaper to integrate the electronics and processing power into a smart box (home hub) than a meter. Dedicated comms infrastructure for SM only is likely to be very expensive; 'piggybacking' on existing comms networks is likely to be a more cost effective solution.

Also, allowing a retrofit option to standard existing meters further reduces the costs. This allows the cost of a dual fuel dumb meter/smart box to come in at well under half the price of the ERA's meter which costs around £240 for electricity and gas including installation.

There is some uncertainty regarding the meter equipment costs, given that none of the equipment has been produced in large numbers and technology is still evolving. However the extent of uncertainty is much less than for the supporting comms equipment. Based on current market, the comms costs are much higher than £10 per meter per year, however indicative quotes from comms providers suggests that costs could be brought down to £5-6 per meter per year for the lower cost options (piggy back broadband and 3G).

There is much greater uncertainty on the benefits side, especially for energy savings. Here there is an issue of the size of the energy saving and associated peak load reduction as well as the value to be placed on these reductions. The relevant literature talks of savings of as much as 15%, however less than half of this figure looks more realistic. We have tested the impact of 1-6% savings. We have also netted out the consumption of metering and comms systems. The total net benefits of these energy feedback effects is £8-9/meter a year in our central case. The equivalent low and high range is £3-20 per meter per year. These figures include the benefits of carbon reduction.

Benefits arising from the remote read functions and AMM are seen in a reduction in suppliers' cost of serving customers. This cost of serve is reported to average a little below £25 per meter per year for all residential customers. The benefits relating to the different meters is closely related to the functionality of the meter. We estimate that the highest spec meter, the ERA meter would bring a total net reduction in cost of serve of about £11/meter/year. This figure is net of the annual opex costs for comms. The net savings for the lower spec BEAMA and dumb meter/smart box options are around £8/meter/year. There are some minor additional benefits arising to DNOs, however these are negligible.

There are a number of roll out options for SM, which include leaving it to the market, mandating that new and replacement meters meet a given spec, mandating that suppliers achieve a particular actual read rate and a full managed programme. There is also the option to install new metering systems for gas and electricity simultaneously or independently. We have examined these options, however our modelling analysis indicates that these roll out options have a comparatively minor second order effect on the costs and benefits of metering options, compared to the bigger issue of technology choice.

Our headline figures for Net Present Values (NPV) and benefit cost ratios shows that the dumb meter/smart box is the most cost effective smart meter option, even adjusting for optimism bias according to Green Book guidelines. The total NPV for this option is £3-4bn. The ERA spec meter, with its high spec has the highest benefit stream, but its NPVs are generally substantially negative due to the high equipment and installation costs. The BEAMA spec meter falls between the two, although generally it fails to yield a positive NPV.

As mentioned above the nature of the roll out has comparatively little impact on NPVs. The economies of concentration for the managed franchise are offset by the high set up and admin costs and the costs of covering for meter providers' "lean years".

The clip-on devices provide the highest benefit cost ratios of all systems, but the retrofit standard meter with a feedback device provides much higher NPVs comparable with the dumb meter/smart box option. (In non-accelerated roll outs this retrofit option provides a higher NPV than the dumb meter/smart box option. In comparison the clip-on realises an NPV of around £2.2bn.

Looking at the costs and benefits for an actual rollout as far as an average customer would see it shows a much less favourable position. This is because two significant benefits which arise to GB PLC, the social value of carbon benefits and the benefits of reduced peak energy are assumed to not flow back to customers. Also in the real world we need to take account of stranding costs which would occur in accelerated roll out options. These are substantial and relate to the commercial arrangements struck between suppliers and meter providers for almost 10 million meters (by 2010). In an accelerated managed roll out these stranding costs could amount to over £2bn.

Even without these stranding costs, all the smart meter options would entail a net annual cost to the customer, which ranges up to £10 for the ERA meter, but even £2 for the dumb meter/ smart box for a new and replacement roll out where stranding is avoided. The non-smart metering options both provide modest benefits per customer of almost £1/year. For an accelerated roll out, the costs per customer rise to £12-14 for ERA and £8-10 for the BEAMA spec. The costs for the smart box option remain just £2/year, since there is no need to replace legacy meters. The benefits for the non-smart meters also remain the same.

Examining the impact on fuel poverty, we find this very significant especially for sophisticated meters with accelerated roll-out options. This can amount up to £50 per meter per year for the most expensive comms options. Feedback technologies, however, have almost negligible impact on the fuel poor.

On the basis that all costs and benefits are passed through to customers, there is a moderate NPV for suppliers (ERA 1.7bn) for all smart meter options under all rollout scenarios. However the NPV for clip-on is negative. The implication is that there is a business case for suppliers to adopt smart metering, and oppose clip ons. If suppliers were not allowed to pass through most of the stranding costs there would not be a business case for suppliers.

1 Introduction

Mott MacDonald Limited (MML) has been appointed by the Department for Business, Enterprise and Regulatory Reform (BERR) to conduct an independent appraisal of costs and benefits for various smart meter (SM) roll-out options.

According to the Terms of Reference, the main objectives of this work are:

- Collection and consolidation of up-to-date cost and benefit data for all technology options.
- Modelling of various SM roll-out scenarios that will include competitive market arrangements.
- Analysis, advice and conclusions on roll-out options.
- Identification of areas that require further investigation.

MML approaches the current analysis under the framework of UK Government energy policy objectives, as they have been defined in the 2007 Energy White Paper (EWP). The EWP objectives are:

- "Tackling climate change by reducing carbon dioxide emissions both within the UK and abroad"
- "Ensuring secure, clean affordable energy as we become increasingly dependent on imported fuel"

The EWP sets out the Government's international and domestic energy strategy to respond to these challenges and deliver four energy policy goals:

- "To put ourselves on a path to cutting CO_2 emissions by 60% by about 2050, with a real progress by 2020"
- "To maintain reliability of energy supplies"
- "To promote competitive markets in the UK and beyond"
- "To ensure that every home is adequately and affordably heated"

Facing the dual challenge of tackling climate change and ensuring energy security, the Government has committed to a strategy that promotes energy saving. Among other EWP energy saving policies, the Government needs to comply, by May 2008, with the EU Energy End-Use Efficiency and Energy Services Directive (ESD). It should be noted that neither the EU Energy Services Directive nor the EWP mandate the roll-out of SM, however SM are worded in the recently closed consultation.

Given the range of technologies and the need for interoperability among meters, the Electricity Retail Association (ERA) has put in considerable effort to come up with a minimum operational and functional specification for gas and electricity meters. This effort has been embodied in the Supplier Requirements for Smart Metering (SRSM) project, Phase 1 of which has proposed an operational framework for smart meters. The ongoing Phase 2 will provide suggestions for a managed roll-out programme.

MML recognises that the ERA SRSM project is the leading contender for the roll-out options of SM; however it is not the only technology option. In addition, communication technology options are still unclear and undefined, even in the SRSM proposal. So the current analysis aims to be holistic in terms of technology options and provide as many independent and pragmatic conclusions as possible.

Our review of metering technologies includes a wider range than the conventional definition of smart meter (which tends to mean a high spec meter with two-way comms). For instance we have included for comparison metering options which provide only feedback to customers as well as conventional "dumb" meters which are fitted (or retrofitted) with telecommunications facilities to transfer data to suppliers via some kind of "smart box" (or home communication hub).

For the baseline, we had two options: either include all avoided costs in each technology option, or just exclude avoided costs in each option. The baseline we adopted includes costs and benefits on top of existing ones (capital and installation costs for existing meters, benefits from existing meters). This baseline facilitates comparison of results with others produced by a number of commentators and includes proposals consistent with the 2007 Energy White Paper (as in provision of feedback on household energy consumption with smart meters within ten years).

Section 2 of this report outlines the available technology options that are currently in the market, both in metering and communications.

Section 3 provides a description of the different SM roll-out options. The options include leaving it to the market, various mandates for uptake and a fully managed programme.

Section 4 presents main categories of costs that are taken into account in the analysis. The cost categories are broken down by technology options, communications options, installation, operation and other costs.

Section 5 presents the anticipated benefits from the various technology and roll-out options for all stakeholders.

Section 6 outlines the modelling approach used for the analysis, and lists several key stochastic variables that are simulated in the Monte Carlo iterations.

Section 7 presents results from the modelling results.

Section 8 explores the complicated issues of distributional impacts and draws conclusions on what it would cost per meter per year to roll out the programmes in practice.

Section 9 presents the key conclusions of the study, providing important caveats and identifying areas where further work is needed.

Finally, Section 10 contains a post-script that summarises the review process of the MML model and the feedback received from stakeholders. This section also contains revised summary results from the model.

Appendix A expands on the technical side of the some of the main technologies outlined in the main text. Appendices B and C include an exhaustive sensitivity analysis conducted in Crystal Ball for all forecasts.

2 Technology Options

2.1 Introduction

This section provides an overview of the main available technology options for smart metering. Although the list of technologies is by no means exhaustive, it contains the main technology options that are currently readily available in the industry and potentially can be mass-produced and supplied in the market to support the roll-out scenarios.

The options are listed below, starting from simple to more sophisticated technologies.

2.2 Clip-on Customer Display Units

Clip-on Customer Display Units (CDUs) (or Electricity Display Devices) are a very simple and fast solution to real-time provision of feedback on electricity use. They consist of a simple pulse transmitter that clips externally on the main power supply wire next to the existing meter. The transmitter communicates wirelessly with a display unit (what we call a Real Time Display (RTD)) that can be placed within a distance up to 30 metres from the transmitter (although walls and other obstacles can affect the reception range). The display unit shows data on electricity consumption in kWh and the cost of electricity in pounds. The user has the option to change the tariff manually if needed. Usually the display unit shows also data on carbon emissions, previous consumption levels, temperature and humidity. More details on this technology are given in Appendix A.1

2.3 Standard Meter with Internal Communications

This technology option is a variation of existing meters, including local comms capability. It comprises of a standard meter, which complies with the Metering Industries Directive (MID) [1]and a transmitter that communicates real time information on energy consumption in a RTD, located in the household. The meter does not communicate with the supplier.

This technology is an improved alternative to Clip-ons, avoiding many of their drawbacks like inaccuracy of data, battery use, and short lifetime of the asset.

A variation of this technology can be used for electricity and/or gas meters, which can equipped with some form of retrofit device (like pulse transmitters, optical readers etc.) and provide consumption data to either an RTD for the consumer, or through a comms link back to the supplier.

This solution, because of its metering accuracy, can potentially be combined with providing consumers the incentive to return their own readings. This incentive could benefit both suppliers and consumers.

Although throughout the report and the model, we call this technology option ‘retrofit’, meaning not smart, we should note that the option of retrofitting existing meters with accurate external reading devices, like optical readers, just for the provision of feedback is also possible. This remains an area that requires further investigation.

[1] Meaning the meter is accurate, tamperproof and meets international metrology standards.

2.4 BEAMA Minimum Meter Specification

The British Electrotechnical and Allied Manufacturers Association (BEAMA), that represents the electricity and gas meter manufacturers in the UK, has suggested a minimum smart meter specification that complies fully with the EU Directive and the EWP.

This specification is the simplest and minimum metering solution possible. It consists of a 'smart-enabled' meter that substitutes the old meter. The 'smart-enabled' meters have the following basic characteristics:

- Fully compliant with the MID
- Import capability (export capability is optional)
- Reverse run capability
- Two-tariff capability (more rates optional)
- Minimum data storage capability
- Time clock (for time stamping stored records)
- Local comms (with standard left to the market to decide)

Notably, the last characteristic does not preclude that the feedback effect will take place with a RTD. Instead, it allows the consumers and suppliers to decide in what form the feedback will take place i.e. RTD, internet, mobile phone, digital TV. In addition, it ensures interoperability.

This metering solution does not provide meter data back to the supplier, although it is possible for suppliers to receive readings from consumers, since the meter is accurate. However, this solution can be combined with external comms technologies. If no comms technologies are used, the meter has in-built data storage capacity so that suppliers can receive full information on electricity consumption and balance the customers' accounts on meter reading visits.

2.5 ERA Minimum Meter Specification

As discussed in the introduction, ERA has suggested in the first stage of the SRSM project a minimum meter specification. This specification has all the features described above plus:

- Electricity meters have import/export capability
- Two-way comms between the meter and the supplier
- Remote configuration
- Multi-tariff capability
- Remote switching between credit and debit function
- Remote connect/disconnect capability

Because gas meters cannot be powered by electricity, batteries are generally used to power the comms, valve (remote connect/disconnect) and meter display. The battery is expected to last up to 5 years.

2.6 Automated Meter Reading

Automated Meter Reading (AMR) is a function that enables the meter to send meter readings back to the supplier as often as required (up to every half hour). AMR means that the meter will need a built-in modem or some other form of comms device that can communicate the readings back to the supplier or meter operator.

AMR function is absent in the clip-on CDUs, optional in the BEAMA specification, and mandatory in the ERA specification.

Because of the need for a comms module in the meter and the development of suitable comms infrastructure, AMR function in every meter is likely to have additional costs. There is uncertainty in the comms technology going forwards over a time-span of 20 years. This dictates a modular rather than an integrated approach to smart meter design. Modular will be more expensive to design and implement, however a modular approach will eliminate the need for a costly meter re-install in the event of comms technology obsolescence.

2.7 Automated Meter Management

Automated Meter Management (AMM) is an additional function to AMR. With AMM, suppliers or meter operators have full control of the meter functions and configuration, including communicating directly with customers, remote switching from credit to debit function and potentially remote connection and disconnecting.

ERA minimum specification has AMM as mandatory, while BEAMA specification has it as optional.

2.8 'Dumb Meter' with Smart Box

The above metering technologies are 'meter-centric', in the sense that the meter includes all metering and comms functions (i.e. integrated modem or wireless transmit/receive unit). However, another option is to transmit consumption data from the standard "dumb" meter to 'smart' boxes that contain the comms module. The data are then transmitted through data hubs back to suppliers, who can communicate with consumers via email, phone, SMS text etc. The system allows for security of the metering data and does not require a site visit to install or maintain. The components are tamperproof, and can send alerts to the suppliers if they are disconnected or the signal is interfered with.

This solution is classified as AMR, and although it does not provide meter management capabilities, it allows communications from suppliers to consumers i.e. via email, phone, TV. Some more expensive options of this modular technology also offer AMM functionality (including remote switching debit to credit).

This technology requires limited infrastructure in meter assets and communications, hence it is likely to be cheaper than other options. More details on this technology are given in Appendix A.2

2.9 Communications

For the purposes of analysing the communications needs, it is best to define an appropriate architecture. Connectivity is required:

- within the home
- from the home to an initial concentration point, (this is optional and is used as a means of cost minimisation)
- from the concentration point to those organisations needing to communicate with the meters remotely

In this report these networks are respectively referred to as:

- HAN – Home Area Network
- LAN – Local Area Network
- WAN – Wide Area Network

There are two types of set-up. The first involves a HAN directly connected into the WAN. We anticipate there would be no usage charges for the HAN once installed, although there would be some maintenance charges for replacement of defective parts, etc. The HAN is most likely to be low power radio. The WAN could be provided by a whole range of technologies, eg PSTN, GPRS broadband etc. The first phase of the HAN is connecting the electric and gas meters with the CDU. Future phases could include complete home controls.

Figure 2-1 Type 1 set-up: Home connected directly to WAN

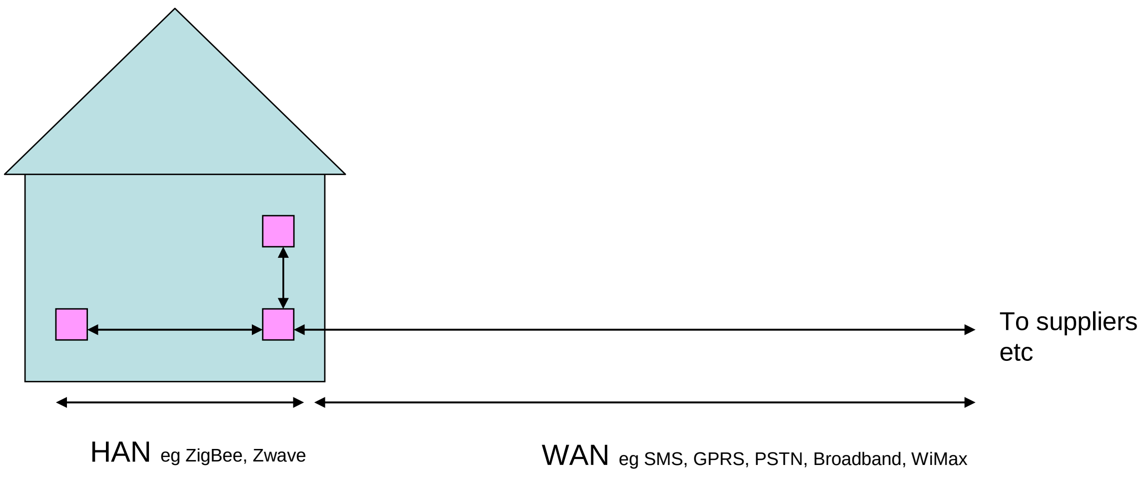
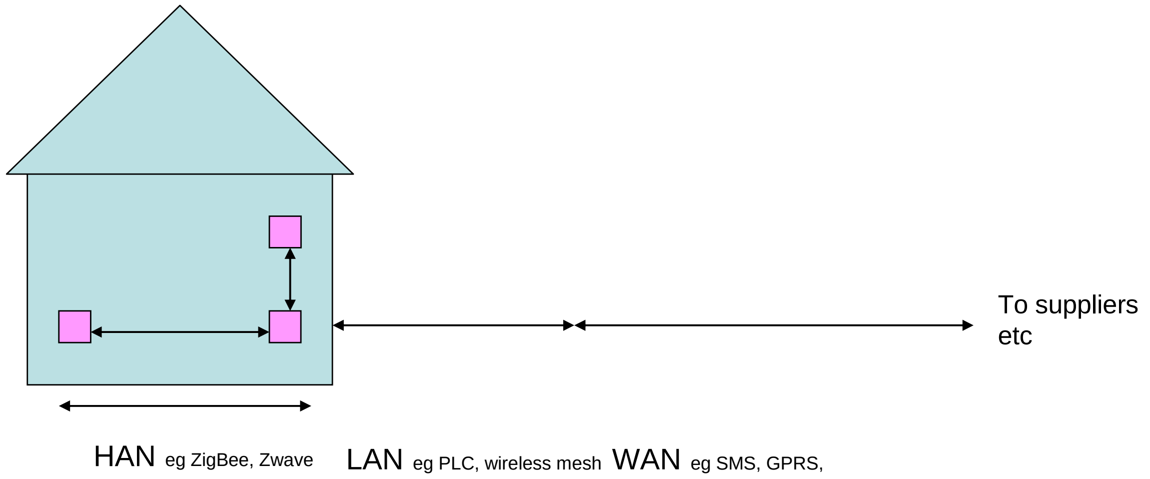


Figure 2-2 Type 2 set-up: Home connected through local aggregation network



The second set-up involves the use of local area network (LAN) eg powerline carrier (PLC) or wireless mesh, fitted with appropriate adaptors to provide the connection into individual homes. These connections are then concentrated for onward connection to a third party WAN. This will not reduce usage charges which are largely distance independent, but may save on installation costs, as the number of mobile numbers, SIMs, and GSM modems can be reduced. Note that it is assumed (for cost modelling purposes) that organisation providing the PLC is a not-for-profit organisation.

With the end-to-end connection in place, data must be transferred between the meter and the application reading the data or sending updates to the meter. There may be different types of data sent and received, for example;

- Data may have to be sent from the gas/electric/other meters to a CDU. This is not for billing purposes, but to assist the customer in monitoring and reducing their demand (and hence bill and carbon footprint). This data is not generally sent across the WAN.

- Data may have to be sent detailing the gas/electricity/other used, from the meter to the supplier's data collection point. Tariffs may have to be sent to the meter from the data collection point. These data may be used for billing as well as for marketing purposes.

- The supplier may wish to manage certain aspects of the meter remotely, ie switch from prepaid to postpaid mode, switch supply on/off, remotely diagnose meter problems, upload a software/firmware upgrade to the meter.

- In the future distributors may wish to switch off or turn down equipment (immersion heaters, freezers, etc) at certain times of day. Demand side management may be beneficial in terms of peak load reduction etc.

These communications functions need to be specified in detail, showing its size, coding and structure etc. This specification would take the form of an application protocol interface. In an ideal world this should be specified to be independent of the type of HAN/LAN or WAN in use. This allows the utility supplier the maximum flexibility in the choice of the communications technology. Due to the large range of locations, urban, suburban, rural, small and large houses, apartment blocks, houses with basements it is not possible to select one technology that will work and be economic in all situations.

2.9.1 HAN (Home Area Network)

A number of factors complicate the choice of HAN communications technology:

- Within people's homes there are aesthetic considerations. If a wired solution is chosen this will necessitate internal cabling, which will add to installation costs and will be unacceptable to many people. This option has not been modelled. It is assumed that a wired internal solution would only be used for new build schemes where the house/apartment is pre-wired with CAT-5 or the like.

- The need for the gas meter to be battery operated and for that battery to have long life, e.g. 10 years. This constraint means that the communications should be low "overhead" to avoid draining the battery by sending and receiving more data bits than is absolutely necessary. It also favours an architecture whereby a hub is used within the home to communicate with the meters on one side with low power comms technology and on the WAN facing side, something with higher power is permissible.

- The need to minimise cost means that any technology used must have low cost, ie chip sets used should be mass market rather than bespoke. Homes in the UK may have existing wireless devices and due consideration must be given to the effects of interference within the home.

Any communications solution deployed must be tried and tested. Technologies which are "bleeding edge" will introduce an unquantifiable risk and so are to be avoided. Characteristics of HAN technology solutions are summarised in Table 2-1.

Table 2-1 HAN Communication Technology Characteristics

Technology	Advantage	Disadvantages	Future work
ZigBee	Is an international standard; ANSI ratified Operates at 2.4 GHz and 868MHz Needs low power	In trials there has been interference with micro-wave ovens and Wi-fi connections at 2.4 GHz. Wi-Fi which is much higher power than ZigBEE, will interfere. There have been investigation and it appears there are ways of mitigation which one would expect to be implemented in the future [9]	868 MHz is a pragmatic solution, chipsets are available, and it is being used for metering within Europe. Siemens have contracted with Cambridge Consultants and Roke Manor, both of whom recommend 868 MHz as the appropriate spectrum for metering. It is currently used for car alarms and has longevity.
ZWave	Is proprietary, though supported by; Intel, Logitech, Cisco, Intermatic	Currently single source supplier	

Technology	Advantage	Disadvantages	Future work
	and there currently exists 100+ interoperable products on the market. Operates at 2.4 GHz and 868MHz Needs low power	Has 1% duty cycle And has the same disadvantages as ZigBee in terms of low power at 2.4 Ghz in comparison with WiFI	
Bluetooth	It is designed for interconnecting devices of very close proximity. Bluetooth 2 has longer range	Where meters are several meters away, or on an outside wall (20 inches thick) or in basement, may be issues. Uses higher power than ZigBee or Zwave	Not considered further
Wifi,	There is a proliferation of devices in the home now; chipsets are cheap [7],[8] Is available at 2.4 Ghz and also 5.8 Ghz	Requires high power so unsuitable for gas meters	Not considered further as a means of connecting to the gas meter, but as a means of connecting electric meter to WAN is considered
Homeplug	A minimum disruption method of using the internal wiring to connect within the home. Only need to connect gas and electric meters into mains ring.	It will not work in cases where there are split rings. (can't jump a ring). There is no way of telling which house has split rings or not before deploying devices, the trend is to increase the number of houses with split rings. Filters for connecting gas meters safely to a ring main are expensive	Not considered further
CAT-5 (optical) or similar	Simple, once installed with long lifetime, and can be used for all other household communications	Requires cabling, suffers from aesthetic problems for some customers if surface mounted. Few households have CAT-5 cabling already	Not considered further
X10	could also be used, but currently this is only used for control within the	Reported reliability issues [5]	Not considered further

Technology	Advantage	Disadvantages	Future work
	home, and would need to be extended to carry out smart metering.	Is one-way comms method Is difficult (ie costly) to set-up	

2.9.2 LAN (Local Access Network)

This section covers options which connect the home to a concentrator, before onward connection to a 3rd party WAN. Currently in the UK there are no service providers offering a PLC or wireless mesh network. A company would need to be set-up to offer this service. Characteristics of technology options for LAN are given in Table 2-2. More discussion on LAN technologies is given in Appendix A.4.

Table 2-2 LAN Comms Technology Characteristics

Technology	Advantages	Disadvantages	Future Work
Powerline (narrowband and enhanced narrowband)	A method which extends outside the home; it requires the installation of filters in the meter and concentrators within the local electricity distributor. Enhanced narrowband can deliver 20 kbps	The provider of the PLC service needs a contract with the electricity distributor, in order to house and maintain the concentrator. In current regulatory regime if distributor offers the service to one utility provider, must offer to all. There may be space problems if concentrators not shared. Access to substation for maintenance will be required, and maintenance charges need to be accounted for. Not proven that different concentrator types can co-exist on the same cable. Fault notification and management – who will do this?	Probably only worth considering as part of a telecoms business plan. Need to obtain the view of the distributors.

Technology	Advantages	Disadvantages	Future Work
Powerline (broadband)		As bandwidth increases quality diminishes. Satisfactory QoS has not been achieved to date. Concentrators for broadband are more expensive.	Probably only worth considering as part of a telecoms business plan
Wireless mesh	A technology such as ZigBee or Zwave could be used as a wireless mesh to connect through a number of homes back to a concentration point	This network would need to be managed by a third party or the distributor, would require building an organisation to provide and manage the network. Information would be passing through several homes, so all communications would need to be encrypted for reasons of confidentiality.	A number of trials are ongoing. Not yet cost modelled

2.9.3 WAN (Wide Area Network)

The large range of homes, from houses, through to apartment blocks and from dense urban environments to rural areas, means that there will be more than one WAN technology, as none will work in all areas. The objective of the WAN should be to get the bits back to the operator/supplier as cheaply as possible. It is not clear that mandating any particular technology would be beneficial for this part of the communications path. Table 2-3 WAN Comms Technology Characteristics summarises WAN technology options

Table 2-3 WAN Comms Technology Characteristics

Technology	Advantages	Disadvantages	Further Work
GSM - CSD (circuit switched data)	Covers 90% of UK households today, - if all mobile operators can be used	CSD is not supported long term, and cannot be used for 25 million homes as there is not enough cell capacity	One problem is that meters must be pre-fitted with T-Mobile/O2/Vodafone/Orange SIMS, as they will not allow Over the Air SIM changes.
GSM	Covers 90% of UK	Prices have been very	This restrictive practice

Technology	Advantages	Disadvantages	Further Work
	households today, -if all mobile operators can be used	high compared to fixed services. Utility suppliers will need to break new ground in price negotiations.	needs to be lifted, and then the network can be selected at meter fitting depending on which offers coverage in the home. OFCOM may need to do a consultation on allowing OTA SIM changes. During the lifetime of the meter 2G licenses may be withdrawn and the spectrum re-farmed for 3G. This requires one of the following: • Modem design will have to specifically allow the emulation mode over 3G (adds capital costs) • or modem upgrades may be needed during meters' asset lifetimes adds operational costs • Persuade OFCOM to allow 2G to operate for a longer period than currently planned.
GSM – GPRS		GPRS could be used for software upload, but usage charges may be higher. GPRS cannot support private IP addressing schemes. This maybe be a problem if utility suppliers need a VPN. GPRS is are expected to be emulated over 3G.	Develop relationship with mobile operators with respect to flat rate and special tariffs for metering applications
GSM – SMS	Covers over 90% of UK households today,- if all mobile operators can be used It may be possible to buy	SMS is cheaper than GPRS, although there will need to be extensions to the current UK mobile numbering plans to	Modem design will have to specifically allow the emulation mode over 3G or modem upgrades may be needed during meters' asset

Technology	Advantages	Disadvantages	Further Work
	SMS bundles extremely cheaply in larger quantities and at "off-peak" times. Utility traffic would account for about 1% of SMS traffic in UK.	provide a mobile number for each meter. SMS would not be useful as a means of upgrading smart meter's software. SMS is expected to be emulated over 3G	lifetimes
3G	Expect flat rate pricing packages, which may be more cost effective.	Coverage is poor at the moment, expected timescale to 80-90% population coverage is 3+ years away	
WiMAX	Made for data transfer. None of the line ownership problems of PSTN and broadband will exist	No national WiMax operators as yet. Expect 3-4 year (minimum) to rollout to 80-90% population coverage.	
Paknet	An x.25 wireless network launched by Vodafone for the benefits of the banks. It is cheap and works and is effective, as long as the banks use it the product will remain available	This is already an outdated technology , so over a 20 year lifespan there is some risk that it will be withdrawn	This is not considered further in this report but it is an area for further work with Vodafone.
Broadband		BT has already rejected the business case to develop a utility product for all UK homes for the purpose of smart metering. Suppliers will not be dependent on a broadband link paid for by the customer, due to problems of churn, and switching off routers when PC not in use etc. would mean meters not connected for	Investigate whether a new service can be deployed in future, based on unbundling and 21CN, which would allow use to be made of existing metallic path to create an additional logical service tailored to the needs of the utility supplier. Probably needs regulatory support, as well as consultation with BT and/or LLU operators.

Technology	Advantages	Disadvantages	Further Work
		large periods of time.	
PSTN – Dial-up pay-as-you-go or flat rate	Available now Modems cheap Usage charges cheap	Suppliers will not be dependent on a telephone line paid for by the customer, due to problems of churn, and switching off routers when PC not in use etc. would mean meters not connected for large periods of time. Service (as currently engineered) will be withdrawn in the meters' asset lifetime. This will probably necessitate modem changeout.	

The WAN options are the least controllable part of the communications system. It should **not** be mandated which option is chosen as the WAN option. The costs vary between options and there are multiple trade-offs to be made. The suppliers should make this decision based on their own business case assessment for the particular house, it is unlikely that "one size" will fit all.

For example, in rural locations it is more likely that there is poor GSM coverage, for GPRS but SMS coverage may be ok, and PLC is a prohibitively expensive media wherever density of users is low. Broadband may be the only option and installing a new telephone line may not be an option, so the supplier may choose in this case to offer "free broadband" to this customer. To cover this realistic prospect, we have created two mixed comms technology options, based on proven and future technologies that are appropriate for either rural (low density) or urban areas (high density). The first, named Hybrid 1, is a combination of PLC and WiMax and the second , Hybrid 2, is a combination of Broadband and GSM (3G), both distributed by 75% and 25% respectively.

As part of 21st Century Network (21CN), PSTN services will be re-engineered it may become difficult to source modems, and BT may wish to withdraw particular services, for example PSTN will be emulated over the new infrastructure, but eventually may not be offered as we currently know it. BT are in the process of testing PSTN modems to determine which will work and which will not work over the 21CN. It is more likely to be more modern modem designs which will work.

Similarly GSM services such as GPRS/SMS may be emulated over 3G within the time period, which could necessitate change-out of modems or some clever modem design such that 3G modem can be switched on when 2G is switched off.

There is a physical phone line in most homes, 90% of the households currently have fixed phone service and more than 90% have the line still in the house, - even if it is not operational.

More than 50% currently have a broadband link carried over the telephone line. In our analysis we created the concept of a piggyback broadband. What we mean by this is that the broadband service is divided into two logical services, one for the consumer, and the contract for this is between the consumer and the communications service provider. The second is for the utility provider, the contract between the utility provider and the communications service provider. This would share the same hub, this hub would communicate with the electricity meter, using WiFi or even ZigBee. The service would not be particularly broadband, only a low data rate is needed, it should be possible for scheduling to allow the utility to carry out its data send and receive during a time when the user is not using the service. This model allows a more sensible price to be arrived at. This requires further work, in that the requirements definition needs to be more clearly specified, working with broadband service providers and BT’s 21 CN programme. It may require some regulatory changes and further work will determine whether or not this is necessary.

It is assumed the communication provider will make use of a Virtual Private Network (VPN) to provide the logical grouping from meters to the appropriate utility supplier/meter operator. More details on home devices that are required for WAN options and application protocols are given in Appendix A.5 and A.6.

2.9.4 Implications of Communications Options on the smart meter specification

In considering the communications system the application is the driver. A number of applications are required:

- An application which allows usage data and control data to be transmitted within the home, which will operate between meters, ie gas and electric, water and electric and between meter and CDUs and also potentially devices to be controlled, e.g. immersion heaters etc. These are the interfaces within the home.
- An application that allows the meter to be read at varying intervals, to upload tariffs and remotely upgrade the meter software. This would allow the meter to interface to the data collector
- An application which can switch service off/on or from postpaid to prepaid.
- An application interface that allows the meter to be remotely diagnosed and fault managed.

There are two standards in common use for metering applications, the DLMS and the MBus standards, both need adaptation to meet the needs of smart metering. Note that the Dutch are much more advanced than the British [2,3] and much of this work has been done. Adoption and adaption of this work would save a great deal of effort, providing clarity for all interested parties. Utility suppliers would only need to insert new fields to cover features which are not currently allowed for.

These two interfaces need to be specified, and must to allow maximum options at the layers below.

What has become clear from the consultations is that the WAN option cannot be mandated as a single option. There must be some flexibility allowed. This means that the communications units at the meter should be modular, either connected via a standard physical interface, such as Ethernet, or as cards which can slide into the meter.

It clearly makes sense to make the electric meter the hub within the home (at last in the short term):

- All home with gas will have electric, but not vice versa
- Electric meters have simpler access to electric power to drive modems/transmitters etc.

2.10 Security Issues

A number of the metering devices can easily be disabled so that consumption data is not sent to suppliers, which raises some issues about how suppliers should manage this risk. In practice all the technologies have a vulnerable point, if not on the main metering system, then on out-bound comms. Only the PLC option combined with a high spec smart meter with comms interfaces embodied within the device, appears to be difficult to tamper with.

In practice, all electricity meters can be bypassed using fairly readily available devices, many of which can be fitted by a DIY enthusiast. Fortunately for the electricity suppliers and distributors such blatant theft is comparatively rare and is mainly confined to a number of large public housing estates in major urban centres.

The smart box metering system is the easiest to disconnect as the customer can easily unplug a cable. However, it is clear that where the smart box is used as a home hub for other services, such as phone, TV, internet, etc, the consumer has little incentive to unplug the service. Clip on devices such as the current transformers are easily unclipped, however this is not a concern to suppliers as these devices are only used to provide data to CDUs rather than suppliers for metering purposes. Other retrofit devices, which are either clamped, fastened, glued on to meters can also be relatively easily prized off or disabled.

The BEAMA and ERA spec smart meters are more difficult to tamper with, however, these meters, along with all the retrofit meter reading devices, still face the risk that their comms link can be disabled. All the comms options, with the exception of the PLC coupled to a secure smart meter can be easily interrupted. Depending on the strength of signals and frequency/ wavelength of comms, placing a large metal object near the meter, or putting a thinner metal screen or mesh around the meter will cut off wireless signals (a biscuit tin or foil is normally enough). There is nothing that can be done to stop this other than encouraging co-operation from consumers.

All the metering systems and retrofits devices are or can be fitted with memory for storing a certain amount of data in case of interruption. Also the comms protocols will include hand-shake routines that would alert suppliers and consumers that meters/comms had been disabled/interrupted. Once reconnected, the stored data would be sent to suppliers as a special delivery and perhaps also to the CDU.

Given this vulnerability to interference it will be important for suppliers to stress the importance to the customer of ensuring that their metering system is working. There would need to be a system of yellow, orange and red card warnings for repeated deliberate interference, after which suppliers would begin the process of switching customers to PPM or meters that can be read by drive-by readers, or else returning them to manual reads. Clearly, to the extent that there is a significant percentage of malicious and persistent tampering, this will require trouble shooting teams and additional PPM costs. This is an area that clearly requires more investigation. Our view is that a combination of appropriate incentives, information campaigns and technical solutions will allow these costs to be contained to £20-40m a year for GB plc.

It is possible that Ofgem and/or suppliers may decide that the two yearly meter inspections will need to be maintained in order to check there is no obvious interference with meters and comms link.

The one metering and comms option that appears to be more robust is combining either ERA or BEAMA spec smart meter with PLC. These systems do however cost considerably more than the lower cost retrofit/ dumb meter smart box systems. It is a matter of evaluating whether the additional costs of these systems is worth the peace of mind regarding security. That said, some commentators argue that all of the systems will be vulnerable: it is just a matter of how long it takes to find a technique to defraud the meter.

2.11 Summary

This section presented available technology solutions for providing feedback on energy consumption to consumers and metering services to the suppliers. Real time information, at least for electricity, does not require smart meters and can be done with existing ‘dumb’ meters. Usually, this technology requires an external reader/transmitter and a display device. It is cheap and easy to install, but does not provide metering services to the supplier, while cheap induction transformers (clip-ons) are generally inaccurate.

An alternative to this technology is simple, ‘dumb’ meters that contain a comms device for the home and communicates accurate meter readings to the RTD for the consumer. This solution is also cheap, easy to implement and can be used also for gas. It can also be combined with financial incentives to the consumers to return their own readings back to the suppliers.

A more automated option is to retrofit existing gas and electricity meters with external readers/transmitters that can communicate meter readings to ‘smart boxes’ in the household. Smart boxes can store data and communicate them back to suppliers. This modular form of technology is very flexible and can combine several services for both the consumer and supplier.

Alternatively, the ‘smart box’ can be integrated in the meter. Sophisticated meters can have a number of functions, depending on the level of ‘smartness’, so they are usually designed according to the metering requirements of the customer. This fact effectively means that there is no single definition for a SM. Meter manufacturers have provided a meter specification that satisfies basic SM requirements and can ensure interoperability. This ‘minimum spec’ mandates several meter characteristics, like data storage, multi-rate capability and comms, and is more expensive than conventional meters.

Very sophisticated meters, such as that proposed by the ERA, have increased functionality and are capable of both AMR and AMM. They also ensure interoperability, if the ‘spec’ is mandated, and are capable of remotely disconnecting supply and switching credit/debit functions. Because of their increased functionality built into the meter, they are the most expensive metering option.

Table 2-4 summarises technology options and Table 2-5 provides a comparison of SM functional specifications. On the communications side there is a need to define clearly the requirements, in terms of frequency and volume of data flows. In particular if device control and load shedding are important this needs to be stated and the requirements articulated. Once this has been done standardisation of the application can be progressed. There are a number of application standards including, Mbus, Smartmeters and others which can be built on; none currently supports all of the AMM functionality.

Table 2-4 Summary of Technology Options

	Existing Meter	RTD	AMR	AMM	AMM+
Clip-On	Yes	Yes	No	No	No
Meter Retrofit	Yes/No	Yes	No	No	No
BEAMA	No	Yes	Optional	Optional	Optional
ERA	No	Yes	Yes	Yes	Optional
Dumb Meter + Smart Box	Yes /No	Yes	Yes	Yes/No	No

The HAN technologies reviewed all have advantages and disadvantages. On balance the ZigBee and Zwave looked most promising. A review of white goods manufacturers showed that none were installing ZigBee or Zwave devices in current generation products, but many were considering these and Bluetooth or WiFi for future generations.

There are many WAN technologies available, none of which are suitable for all applications in all homes. There are many changes occurring within the telecommunications world both in fixed and wireless. Further work should include working with communications service providers on the modification to existing products which could result in an appropriate product that will suit all applications for 60% or more of homes, and with good commercial agreement and commitment from the utility suppliers could yield acceptable price points.

Likewise in the wireless field price can be negotiated downwards, since much of the meter reading data and upgrades can be carried out overnight (when the networks are not busy).

It is also worth consulting with OFCOM on the possibility of using “over the air” (OTA) updates to SIMs to ease the logistics burden on smart meter installers (who otherwise would need to travel to homes with say 4 meters pre-equipped with 4 network specific SIMs. The issue of 2G evolving to 3G needs also to be clarified, as one option is to use a mixture of SMS (for meter reading and so on) and GPRS for software upgrades. If 2G can be used for a 15-20 year period then this becomes an option.

PLC does help with cost reduction, but it requires a regulated body to be set up to provide and manage this network.

Another future product is WiMax, however currently there is not a service provider with nationwide coverage, though this may change as a result of the spectrum auction in spring 2008.

Table 2-5 Comparison of Minimum Smart Meter Functional Specifications

Functions	BEAMA	ERA
MID Compliant	Yes	Yes
Tamperproof	Yes	Yes
LCD Display	Yes	Yes
Import Capability	Yes	Yes
Export Capability	Optional	Yes (not for gas)
Reverse Run	Yes	Yes
Data Storage	Yes	Yes
Time Clock	Yes	Yes
Local Comms	Yes	Yes
Multi-Tariff	Yes (up to two-more optional)	Yes
Credit/Debit	Optional	Yes
AMR	Optional	Yes
AMM	Optional	Yes
Remote Disconnect	Optional	Yes
Remote Credit/Debit	Optional	Yes

3 Roll Out Scenarios

3.1 Introduction

The previous chapter examined the options of various SM and comms technologies. This chapter explores the possible scenarios by which smart meters could be deployed in GB. A number of parameters need to be considered in building these roll out scenarios. These can be grouped under:

- Technology options
- Extent of government/regulatory intervention
- Rate of deployment, which is likely to be largely linked to nature of intervention
- Ultimate penetration rate
- Dual or single fuel

The technology options were summarised in 2.11.

3.2 Extent of agency intervention

Here, there are effectively three options for meter roll-out:

- Free market with or without mandated delivery time
- Mandate for smart metering for new and replacement installations
- Mandate for full introduction of smart meters (a fully managed programme).

It should be noted that the government has alternative options in mandating either monthly billing, or billing with provision of feedback etc. Although such options remain available, it is beyond our scope to examine the impact of their implementation.

3.2.1 Free market roll out

We consider that there is no reason why the market, left to itself, would not encourage the deployment of smart meters in cases where there was a clear positive benefit to cost ratio for customers. The initiative would probably be led by suppliers who would compete to offer customers a bundled package of SM plus supply contract. It is possible that the meter operator or asset owners would offer a metering package without a tied supplier, although the experience of the mobile phones market suggests the equipment will be offered by the supplier. The customer would be contractually bound to pay off the meter cost, either through a minimum supply contract term, a termination charge or a separate meter equipment contract.

Generally, the owners of existing meters (such as the DNOs and NG) that do not have commercial contracts in place would lose their regulated income unless Ofgem established a compensation arrangement. However, the old meters would be returned to them, so they could capture the resale/ salvage value.

For the market to function efficiently, an agreed set of guidelines on interoperability would be required. A market could function efficiently without such a set of rules, however, the likelihood of lock-in would reduce the ability of customers to switch supplier.

For the purposes of our appraisal, we have assumed that the market can deliver a roll-out of SM and comms technologies in 14 years. The roll-out starts increasing slowly, reaching a maximum of 12% of legacy meters changed in year 6, and then declining slowly to complete replacement in year 14.

3.2.2 Free market with a tipping point

We have considered an alternative to the market roll-out, based on opinions of stakeholders in the industry. This roll-out method is also market led, however the market picks up replacement rates slowly until it reaches a ‘tipping point’, where metering technology returns become so cost efficient that it is more economical for suppliers to roll-out meters on a massive scale.

For the purposes of our model, we have assumed that this roll-out method will take 8 years to complete, with the first 49% of the legacy meters taking five years to be replaced, and the remaining 51% delivered in three years.

An important feature of this roll-out option is that it has the potential to reduce the stranding cost, that will definitely appear in the last years and end-up eventually to the consumer. Ofgem expects that a roll-out of meters in a competitive environment might induce suppliers not to pass stranding costs to consumers so that they gain market share through lower tariffs. We have included this possibility in our model.

In addition, and following suggestions from BERR, we have modelled a version of the above scenario, called ‘Market Tipping Point Fast’ that delivers in seven, instead of eight years. This scenario delivers 55% in five years, with the remaining 45% delivered in two years.

3.2.3 Mandate for new and replacement

The market solution could be supplemented by a mandate that new and replacement installations comprised smart meters. Under such an arrangement, sufficient notice would need to be given so that a number of suppliers and metering equipment providers could compete for the business. This could be provided via a common access database of metering installations. There would also need to be rules on when meters should be replaced.

Given a replacement rate of about 5%, this suggests that 2.1 million meters will be replaced each year. In 10 years, half the current metering stock would then be replaced. Adding new installations, which is currently running at about 400,000 a year, would mean that within 10 years, 60% of the market would be converted to smart meters, even assuming compulsory take-up.

Based on feedback we received from suppliers that have conducted trials of clip-on devices, only around 4-5% of their customers are currently interested in receiving a device that provides them with feedback on their electricity consumption. Based on this market diagnostic, we have assumed that a maximum of 4% of the customer base would be willing to accept an RTD with a SM every year. Because this figure is widely uncertain, we have allowed 1% standard deviation for voluntary uptake and included it in our stochastic simulations for this roll-out option. This scenario delivers in ten years from 2008.

3.2.4 Fully managed

The surest way to roll out smart meters would be a fully managed programme. This would require a mandate that smart meters be installed on a universal basis. The mandate would specify the time frame in which the industry or customers had to replace all legacy meters. Such a managed programme could be run by a number of possible parties, including network operators/owners, energy suppliers, meter operators and third parties. It could run under a re-regulated metering sub sector, with its own price control, or through some kind of franchise model or even a public, private partnership arrangement. The task could be run on a national or regional basis through franchisees. Arrangements could be designed to cover just transitional arrangements, i.e. the installation period, or they could provide a longer term framework. There are many options as how to manage such a roll out, but it is beyond the scope of this study to evaluate the different arrangements. What we have done is consider the costs and benefits of a generic managed programme for a 10 year roll-out.

Following suggestions from ERA, we have assumed that a fully managed regional programme would require two years of planning, contractual and legal arrangements, followed by five years of mass SM roll-out (90% of legacy) and three years for the remaining legacy meters.

3.3 Rate of roll out

The rate of roll out of smart meters will depend largely on the extent to which there is a mandate for replacement of legacy meters. A fully managed programme for replacement of all meters will clearly set its replacement rate, although it won't know the final penetration level. Similarly, a programme for replacing existing life expired meters will also predetermine the rate of deployment.

While it would in principle be possible to have an accelerated roll out under a fully managed programme, it is unlikely that this would be done in much less than 10 years. In the UK, there appears to be little enthusiasm for a 6-7 year roll-out as Italy and Ontario have done.

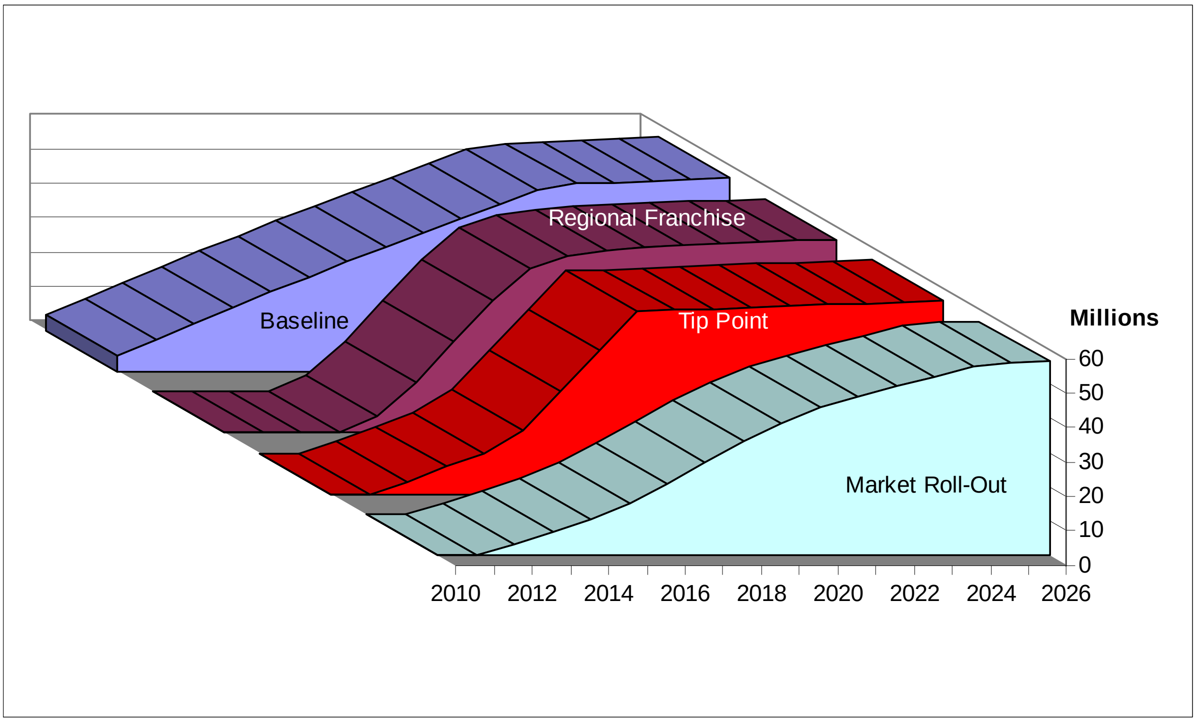
Under a mandate to replace life expired meters the rate of roll out will depend on the retirement age of equipment and its age profile. We have assumed that asset life depends on the meter years and that with an even age profile, this implies an annual replacement of 5% a year. This is the current replacement rate of meters.

The major uncertainty concerns the take up under a market arrangement, whether this is incremental from a mandate of replacement of life expired meters or from a totally voluntary market. Voluntary take up will depend on how attractive the smart meter package is considered by customers, and this will depend on what benefits the supplier can pass back to the customer. Where the new offering can be provided without any up-front costs, it is likely that take up will be higher, even if customers are required to sign up to minimum contract terms of three years or more.

As with any technology device it is likely that there would be an initial burst of take up as the early adopters signed up. This would be followed by a slower rate of growth before cost reductions eventually led to an accelerated take-up. This pick up might not occur until 6-8 years after the initial devices had been offered. This possibility is modelled as described in 3.2.2

The number of new sites requiring electricity and gas meters is another significant uncertainty. This depends largely on the domestic building rate, but also the number of house to flat conversions. On the basis of recent experience and the government forward plans, we project that there will be around 400,000 new installations a year. Roll-out options are summarised in Figure 3-1.

Figure 3-1 Possible Smart Meter Take-up under Different Intervention Options



3.4 Dual or single fuel

In households with both electricity and gas supply, there are clear advantages in fitting electricity and gas meters at the same time as this reduces travel time for installers and waiting time for consumers. The disadvantage of a simultaneous conversion is that one of the meters may have a much longer remaining life. Since gas meters cost significantly more than electricity meters, one option is to replace the electricity meter and leave the gas meter, but retrofit a reading device and internal comms link to the electricity comms hub. As mentioned above in the technology section, a retrofit smart functionality for gas would not provide the remote disconnection capability that ERA have said their members need.

A decision to enforce installation of displays in new and replacement installations would almost certainly increase the incentive for piggy backing gas retrofits/ replacement off the back of electricity meter replacements.

In considering our roll out scenarios we have considered three options:

- Electricity only
- Electricity with gas retrofits
- Electricity with gas.

We consider it unlikely that gas would be smart enabled without electricity, because of the higher costs of gas metering equipment, the lower value of legacy electricity meters and the requirement for customer displays for electricity. Hence, we have assumed that any roll-out option will be dual fuel.

However, we have allowed for cost efficiencies in installation charges arising from co-ordinated dual fuel roll-out. These efficiencies can be present in either of the roll-out options.

Given the considerable range of uncertainty and choice of options on technology, with extent to agency intervention it is easy to generate a large number of possible roll out scenarios. Taking five technology options (clip-on, meter retrofit, smart and dumb, SRSM specification, BEAMA specification), four intervention options (market, market tip, new + replacement and fully managed) and six comms options (PLC, broadband, 3G, Wimax and two mixed cases) alone produces 140 combinations. In order to narrow down this range we have provisionally selected least cost or higher NPV options. In doing this we have assumed that all mandates entail that both electricity and gas are smart enabled and that all are either replaced or retrofitted.

3.5 Regulatory Issues for comms technology roll-outs

For certain types of technology options some regulatory changes may be required, since the current regulatory framework does not allow for their economic implementation for use in smart-metering. These are described below:

- **WiMax:** It requires that the spectrum auction scheduled for 2008 goes ahead and a license provided, so that someone can build a WiMax network

- **“Piggyback” Broadband:** It is unclear whether this would be supported under the current regulations for Shared Metallic Path Facility (SMPF) or Metallic Path Facility (MPF). We were unable to get a response from OFCOM on provide a more definite answer. It is likely that a cost model would need to be drawn up and some price regulation applied. It basically needs to be a wholesale and a retail product in order to ensure competitive prices to end users

- **GSM/3G options:** Require changes to the regulation to allow updates of SIMless GSM/3G modems. It was initially thought that regulatory changes would need to be sought to enable 2G services to be supported for the next 20 years to avoid the change-out costs of 2G mobile modems for 3G mobile modems during the life of the meters. Vodafone has a GSM/3G modem which works with 3G networks and if there is no 3G network available will default to a GPRS connection. So this proposed regulatory change will only be needed if SMS is used.

- **The Smart box approach:** This is a technically simple but commercially difficult approach. Issues that need to be resolved are:

  - Who owns the smart box?

  - Who configures the smart box?

  - Can a contract between the communications service provider and the energy retailer be easily facilitated?

Assuming contractual and legal arrangements permit, then the smart box approach can be used to reduce capital and ongoing costs. Configuring the smart box to serve multiple purposes will entail software changes and more complex configuration, it is unreasonable to expect the communications service provider to do this work for free.

The smart box/home-hub communicates with the meter through the appropriate interface. This could be WiFi, Ethernet, or ZigBee/Zwave. Ethernet would require cabling so is less favoured.

If the wireless options are ZigBee and Zwave then the number of components in the electric meter can be reduced, i.e. no WiFi card, which will entail additional cost savings. There is an additional ZigBee/Zwave device within the home-hub/smart box, which can be used to offer communications and control services by any number of applications providers for whatever ZigBee/Zwave devices are within the home.

The benefits of this prospect are quite obvious. Consumers can sign up to a provider for controlling their home appliances (dynamic and remote load management) that is not necessarily the energy supplier, and can use the service for reasons other than just energy use reduction, e.g. security, remote CCTV surveillance, etc.

4 Costs

4.1 Introduction

This section outlines costs for different technology options. Based on interviews and meetings we had with stakeholders, the estimates given below represent the current reflections of the industry players on cost reductions from scale economies. Most of the estimates given below are based on orders of 500,000 items or more. For most of the costs we list in this section we cross-examined, wherever possible, the quotes we have received from different parties. All costs have been corrected in final calculations for optimism bias (see Section 6). None of the costs provided herein include VAT.

4.2 Clip-on CDU costs

Currently, clip-on devices are sold in retail for £50 (Current Cost) or £60 (Electrisave). From our discussions with suppliers, costs can be significantly reduced for large orders. Estimates range from £15 (Current Cost) to £20 (Electrisave), although we have heard of prices as low as £10 or £12.5. For the purposes of our model, we have assumed that clip-on devices will cost £17.5.

4.3 Real Time Displays

The real time display (RTD) unit (this is the component with a LCD that can be placed within the house so as to inform customers directly) of a clip-on can be separately installed with a retrofit meter or a smart meter, although such product does not exist readily in the market. Our assumption is that these displays will cost £15 to £40, depending on functionality, quality and local comms. As a base value we have used the lower range, because of wholesale discounts.

4.4 Dumb meter smart box costs

We were unable to obtain specific cost estimates for these devices although they exist in the market, since manufacturers refused to give us a quote. However, we have estimates for retrofit pulse transmitters, which were around £9. This cost includes a life-long battery. For UK purposes, pulse transmitters can only be applied to meters that have in-built pulse functions; as we were informed the majority of gas meters do not have pulse functions. So for this solution, we have assumed that at least a simple pulse gas meter would be required. Such a meter costs currently around £18. Alternatives, like optical or magnetic readers, can also be used with existing gas meters, although we do not have cost estimates for these. It might well be the case that in some installations it might be more economical to retrofit a meter than to install a new one. We recognise that in this case we over-estimate the cost for the gas meter in this technology.

For the smart box, although we have not been able to obtain specific estimates, we benchmarked its cost to the wholesale cost of a wireless router. This is currently around £15-25. Given that the smart box is relatively simpler and cheaper device than Wi-Fi routers, or that it can be integrated in existing smart boxes, like BT's Home Hub or Tiscali HomeChoice, we estimate that the actual cost of the smart box will be around £8, for very large orders. This estimate includes power supply (£1), LPR transceiver (£5), and memory chip (£2).

If an RTD is included, then the total cost of this solution is estimated at £32 for one electricity meter, with a gas retrofit (pulse meter plus transmitter) adding another £27, without WAN comms costs included. For PPM, we have assumed that this solution is not required to send data back to the supplier, since this technology does not bring about AMM functions. Hence costs for PPM only include a transmitter (£9).

4.5 Core meter equipment costs

4.5.1 Basic Meters

A standard electric meter currently costs £7, while gas meters cost around £18. Prepayment meters (PPM) are more expensive, with electric PPM cost £45-50 and gas PPM around £100.

4.5.2 Standard Meter with Internal Comms

This is the most basic metering solution alternative to Clip-ons, although this technology is not readily available. The cost of a single phase meter with in-house comms capability (Zigbee or Low power radio) is currently estimated by manufacturers at £16. Hence, the whole metering solution, including an RTD, is estimated to cost £31-56 for an electricity meter. Standard pulse gas meters with internal comms is, by proportion, estimated to cost £27. No external comms are included.

4.5.3 BEAMA Minimum Specification Meter

BEAMA has provided cost estimates for the ‘smart-enabled’ metering technology that does not exist readily in the market, but could be developed quickly if required. A mass market roll-out estimate for a single phase ‘smart-enabled’ meter is £20, or £35 for an electricity meter with an RTD.

If this technology is combined with a retrofit local comms solution for gas meters, this would add an additional £9-10.

Smart meters for gas that do not use retrofits are likely to be more expensive. More sophisticated ‘smart-enabled’ meters are likely to cost £30-35 or £40-45 with local comms.

4.5.4 ERA SRSM Meter

A meter that meets SRSM specifications is also not readily available in the market but the manufacturers can develop it if required. Although we were unable to obtain exact estimates for this meter specification, we benchmarked the SRSM meter cost with the cost estimate for the BEAMA meter and build up cost for additional functionality, based on our discussion with industry participants. Starting from the BEAMA spec (£35-60 for an electricity meter), the ERA spec should also have import/export capability, remote switching to debit/credit, advanced data processing capability, remote disconnect function and external, as well as internal, comms.

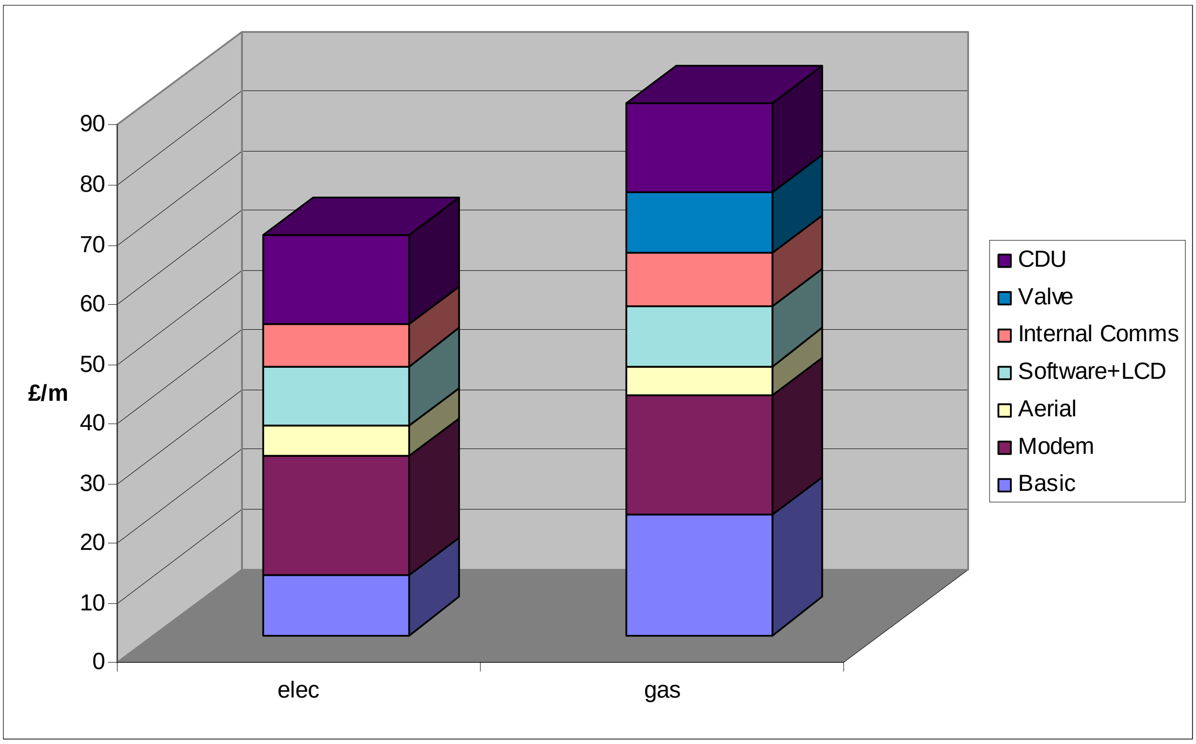
Additional functionality in the electric meter is likely to cost an additional £10. For house installations that require external aerials, these are likely to cost an additional £5. In addition, an external comms module (modem or wifi card) is likely to cost an additional £10 (capex and install). Hence, an electric meter that meets the SMOF is likely to reach £55-60.

Gas meters are more costly. Starting from the current gas credit meter cost, we have added increased functionality features (£10), local and external comms (£20-30), an RTD (£15) and a gas valve (£10). The total for a gas meter that meets the SMOF spec is then likely to reach £75-80 or £80-95 with an RTD.

An indicative build up of these costs (with the provisional add-on of an aerial) is shown in Figure 4-1. It should be stressed that cost build-ups for each metering technology are just indicative, as the exact figures per meter will depend not only on functionality but also the on the type of comms technology, innovation and the roll-out option, all of which cannot be pinpointed currently to a single cost estimate. Hence, the same specification might cost differently under various assumptions.

The SRSM specification includes external comms modules in the meter as standard. This feature entails a risk of technology lock-up for the comms set-up, given that the comms technologies evolve faster than the metering requirements of the energy supply industry. For instance, most SM in the I&C sector that currently utilise GSM networks might have a comms compatibility problem if the mobile phone industry moves to fourth generation networks in the following years. The same is true in the case that comms requirements in the metering market will be served by not one but more comms technologies (i.e. broadband and GSM). In addition, the evolution of alternative wireless networks, like WiMax, might create opportunities for low cost comms for meters that will not be utilised if all meters are using GSM networks. This inherent risk in the SRSM specification risk is reflected by including HAN and WAN comms modules costs in the SRSM cost build-up.

Figure 4-1 Indicative cost build-up for SRSM Specification



4.6 Comms Modules Costs

A large number of communications technologies were considered. The costs for various elements were obtained from known (retail) market rates or from BEAMA, Current Technologies, and from communications service providers where possible. We obtained cost estimates for the following technologies:

- PSTN charged on a usage basis, ie pence per minute
- PSTN charged on a usage independent or flat rate basis
- Broadband charged on a usage independent basis
- "Piggy-back" broadband charged on a usage basis
- SMS
- GPRS
- 3G
- PLC
- WiMax

To estimate a cost for large volumes a discount factor was applied. This was different for different technologies. We applied more or less discount depending on how the technology was currently priced in the market. For example, PSTN call rates are very competitive in the UK, whereas GPRS prices are less competitive, and hence probably have farther to fall.

Table 4-1 Summary of up-front costs for various comms technologies

Technology	Annuitised (mil£)
PLC & SMS	284.6
PLC & Broadband	370.7
PSTN Flat Rate	509.1
PSTN Pay-As-You-Go	509.1
Broadband	615.7
Piggyback Broadband	263.8
WiMax	433.8
GSM SMS	175.4
GSM GPRS	207
3G	269.1
Hybrid 1 (PLC and WiMax)	386.5
Hybrid 2 (P.Broadband & 3G)	265.1

One-off capital costs (including build and installation of HAN, LAN and WAN and setting up of VPN where required) for all technologies were annualised using a 10% interest rate over a period of 20 years. These are summarised in Table 4-1 Summary of up-front costs for various comms technologies.

We have summarised in tables the cost elements involved for each technology, the type of charge, either one-off or recurring, the source used for values in the model, and any discount that was applied to values for volume or other reasons. These are described separately for each technology below.

4.6.1 PSTN

For all existing PSTN lines the contract is between the consumer and the service provider. It is therefore assumed that a new line is installed and that line rental is charged. For this new line the contract will be between the communications service provider and the energy retailer. Table 4-2 outlines cost assumptions for PSTN.

Note that it is assumed that the meter has an Ethernet port for attachment to the modem. No charges for internal wiring were added in the model. It could be argued that these are necessary, although as PSTN is not one of the recommended options we have not done this.

Table 4-2 PSTN Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Line installation	one-off	BT retail website	5%	Difference between wholesale and retail prices is 30%, a margin needs to exist for the service provider.
Line rental	monthly	BT retail website	5%	Difference between wholesale and retail prices is 16%*
Zigbee card in gas meter	one-off	BEAMA/Horstmann	None	
Zigbee card in electric meter	one off	BEAMA/Horstmann	None	
Replacement costs of ZigBee cards – due to faults	Annual at rate of 5%			Estimated at 5% in absence of figures
Modem (56k)	One-off	Retail websites, amazon, ebay	None	
Pence per minute charge	Monthly/quarterly	Tiscali retail website	10%	
Flat rate charge	monthly	Tiscali retail website	50%	On basis that usage will be low

**wholesale prices are available from BT wholesale website*

4.6.2 Broadband

For all existing Broadband lines the contract is between the consumer and the service provider. It is therefore assumed that a new line is installed and that line rental and broadband fees are charged. For this new line the contract will be between the communications service provider and the energy retailer. Table 4-3 outlines cost assumptions for broadband.

Table 4-3 Broadband Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Line installation	one-off	BT retail website	5%	Difference between wholesale and retail prices is very low
Line rental	monthly	BT retail website	5%	
Zigbee card in gas meter	one-off	BEAMA/Horstmann	None	
Zigbee card in electric meter	one-off	BEAMA/Horstmann	None	
Replacement costs of ZigBee cards – due to faults	Annual at rate of 5%			Estimated at 5% in absence of figures
router (56k)	one-off	Wholesale price for tens thousands informal from SP	30%	For much larger volumes
WiFi card in meter	one-off	Horstmann		
Broadband charge	monthly	Tiscali retail website	30%	On basis that volumes are low, and this value still leaves some margin for service provider

4.6.3 "Piggy-Back" Broadband

This service does not exist in the market today, and may need regulatory intervention. However, it may be feasible within the current regulatory framework for SMPF or MPF, i.e. Local Loop Unbundling, and so these types of service may begin to become available within the next year.

As part of this intervention some work would need to be done to establish a fair wholesale cost and hence price. For the purpose of this exercise we have provided a price; although our estimate may be on the low side.

The principle is that the physical metallic path is split into two (or more) logical paths. The consumer has a contract with the service provider for one path, say voice and broadband access for home internet use. An energy retail user has a contract with the communications service provider for the second path. This means that no second line is installed, producing cost savings; in addition the second path, with constrained bit rate attracts a lower charge.

We also assume that the communications service provider finds a way to use a single home hub, for both uses, (these are already provided "free" under many marketing promotions). Under this solution it may also be possible to deploy a router with a ZigBee interface capable of talking directly with the meters, thus reducing the need for the WiFi card in the electricity meter. Table 4-4 summarises our assumptions for costs of this technology.

Table 4-4 Piggyback Broadband Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Zigbee card in gas meter	one-off	BEAMA/Horstmann	none	
Zigbee card in electric meter	one-off	BEAMA/Horstmann	none	
Replacement costs of ZigBee cards – due to faults	Annual at rate of 5%			Estimated at 5% in absence of figures
WiFi card in meter	one-off	Horstmann		
Broadband charge	monthly	Based on a pro rata amount of Tiscali retail's broadband price. We use maximum GB limit per month against meter's data requirements to calculate the amount	0%	The value was so low a discount seemed inappropriate
"Piggy-back" Install & configure charge	one-off	None		The pro-rated rate is so low, it is not worth the comms service provider's effort. Applying an install & configure charge provides a means of recovering costs of software which will be needed.

4.6.4 SMS/GPRS/3G

For mobile phone based technologies we have used existing cost estimates that are available in the market. Note that publicly available GPRS rates are currently astronomical in relation with data requirements of smart metering, however it is reasonable to assume that GPRS pricing may move to a flat rate charging model, like 3G. This would reduce significantly the costs associated with GPRS usage. Table 4-5 outlines sources and assumptions we have used for costing these technology options.

Table 4-5 GSM/GPRS/3G Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Zigbee card in gas meter	one-off	BEAMA/Horstmann	None	
Zigbee card in electric meter	one-off	BEAMA/Horstmann	None	
Replacement costs of ZigBee cards – due to faults	Annual at rate of 5%			Estimated at 5% in absence of figures
GSM modem card in meter	one-off	Horstmann		
SIM purchase	one-off	BEAMA (Swedish case study)	Waived above 1 m units	
SIM rental	monthly	BEAMA (Swedish case study)		
SMS charges	Per text	BEAMA case study	90%	Discount selected after discussions with Vodafone, re volumes and off-peak use of networks
GPRS charges	monthly per meter	Retail price	46%	Based on discussions with Vodafone, re volumes and off-peak use of networks
3G	monthly per meter	based on discussions with Vodafone	46%	Based on discussions with Vodafone, re volumes and off-peak use of networks

4.6.5 PLC (with broadband)

The PLC network acts as an access network reducing the number of broadband links needed to connect the meters. This provides savings on line install, rental and broadband charges. PLC connects meters within homes to a point within the electricity distributor's network. The backhaul costs from these 500,000 sites are considerably lower than for the 27 million sites. In these costs we have assumed that the energy retailers or a separate institution operates the PLC as a not-for-profit network. This assumption underpins our cost element assumptions that are summarised in Table 4-6.

Table 4-6 PLC Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Line installation	one-off	BT retail website	5%	Difference between wholesale and retail prices is very low
Line rental	monthly	BT retail website	5%	
Broadband charge	monthly	Tiscali retail website	30%	On basis that volumes are low, and a margin is required by service

				provider
Zigbee card in gas meter	one-off	BEAMA/Horstmann	None	
Zigbee card in electric meter	one-off	BEAMA/Horstmann	None	
Replacement costs of ZigBee cards – due to faults	annual at rate of 5%			Estimated at 5% in absence of figures
Install costs & capex	one-off	Current technologies	None	
maintenance	annual	industry best practice	None	

4.6.6 WiMax

The WiMax service provider we approached was Utilihub. This service provider does not have their own WiMax licence or network, but is currently negotiating with potential bidders for the WiMAx spectrum. They are ex energy company people and understand the price point which is required. Their current commercial proposal is that electric meters are service for free, while gas and water meters will be charged. We have used this basic assumption in our model for costing WiMax. Further assumptions and sources are outlined below in Table 4-7.

Table 4-7 WiMax Cost Assumptions & Sources

Cost elements	Nature of charge	Source	Discount Factor	Comment
Zigbee card in gas meter	one-off	BEAMA/Horstmann	None	
Zigbee card in electric meter	one-off	BEAMA/Horstmann	None	
Replacement costs of ZigBee cards – due to faults	annual at rate of 5%			Estimated at 5% in absence of figures
router	one-off	Wholesale price for tens thousands informal from SP		
WiFi card in meter	one-off	Horstmann	None	
Flat rate charge	Per meter per year	Utilihub	None	

4.6.7 VPN (Virtual Private Network)

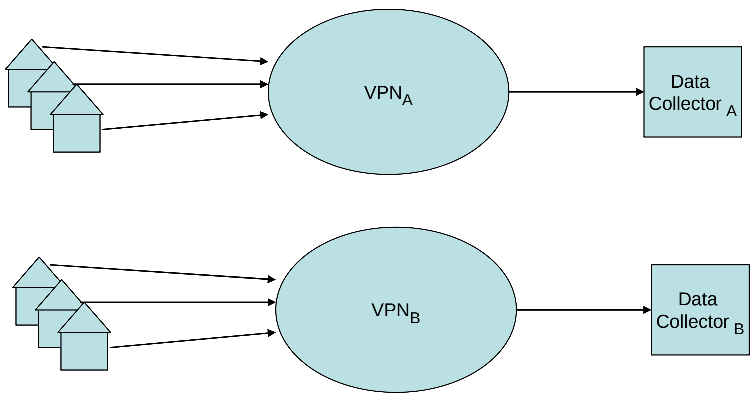
It is assumed that PSTN, Broadband and WiMax options require a VPN. This is to enable the individual access links to be grouped together by the owning energy retailer. It is not possible to get prices for a VPN without issuing an official Request For Quote. They are almost always bespoke.

We have modelled the VPNs as three cost elements;

- a VPN set-up charge a one-off fee related to size of the VPN in a non-linear way
- a charge per link included, a one-off fee
- a management charge per link.

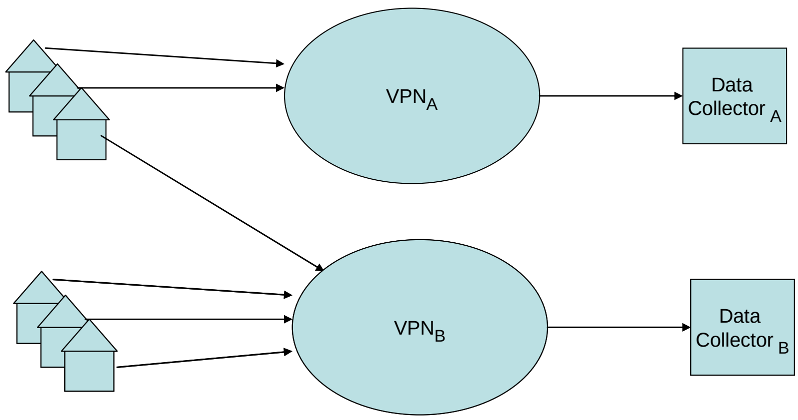
The mobile options do not need a VPN as they have an alternate approach to grouping the links.

Figure 4-2 VPN Architecture



A VPN will be important in allowing efficient change of supplier process, as the end point of the churning customer will be transferred logically, not physically, from one retailer's VPN to another. This eliminates the need for expensive cancellation of contracts and re-installs of communications equipment. Each retailer would have a framework agreement with an agreed number of connections as a minimum and possibly an agreed number of changes per year/month. This would allow changes amongst the retailers as customer churned without the need for individual contract renewals etc. The impact of a customer churning from utility provider A to utility provider B is shown in Figure 4-2 and Figure 4-3 . If the VPN provider is the same in each case then there will be a charge for a change to the VPN. If there are two different communications providers there may be additional migration charges, or new set-up costs if a different WAN technology is used.

Figure 4-3 VPN Architecture with many data collectors



4.6.8 Comms Usage Rates

We have modelled costs for two communication scenarios: a low usage and a high usage scenario for both gas and electric meters. The low usage reflects the standard current minimum metering requirements (quarterly billing) for both gas and electric accounts. The high usage reflects advanced metering requirements that include:

- Weekly consumption data transfer
- Monthly tariff updates
- Daily meter alerts
- Weekly debit balance adjustments
- Monthly updates for access control policies
- Quarterly software updates

The two scenarios can represent, by rough approximation, AMR and AMM functions respectively.

If there is good standardisation such that all suppliers can read all meters then this can be handled commercially through meter operators.

Table 4-8 Usage: High Scenario

High end usage	Scenario 1								
						Total data usage			
Table 1a: Electric Meter Interaction	Total Bytes per Transaction per Meter	Frequency pa	Bytes per h/h pa	% of Porfolio	Number of Household Meters (millions)	Total M Bytes/pa	Minutes	SMS per Transaction	Number of SMS (millions)
Meter reading - non interval tariff, simple tariff	255	52	13,260	100%	27	352,716		2	2,766
Meter reading - interval tariff	455	52	23,660	100%	27	629,356		4	5,533
Tariff setting	315	12	3,780	25%	27	25,137		3	239
Meter alerts	235	365	85,775	5%	27	114,081		2	971
Debit balances	415	52	21,580	20%	27	114,806		3	830
Access control policies	465	12	5,580	50%	27	74,214		4	638
Software application	15,215	4	60,860	10%	27	161,888		108	1,149
Total Mbytes per h/h pa			**0.214**						
Total SMS pa									**12,127**
Total M Bytes pa						**1,472,197**			
Usage in minutes over 56 K modem							**3,505,231**		
						Total data usage			
Table 2a: Gas meter Interaction	Total Bytes per Transaction per Meter	Frequency pa	Bytes per h/h pa	% of Porfolio	Number of Household Meters (millions)	Total M Bytes/pa	Minutes	SMS per Transaction	Number of SMS (millions)
Meter reading - non interval tariff, simple tariff	255	12	3,060	100%	22	68,544		2	538
Meter reading - interval tariff	455	12	5,460	100%	22	122,304		4	1,075
Tariff setting	315	12	3,780	25%	22	21,168		3	202
Meter alerts	235	365	85,775	5%	22	96,068		2	818
Debit balances	415	52	21,580	20%	22	96,678		3	699
Access control policies	465	12	5,580	50%	22	62,496		4	538
Software application	15,215	1	15,215	10%	22	34,082		108	242
Total Mbytes per h/h pa			**0.140**						
Total number oif SMS pa									**4,110**
Total number of M Bytes pa						**501,340**			
Usage in minutes over 56 K modem							**1,193,667**		

A framework agreement between each utility supplier and the communications service provider should allow a particular home to be moved from utility supplier A's to utility supplier B's account, within the same service provider. If utility A and B are using a different communications service provider this would involve some physical changeovers, routers, SIMS etc and some logical changes. In the case of broadband the difficulties of service migration between communication service providers are well documented [11].

Table 4-9 Usage: Low Scenario

Low end usage	**Scenario 2**								
						Total data usage			
Table 1b: Electric meter Interaction	**Total Bytes per Transaction per Meter**	**Frequency pa**	**Bytes per h/h pa**	**% of Porfolio**	**Number of Household Meters (millions)**	**Total M Bytes/pa**	**Minutes**	**SMS per Transaction**	**Number of SMS (millions)**
Meter reading - non interval tariff, simple tariff	10	4	40	100%	27	1,064		1	106
Meter reading - interval tariff	10	0	0	100%	27	0		1	0
Tariff setting	60	0	0	25%	27	0		1	0
Meter alerts	20	0	0	5%	27	0		1	0
Debit balances	20	0	0	20%	27	0		1	0
Access control policies	25	0	0	50%	27	0		1	0
Software application	1,000	0	0	10%	27	0		8	0
Total Mbytes per h/h pa			**0.000**						
Total number of SMS pa									**106**
Total number of M Bytes pa						**1,064**			
Usage in minutes over 56 K modem							**2,533**		
						Total data usage			
Table 2b: Gas meter Interaction	**Total Bytes per transaction per meter**	**frequency pa**	**Bytes per h/h pa**	**% of porfolio**	**Number of household meters (millions)**	**Total M Bytes/pa**	**minutes**	**SMS per transaction**	**number of SMS (millions)**
Meter reading - non interval tariff, simple tariff	10	4	40	100%	22	896		1	90
Meter reading - interval tariff	10	0	0	100%	22	0		1	0
Tariff setting	60	0	0	25%	22	0		1	0
Meter alerts	20	0	0	5%	22	0		1	0
Debit balances	20	0	0	20%	22	0		1	0
Access control policies	25	0	0	50%	22	0		1	0
Software application	1,000	0	0	10%	22	0		8	0
Total Mbytes per h/h pa			**0.000**						
Total number of SMS pa									**90**
Total number of M Bytes pa						**896**			
Usage in minutes over 56 K modem							**2,133**		

The process of changes is simplified if all the utility providers agree to use the same communications service providers. A tender process should be established whereby 2-3 service providers are selected as preferred suppliers for a period of years. It might be a good idea to have service providers offering a range of the options or one per technology.

Before any such tender is issued further work is required to clarify the exact requirements of the system. There may be a number of parties interested in data for each meter; the supplier, the meter operator the service provider, and possibly the meter asset provider. In a competitive market place these organisations may change over time, so the communications service provider needs to track these changes in order that only the correct parties get the information.

Our assumptions for network usage for the two scenarios are shown in Table 4-8 and Table 4-9. On top of these assumptions, we have assumed that comms usage charges decline at a rate of 6% per year due to technical innovation and increased competitiveness. This is a well established assumption that has empirically been certified in the comms industry in several previous technology applications.

4.7 Meter installation costs

Installation costs are likely to vary depending upon the method of delivery and the period of the roll-out. Ofgem has assumed flat installation costs of £30 per meter. This figure is likely to be lower if a systematic managed roll-out programme is employed. Cost figures provided by the Association of Meter Operators (AMO) range from £20 to £30 per electricity meters, while figures from National Grid range from £50 to £60 for gas meters.

We have been officially informed by AMO that installation costs are likely to be the same regardless of the roll-out option (managed against scattered). At a first glance, this claim seems counter intuitive because of differences in job density and travel time between jobs when comparing a street-by-street roll-out to a scattered roll-out. Previous work by Frontier Economics [55] supports this argument.

However, current meter installation of new and replacement meters is conducted with high efficiency and low costs, although it is done at a scattered basis with low density. This is the case because meter operators schedule carefully geographical dispersion of jobs so as to minimise travel time, and use appointments to make sure that they will have access to the property so that they achieve high access rates.

In addition, a managed programme would still require a ‘mop-up’ period, which can be long and is likely to cost significantly because it would be done on a very low density.

In the case of an accelerated roll-out, meter operators would have to employ and train up to five times more staff. Higher demand for skilled labour in the MO business is likely to drive up compensation packages, especially in the south-east where density is higher. MO would have to make provisions in their charges for redundancy payments of the workers they will not need after the roll-out period is over.

In addition, MO would require additional capex (for vehicles, equipment, buildings and associated overheads) to deliver an accelerated roll-out, hence driving up their charges.

Furthermore, meter operators suggest they would have to make provisions for the ‘feast-and-famine’ period, which will have an impact on their business in the case of an accelerated roll-out. It should be noted that none of the above arguments were taken into consideration in the Frontier work.

Taking all these arguments into consideration, we have concluded that potential efficiencies from an accelerated roll-out are offset by higher operating costs that would occur in the MO business. Hence, we find that AMO suggestions on meter installation costs are plausible.

To capture this possibility, we have assumed that installation costs are not different for each roll-out option, as spread over a period of more than 20 years. Sophisticated meters, that require customer introduction on their properties and functionality, are assumed to require slightly higher installation costs.

However, we have assumed that a dual fuel roll-out will be more cost efficient in terms of installation costs, since dual fuel meter replacement will not require an additional visit for replacing the gas meter. This would certainly incur a cost saving. There’s no disagreement among stakeholders in the industry that a dual fuel roll-out would be cost efficient. Hence, we have assumed a £10/ meter reduction for dual fuel installation.

4.8 HAN Installation Costs for Comms

Installation costs for the comms vary depending on which technology is used.

In the designs considered in this report for HAN installation costs, the costs of a ZigBee/Zwave device for a gas meter was taken as £20 and for an electricity meter £8.

The cost of a GSM modem was taken as £5 (Siemens have claimed that the price could drop to this level for modems specifically designed for use as modems rather than with expensive mobile handsets).

The cost of a PSTN 56K modem was taken as £4. All modems were assumed to be integrated in meters or concentrators.

For broadband options, the cost of the router was taken as £18. For PLC cost per household for all capex and installation was taken as £35.

For the piggyback broadband option the cost of installation was assumed to be £10 per household. This is assumed to be an allocation of the cost of the household router. Also included is the cost of a WiFi receiver in the electricity meter £20.

4.9 Stranded Assets

Roll-out options that involve accelerated meter roll-out, would necessarily impose premature retirement of meter assets that have not reached their full economic life. In other words, several millions meters would have to be stranded. This prospect would generate stranding costs for different parties in the industry. The amount of stranded assets depends largely on the roll-out option: the faster the roll-out, the higher mean residual value of the stranded asset and hence the higher stranding costs are. We depict the relation between asset retirement age and stranding cost in Figure 4-4. Gas meters cost more and have shorter life than electric meters.

Ownership, metering charges and liability from stranding are not currently universal in the UK metering market. Electric meters are mostly owned by DNOs. Under current practice, meter installation costs are charged up-front, while asset costs are usually annuitised over the economic life of the meter and added to overheads and then charged as an annual fee. In the case of premature retirement of the assets, the suppliers stop paying the fee and do not bear the stranding cost that stays with the DNO. Suppliers face only the sunk cost of meter installation.

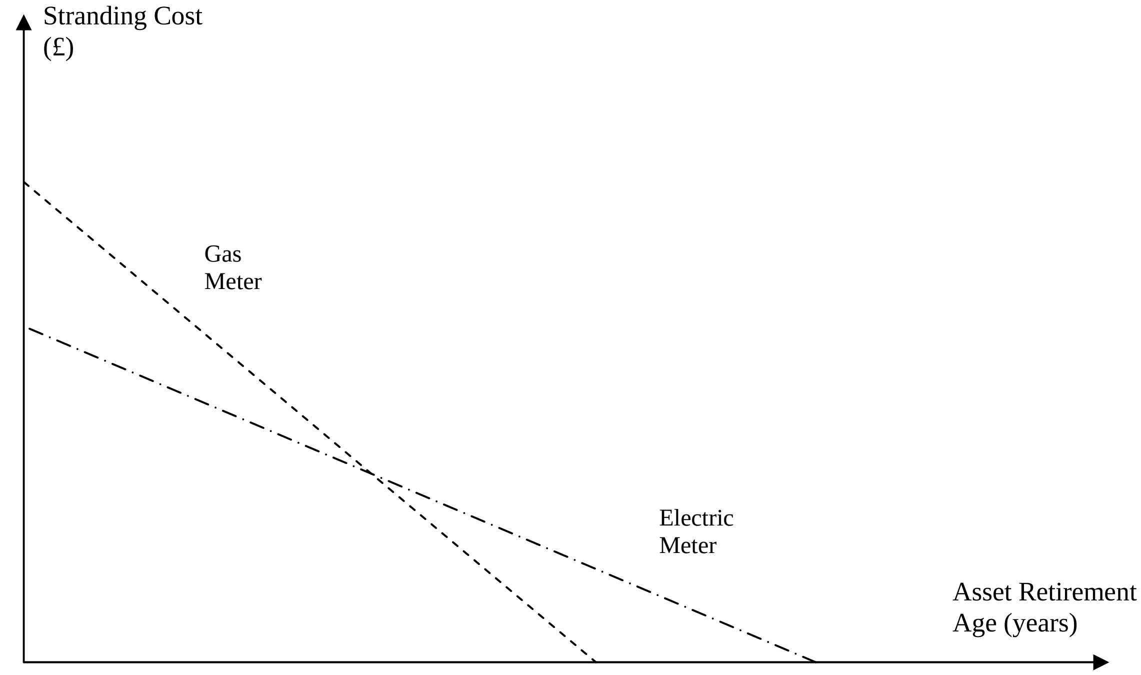
At this point it is useful to provide a definition of sunk costs:

Sunk costs are costs that have already incurred before the evaluation date of a project and cannot be recovered. Therefore they cannot be counted in investment appraisal of a project. [23,24]

Commercial meter operators (CMOP), since the deregulation of the metering market in 2001, have been entering into contracts with suppliers, especially British Gas, that include asset cost, installation cost, overhead and margin. These contracts are estimated up to £9 million by 2010 by CMOP. In the case of massive premature retirement, the suppliers bear the full stranding cost *which can be recovered* from their consumers. Therefore this stranding cost is not sunk and would occur for all accelerated meter roll-outs. However, for a GB PLC assessment this cost is still excluded as they would have been incurred irrespective of whether the new meters were fitted prematurely.

Most gas meters, except for those that are commercially owned, are currently owned by National Grid. National Grid has been providing MOP services to suppliers under two types of contracts: up to 2001, annual charges included asset cost, installation cost and overheads; but from 2001 NG changed its charging policy and excludes from rental charges installation costs, which are paid upon installation. The liability for stranding under NG contracts remains with the suppliers, who (except for EDF) face additional premature termination charges.

Figure 4-4 Stranded Asset Retirement and Costs



We have been informed by suppliers that they expect that all stranding costs, in the case of accelerated roll-out will be passed through to consumers. In the case of a managed roll-out programme, suppliers envisage that a ‘pot’ will be created that will absorb all stranding. The total amount will then be passed evenly to all consumers over a period of time. In the case of a market based roll-out that involves significant stranding costs, suppliers will still be free to pass these costs to consumers, although the expectation of Ofgem is that there is a chance that competition might inhibit 100% pass-through to consumers.

While stranding costs are not included in the GB PLC analysis, they certainly factor in impact assessments for consumers, suppliers and meter asset owners. Nonetheless, it should be stressed that stranding costs occur only in accelerated scenarios and are definitely not a sunk cost (at least not in the way that sunk costs are commonly understood) if a 100% pass-through is allowed. Liabilities on suppliers will be passed through to consumers. The liabilities on DNOs will only be passed through to customer, via increased Distribution Use of System (DUoS) charges, if Ofgem allows this. Even so, all stranding costs is likely to be recoverable in the real world.

In our model, we have assumed that stranding occurs only in the regional franchise, market tip-point and market tip fast rollout options. Total stranding is calculated to £ bil 2.3, 1.2 and 1.5 respectively. Annuitised values, assuming a 10 year recovery and interest rate of 10%, are £ mil 378 for the first option, £ mil 169 for the second option and £mil 194 for the third option; these estimates translate to an average of £7, £3 and £4 per meter per year respectively for 10 years.

4.10 Settlement and IT costs

We understand that suppliers do not intend (at least until there is a very high uptake of smart meters) to use measured half hourly profiles for settlement purposes. If this is the case there is no impact on settlement systems. There may be some migration from profile 1 (unrestricted) to profile 2 (two-rate or E7/E11) and the creation of more Standed Settlement Configurations (sub-profiles), however this should be easily handled with the current systems. However, once a decision to use measured half hour data is made, suppliers and central settlements would need to modify the existing data processing requirements. Previous experience from Ontario shows that the new IT system, for data management, settlement and storage is likely to be needed before the roll-out starts. Costs would be non trivial, but still a small fraction of the costs of developing the initial “1998” settlement infrastructure. Suppliers estimate that a one-of cost of around £10 mil, would be required for a new settlement IT system and an additional annual cost of £ 1 mil, for operation and maintenance.

4.11 Meter Operation and Maintenance

Under current market arrangements, meter operators are required to undertake at least one visit per two years for visual inspection of the meters. This visit might also involve maintenance functions. Industry estimates for a standard site visit are £10, although this cost might change with smart metering, because of comms faults. SM maintenance costs are widely uncertain, because an integrated solution with a comms network has never been tried in the UK. For sophisticated meters with comms networks, we have used the assumption that these costs will be 2.5% of capital costs for the asset. For clip-ons we have assumed an annual cost for batteries.

Meter reading costs during the roll-out period are likely to increase because of lower densities. In our model, this increase is modelled as doubling of the pavement meter reading costs half way through the roll-out period. Once all legacy meter are replaced, we have linked meter reading costs with comms network charges.

4.12 Legacy Disposal Costs

These are likely to be substantial, especially for gas meters. We have assumed that it costs £1, on average, to dispose of the mercury from a gas meter in an environmentally safe manner.

4.13 Legal, institutional and planning costs

A managed programme will require establishment of at least two institutional bodies, an Authority that will deliver the programme and a Meter Registry Agent, that will handle the stranding costs. In addition, contracts will have to be made between operators, suppliers and franchisees. We have assumed that a managed programme will require a total of £ 300mil to set up and deliver the managed programme. We have seen estimates from suppliers ranging up to £ 900mil.

4.14 Energy and carbon costs

Sophisticated meters, RTDs and comms exchanges require power to run. We have included this by assuming that a meter consumes 2 watt per hour (Wh), the RTD 1.3 Wh and the overall energy requirement of SM comms is 2.5 Wh. In addition we have included the carbon cost that SM energy requirements imply. For carbon, we have used Defra guidelines to include the shadow price of carbon, although, for the sake of simplicity, we have not accounted for greenhouse gases other than CO_2 .

There is certainly a carbon content in production and transportation of a new meter and disposal of an old meter. This carbon content ideally should be netted off the carbon savings arising from lower energy use. However, we were unable to obtain data on the carbon intensity over the whole lifecycle of a meter. This carbon content might be significant, given that almost all electric meters are manufactured in China and shipped over to the UK. Due to lack of data, we have assumed that all meters are carbon-neutral throughout their lifecycle.

Table 4-10 summarises the main costs for metering, installation and maintenance, as used in our model.

Table 4-10 Summary of Asset, Installation and Maintenance Costs (w/o comms)

Costs (£/m)	Elec	Elec PPM	Gas	Gas PPM	Comments/Source
Asset					
RTD Only	15	15	15	15	Benchmarked against current clip-on prices, BEAMA range 15-40
Clip-on Wholesale	17.5	17.5	-	-	Mid-range value estimate from currentcost (15) and electrisave (20)
Basic Meter	7	45	18	100	BEAMA, Suppliers, MO
Simple Meter with Local Comms	16	54	27	110	BEAMA’s uplift (£9) for local comms module or retrofit in the meter
Dumb+Smart	17	9	27	9	Adapted retrofit and box for electric, local comms and meter for gas, transmitters only for PPM
BEAMA Min Spec	20	58	31	110	BEAMA’s quote for gas and electric, adapted PPM for local comms
ERA Min Spec	60	60	80	80	BEAMA, Suppliers
Installation					
Clip-on	0	0	0	0	Plug’n’Play
Basic Meter	20	30	40	50	Meter Operators

Costs (£/m)	Elec	Elec PPM	Gas	Gas PPM	Comments/Source
Simple Meter with Local Comms	20	30	18	18	Meter Operators/Gas Retrofit
Dumb+Smart	10	0	10	0	Plug'n'Play/Retrofit
BEAMA Min Spec	20	30	40	50	AMO
ERA Min Spec	30	40	60	70	AMO
Maintenance					
Clip-On	0.5	0.5	-	-	Battery
BEAMA Min Spec	0.5	1.5	0.8	2.8	BERR estimate 2.5% of capital costs
ERA Min Spec	1.5	1.5	2.0	2.0	BERR estimate 2.5% of capital costs

4.15 Summary

In summary, capital, installation and O&M costs for meters and comms comprise of the largest part of overall costs. Capital costs and recurring charges for comms are another big part of costs, but they only occur with technologies that bring about AMR or AMM functions. Recurring charges for comms, however, are expected to decline sharply; in our model usage charges are projected to decline at a rate of 7% per year.

Capital costs and installation costs for meter assets are given in Figure 4-5 and Figure 4-6. These data include all technology embedded in the meter, local comms and CDU. The figures do not include meter operation and maintenance costs. In short, the SRSM set-up is the most costly one and also entails the highest installation costs.

A summary of typical cost allocation is given in Figure 4-7 Typical Cost Distribution (Sophisticated Meter with PLC & Wimax) for a sophisticated SRSM meter with PLC and Wimax, where capital costs account for about 41%, installation and O&M for another 27% and comms for 32%. With the comms technologies and industry moving very fast, it should be noted that the SRSM specification, which is fully comms enabled, entails the risk of comms technology lock-up from the onset. This risk is reflected by the cost of pre-determined comms modules in the SRSM meter before comms capabilities are identified in the market.

We have identified several other cost categories that are related to roll-out options not technologies. Out of these, stranded assets are the most significant ones and depend largely on the roll-out option.

Figure 4-5 Summary of Meter Capital Costs

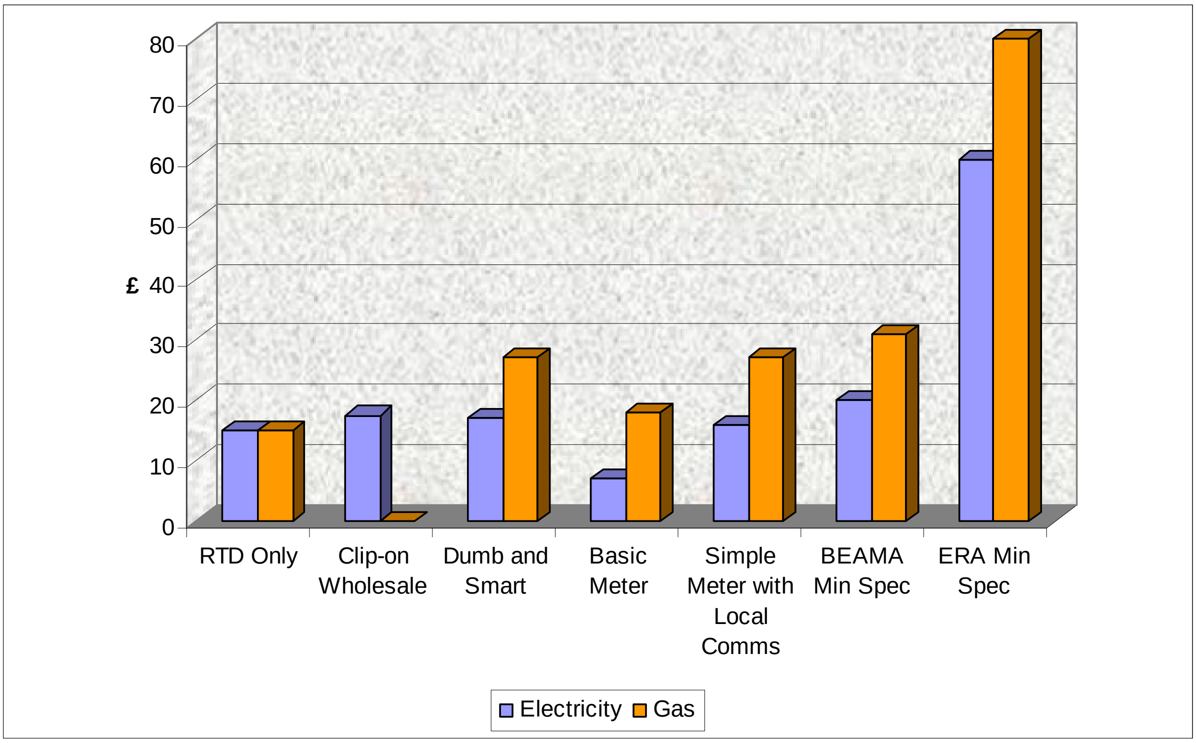


Figure 4-6 Summary of Installation Costs

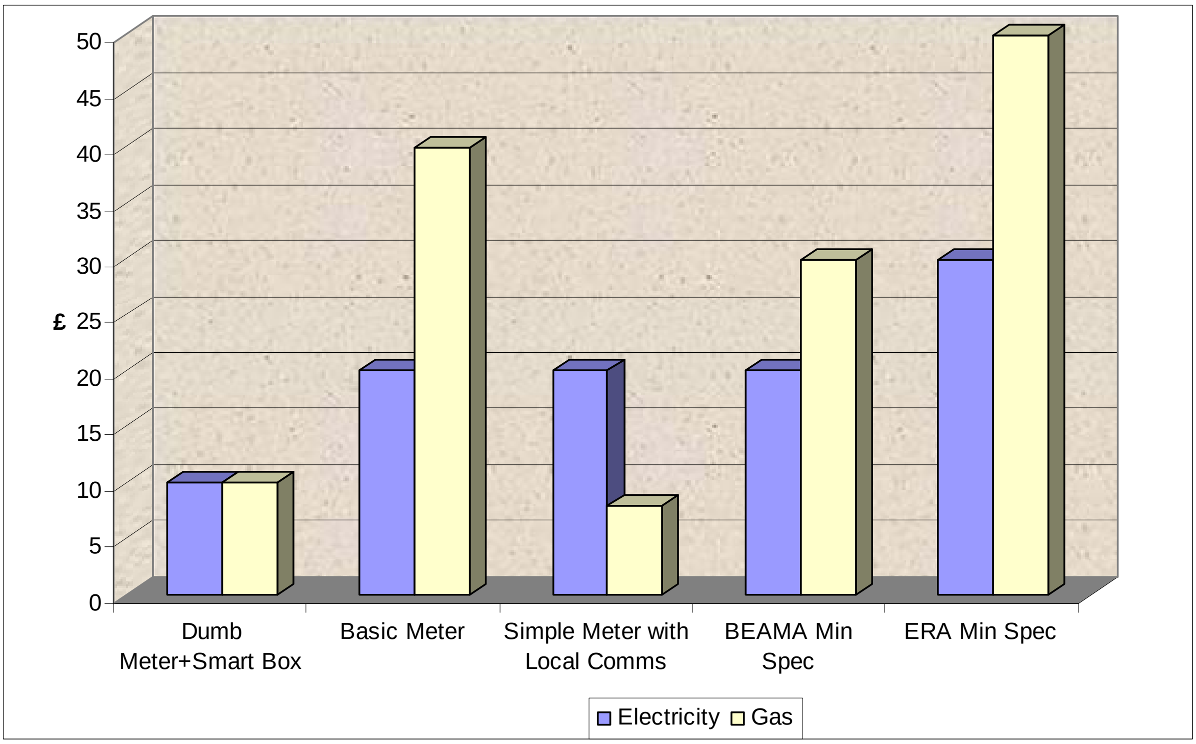
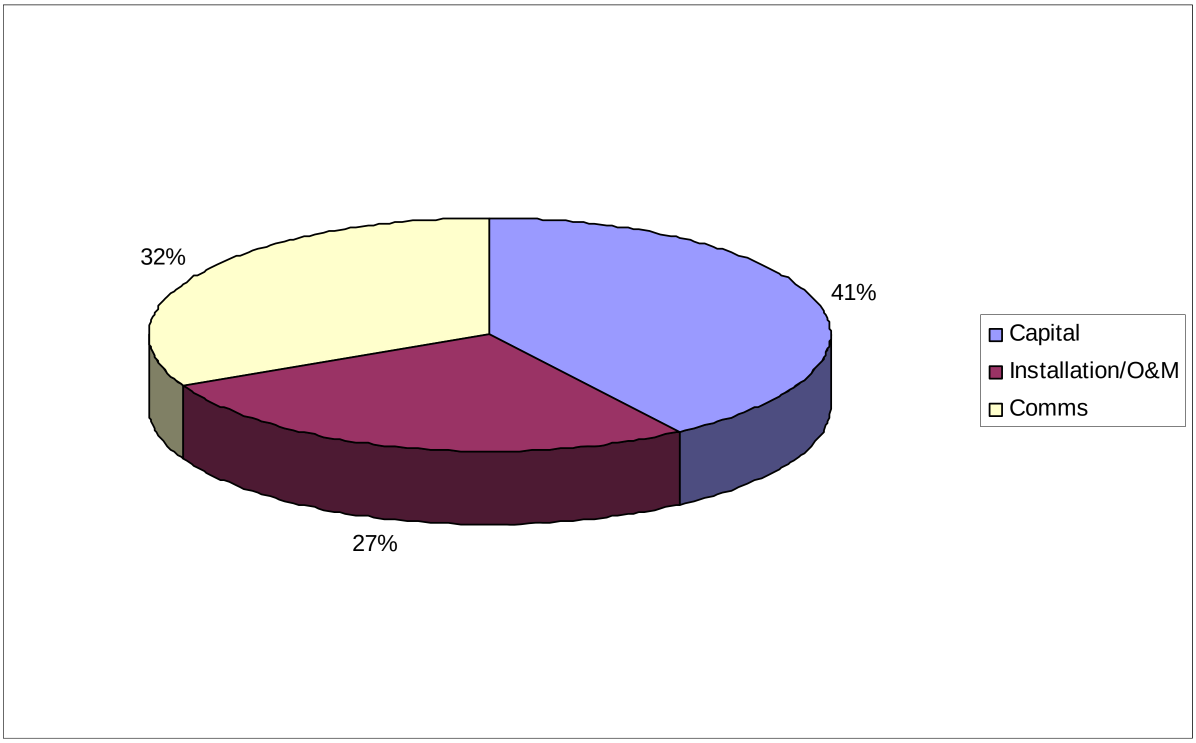


Figure 4-7 Typical Cost Distribution (Sophisticated Meter with PLC & Wimax)



5 Benefits

5.1 Introduction

The benefits of smart metering are less well defined and more uncertain than core metering costs and installation. This reflects the lack of prior experience in the UK for smart meters, paucity of data on consumer trials and the comparatively limited assessments undertaken by suppliers and other parties of the impacts of smarter metering on their costs and sales.

Much of what is covered here is therefore of a tentative nature or else it is drawn from suppliers and other parties' analyses. In reviewing and compiling the benefits we have largely focused on the benefits as seen by "GB plc", in other words the real resource cost impacts, which includes the social benefit of avoided carbon emissions. Distributional impacts on the key parties including consumers, suppliers, meter asset owners and operators are examined in another section.

The benefits seen from the national perspective are reviewed under the categories of consumer benefits, supplier and distribution operator benefits. The categorisation is based on the agent whose action brings the benefits rather than the party which gets the benefits.

5.2 Consumer Benefits

5.2.1 Energy savings

The benefits relating to energy savings (along with peak load reduction) are probably the most uncertain of all. It is difficult to make hard conclusion from previous studies, literature reviews or experience from smart meter roll-outs in other countries because of the often very different contexts, market structures and policy objectives of studies.

Energy savings are not easy to quantify, either in terms of quantity and persistence. There is also an issue as how to value the savings. It is widely assumed that feedback on quantity and cost of energy used on prompt basis (real-time, hourly, daily, weekly, monthly) will deter consumers from using energy wastefully, and hence reduce consumption. The evidence also suggests that there is a wide range of consumer reaction to messages, depending on the income and lifestyle patterns of households, how information is presented, availability of supporting advice and access to facilities for energy management.

Generally one would expect that where a customer volunteers to have smart metering the savings would be higher than where a customer is provided such equipment as part of mandated programme of replacements. However, on the other hand it is possible that if strong community awareness could be raised as part of a managed rollout then energy saving could be higher than individuals acting alone. Lacking evidence to the contrary we have assumed that consumer energy saving behaviour is the same irrespective of how the technologies are rolled out.

There is a growing body of evidence that money saved on energy savings will be spent on other goods and services, which means there is an indirect offsetting increase in energy use. For the purposes of this study we have ignored this so-called "rebound effect" [22].

None of the previous studies appear to have taken into account the energy requirements of the metering, display and comms equipment, which should be included in order to provide a net energy savings. Our assessment is that consumption from such equipment and the associated support systems could easily reach 0.75-1% of the residential sector's energy consumption.

Ofgem's cost-benefit analysis assumed a 1% energy saving realised from smart meters, which is at the lower end of the saving (1-3%) reported in the Owen and Ward (2006, 2007). Other studies have been more optimistic. Energywatch gives a range of energy saving of 3.5-7%. Darby's literature review of 2006 reveals a wide range of estimates from different studies around the world including some making savings of 15% savings or more a year. All these appear to be gross savings, with no netting out of own equipment consumption. We have summarised previous energy savings estimates for the UK in Table 5-1.

For our analysis we have split consumers into three categories of enthusiasts, followers and laggards, and then applied different saving rates. In our central case, the weighted average for our gross saving is 2.8% for electricity, 2% for gas credit and 0.5% for gas PPM. We have also tested sensitivities which provide savings up to 5% for electricity credit meters and 4% for gas credit users, with corresponding improvements for PPM.

Previous analysis (by Ofgem and BERR) has valued the energy savings on the basis of the energy component (assumed to be about 35%/50%) of the residential tariff or average annual bill (for electricity and gas, respectively). There is some merit in this approach, although the energy percentage needs to be adjusted up by the technical loss rates on the transmission and distribution networks (about 8% combined for electricity and 3% for gas). Also the energy component should reflect expectations of future energy costs, including for electricity the value of EU Allowances (carbon emission allowances). Making allowance for the higher energy costs and the losses increases the energy related component to almost 50%, or 4.5p/kWh for electricity and 55% for gas.

All this assumes that residential consumers energy costs are based on base-load (or flat) prices, which is not the case in practice. The patterns of residential load for electricity and gas both show marked daily and seasonal variations, with annual average load factors averaging 37% and 53%, respectively. Given, that wholesale energy prices are higher at peak periods this implies that the average price of meeting the residential load shape is higher than the base-load price. In recent years this market premium has been about 10-15% for both electricity and gas. Adjusting for this peaky profile premium increases the value of energy to 5p/kWh and 2.5p/kWh for electricity and gas respectively.

Of course, this reflects a short run value of energy saved, as no allowance is made for avoided overheads, investment and operating costs of network operators and retailers.

On a national basis, assuming an average electricity and gas consumer uses 4,000kWh and 25,000kWh a year respectively, the annual value of the savings works out to £5.60 for electricity and £6.25 for gas.

Residential consumers making energy savings will capture the full tariff price of the energy, assuming they have no standing charge element in their tariff. Their suppliers will therefore see the loss of the full tariff price. The suppliers energy purchase costs should fall in direct proportion, while both transmission and distribution charges could see significant reductions depending on whether the energy saving is matched by a similar load reduction. So perhaps 3p out of 4p of the transmission and distribution charges will be offset. However, the supplier's own business costs are largely fixed, in the sense of being weakly correlated with customer numbers (and even less so with sales). The implication of this is that energy savings will squeeze the margin of suppliers, perhaps by around 2p/kWh.

Table 5-1 Summary of Consumer Benefits: UK Existing Estimates

Consumer Benefit (source and type)	Elec Credit/pa	Elec PPM/pa	Gas Credit/pa	Gas PPM/pa
Ofgem				
Energy Savings	1.33	0.66	2.22	1.11
TOU Tariff	1.33	1.33	2.22	2.22
Peak Load Shift	7.2	7.2	1.6	1.6
Avoid PPM	1.1	0	1.1	0
Total Ofgem (£)	10.96	9.19	7.14	4.93
Energywatch				
Energy Saving	6.3-12.6		8.6-17.4	
TOU Tariff	14.5			
Avoid PPM	6.3		6.3	
Total Energywatch (£)	27.1-33.4		14.9-23.7	
Sustainability First				
Energy Saving (1-3%)	1.3-4	0.6-1.9	2.2-6.7	1.1-3.3
	Electric	Gas	Gas & Electric	
ECI (Darby)				
Energy Saving – 7 UK studies (%)	3-14%	5-22%	3-13%	
TOU Tariff (% shift load)	11-25%			

Note: The Darby study contains more studies from other countries, and quoted savings range from 1% to 27% for feedback, 0% to 13% from improved billing and 5% to 27% from TOU tariffs. The research design, form of feedback and control methods varied widely.

5.2.2 Peak load shifting and reductions

(i) Peak load shifting and TOU tariffs

The potential of shifting peak load is not universal across consumers and is more significant in households with storage heaters. Beyond heating, a small percentage of peak load (5-6%) is accounted for by appliances (dishwashers/washing machines and driers) that consumers might be prepared to run during off-peak periods.

In practice, savings to customers from shifting would be modest and customers would need to be given a financial incentive through time-of-use (TOU) tariffs, unless some kind of automated load management was combined with a single rate tariff.

While a significant proportion of peak load could in principle be shifted, it is difficult to structure a TOU tariff that provides a strong enough incentive to persuade customer to run dishwashers and washing machines in the off-peak period, without increasing their overall costs, as most on-peak use is not moveable. A tariff with low price period of several hours at night would offer the best prospects, but a high take up is unlikely, given the low savings and the requirements that consumers run time delay programmes. There are also issues as whether consumers will run noisy appliances at night and whether they would be happy to leave washing in machines for several hours before attending to them in the morning. We therefore estimate that 20% of households would take TOU tariffs and shift load, giving us an average reduction of 1.0% (20% achieving a 5% saving) on peak load. Due to the profound uncertainty of the percentage of people taking TOU tariffs, we have examined this assumption stochastically.

There will be a cost related to supporting TOU tariffs (in terms of additional data collection and processing, billing and settlement) which needs to "netted off" the value of peak load reduction. Neither Elexon nor the energy retailers believe that these costs will be significant. They argue that existing settlements arrangements using Standard Settlement Configurations (SSCs), are likely to be sufficient to handle most tariffs. Suppliers acknowledge that they will probably need to modify billing systems, but this is likely to be part of a continuing upgrade of systems as they seek to present new packages to consumers. We feel this is a convincing argument and so have not included any additional settlement costs.

(ii) Peak load reduction

It is important to remember that if there is significant energy saving, then there would also be an impact on peak load. This is because savings are likely to occur across all periods (energy conscious consumers do not revert to their old behaviour at peak). There is little evidence to suggest that peak load reduction is less than overall energy, in fact it could be greater since some energy measures – like installing low energy lighting, will have a greater impact at peak. We have taken a prudent view and assumed that percentage energy saving will be matched by the same percentage reduction in peak load.

(iii) Value of peak load saving

Estimating the value of peak load savings is also not straight forward. There are a number of complications.

Taking a long time frame, the value of peak load reduction will comprise avoided investment costs in both generation and network assets. On a shorter time horizon, the value would be approximated by prices for reserve, transmission use of system (exit) charges and the MW related part of distribution use of system charges. An alternative approach would be to estimate the impact of the reduction in load on the loss of load expectation and then calculate the benefit as reduced value of un-served energy.

The IEA-DSM studies also indicate that the value to the electricity industry is most if load shifting is firm. In this context, automated load management, using tele-switches and turn-down on appliances such as refrigerators/freezers and thermostats (which can be combined with a simple energy tariff) would make a more valuable contribution to peak loads management than “unfettered” TOU tariffs.

One way to estimate the avoided investment costs would be to run a generation and transmission planning study and test the impact of varying peak load. An efficient market system should provide a very similar configuration. Such a system planning exercise is beyond the scope of this study, however, we understand that the costs will fall in the £350-550/kW range for generation and £50-80/kW for transmission. These costs need to be annuitised after which an annual opex overhead needs to be added. This provides a cost around £60/kW for generation and £10/kW for transmission. We have assumed a figure of £25/kW for distribution, which gives roughly £100/kW.

Significant energy savings for gas would also be expected to bring about similar peak load reductions for gas, which could be evaluated on the basis of avoided investment for production/storage and transport. We have not yet applied this in our model. The preliminary estimate is a value of £35/kW, a third of electricity’s costs.

5.2.3 Carbon savings

We have calculated the carbon emissions from projected energy savings using Defra’s latest guidelines. However, we have netted off from the shadow carbon price the value of carbon passed through in the wholesale electricity price from the opportunity cost of EU Allowances. We have also netted off the carbon emissions related to the energy used by the metering system equipment itself, although we have not taken into consideration the embodied carbon emissions in manufacturing, supplying and installing this equipment. To do so, we have assumed a fixed EUA price of €20.

5.2.4 Quality of Service

In previous studies, a number of benefits relating to quality of service have been mentioned, such as consumers’ avoided aggravation/angst relating to inaccurate estimated bills and avoided time waiting at home for meter readers.

Energywatch had estimated the benefits of avoided time spent on making complaints to suppliers at £60m a year or £1.31/ meter. This was on the basis that consumer time matched that of suppliers and consumers’ time was valued at the minimum wage of £5.35/hour. On the basis that suppliers receive around 4 million complaints a year (according to Energywatch) then this suggests the average cost per complaint is £15, which implies some complaints must be very costly since the great majority would be handled by less than 30 minutes on the phone.

Energywatch has also derived an avoided “waiting in time” benefit, again based on using the minimum wage (and in this case one reader visit a year and a 1 in 6 need for occupier to stay in). On the basis that all meters were smart this gives an annual benefit of £25m or £0.45 a meter.

These figures seem reasonable and have been used in our analysis for the smart meter options, but none of the benefit is attributed to the retrofit CDU option combined with self reads. We have included a total of £1.8 per meter per year as benefit arising from all quality of service improvements.

However, it is also clear that much of the consumers’ hassle could be avoided through encouraging self reads (taken from CDUs, with requests prompted by SMS/email reminders). At least one supplier is already offering its customer the option to manage their accounts online through a special website, which allows meter reads to be uploaded, consumption data to be charted, and paperless bills to be issued. Scottish Power is reportedly managing 600,000 accounts in this way and has seen big reductions in call centre inquiries as result (Utility Week, Sept 2007).

The biggest boost to quality of service from smart meters promises to be the new services that could be delivered into the home from a high power “home gateway”. Of course, as mentioned before, there is no reason why this should be anchored on a meter. Most IT experts see the meter as just one peripheral using such a gateway. Seen in this context what is required to provide the extra services is a meter that can have a dialogue with the home gateway.

One aspect of the quality of service which appears as a negative for smart metering is the intrusion that some consumers have said they would feel from having their detailed energy consumption patterns logged and accessible to suppliers. It is unclear how widespread this concern is, and whether it can be easily resolved through recourse to the data protection rules. Another related concern, is that data flows on the telecoms links to meters could be tapped into by burglars and other criminals.

5.2.5 Microgeneration

It is sometimes argued that the deployment of smart metering will accelerate the take up of microgeneration because of the heightened energy awareness of consumers: awareness leads to empowerment. There may be some truth in this, but there is no obvious way of quantifying the size of the impact. Our view is that an increasing awareness of energy use will make consumers more willing to invest in microgeneration, energy and carbon saving, and load management devices. Of course, a more aware and better informed consumer should also be a more discerning customer.

However, there are several issues that complicate the linking between SM and benefits to microgeneration. One argument is that although SM have import/export capability, they do not explicitly measure electricity generated, so they cannot be used for counting ROCs for microgenerators. Another meter, attached to the microgenerator unit, is likely to be needed for this function. This meter could clearly be integrated such that data flowed via a new smart meter hub. It is unclear what the additional uptake of microgeneration would be from having SM in place. In this study we have not attributed any benefits from microgeneration to SM.

5.3 Benefits to Suppliers

5.3.1 Reduced meter reading costs

The current cost of reading a meter is £5-8 per year. This assumes 2 reads a meter a year and that a 70% reading access target is satisfied. For approximately 45 million meters, the total meter reading cost is £225-360m a year. We have assumed an average read cost of £6/meter for both electricity and gas. These costs are entirely avoided once smart metering is installed.

Meter reading costs would reduce as smart meters penetrate the system, however cost for reading the remaining meters is expected to rise. This is because as smart metering rises, the density of customers on non-smart meters falls, and so the cost per read increases (more travel time between reads). This inefficiency is a concern among suppliers and certainly favours an accelerated roll-out option. We have captured this inefficiency in our model by assuming that the cost of reading a meter during the roll-out period is a function of non-smart meter density and the meter reading cost with 100% density. This relationship is given by the simple equation:

Equation 1: $c = \sqrt{\frac{M}{m}} PRC$

(where *c* is the cost of reading a meter, *M* is the initial number of legacy meters, *m* is the number of remaining meters and *PRC* is the cost of reading a meter when *M*=*m*). We have constrained meter reading inefficiencies to be up to twice the meter reading cost for 100% density.

In addition, if the biannual meter inspection is no longer required once smart metering is installed then another £1.50 a year for electricity and £3 for gas can be avoided.

Smart meter reading would itself impose a certain cost. This depends largely on the choice of comms technology and the frequency of readings. This cost is included in comms O&M costs. Although there is a chance that SM reading would itself impose a fixed cost that is not related to comms, we believe this would be trivial and hence have not included it in our model calculations.

5.3.2 Reduced billing inquiries

A large proportion of inquiries to customer call centres are associated with estimated bills. These should be substantially reduced once smart metering is widely deployed. There are also significant inquiries related to change of occupier and change of supplier. Suppliers estimate that inbound call volumes could fall by around 30% and that they would make a 20% saving in call centre overheads, which gives an annual saving of about £2.20 a meter.

It is likely that the introduction of novel metering equipment (including clip-on CDUs) would themselves generate an initial high level of inquiry. This is because the complexity of a smart metering system is higher than it is for current simple meters.

5.3.3 Reduced Debt Handling

The ability to detect and stop debt earlier as a result of having smart metering is estimated to offer a potential benefit of as much as £1.7 a meter a year according to some suppliers. Working capital reductions are claimed to bring further benefits as suppliers are able to shift consumers on to pay as you go and variable monthly direct debit schemes which have much lower debtor days than quarterly credit tariffs. These values appear high in relation to the total cost of serve however, we have for now, used these for our central case.

5.3.4 Reduced cost of servicing PPM customers

Replacing prepayment meters by smart meters will bring significant savings in the cost of serve for prepayment customers, who may well switch to pay as you go or credit tariff arrangements. These cost savings arise because of the lower equipment costs, the ability to (eventually) phase out the support infrastructure (charging stations, cards, tokens etc) and the reduced maintenance and service needs. Ofgem estimates that the additional cost of serve for a dual fuel PPM consumer versus a direct debit credit customer is about £85 a year, and £60 a year versus standard credit meters. These cost premiums reflect the current mix of prepayment assets and infrastructure and so it is possible that the premiums would decline as more reliable and more robust equipment such as key meters replace the token and card meters.

It is also clear that the suppliers will need to provide some support infrastructure to support the pay as you go service which is likely to replace current prepayment arrangements once smart metering is put in place. These costs should however be very low compared to current infrastructure costs, so we have not included them here.

We have assumed an annual PPM cost of serve savings of £40 and £50 a meter for electricity and gas. Out of these figures, we have assumed that only 20% of the PPM cost will be saved. Averaged over all customer this works out at a potential benefit of about £8 per electricity meter and £10 per gas meter.

5.3.5 Value of Remote functions

For the SRSM specification, we have included additional benefits arising from the ability to remotely switch the meter from credit to debit (and visa versa) and also to remotely disconnect electricity and gas meters. The direct benefits associated with these capabilities are the avoided site visits and equipment upgrade costs. These costs can be several £100s for a customer, however the number of switches is small, while disconnections amount to just a few thousand a year. Once averaged over the total customer numbers these costs work out at around £0.5 for each electricity and gas meter for the remote switch and a similar number of remote disconnection.

A number of suppliers have said that the indirect benefits of these remote switching/disconnection capabilities are much greater than the direct cost saving because by having the “threat” of switching (from credit to debit) and disconnection, suppliers will be able to force large reductions in debt costs. We acknowledge that there will be certain benefit here, however it is likely that the existing safeguards on disconnection (which require an incremental approach and an onus on suppliers to put in place affordable debt recovery) would anyway dilute the threat.

5.3.6 Reduced costs for change of supplier

Some suppliers have claimed that the introduction of smart metering will allow a rationalisation of the arrangements for handling change of supplier and that as a result the trouble shooter teams employed to sort out exceptions would no longer be needed. Owen and Ward estimated that these costs amounted to £100m a year, which works out at about £2 a meter. From our interviews with industry stakeholders, we found out that these cost savings might be significantly higher. Indeed, a big supplier reports to its annual report ‘Imbalance charges’ of £170m only for 2006. However, due to the high uncertainty of the system that would be required to eliminate those costs, we have opted to use the conservative estimate of Owen and Ward.

5.3.7 Conclusion on supplier benefits

Adding the supplier benefits identified here gives a grand total of around £14 per meter for the high spec SRSM meter. However, this figure does not reflect all reductions in the cost of serve, since this would have to include comms charges for reading SM. If we include this cost, then the average reduction in the cost of serve is about £11, which implies something like a 40% reduction in suppliers’ cost of serve. Interestingly, suppliers’ own estimates of supplier benefits ranged from £8.6 to £12.6 a meter, although they covered different items and always claimed that their figures were not comprehensive.

5.4 Benefits to Network Operators

A number of benefits are said to accrue to network operators. These comprise:

- SM improve the accuracy of measuring energy consumption on the network. However, it is difficult to see material benefit from this function.
- They enhance fraud detection and loss management capability, although today’s losses are already low using existing systems based on LV feeders.
- They can facilitate better integration of distributed generators.
- They provide detailed power quality data.
- SM rapidly detect outages and verify restorations, thereby reducing Customer Minutes Lost. (CML). Benefits from improved CML are likely to be modest benefit, given faults reported promptly already.
- SM improve network investment/asset management decisions, hence contributing to better use of capital. This benefit would only be significant in the long-run and only if there were significant shifting of peak load.
- They provide control of power use on an individual/group basis - alternative to rota disconnection. Yet, rota disconnection is very rare.

Although it is very difficult under the current scope to estimate the exact impact on DNOs, our view is that these benefits are likely to be very modest. The commercial value is unlikely to be more than a few £10m a year for all the DNO networks.

5.5 Attribution of benefits to meter functionality

Another way to view the benefits of smart meters is by the function of the meter. We have attributed the benefits to four functions:

- CDU, displays and information feedback – benefits from energy and carbon emission reductions; peak load shifting
- AMR – benefits from avoided meter reads/ reduced call handling/ reduce costs open/closing accounts, debt handling, reduced theft and losses
- TOU pricing – benefits from peak load shifting and adoption of TOU tariffs.
- AMM – benefits from remote disconnection, debit/credit switching,

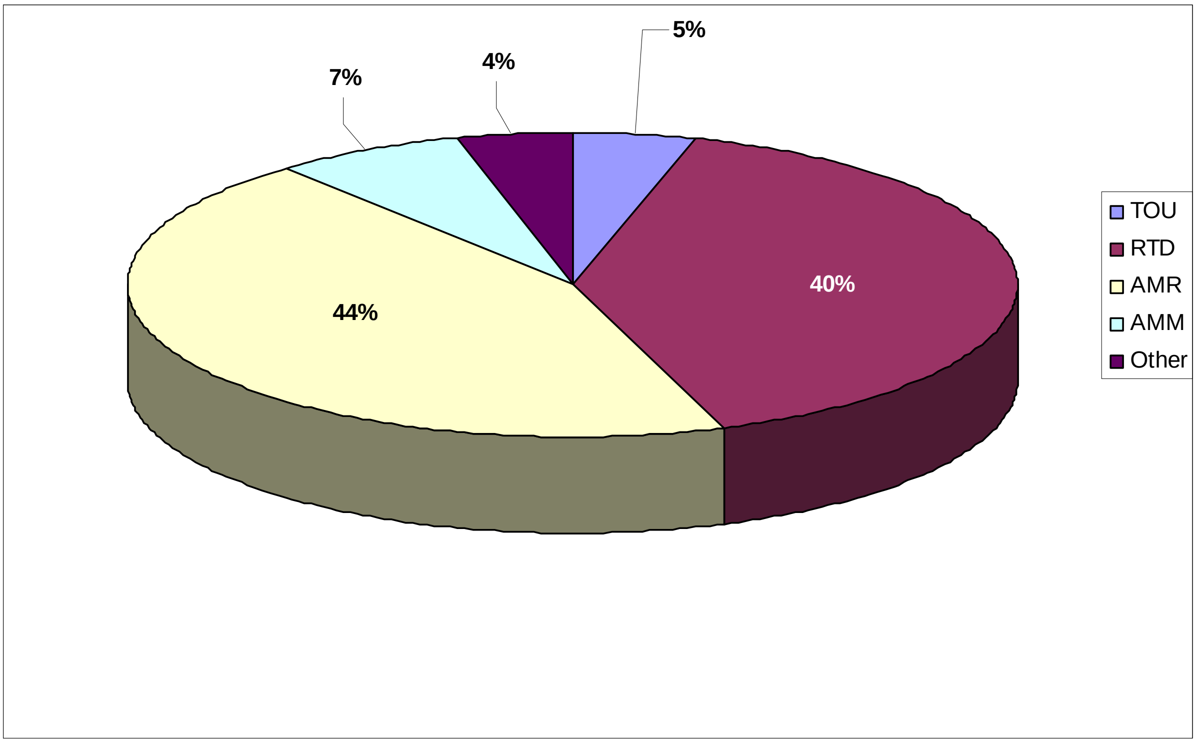
Benefits, as attributed per technology, are presented in Table 5-2.

Table 5-2 Attributed Benefits per Technology

	Clip-on	Retrofit	D+S	BEAMA	ERA
Energy Saving	+	+	+	+	+
Load Shifting				+	+
TOU Tariffs				+	+
Peak Load Reduction	+	+	+	+	+
Net Carbon	+	+	+	+	+
Avoided Meter Reading		+	+	+	+
Inbound Enquiries		+	+	+	+
Customer Service Overheads		+	+	+	+
Debt Handling		+	+	+	+
Avoid PPM COS					+
Remote Switch					+
Remote Connect/Disconnect					+
Avoided Site Visit				+	+
Reduced Theft			+	+	+
Reduced Losses			+	+	+
Reduced Imbalance Charges			+	+	+

Figure 5-1 shows our estimate of the breakdown of benefits by meter functionality for the most functional technology. AMR function seems to yield 44% of benefits, while 40% can be attributed to feedback benefits. AMM function brings about 7%, followed by TOU and other benefits.

Figure 5-1: Attribution of Benefits to Meter Functionality



5.6 Summary

This section outlined our assumptions for benefits from SM technologies and roll-out options. The greatest uncertainty lies within energy savings. Benefits related to technology are more certain and they are mostly relevant to the suppliers. Table 5-3 summarises our assumptions for benefits per meter per year.

Table 5-3 Summary of GB PLC Benefits per meter

Benefit pa	Elec	Elec PPM	Gas	Gas PPM	Comments/Source
Via Consumers					
Energy Saving (%)	2.8	1	2	0.5	Electric split into 3 groups (6%, 3% and 1%). Net of metering/CDU consumption
Peak Load Reduction (%)	2.8	2.8	2	0.5	Assumed that energy saving ‘shaves’ peak load by equal amount
TOU Tariffs (%)	5	5	0	0	Mott Mac Assumption
Peak Load Shifting (£/m)	1.44	1.44	0	0	Mott Mac Assumption

Benefit pa	Elec	Elec PPM	Gas	Gas PPM	Comments/Source
Carbon Savings(£)	1	1	1	1	Following Defra guidelines for SPC, net of carbon premium in tariff
Via Suppliers					
Meter Readings (£)	6	0	6	0	Assumes 2 reads per year & 70% access rate
Safety Inspection (£)	0.5	0.5	1	1	Assumes one visit per year for gas, and one per two years for elec
Reduced Billing Enquiries (£)	2.18	2.18	2.18	2.18	Includes overheads and spread among all meters
Reduced Debt Handling (£)	3.9	0	3.9	0	Includes reduction in bad debt, debt handling and gratuity payments
Reduced Cost of Serving PPM(£)		4		4	
Remote AMM(£)	1	0.5	1	0.5	Includes remote switch debit/credit and remote disconnect for credit
Change of System(£)	1.02	1.02	1.02	1.02	Reduction in imbalance charges
Via DNOs					
Losses(Technical & Non-Technical)(£)	0.1	0.1	0.01	0.01	Mott Mac Assumption

6 Modelling Approach

6.1 Introduction

This section outlines the modelling approach we have used to appraise SM technology and roll-out options. We provide a brief description of cost-benefit analysis, a description of our model structure and assumption sheets, a discussion of the method we have used to increase robustness of forecasts and finally a list of guidelines we have followed to produce results.

The model is built on MS Excel and Crystal Ball, a MS Excel add-in. It models four meter types (elec credit, elec PPM, gas credit, gas PPM) on a period to 2040. We have deliberately chosen this period, because it covers the full twenty year lifetime of the last meter to be installed.

6.2 Cost Benefit Analysis

CBA is a widely established and frequently used method for decision making in public policy and elsewhere. The method simply compares discounted values of sums of costs and benefits for each alternative and produces mainly three key indicators: net present values (NPVs), economic internal rates of return (EIRRs), if applicable, and Benefit/Cost ratios (BCR).

The first indicator shows how much the total investment option is worth in today's money terms. A positive NPV means that the investment is well-worthwhile, while the highest NPV among different options means higher net value of the specific investment decision. EIRRs represent the expected rate of return on the investment value, but are not suitable for mutually exclusive options and hence not used in our analysis. We have used however BCR, net present value of benefits over net present value of costs, which that should be above unity for worthwhile options.

Finally, we have used marginal BCR, that indicate whether is preferable to move from a less functional option to a more functional one. This indicator can only be used when comparing options in pairs (i.e. going from clip-on to retrofit) and should also be above unity for worthwhile options.

6.3 Model Structure and Operation

The model consists of two cost sub-models, the metering model and the comms model, and contains four categories of sheets: Assumptions, Calculations, Scenario Building & Results and Presentations.

The comms model calculates capital and O&M costs for several comms technologies based on assumptions made for usage of the network and charges. All assumptions of the comms model are found in three tabs, the 'Charges', 'Usage' and 'General Comms Variables'. Results are found in the 'Comms Costs Summary' tab, through which they are linked to the metering model.

The metering model uses assumptions found in tabs 'General Assumptions', 'Costs Assumptions', 'Benefit Assumptions' and 'Crystal Ball' to feed calculation tabs 'Roll-Out Options', 'Clip-on', 'Meter Retrofit', 'Smart and Dumb', 'BEAMA Spec' and 'ERA Spec'. The user can build scenarios using two selection boxes, for roll-out options and comms, in the sheet 'Scenario Builder' that contains results for main indicators.

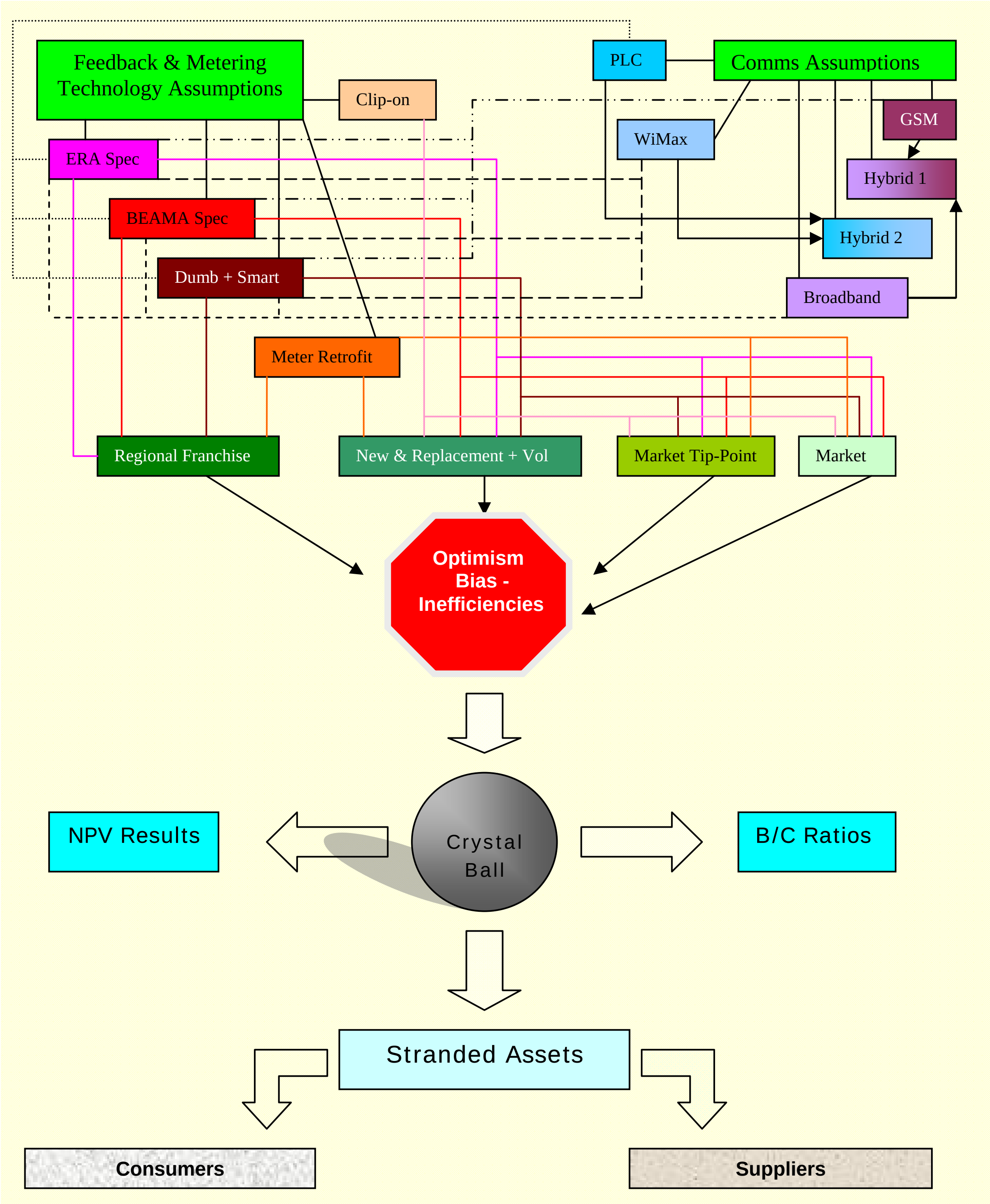
The model also allows for including or excluding optimism bias and dual fuel efficiencies. Results from preferred scenarios are presented below the scenario builder, 'Statistical Report' and 'Graphs'. Distributional Impacts are also shown on 'Scenario Builder', where the user can select the level (on a scale 0 to 100%) of cost, cost saving and stranding cost pass-through.

The model is calibrated to model specific roll-out proposals, reflecting potential policy decisions, as expected for 2010. Only the New and Replacement Option starts from 2008, and can be accelerated or slowed down on request, based on a fixed voluntary meter take-up percentage (which in the model is set by default at 3% of all meters).

The model structure is shown in Figure 6-1. Starting from top to bottom, assumptions feed calculations for comms and metering technologies, which in turn are calibrated on the roll-out option. The flow of new kits or meters determines the amount of costs and benefits for each technology option. Depending on the nature of intervention, additional cost or benefit items are added in each option. In each technology option, the model adjusts for optimism bias and roll-out efficiencies or inefficiencies. Stochastic assumptions are then fed into Crystal Ball, which produces a range of results of NPVs and Benefit/Cost Ratios. In addition, Crystal Ball also calculates stranding costs for the accelerated roll-out options. Stranding costs are then included in the calculation of distributional impacts for consumers and suppliers, the results of which are also reported in the main results tab.

For easier navigation across the assumptions tables, the model includes in the 'Title' tab a linked table of contents for all assumption tabs.

Figure 6-1 Schematic Representation of the Model



6.4 Underlying Assumptions of the Model

General underlying assumptions of the model can be found in two assumption sheets: 'General Comms Variables' and 'General Assumptions'. Table 6-1 summarises the main assumptions from both sheets.

Table 6-1 Main Underlying Model Assumptions

Assumption	Value	Source/Comment
No of Electric meters	22,800,000	Owen and Ward 2007
No of Electric PPM	3,800,000	“
No of Gas meters	20,300,000	“
No of Gas PPM	2,100,000	“
No of new meters every year	400,000	Owen and Ward, Ofgem
Current legacy replacement rate	5%	Owen and Ward
Customers that can physically take a clip-on	80%	Defra
Voluntary SM uptake	4%	Suppliers suggested 5% based on voluntary uptake of clip-ons. Reduced to 4% pa for the period.
Population Distribution Urban	75%	Mott Mac
Population Distribution Rural	25%	Mott Mac
CO_2 factor Electric	0.43	Ofgem
CO_2 factor Gas	0.19	Ofgem
Losses Reduction Target Electric	6%	“
Losses Reduction Target Gas	1.3%	“
Interest Rate	10%	HM Treasury
Economic Discount Rate	3.5%	HM Treasury
£/€ Exchange Rate	0.68	Spot Price 08/10/07
Persistence of Savings	-	Savings assumed to exist for the duration of the appraisal (up to 2040)
Bill reduction from TOU	5%	Low end estimate from Darby and Energy watch
Current Self Reads	10%	Suppliers

Assumption	Value	Source/Comment
Incentive to provide Self Read	£4	Low end estimate from suppliers for reading cost per meter
Net response to Self read Incentive	40%	Ipsos Mori 2007 (low range estimate from 35-50% of consumers willing to act on information received to reduce energy in the home)
Bill Premium per PPM pa elec	10.2%	Owen and Ward
Bill Premium per PPM pa gas	12.6%	Owen and Ward
Share of Customers Taking TOU	20%	Mott Mac

6.5 Stochastic Parameters and Monte Carlo Simulations

The model uses Crystal Ball to mitigate uncertainty in results, arising from a number of widely speculative parameters. Crystal Ball calculates statistical iterations of results, by using a distribution of values for each uncertain parameter that are set by the user. These iterations, known as Monte-Carlo simulations, re-create forecasted values for NPVs of different scenarios by randomly sampling values from each distribution of parameters. Therefore, each iteration is different and is defined through the value of the stochastically determined parameters.

Through repeated sampling and calculation experiments, up to a 1000 times in our model, Crystal Ball produces a distribution of likely outcomes for each scenario. Results can be drawn by using statistical inference, or simply significance level values for positive NPVs.

In the model, we have assumed the following stochastic parameters:

- Voluntary Uptake: This is the percentage of meter uptake in the new and replacement scenario. It takes the mean value of 4% , with standard deviation 0.01 and is distributed log-normally.
- Population response to energy saving. We have split the population into three main groups: the energy saving enthusiasts, the energy saving followers and energy saving laggards. Their properties are:
    - Enthusiasts: They are 20% of the population, with low 10% and high 30% and distributed according to the triagonal distribution.
    - Followers: They are 40% of the population, with low 35% and high 45% and distributed according to the triagonal distribution.
    - Laggards: They are 40% of the population, with low 35% and high 45% and distributed according to the triagonal distribution.
- Energy Saving Response. This depends on the population group:

  - Enthusiasts: They are saving a mean of 6%, with standard deviation of 0.04 and savings are distributed normally.
  - Followers: They are saving a mean of 3% with standard deviation of 0.04 and savings are distributed normally.
  - Indifferent: They are saving a mean of 1% with standard deviation of 0.04 and savings are distributed normally.

- Percentage of meter population that take up TOU tariffs. This variable has been given the range of 10 to 20%, with most likely value 15%. It is distributed according to the triangular distribution.
- Persistence of energy savings. This variable is by default set to 35 years so that energy savings last throughout the period. However, it can be activated to range stochastically between 20 and 30 years, distributed normally.
- Average Residual Legacy Meter Asset Age. This variable determines what is the average age of legacy meters in each year of the accelerated roll-out options. The range is 0 to 20 for electricity meters and 0 to 10 for gas meters, while both ranges are distributed according to the uniform distribution (each value in the range has equal probability of occurring).

The model has been constructed to include other stochastic parameters like peak load reduction, meter replacement rate and SM readings if required by BERR. Also it is possible, if required, to correlate savings habits of enthusiasts with voluntary uptake of new meters and persistence of savings. This would essentially introduce a deliberate bias to capture the fact that energy saving enthusiasts are likely to save more energy and for a longer time period.

6.6 Policy Appraisal Guidelines

Our appraisal has been based on guidelines we received from BERR and DEFRA, regarding public policy appraisal studies. Specifically we have used the HM Treasury Green Book to set interest rate for upfront capital at 10% and have used an overall discount rate of 3.5% until 2040. Following the Green book, we have not included stranding costs in our GB PLC analysis. Also, we have followed Defra’s guidelines for the shadow price of carbon, that is assumed to be currently £25/tCO2 and growing by 2% per year.

6.7 Risk Mitigation and Optimism Bias

Delivery of SM roll-out options entails several risks regarding the actual costs, benefits and duration of roll-out. Following Green Book guidelines, MML has identified potential risks as an attempt to quantify and address optimism bias (OB) in roll-out options. Optimism bias is expected by default to be inherent in projection of capital costs, benefits and duration of works. Previous work by Mott MacDonald [22] has shown that a certain percentage of optimism bias exists in all large public procurement projects. The existence of risk management or mitigation strategies helps to reduce OB, where applicable. The following subsections provide our assessment of risks and calculation of optimism bias.

6.7.1 Technology Risks

The actual cost of delivering a SM roll-out is determined largely by meter asset costs and comms capital and operational costs (see Figure 4-7). Since our costs assumptions are mainly drawn from industry parties, we expect that both these categories of costs are likely to be underestimated, where applicable, due to optimism regarding assembly costs and future positive scale economies.

In addition, we expect that the actual cost estimates for delivering an appropriate metering data management system is also negatively biased. Therefore, we identify three categories of technology risks.

- Metering Infrastructure Capex Levels
- Comms Infrastructure Capex & Opex Levels
- Metering Data Management Systems (MDMS) Capex and Opex. This includes the IT and settlement system that is required to be in place for yielding the full benefits from SM.

6.7.2 Project Risks

Optimism for the actual delivery period is also a common source of OB. The bias in this case appears from optimistic estimations of the time needed to complete the programmes. In the SM roll-out options, delivery is likely to be entirely dependent on the existence of a common operational framework, for meters, comms and support IT systems. Therefore, we have identified five potential risk areas in project level:

- Delivery of MDMS functional framework
- Delivery of comms functional framework
- Delivery time of MDMS
- Delivery time of metering infrastructure
- Delivery time of comms infrastructure

6.7.3 Accounting for Optimism Bias

Following [22], we provide in Table 6-2 upper and lower bounds of optimism bias for generic categories of projects. A SM roll-out programme matches the ‘Equipment/Development’ category. Although the highest recorded optimism bias in large public procurement projects in this category is 200%, we have taken into account as upper range the value 150%, since according to [22] projects that were exhibiting more that 150% bias were not finally allowed to proceed.

We have introduced a risk mitigation factor on each of the identified risks, ranging from 0 (where no mitigation plan exists) to 1 (where risks are fully managed). Risk mitigation factors, upper and lower values and OB estimates are given in Table 6-3. The relationship between risk mitigation factor and OB is given by:

Equation 2: $OB = (1 - RMF) * U$

(where *OB* is the estimated optimistic bias, *RMF* is the risk mitigation factor for this area and *U* is the upper limit for biases). Notably when a technology receives *RMF=1*, then the appropriate level of OB is the lower range. Existing technologies, like the clip-on, do not entail capex risks and hence they receive the lowest bias correction. ERA spec receives also low bias because of the existence of the SMOF, as defined in the SRSM project. Dumb+Smart receives the largest bias correction, because there is no single spec and operational framework for this technology.

In terms of comms technologies, there is also no operational framework for any of the options. Hence, even the proven technologies have a relatively high risk mitigation factor and OB. Future technologies are ranked as bearing double the amount of risk than proven technologies. This might not be entirely true, given the incredible speed by which innovation is progressing in the comms industry, however, given the lack of further data, we have opted for doubling the risk factors.

Table 6-2 Current Practice Optimism Bias

Project Type	Optimism Bias (%) [7]			
	Works Duration		CAPEX	
	U	L	U	L
Non-standard Buildings	39	2	51	4
Standard Buildings	4	1	24	2
Non-standard Civil Engineering	25	3	66	6
Standard Civil Engineering	20	1	44	3
Equipment/Development	54	10	200	10
Outsourcing	N/A	N/A	41*	0*

* The optimism bias for outsourcing projects is measured for operating expenditure, OPEX

The model includes provision of biases for works duration, which might be especially relevant for SM roll-out options. Although there is some risk mitigation plans for rolling-out SM (like the SRSM project), there is no plan whatsoever on rolling-out the comms infrastructure and the back-office systems. Hence, biases for works duration are averaging to 40% (meaning that if a project was scheduled to last 10 years, bias correction would bring it up to 14 years).

In addition, in the model there is provision for estimating OB in benefits, either in quantity or duration (persistence). In the case of benefits, there is a possibility that stakeholders have overestimated the benefits they expect to yield from rolling-out SM, given their optimism and enthusiasm for the new prospect. This can also be true in academic studies (like the Darby paper), given that measurement of controlled or uncontrolled groups can suffer from the 'Hawthorne effect'[2]. Moreover, authors of experimental or semi-experimental studies in academia might be subject to 'publication bias'[3], a well known phenomenon in academia.

[2] The Hawthorne effect occurs when participants of a controlled study change their behaviour because they know they are being watched.

[3] 'Publication Bias' is very common in academic publishing, whereby editors of academic journals tend to publish papers that find something innovative to report. Research papers that find 'nothing' new to report are not usually accepted for

However, following suggestions by BERR and DEFRA, we have excluded bias correction for both works duration and benefits, given that corrections for capex were already quite sizeable. In any case, further bias corrections can be introduced if required by BERR or stakeholders.

Table 6-3 Risk Mitigation Factors and Optimism Bias

Risk Area	Risk Mitigation Factor	OB Upper (%)	OB Lower (%)	OB Estimate (%)	Comments
Feedback/Metering Technology Capex					
ERA Spec	0.8	150	10	30	SMOF
BEAMA Spec	0.5	150	10	75	BEAMA Draft Spec
Dumb & Smart	0.3	150	10	105	No spec
Retrofit	0.5	150	10	75	Based on existing spec
Clip-on	1	150	10	10	Proven
RTD	0.8	150	10	30	Proven but yet to develop
Comms Technology Capex					
PLC	0.4	150	10	90	Future Spec
Broadband	0.8	150	10	30	Proven
WiMax	0.4	150	10	90	Future Spec
GSM	0.8	150	10	30	Proven
Hybrid 1	0.4	150	10	90	Future Spec
Hybrid 2	0.8	150	10	30	Proven
MDMS	0.1	150	10	135	No Spec

publication in academic journals, even if they are scientifically sound and robust. Another version of this type of bias is relevant to authors, who might be reluctant to pursue publication of their research if research findings do not confirm the research hypothesis and thus might be very difficult to publish.

7 Model Results

In this section we provide results from our Cost Benefit Model, as described in the previous section. We also include discussion on the statistical analysis and sensitivities, as yielded from Crystal Ball. Detailed results from simulations are provided in the Appendix. In addition, we discuss results for the comms options and costs.

7.1 CBA Model Results

The CBA model has been run for a large number of combinations of roll out and comms technology for each meter technology option. Results compile a wide range of NPVs, that depend largely on whether we correct for optimism bias (OB) and dual fuel roll out efficiency. As a base case, we explore the case where OB and dual fuel efficiency is taken into account, whereas for comms we have selected Hybrid 2 which is a proven and realistic combination of technologies. Table 7-1 summarises Benefit Cost Ratios per technology and roll-out option.

It is clearly evident that out of the five technology options, the clip-on performs best. This result is mainly due to the large amount of costs and benefits associated with the metering technologies. The meter retrofit option also yields consistently positive NPVs, that outperform metering technologies.

Out of the smart metering solutions, only Dumb and Smart is consistently above unity. In terms of roll-out options, market with tipping point (delivering either in 7 or 8 years) out performs the rest of the options, which are otherwise very similar. (Stranding costs are not included in these calculations). It seems that accelerated market roll-out options have the potential to deliver the highest BC ratios. The option for a fully managed programme ranks third for metering technologies, above the new replacement and plain market options. We could not justify the existence of a regional franchise model for clip-ons, therefore this ratio is not available.

We also provide results for BC Ratios uncorrected for bias, so as to be able to compare with the Frontier Economics (FE) study [25]. Comparing our results with the ones from the FE shows that they are in the same range. As in the FE study, we find the ERA spec to be higher than unity for all roll-out options, although we could not support FE's finding that the managed programme is preferable in terms of BC ratios. We attribute this difference to the fact that FE estimates are not corrected for bias, whereas in our case installation costs for the managed roll-out option are not different over the whole period from the ones in other options (see Section 4.7 for more discussion on this issue), except for dual fuel roll-out economies. In addition, benefits from provision of feedback are increased in the FE study for the regional franchise option, whereas in our study they are equal across all roll-out options.

Even with these different assumptions, the lower range of BC ratios in both the FE study and our study are very similar. This is an important point that supports the robustness of our results. Since FE did not include any other technologies, and their appraisal period is only a third of ours (up to two thirds lower than ours), no further comparison is possible in terms on NPV values.

Table 7-1 Summary of B/C Ratios with Hybrid 2

	ERA Spec	BEAMA Spec	Dumb+Smart	Retrofit	Clip-On
Results corrected for optimism bias					
New& Replacement	0.831	0.965	1.23	1.41	2.44
Regional Franchise	0.832	0.964	1.25	1.35	N/A
Market	0.829	0.961	1.24	1.41	2.44
Market Tip	0.84	0.977	1.27	1.41	2.44
Market Tip Fast	0.842	0.979	1.28	1.405	2.4
Results not corrected for optimism bias					
New& Replacement	*1.033*	*1.359*	*1.72*	*2.274*	*2.642*
Regional Franchise	*1.026*	*1.344*	*1.76*	*2.134*	*N/A*
Market	*1.029*	*1.352*	*1.76*	*2.273*	*2.65*
Market Tip	*1.043*	*1.377*	*1.81*	*2.27*	*2.646*
Market Tip Fast	*1.045*	*1.38*	*1.82*	*2.269*	*2.64*

Our results show that an accelerated market based roll-out out-performs the managed roll-out, whether we correct for bias or not.

In general, it seems the ranking of the five technology options selected is unaffected by the choice of roll out options, which tends to have by comparison a second order impact. This is also true in terms of Net Present Values.

Of the non-smart options, see Figure 7-1, the meter retrofit option (retrofits /or dumb meter with transmitter coupled to display) provides very good returns, and easily beats the clip-on option. The higher NPV reflects the additional benefits arising to customers and suppliers from facilitating a higher take up of self-reads coupled with on-line account management. Both the meter retrofit and clip-on options would provide a positive NPV with no supplier benefits included.

Of the smart metering options, see Figure 7-2, the dumb meter/smart box option provides the most favourable NPV. This is mainly because of the much lower core metering and installation costs, along with high benefits introduced from AMR functionality. The smart box technology brings all the same energy savings as the highest spec (ERA) meter, and most of the supplier benefits although it does not capture the remote switching and disconnection benefits of the ERA meter.

Figure 7-1 NPVs of no comms solutions over roll-out options

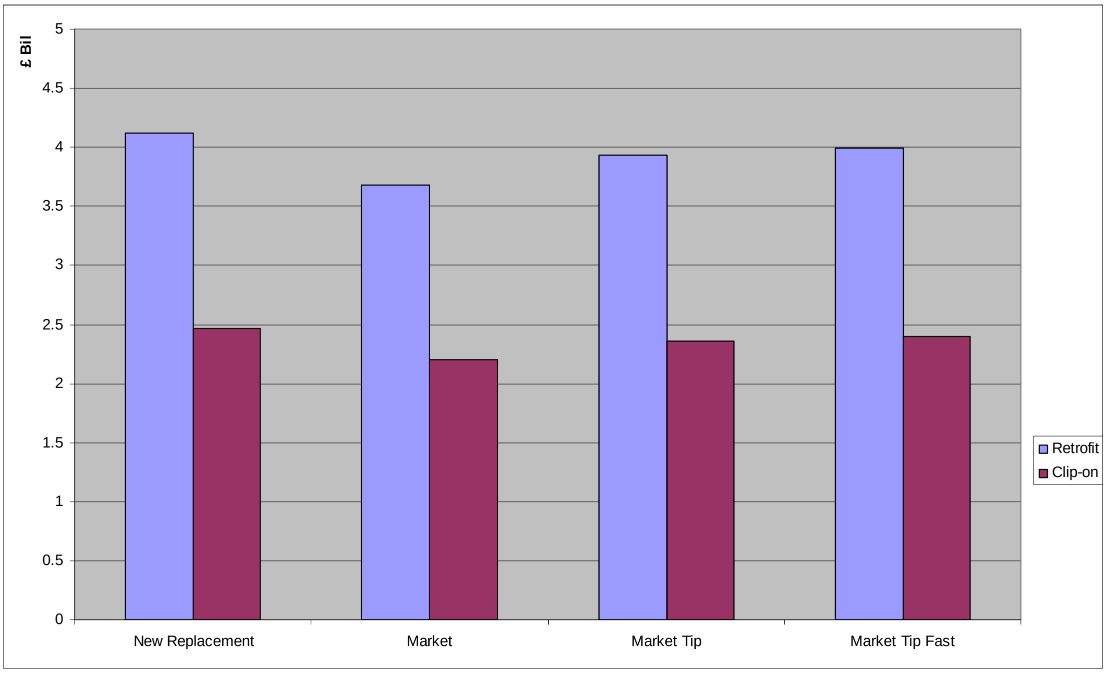
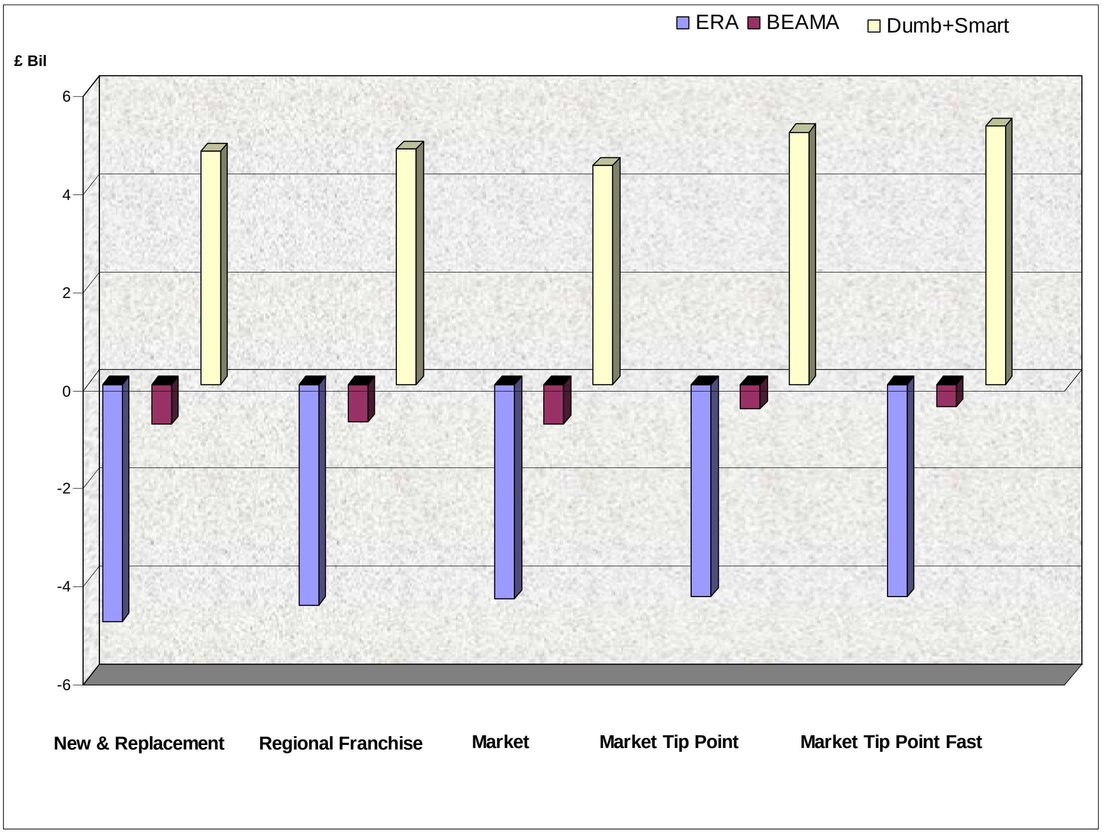


Figure 7-2 Summary NPVs per SM and roll out option with Hybrid 2



Under some scenarios the meter retrofit option has a higher NPV than dumb meter/smart box option, but this depends on the comms options selected and the extent of energy saving and peak reduction.

The ERA spec does record a positive NPV, but only when no comms are included in the NPV calculations; yet it's never as high as the lower cost BEAMA spec. The ERA's spec's additional equipment costs are higher than the additional benefits arising from the higher end AMM functionality. The BEAMA spec also records a positive NPV only in the case that comms are excluded.

The Dumb+Smart option yields a positive NPV with all comms technologies except for WiMax, which is the most expensive comms option. The highest NPV across all comms and roll-out options is £mil 5,306, with broadband in the market tip point fast roll-out.

Compared with technologies, the choice of roll-out option has relatively less impact on costs and NPVs. The managed programme's "economies of concentration" benefits largely offset by the high transaction and oversight costs in setting up and running a franchise arrangement. Net Benefits from the regional franchise option for smart metering technologies are shown in Figure 7-3. In a number of scenarios the market tipping roll-out provides the highest NPV, followed closely by the regional franchise option. We have adopted a fairly cautious energy savings assumption at just over 2% net for combined electricity and gas. Increasing energy savings would lift all the NPVs by same amount.

Indicative results from the model per roll-out option, with Hybrid 2 comms, dual fuel efficiency and bias correction are given in Table 7-2. Out of the feedback technologies, meter retrofit yields the highest NPV, £mil 4,120, in the new, replacement and voluntary option. For the smart metering technologies, Dumb and Smart with the Market Tip Fast option yields the highest NPV, £mil 4,065.

Detailed results for all technologies and roll-out options are given in the Appendix.

Figure 7-3 Net Benefits of smart metering – Regional Franchise with Hybrid 2

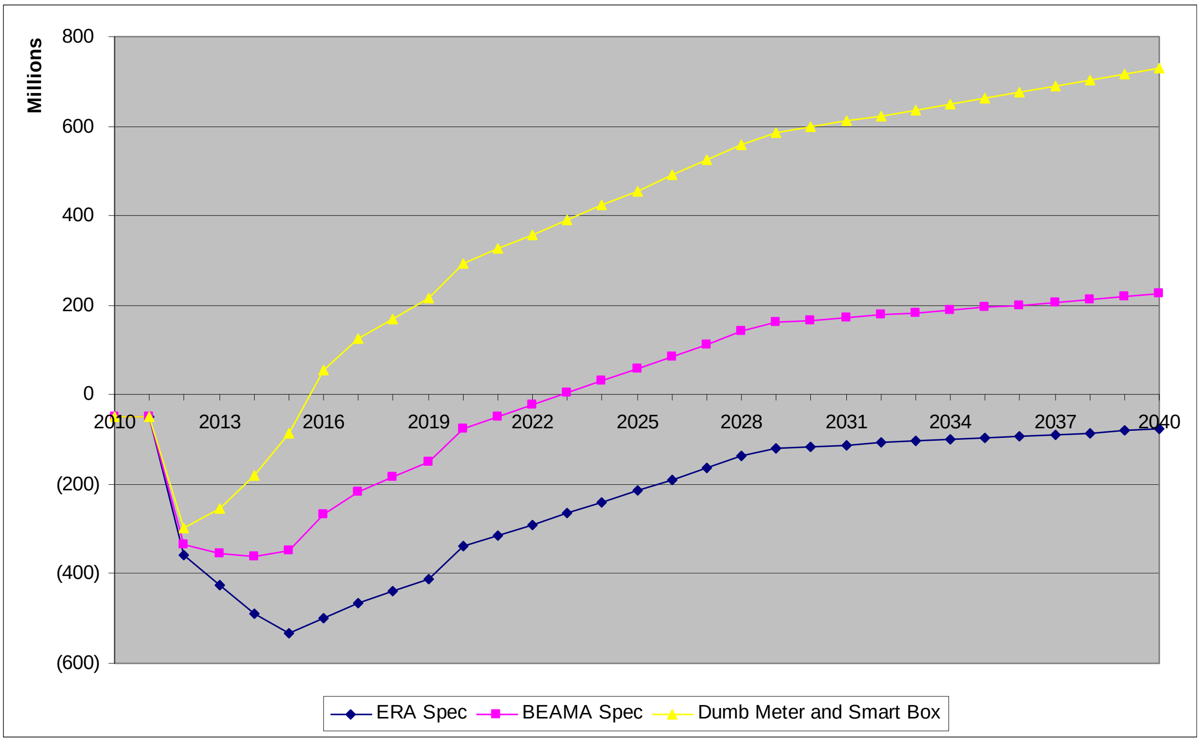


Table 7-2 Summary Results including optimism bias and dual fuel efficiencies to 2040 (Hybrid 2)

Roll-Out Option/ Technologies	PLC NPV (£mil)	B/C Ratio	Total Costs (£mil)	Asset, Install, O&M Costs (£mil)	Comms Costs (£mil)	Other Costs (£mil)	Total Benefits (£mil)	Consumer & CO2 Benefits (£mil)	Supplier Benefits (£mil)	Other Benefits (£mil)
New, Replacement and Voluntary										
ERA Spec	-4,823	0.831	28,603	19,264	6,378	2,962	23,780	11,872	10,899	1,009
BEAMA Spec	-812	0.965	13,609	13,609	6,378	2,958	22,133	11,872	9,252	1,009
Dumb+Smart	3,563	1.23	15,760	7,929	6,378	1,454	19,323	10,874	7,530	1,009
Meter Retrofit	4,120	1.406	10,158	9,886	N/A	272	14,278	10,638	3,640	N/A
Clip-On	2,467	2.435	1,719	1,509	N/A	210	4,187	4,187	N/A	N/A
Regional Franchise										
ERA Spec	-4,497	0.832	26,710	17,953	5,771	2,987	22,214	11,099	10,175	940
BEAMA Spec	-766	0.964	21,440	12,683	5,771	2,986	20,673	11,099	8,634	940
Dumb+Smart	3,616	1.25	14,351	7,031	5,771	1,549	17,967	10,085	6,941	940
Meter Retrofit	3,476	1.352	9,871	9,213	N/A	658	13,347	9,949	3,398	N/A
Clip-On	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Market										
ERA Spec	-4,360	0.829	25,502	17,076	5,739	2,687	21,142	10,570	9,768	894
BEAMA Spec	-804	0.961	20,480	12,064	5,739	2,677	19,677	10,570	8,212	894
Dumb+Smart	3,337	1.24	13,782	6,726	5,739	1,317	17,199	9,606	6,619	894
Meter Retrofit	3,679	1.407	9,029	8,763	N/A	266	12,708	9,476	3,232	N/A
Clip-On	2,203	2.443	1,526	1,338	N/A	188	3,729	3,729	N/A	N/A
Market with Tipping Point										
ERA Spec	-4,314	0.840	27,039	18,374	5,968	2,697	22,724	11,348	10,414	962

Roll-Out Option/ Technologies	PLC NPV (£mil)	B/C Ratio	Total Costs (£mil)	Asset, Install, O&M Costs (£mil)	Comms Costs (£mil)	Other Costs (£mil)	Total Benefits (£mil)	Consumer & CO2 Benefits (£mil)	Supplier Benefits (£mil)	Other Benefits (£mil)
BEAMA Spec	-498	0.977	21,645	12,981	5,968	2,697	21,147	11,348	8,837	962
Dumb+Smart	3,959	1.27	14,438	7,241	5,968	1,229	18,397	10,311	7,123	962
Meter Retrofit	3,936	1.405	9,713	9,430	N/A	284	13,649	10,172	3,478	N/A
Clip-On	2,363	2.44	1,641	1,440	N/A	201	4,004	4,004	N/A	N/A
Market with Tipping Point Fast										
ERA Spec	-4,328	0.842	27,378	18,642	6,025	2,711	23,050	11,508	10,566	976
BEAMA Spec	-456	0.979	21,906	13,171	6,025	2,711	21,450	11,508	8,966	976
Dumb+Smart	4,065	1.28	14,594	7,346	6,025	1,223	18,659	10,456	7,227	976
Meter Retrofit	3,988	1.405	9,855	9,567	N/A	288	13,843	10,314	3,528	N/A
Clip-On	2,395	2.439	1,665	1,461	N/A	204	4,060	4,060	N/A	N/A

Notes: Comms are included only in the first three technologies, Regional Franchise does not apply for clip-ons,

7.2 Results from Monte Carlo Simulations

Model results reported in the previous section have been drawn from the model, based on baseline assumptions for stochastic parameters. Further detailed simulations were undertaken in Crystal Ball to outline sensitivity in NPV results. Only a summary of these results is given in this section; full statistics and associated graphs from each experiment are given in Appendix B and distribution overlay charts are given in Appendix C .

Overall, we conclude that the most sensitivity in results derives from uncertainty in two variables: the amount of energy savings achieved by the parts of the population we call Enthusiasts and Followers. We have chosen as an indicative case the Market Tip Fast option with comms Hybrid 2 to depict this conclusion; as can be seen in Figure 7-4, 85-90% sensitivity in contribution to variance per technology derives from the amount of energy savings realised by the majority of the population. The Figure shows that variability in High and Med savings, achieved by Enthusiasts and Followers, is almost entirely responsible for sensitivity in results.

Although it cannot be depicted herein due to space limitations, this sensitivity pattern is uniform across all the experiments we have conducted.

Another useful conclusion coming out from the Monte-Carlo simulations is the relative robustness of the baseline NPV estimates coming out from the model. In Table 7-3, we provide a comparison of the NPV estimates derived from the model with the ones derived from the Monte Carlo simulations. In general, simulations have very low mean standard errors and NPV estimates are very close to those predicted by simulations.

Detailed certainty levels per technology, roll-out option and comms are given also in Appendix B for each experiment. However, we can say with confidence that most experiments yield positive or negative estimates with a high degree of certainty. For instance, the ERA spec is found negative in all experiments with certainty above 99%. Only in experiments without comms costs is found positive, but with certainty up to 75%. Another example is the Dumb and Smart option that is found positive on all experiments with an average of (approximately) 70% certainty and never falls below 50%. This means that under the worst case scenario, there is still 50% certainty that the Dumb and Smart option will deliver positive NPVs.

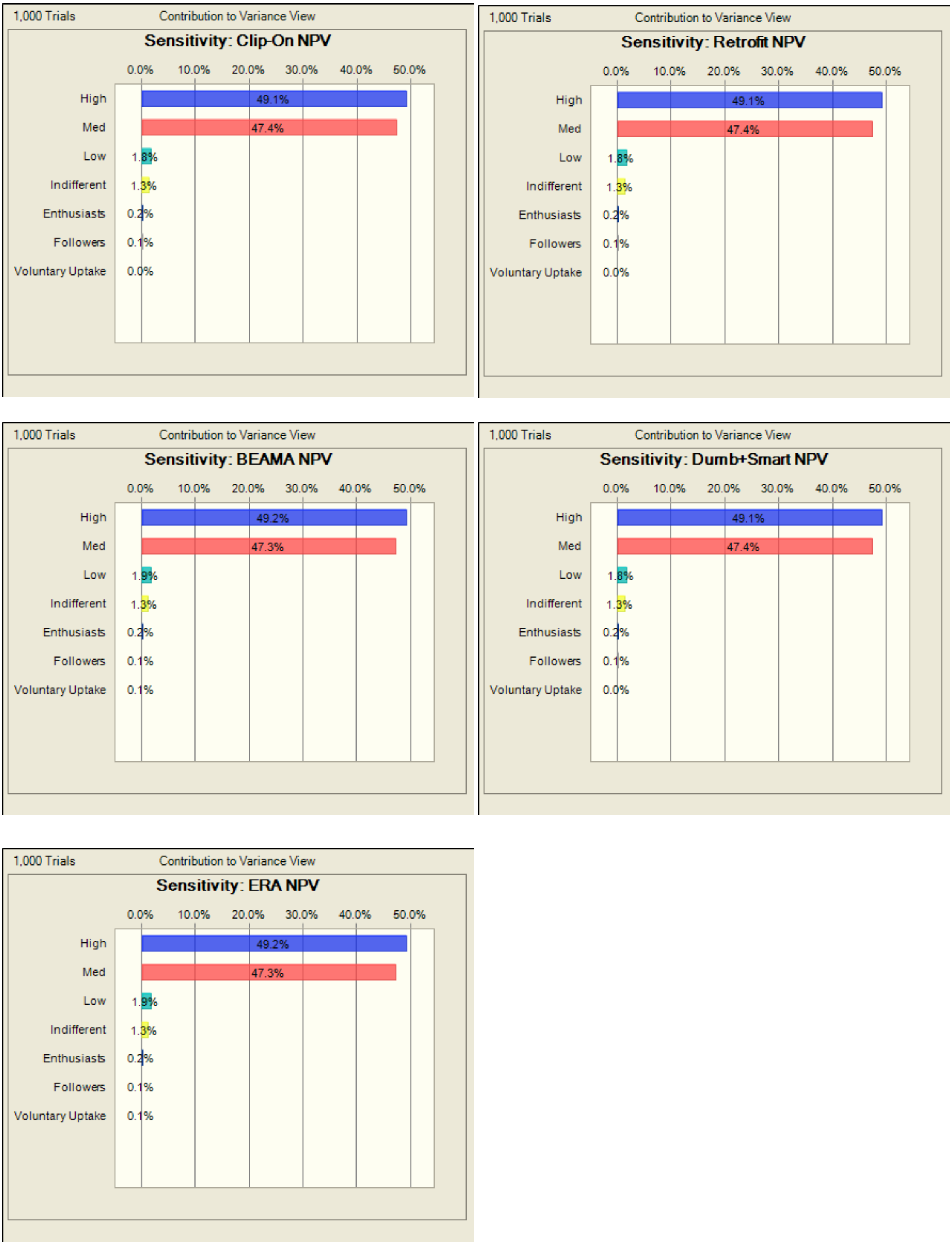
For stranding costs, we can say with 100% certainty that they will be between £bil 1.4 and 3, with a mean of £bil 2.1, for the regional franchise option. For the market tip option, stranding is found between £bil 0.6 to 1.6 at 100% certainty, with a mean of £bil 1.1; the market tip fast option yields a range £bil 0.9 to 2.2 at 100%, with a mean of £bil 1.5

A final result coming out of Crystal Ball is that many of the fitted distributions in each experience resemble the Gamma distribution, which, under certain circumstances, can be approximated with the chi-square *(x^2)* distribution. Under this approximation, it is possible to derive confidence intervals and levels of statistical significance for each predicted NPV value in the model, where applicable. This result shows that the statistical robustness of simulation results can be increased even more; however this task is beyond our scope but can be followed up in further work.

Table 7-3 Base NPV estimates and simulated NPV means

Roll-Out Option/ Technologies	PLC NPV (£mil)	Simulated Mean NPV (£mil)	Mean Standard Error
New, Replacement and Voluntary			
ERA Spec	-4,823	-4,785	67
BEAMA Spec	-812	-785	68
Dumb+Smart	3,563	3,576	68
Meter Retrofit	4,120	4,144	67
Clip-On	2,467	2,486	50
Regional Franchise			
ERA Spec	-4,497	-4,462	63
BEAMA Spec	-766	-732	63
Dumb+Smart	3,616	3,647	63
Meter Retrofit	3,476	3,507	63
Clip-On	N/A	N/A	47
Market			
ERA Spec	-4,360	-4,328	60
BEAMA Spec	-804	-771	60
Dumb+Smart	3,337	3,367	60
Meter Retrofit	3,679	3,709	60
Clip-On	2,203	2,225	45
Market with Tipping Point			
ERA Spec	-4,314	-4,279	65
BEAMA Spec	-498	-463	65
Dumb+Smart	3,959	3,991	65
Meter Retrofit	3,936	3,968	65
Clip-On	2,363	2,386	48
Market with Tipping Point Fast			
ERA Spec	-4,328	-4,293	67
BEAMA Spec	-456	-421	66
Dumb+Smart	4,065	4,097	66
Meter Retrofit	3,988	4,020	66
Clip-On	2,395	2,419	49

Figure 7-4 Sensitivity in contribution to variance: Market Tip Fast with Hybrid 2



7.3 Comms Results

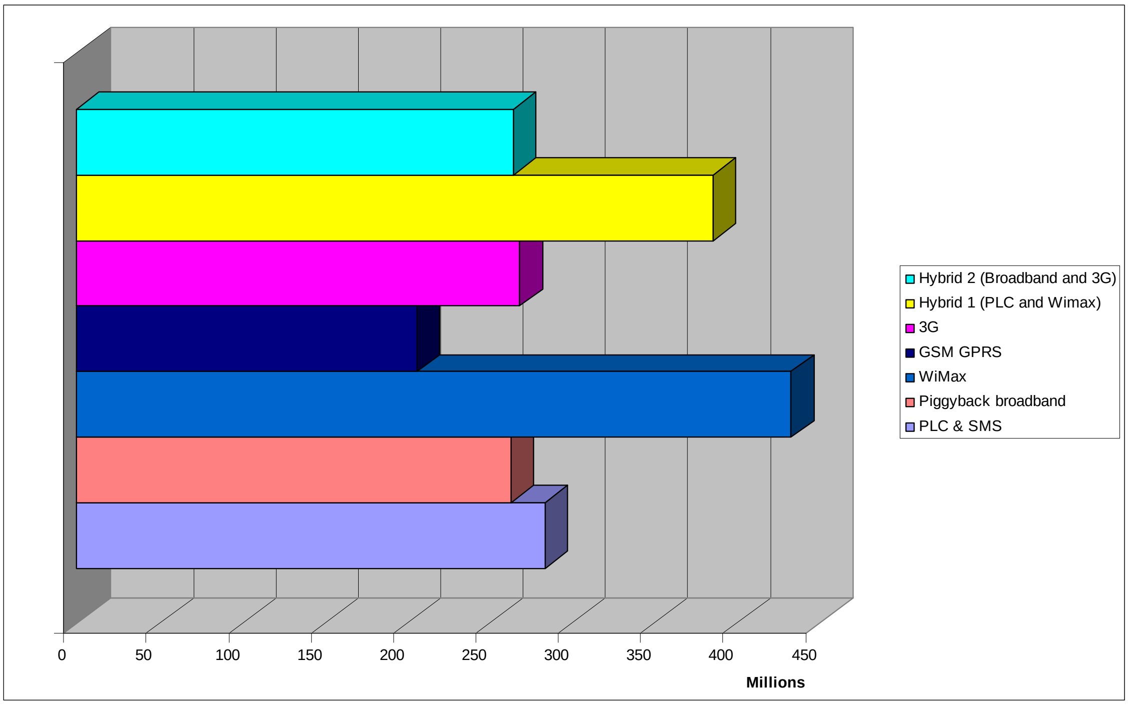
In terms of Net Present Value for wireless technologies, we estimate that currently GSM with SMS is the least cost option, however with the development of GPRS and 3G, it is likely that in a few years this technology will be obsolete. This technology risk is significant and we have factored it in our analysis by selecting 3G instead and lowering usage charges costs so that they reflect current costs by SMS. From non-wireless technologies, we estimate that broadband is the least cost option, when the metering data uses existing internet connections. Figure 7-5 summarises costs for various comms options after correcting for bias (including capex, installation for all infrastructure, excluding recurring usage charges).

It should be noted that in terms of bias correction, proven technologies (like GSM or broadband) receive half the amount of bias in capex than future technologies. This deliberate introduction of bias reflects the inherent risks of technologies that are not yet fully operational and have been stablished in the market.

Because not all households have broadband connection and GSM signal is not found everywhere, we estimate that hybrid solutions provide a more realistic representation of the final technology mix. Our scenarios differentiate between current technologies (3G and Broadband) and future technologies (Wimax and PLC). Although current broadband penetration in the UK is about 60%, we expect that this figure will be up to 75% by 2010.

Results from the comms model show that, in general, it is much more economically efficient to use existing comms infrastructure networks for smart metering comms requirements than to develop new networks just for SM. This is mainly because the data transfer requirements of SM are so small compared to other comms needs that cannot justify economically the development of new networks.

Figure 7-5 Annuitised HAN, LAN, WAN Costs for Comms



8 Distributional Impacts

In this section we provide results for distributional impacts, principally for consumers and suppliers. Impacts on consumers are approached in two ways: in the first we comment on the impact per meter; in the second we examine equity adjusted impacts on the fuel poor, by using distributional weights derived from the fuel poverty dataset for England. We also comment briefly on the impacts on manufacturers, meter operators and meter readers.

8.1 Impact per account (meter)

Distributional analysis for consumers is based on the existing meter numbers that we have used for GB PLC analysis. Following Government guidelines, we have assumed that all costs and benefits to suppliers, including stranding, are passed through 100% to consumers. Although, it is very likely that cost and benefits pass-through will take a while to realise, or that there will be some lag between occurrence of costs and benefits, we assumed for simplicity that all cost and benefit streams appear simultaneously and instantaneously in time.

Following Government guidelines, we have included carbon savings in the consumer impact per meter. However it is not likely that consumers will ever yield any real benefits from carbon savings, at least not for the period of the appraisal up to 2040, except maybe from the ‘moral’ satisfaction that they take action against climate change.

Benefits from peak load reduction should also return to consumers. However, it is not clear how and when reductions in peak load will be offset by increasing demand; if the net benefit will ever reach consumers. Hence, we have opted to leave this benefit out of our appraisal.

Table 8-1 summarises the model results for the consumer per roll-out option, with Hybrid 2 for comms and all biases and efficiencies/inefficiencies included. It is clearly evident that provision of feedback on energy consumption can be done with little or no impact on the consumer. The clip-on has trivial impact and positive NPV, while the meter retrofit option has negative NPV but with a relatively small impact on the consumer.

However, the same is not true for the smart metering options. As with the GB PLC analysis, the ERA spec scores the lowest NPVs, with impact per account ranging from -£8 to -£11.6 per year. For dual fuel households, this impact will double. BEAMA spec scores a bit better than the ERA one. The Dumb and Smart option outperforms the other two with negligible impact per account; this option is up to three times more cost efficient per account than ERA or BEAMA spec.

These results are given with Hybrid 2; other more expensive comms technologies will increase costs to consumers even more. For instance, WiMax or PLC can amount up to £15 per meter per year with sophisticated meters and accelerated roll-out options.

Table 8-1 Consumer Impact with four roll-out options and Hybrid 2

Roll-out option/ Technology	Consumer NPV (£mil)	Average Annual Impact per meter (£)
New, Replacement and Voluntary		
ERA Spec	-8,287	-8.29
BEAMA Spec	-4,276	-4.3
Dumb+Smart	343	0.48
Meter Retrofit	982	0.85
Clip-On	617	1.05
Regional Franchise		
ERA Spec	-10,071	-11.59
BEAMA Spec	-6,340	-7.81
Dumb+Smart	696	-0.16
Meter Retrofit	-1,803	-2.56
Clip-On	N/A	N/A
Market		
ERA Spec	-7,415	-8.17
BEAMA Spec	-3,859	-4.63
Dumb+Smart	543	-0.24
Meter Retrofit	902	0.75
Clip-On	564	0.95
Market with Tipping Point		
ERA Spec	-8,681	-9.88
BEAMA Spec	-4,864	-6.01
Dumb+Smart	950	0.28
Meter Retrofit	-126	-0.66
Clip-On	599	1.03
Market with Tipping Point Fast		
ERA Spec	-8,901	-10.16
BEAMA Spec	-5,029	-6.23
Dumb+Smart	1,012	0.36
Meter Retrofit	-275	-0.87
Clip-On	606	1.04

Notes: Regional Franchise without clip-ons

8.2 Impact on the Fuel Poor

Following Green Book guidelines, we have examined separately the impact of the introduction of smart meters on the fuel poor. Following the 2003 and 2007 EWP policy goal ‘to ensure that every home is adequately and affordably heated’, the UK government has been consistently pursuing policies to eliminate ‘fuel poverty’. A rough definition of fuel poor households is simply households that spend 10% or more of their annual disposable income on home energy use (electricity or gas for space heating/cooling, cooking, hot water, lighting etc).

BRE has been updating the 2004 fuel poor dataset, which was kindly provided to MML for the purposes of this study. According to the latest figures from the BRE survey, around 5-6% of all households in the UK live below the fuel poverty threshold; although there is some evidence that this number is following a declining trend.

The BRE survey sample, consisting of 15,874 observations for England, was separated according to a fuel poor index into fuel poor and non-fuel poor households (households indexed 0.1 or above are fuel poor, while those indexed as below 0.1 are non-fuel poor). The fuel poor part of the sample was then divided into four bands (lower, mid lower, mid upper, upper) according to their ranking in the fuel poor index. Following Green Book guidelines, and assuming that the income elasticity of marginal utility is unity, we have derived distributional weights for each income band of the fuel poor part of the sample. Distributional weights for the fuel poor range from 2.4 to 3.6, going from upper to lower.

Ideally, distributional analysis should scale all benefits and costs for the population sample under examination. However, this was not entirely possible for the fuel poor for two main reasons: one is that the main analysis in based on four meter types (electric, electric PPM, gas, gas PPM) and this categorisation does not reflect entirely the fuel poor sample; two is that assumptions for main benefits for consumers (energy saving, shifting peak load etc) are unlikely to hold for the fuel poor. We would not expect fuel poor or vulnerable households (low income single parent, incapacitated, or elderly households) to be able to reduce their energy consumption as a result of direct or indirect feedback, at least not as much as non fuel poor households. There might be possibilities for peak load shifting, although bill reductions from TOU tariffs are expected to be minor for such households. Therefore, we have not scaled up consumer benefits for the fuel poor.

However, based on the assumption that supplier costs and benefits will be passed on to the consumers on an equal basis, we have weighed up net benefits per consumer from the introduction of smart meters. The average annual impact per meter was multiplied by the distributional weight for each of the fuel poor income bands to yield the average expected impact per fuel poor household for each technology, comms and roll-out option.

Results are expressed as net change per household in GB £(dual fuel households face double the impact) and as a percentile change in the weighted average of fuel expenditure over full income across all fuel poor households in the sample. Table 8-2 summarises impacts on the fuel poor per technology and roll-out option, for comms option Hybrid 2. The lowest income bands, that receive the highest weight, face the highest cost, which can reach up to £40 in real terms for the more sophisticated meters. For Dumb and Smart the impact is negligible, while feedback technologies have positive impacts that can be as high as £3.9.

In addition, we present results for annual percentage changes in fuel poverty for dual fuel and electricity only fuel poor households. Results, presented as annual weighted percentile change in fuel expenditure over income among fuel poor households are given in Table 8-3.

Table 8-2 Impacts on the Fuel Poor with four roll-out options and Hybrid 2

Roll out/Technology	Lower (£)	Mid Lower (£)	Mid Upper (£)	Upper (£)
New, Replacement and Voluntary				
ERA Spec	-30.48	-24.99	-23.54	-20.54
BEAMA Spec	-15.8	-12.95	-12.2	-10.66
D+S	1.77	1.45	1.37	1.19
Retrofit	3.14	2.57	2.42	2.12
Clip-On	3.87	3.17	2.99	2.61
Regional Franchise				
ERA Spec	-42.62	-34.93	-32.91	-28.76
BEAMA Spec	-28.73	-23.55	-22.19	-19.39
D+S	-0.59	-0.48	-0.45	-0.4
Retrofit	-9.42	-7.72	-7.27	-6.36
Clip-On	N/A	N/A	N/A	N/A
Market				
ERA Spec	-30.06	-24.64	-23.21	-20.29
BEAMA Spec	-17.02	-13.95	-13.14	-11.48
D+S	-0.88	-0.73	-0.68	-0.6
Retrofit	2.77	2.27	2.14	1.87
Clip-On3.48	3.48	2.85	2.69	2.35
Market with Tipping Point				
ERA Spec	-36.32	-29.77	-28.04	-24.51
BEAMA Spec	-22.09	-18.11	-17.05	-14.91
D+S	1.04	0.85	0.8	0.7
Retrofit	-2.44	-2	-1.89	-1.65
Clip-On	3.78	3.1	2.92	2.55
Market with Tipping Point Fast				
ERA Spec	-37.38	-30.64	-28.86	-25.23
BEAMA Spec	-22.91	-18.78	-17.69	-15.46
D+S	1.32	1.08	1.02	0.89
Retrofit	-3.2	-2.63	-2.47	-2.16
Clip-On	3.83	3.14	2.96	2.59

Notes: Including carbon benefits, dataset for England only

Table 8-3 Annual percentage change in Fuel Poverty

Roll out/Technology	Dual Fuel (%)	Elec only (%)
New, Replacement and Voluntary		
ERA Spec	0.735	0.368
BEAMA Spec	0.381	0.191
D+S	-0.043	-0.021
Retrofit	-0.076	-0.038
Clip-On	-0.093	-0.047
Regional Franchise		
ERA Spec	1.028	0.514
BEAMA Spec	0.693	0.347
D+S	0.014	0.007
Retrofit	0.227	0.114
Clip-On	N/A	N/A
Market		
ERA Spec	0.725	0.363
BEAMA Spec	0.411	0.205
D+S	0.021	0.011
Retrofit	-0.067	-0.033
Clip-On	-0.084	-0.042
Market with Tipping Point		
ERA Spec	0.876	0.438
BEAMA Spec	0.533	0.266
D+S	-0.025	-0.013
Retrofit	0.059	0.029
Clip-On	-0.091	-0.046
Market with Tipping Point Fast		
ERA Spec	0.902	0.451
BEAMA Spec	0.553	0.276
D+S	-0.032	-0.016
Retrofit	0.077	0.039
Clip-On	-0.092	-0.046

Dual fuel households, which consist approximately 70% of the fuel poor households in England, face up to 1.02% deterioration in fuel poverty per year in the accelerated scenarios with sophisticated meters. This impact is much lighter, if not reversed, for feedback technologies, which can in many instance improve the overall fuel poverty of both dual fuel and elec only households. Consistently with previous results, Dumb and Smart has negligible impact on fuel poverty.

8.3 Suppliers

For suppliers, we initially examined the 'business case' on the basis that none of the costs or benefits are passed through to consumers. We also included the cost to suppliers from losing sales, stranding costs, and the benefits from reduction of bad debt and higher margin from new sales. The latter benefit depends on meter functionality (£mil 80 for lower specs and £mil100 for ERA spec). This benefit is included only after ten years that all smart meters are out. All results for suppliers, using the comms option Hybrid 2 are given in Table 8-4.

A potential benefit to suppliers is the reduction in financial exposure because of less working capital employed and less risk mitigation costs. These costs savings are likely to appear once the whole smart metering system is fully operational and cashflows become smaller in amount and shorter in duration. This cost saving could potentially be important; however it is very difficult to quantify so we have not included it in our calculations.

Over all, there is no business case for suppliers in any of the technologies we have examined. NPVs are all negative, ranging £ 2 bil for clip-ons to £15 bil for the most sophisticated meters. The average annual impact, spread over all meters, is also negative; ranging from £ -2 to -15, depending on functionality and roll-out option.

However, we found very interesting the examination of the suppliers case when we assume a 100% pass-through for consumers. In this case we find a small positive business case for suppliers, of around £ 1,5 bil for the most sophisticated option. For less functional meters, NPVs are around £ 1bil. Even in this case the clip-on does not yield a positive NPV for suppliers.

Figure 8-1 Suppliers Business Case

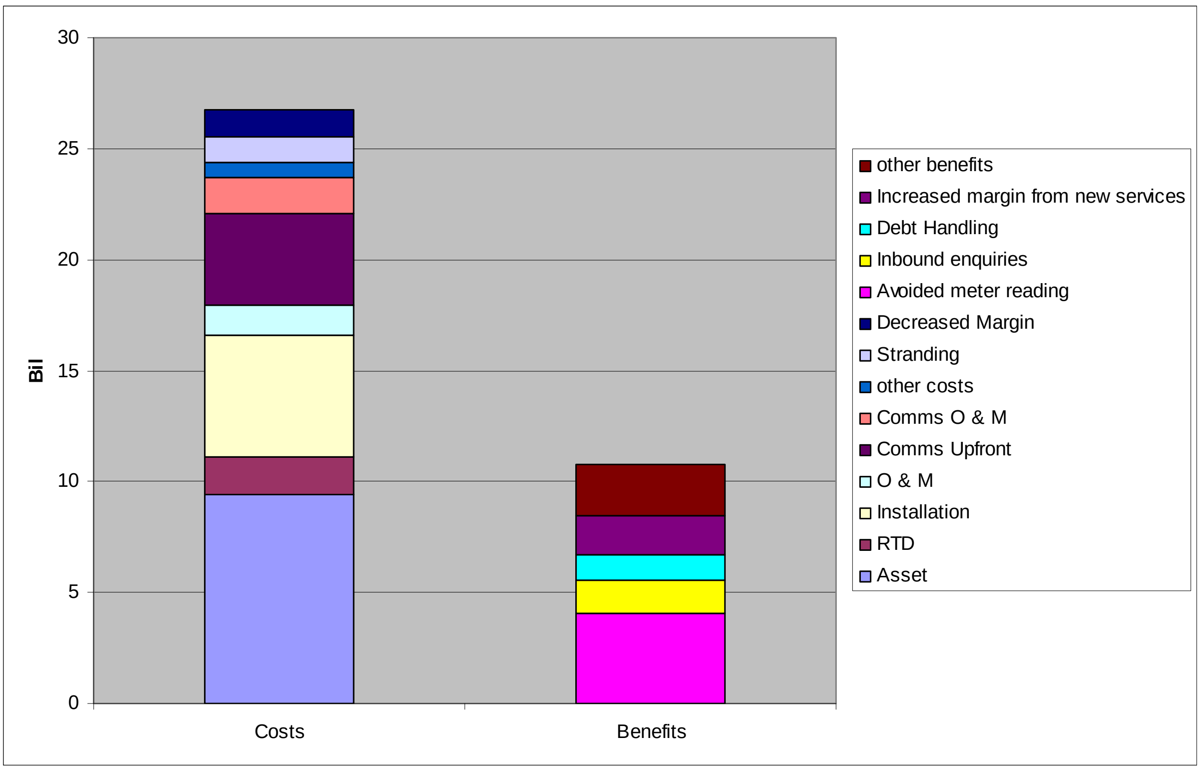


Table 8-4 Impacts on Suppliers with Hybrid 2

	Business Case (0% Pass through)		100% Pass-through	
	Suppliers NPV (£m)	Average Annual Impact per meter (£)	Suppliers NPV (£m)	Average Annual Impact per meter (£)
New, Replacement and Voluntary				
ERA Spec	-15,687	-14.83	1,496	1.64
BEAMA Spec	-9,081	-8.21	1,107	1.2
D+S	-5,196	-4.16	1,107	1.2
Retrofit	-5,952	-5.99	329	0.33
Clip-On	-2,168	-2.19	-691	-0.7
Regional Franchise				
ERA Spec	-15,625	-15.05	1,474	1.62
BEAMA Spec	-10,774	-9.79	1,085	1.19
D+S	-4,451	-3.85	1,085	1.19
Retrofit	-8.277	-7.86	307	0.32
Clip-On	N/A	N/A	N/A	N/A
Market				
ERA Spec	-13,907	-13.66	1,459	1.61
BEAMA Spec	-8,078	-7.59	1,070	1.18
D+S	-4,327	-3.67	1,070	1.18
Retrofit	-5,271	-5.5	292	0.3
Clip-On	-1,922	-2.01	-613	-0.64
Market Tipping Point				
ERA Spec	-15,345	-14.81	1,481	1.63
BEAMA Spec	-9,438	-8.75	1,092	1.19
D+S	-4,325	-3.66	1,092	1.19
Retrofit	-6,743	-6.75	314	0.32
Clip-On	-2,068	-2.12	-659	-0.68
Market Tipping Point Fast				
ERA Spec	-16,064	-15.45	1,486	1.63
BEAMA Spec	-9,675	-8.95	1,097	1.2
D+S	-4,345	-3.67	1,097	1.2
Retrofit	-6,982	-6.95	319	0.33
Clip-On	-2,098	-2.15	-669	-0.68

It should be noted that the impact to individual suppliers will vary, depending on their existing liabilities for stranded assets and the roll-out programme. For instance, in the case of an accelerated option and sustained competition in the metering market, big gas suppliers will be found in an uncompetitive position because of high stranding liabilities, as compared to other suppliers that are not burdened with similar liabilities. This exposure will create distortion in the metering market and create additional uncertainties that will probably end up as higher charges for consumers.

Another potential risk of an entirely unregulated roll-out programme is that big suppliers might take advantage of their subsidiaries in their DNO host areas to take over ownership of assets and beat all competition. This would be very beneficial to host suppliers but anti-competitive for smaller suppliers that operate in the area. Although not captured in our model, this possibility could yield significant benefits for bigger suppliers in terms of client retention and decrease of churn.

Finally, smaller suppliers that ‘own’ younger meter assets will be more sensitive to exposure from stranding liabilities. Unless stranding costs are spread evenly across the customer base, smaller suppliers could face disproportional costs, which can reduce their competitiveness.

8.4 Meter Operators & Meter Asset Owners

The impact on meter operators depends largely on the SM roll-out option and/or the existence of a mandate for delivery of a metering technology. Commercial contracts would typically incur annual charges that reflect meter asset value, installation charges, capital costs, overheads and margin.

In the case of an accelerated roll-out scenario, annual charges will have to include costs for increased labour (hiring and training up to five times more staff), provisions for the ‘feast-and-famine’ period (including redundancy payments, depreciation costs and overheads for the famine period) and risk-mitigation charges. Risk mitigation charges derive from uncertainty in the market regarding the expected life of the new meters that replace the legacy ones. Increased uncertainty in the market, regarding either the nature or duration of the roll-out programme, is likely to result in higher annual charges to suppliers and hence an additional burden to consumers. Although we have not quantified this possibility, it should be taken into account prior to delivering a policy option.

It should be noted that labour costs would not be linearly equivalent to labour costs in a non-accelerated scenario. This is because in the case of an accelerated programme, relevant workforce would be scarce, and hence more expensive. This effect is likely to be even more profound in areas with large meter concentration, like the south east of England.

The impact on meter asset owners, whether they are CMOs or DNOs or NG, depends largely on the nature of the contracts that are already in place for legacy meters and who takes over owner ship of the new meters. Commercial and NG contracts are fully covered and insured towards business risks. Only legacy contracts between suppliers and DNOs are not currently insured. This means that in the case of an accelerated programme, DNOs will be exposed to the extent that they are not allowed by Ofgem to recover any stranding cost.

In addition, if the metering market remain competitive, in a managed programme ownership of new meters is likely to end-up with the best bidders. This means distortion of competition in the metering market, since no CMO is currently in position to bid competitively against e.g. National Grid Metering for ownership of gas meters.

8.5 Manufacturers

Manufacturers certainly have a positive business case, especially in the case of the massive production required to supply an accelerated roll-out programme. In principle, manufacturers should be relatively indifferent to whether meters are rolled-out in a new and replacement or accelerated fashion, since all legacy meters will be changed even in the slowest new and replacement option.

However, we have heard of arguments that massive smart-meter production entails scale economies that can lower significantly the per unit cost of a meter. This is partly true; however, even manufacturers have to allow for the 'feast-and-famine' period in their costs. In addition, massive production requires investment in infrastructure, which essentially entails returns for investors. These returns will be factored in the final unit cost of meters and potentially offset some the scale economies.

8.6 Meter Readers and other impacts

Out of all industry stakeholders, meter reading businesses are likely to suffer the highest impact on their business. Meter readings and density are highly dependent on the asset legacy; as the legacy is being replaced, less meter readers will be needed. In the case that safety inspection visits are retained as necessary every one or two years, this function might still be served by either meter readers or meter operators.

We estimate that at least an overall £4 bil of turnover in the meter reading businesses will be lost until 2040 in present terms. However, this figure is not representative of the total economic impact on GB PLC, because one would have to include redundancy payments for approximately 7,000 workers, the associated unemployment costs for this labour force and the costs of bringing them back to full time employment (training e.t.c.). In addition, a full assessment would have to include the social costs from this increase in unemployment.

AMR or AMM functions in smart metering will yield significant reductions in call centre activity because of better service and customer satisfaction. Hence, we expect that approximately 50% of all call centre staff will have to be made redundant until all SM are rolled out. Although exact numbers have not been brought into our attention, we expect that approximately 6,000 call centre staff will lose their jobs.

Just like for meter reading business, there will be costs for redundancy payments, unemployment benefits and social costs associated with bringing all these employees back to full time employment.

All these costs would have to be included in the impact assessment for full SM, although it is beyond our scope to examine the overall change in welfare from the increase in unemployment from meter readers and call centre staff.

9 Conclusions

9.1 Conclusions from modelling analysis

A first and important conclusion is that there are several technology options available for either provision of feedback and/or smart metering. There are better technology alternatives to both clip-ons and the sophisticated SRSM meters.

A further conclusion is that the energy savings and associated peak load reduction and carbon benefits arising from customers reaction to being provided feedback on their consumption is the most uncertain of all parameters we have modelled. We are more confident of the benefits to suppliers in terms of avoided costs of serve. On the cost side, we are fairly confident on technology costs, except for comms, where a great deal of planning needs to be done, prior to rolling-out SM.

The modelling results show that provision of feedback on energy consumption is very cost effective and can bring significant benefits in a GB PLC context. The alternative technology to clip-ons, that is to retrofit existing meters with some internal comms for the provision of feedback, can potentially bring about very significant benefits, since it overcomes many of the drawbacks of the clip-ons (particularly their lack of accuracy and robustness). The benefits from this option will be enhanced if suppliers encourage consumers to read and communicate via phone or internet self-reads. This technology also has the option of being upgraded to a smart metering system using a smart box with an integrated external comms link. Because of the low cost of a clip-on, this technology performs best in terms of Benefit Cost ratios. However, the retrofit option is more favourable than the clip-on in NPV terms, with around £4bn versus £2.5bn over our appraisal period to 2040.

Provision of feedback through advanced metering solutions is heavily burdened by the high costs associated with replacing legacy meters and developing the comms infrastructure. Therefore it is not favoured in terms of overall NPVs (- the ERA and BEAMA meters NPVs are -£4.2-4.7bn and -£0.7bn, respectively. Only the modular technology of combining a dumb meter with a smart box yields significantly positive NPVs in all roll-out options (with £3-4bn). This result appears robust to changes in energy supply and supplier benefits.

For other smart metering technologies, BEAMA’s spec typically yields negative NPVs and ranks second, while the most expensive ERA spec achieves positive NPVs only without any comms costs included. However, it should be noted that the more advanced metering technologies yield the highest benefits to suppliers. In addition, increased meter functionality may open up new business opportunities and load management techniques that potentially can give rise to a range of whole new benefits. Sophisticated meters bear the risk of a technology ‘lock-in’ in case some of their functions never pick up commercially.

Overall, on accelerated roll-out scenarios, the Dumb+Smart metering option yields the highest NPVs while, in non-accelerated scenarios the meter retrofit performs best; although NPV differences are modest.

The choice of roll-out option has a second order effect compared to overall costs. The accelerated options (regional franchise and market tipping point) incur scale economies of concentration, however, these are largely offset by higher costs for setting up and administering the managed programme and for the 'feast-and-famine' effect in the meter equipment and installation sector. In addition, accelerated scenarios incur significant stranding costs (up to £2.3bn), most of which will finally end up being paid by the consumer.

Stranding is an issue that needs to be taken very seriously. Although stranding costs are not taken it into account in the GB PLC analysis, without regulatory intervention they would most likely be passed through to the consumers. We note that the current contractual arrangements in the metering market do not facilitate any form of accelerated roll-out. Provision of feedback on energy consumption does not require nor impose any form of stranding, which only occurs from accelerated scrapping of old meters.

Accelerated SM roll-out would be more appropriate under different market circumstances, where either the metering market is not competitive or regulation can guarantee a lower level of pass through to the consumer. Existing experience from Italy and Ontario seems to confirm this conclusion.

9.2 Recommendations for further work

There are a number of areas where there is huge uncertainty and where further work would be appropriate.

It would be valuable to look again at the energy savings studies to assess what could be achieved in energy savings and in peak load reduction from simply providing feedback supported by advice on energy saving measures for households. The extent of peak load shifting from TOU should be analysed and compared with what would be achievable using tele-switched appliances (turn-down/ turn off of heating thermostats, freezers and refrigerators, etc).

In this study we have attempted to attribute supplier benefits to particular meter functionality. This has been done on a preliminary basis and so requires further scrutiny as this could affect the relative size of the metering systems' NPVs. In particular, the incremental supplier benefits attributed to the ERA meter versus the BEAMA meter are comparatively modest, while the cost premium is significant. This needs to be confirmed.

Another area of further work is to examine how accurate external retrofit devices (like optical, pulse or magnetic readers) can perform against the other technology options in terms of net benefits, functionality and security.

The biggest uncertainty regarding the costs of smart meter roll-out is the comms element. There are a large number of outliers, most of which were rejected because technologies are too untested, in danger of becoming obsolete or just moving to fast. Comms is such a rapidly moving market with continuous innovation that this needs to be continually reviewed. In addition, integrating a comms link in the household with energy supply business might open up opportunities for new entrants. This is also true for water utilities. There are number of specific areas where further work is required on comms issues:

- From the communications perspective it is clear that whilst the utility supplier must be free to choose the most cost effective solutions there is a problem which will incur on changeover, in that the communications as well as the meter must be "transferred" between the utility suppliers. The effects of this can be minimised by standardisation and commercial agreements between the suppliers. Further work is required, in particular which parties need access to which data, is there one data collector or one per supplier, how much data collection can be done in "off-peak" periods, etc.

- Standardisation work must proceed on the applications layer, eg Mbus/DLMS/Smartbus etc. One standard must be selected and developed to support AMM features.

- The home area network (HAN) communications devices must be standardised, otherwise where there are two distinct suppliers, the meters will not be able to communicate with each other. This could leave the gas, and in the future the water meters, unable to communicate (-on the basis that the electricity meter is the hub). ZigBee and Zwave still need some development to carry out the AMM features and also in terms of extending battery life under a two-way communications system. Including support for control of all devices in the home will unnecessarily delay the roll-out of smart meters. This should probably be viewed as a phase two project. Clearly the electricity meter need not be the main or the only hub in the home for control of energy using devices.

- PLC has been considered in the cost modelling, however there has been no consideration given to who will operate this network, nor how. A decision must be made about who will build and operate it and the nature of the commercial arrangement, eg shared cost among the utility suppliers and not for profit versus commercial venture run as a profit making operation.

- There is a WAN solution which is available today and has potential to meet the required price point. This is 2G using a combination of SMS and GPRS. The model developed can be used to determine a price point at which these mechanisms become acceptable. Quotes have yet to be obtained from communications service providers. It will provide almost global coverage and requires very little communication expertise from the installer. The installer has to check that there is coverage, a test SMS and GPRS message could be sent from the meter to installer and vice versa once installed to validate it is working. A mobile operator has indicated a willingness to explore pricing options, and revenue earned in off peak hours (ie midnight to 06:00 am) is often viewed as near 100% margin: since most communication networks are idle during this time. Further work is needed to clarify the scale and scope of the requirements and to negotiate with mobile operators.

- A further option that is possible is a "piggy-back" broadband option, this would use the existing physical broadband infrastructure into the home and split this into two logical services, one for the consumer and one for the utility suppliers. Contractually each supplier would have a contract which consisted of a number of logical services (which could move with churn). There would be no need for any physical changes, a notification would transfer ownership between the utility suppliers without service interruption.

In addition, it would be perhaps interesting to examine what would be the overall GB benefit by including water smart meters in our current model. Water meters are consistently neglected by the industry, however it would make much more sense to include them in a SM roll-out.

Our study has assumed a 40% penetration of self reads for the meter retrofit option. This assumes that financial incentives, CDU /email/SMS prompts, and an easy online/ phone interface encourages a high uptake. This all requires further investigation.

It is clear that there is a serious risk that most of the new metering systems would be vulnerable to tampering. There appears little that can be done to address this. Only the ERA or BEAMA spec (or other comparable) meter coupled with PLC provides a more robust solution (and even here this is not guaranteed. The implication is that procedures will need to established to provide consumers with strong incentive to ensure that their metering systems and comms links are working. A small element of malicious damage and fraud will be inevitable and measures will be required to address this. This whole area requires further investigation.

This study has revealed that combination of a dumb meter/retrofit and smart box could provide a very high NPV. These technologies are outside the conventional meter manufacturers core skills, with innovation being lead by smaller companies, often from the comms equipment sector.

While a number of companies are actively selling such devices to industrial and commercial customers (Futumeter and Meter Mimic, for instance), these are far from the low cost device that we have outlined in this study.

The Edelia plug and play AMR solution is the closest to our concept smart box, although it does not have the full range of retrofit read options that the other manufacturers are already using. BT's "homehub" is another device like our smart box. We understand that some meter operators and even energy suppliers are now looking at such modular smart box options. Given the apparent cost advantages, the technical flexibility in putting the smartness in an accessible box, it is important that this technical option is more fully scrutinised for functionality and assessed for its roll out costs.

Finally, it would perhaps be interesting to examine the potential segmentation of SM roll-out, using sophisticated ERA meters for PPM and modular metering technologies for credit meters. This segmentation, possibly, can yield the highest NPVs of all technology options we have explored so far. Further work on this issue is recommended.

10 Postscript

10.1 Introduction

Following the delivery of the draft final report in December 2007, MML assumptions, methodology and spreadsheet model have been extensively scrutinized by BERR, DEFRA and HM Treasury economists. The objective was to make results as robust as possible, prior to addressing stakeholders for feedback on underlying assumptions and methodology.

This was a painstaking process that lasted about three months. Given that no previous work had addressed cost and benefits in that level of detail (in terms of metering and comms technology options and roll-out options), BERR and MML project managers tried to update assumptions using the most up-to-date information and ensure that analytical tools present results to the highest level of accuracy.

The BERR version of the MML model and the MML report were finally distributed to stakeholders in March 2008. BERR and MML had the opportunity to receive feedback from stakeholders in a number of meetings, which was greatly appreciated. Responses were mainly in the form of queries on how the model works, and challenges of underlying assumptions.

This postscript is intended to outline MML responses to stakeholder feedback and revise results, given errors, omissions and suggestions received since the submission of the draft in December 2007. Below we provide the main areas of feedback and MML responses.

10.2 Asset Cost Assumptions

Stakeholder views were mainly targeted towards revised estimates for asset costs that BERR had taken into account. Some suppliers pointed out that maybe these are high, while other stakeholders pointed out that asset costs are about right for the time being. BEAMA and meter manufacturers did not return any comments on asset costs. Notably, most stakeholders returned comments only on the ERA specification and not on other asset costs,

MML has used higher asset costs than BERR, but less bias correction. So essentially, BERR and MML estimates are about similar. As a result MML has decided to leave these unchanged.

A point coming from a number of stakeholders was that they would expect asset costs to come down with time. This seems reasonable and would make sense to include in the model. However, as one manufacturer pointed out it is not certain at this time whether replacement meters of the first roll-out would be of equal specification or higher specification. Cost reduction over time would make sense if one would assume that the spec that goes on the wall in 2010 would be the same as the one in 2030. Given the evolution of comms technologies this seems rather unlikely. Therefore MML has decided not to include this cost reduction.

10.3 Installation Costs Assumptions

Most of the independent meter operators agreed with the installation costs given in the MML report. Given that MML estimates were based on discussions with AMO, MML is reasonably confident on these assumptions.

10.4 Optimism Bias Assumptions

Optimism bias correction created a great deal of disagreement, especially among suppliers. The main area of disagreement was the bias correction on the ERA specification, even with the existence of SRSM project. MML recognises that the existence of the SRSM project decreases risks from producing and supplying the meter. Hence in the MML model, the ERA spec received the lower bias correction among smart metering options. None of the stakeholders provided any sort of evidence on why the bias should be lower or higher, although there was some unanimity that the bias should reduce over time. MML agrees with the last point; if the assessment would take place in two or three years time the bias correction might have been lower. However, this point is not relevant for the bias correction to date. Therefore MML has decided not to make any changes in the bias correction.

10.5 Cost of Capital

Stakeholders were largely unsatisfied with the 10% cost of capital assumption that was used for all capital costs. This assumption was passed to MML from BERR and was double-checked by DEFRA economists. Given that all metering contracts at the moment are based on financing (including asset, installation, interest and margin), MML has no convincing suggestion from stakeholders to change this assumption.

A discussion has emerged between BERR economists and Frontier Economics regarding the application of bias on top of annuitised values for costs that already include the cost of capital. The issue was whether it is appropriate to include bias correction for the cost of capital. MML, after discussions with meter operators, believes that if capex proves an underestimate, metering contracts will have to be based on additional financing; which of course costs additionally. Therefore, no changes are to be made to this assumption.

10.6 Period of Evaluation

This was also an area of concern. Although the period of the evaluation does not make any difference in terms of benefit cost ratios, it makes a difference in terms of separate NPV estimates for costs and benefits. The period of evaluation is usually a weak point in most CBAs. All previous CBAs for UK smart meters do not provide a justification on why they use an evaluation period of 15, 20 or 25 years. MML has used an evaluation period of 30 years, as documented in the report, to pick up the full benefit from the last meter going on the wall. Assuming a meter life of 15 years and the slowest roll-out lasting 15 years, the evaluation period is 30 years. To this time, MML has not heard convincing arguments from any stakeholder on why the evaluation period should be less than 30 years.

Some stakeholders have suggested using ‘residual’ values that are discounted altogether at the cut-off date. MML believes that this method for the specific task entails a degree of arbitrariness, as we would have to assume a residual value based on current expectations of the future. Instead, MML believes that since costs are annuitised, NPVs can reflect accurately the exact amount of cost and the exact amount of benefit to be discounted in each year.

10.7 Communications

Stakeholders generally had little comments on the comms side. It was generally recognised that this area requires further work. Onstream (of National Grid) offered some valuable comments and picked up an error in the model associated with the Wimax option. This error is now resolved.

A few stakeholders noted that there seems to be an inconsistency in how the comms model works. The problem here was that for some comms technologies the whole infrastructure would have to be in place prior to smart metering yielding full benefits; and for other technologies that utilise existing networks every meter would yield benefits from the day it goes on the wall. MML recognises that this is truly an issue and the model was corrected.

10.8 Benefits

Stakeholders were less concerned about the benefits and there was a consensus that most of the benefits were captured. There were some concerns over benefits from TOU tariffs, as some stakeholders noted that more attention should have been drawn on benefits from multi-tariffs. MML assumptions on customer take up of TOU tariffs were conservative since previous UK experience does not support that customers would be enthusiastic. In addition there is some small evidence suggesting that a percentage of customers taking up TOU might end-up with higher bills, simply because they do not synchronise energy use with different tariff periods. Given that in the UK the amount of load that can actually be shifted is relatively low, MML believes that there is not enough evidence to support higher benefits from TOU.

In addition, there some concerns on other intangible benefits (i.e. microgeneration, safety, increased competition from easier customer churn, dynamic load management etc.) that were not included. MML recognises that these might be important indeed; however given the current lack of data and the difficulty in quantifying these benefits, it has not been possible to include these in the model.

10.9 Other Changes

A number of small formula errors have been identified and corrected in the model, prior to the model being sent to stakeholders. These are listed in the Log tab in the spreadsheet.

10.10 Revised Model Results

Following the comments from BERR and stakeholders, the following changes were made in assumptions:

- ERA specification asset costs were reduced to £55 for electric and £70 for gas.
- The expected asset life for comms was reduced to 15 years

The model was adapted to reflect changes from a number of comments by BERR. The revised results are given in Table 10-1. Overall, we could say that results from the model still hold without affecting significantly NPVs and technology rankings. There has been some change in terms of the most favourable roll-out option; the slow market seems to be performing better than any other. We attribute this to the fact that comms upfront costs are linked to the number of meters rolled out. The market option roll-outs most meters later in the future, hence, because of discounting, becomes the most cost efficient. This result is entirely dependent on the discount rate assumption. However, consistently with the previous version of the model, the market options consistently outperform the managed one.

Table 10-1 Revised Summary Results including optimism bias and dual fuel efficiencies-Hybrid 2

Roll-Out Option/ Technologies	PLC NPV (£mil)	B/C Ratio	Total Costs (£mil)	Asset, Install, O&M Costs (£mil)	Comms Costs (£mil)	Other Costs (£mil)	Total Benefits (£mil)	Consumer & CO2 Benefits (£mil)	Supplier Benefits (£mil)	Other Benefits (£mil)
New, Replacement and Voluntary										
ERA Spec	-4,618	0.831	27,335	18,050	5,779	3,546	22,757	10,764	10,899	1,094
BEAMA Spec	-1,860	0.919	22,929	13,609	5,779	3,541	21,069	10,723	9,252	1,094
Dumb+Smart	2,475	1.16	15,824	7,929	5,779	2,117	18,299	9,757	7,448	1,094
Meter Retrofit	2,932	1.284	10,319	9,886	N/A	433	13,251	9,611	3,640	N/A
Clip-On	1,395	1.753	1,853	1,509	N/A	344	3,247	3,247	N/A	N/A
Regional Franchise										
ERA Spec	-4,923	0.812	26,180	16,822	5,825	3,533	21,257	10,062	10,175	1,019
BEAMA Spec	-2,362	0.893	22,040	12,683	5,825	3,531	19,678	10,024	8,634	1,019
Dumb+Smart	2,056	1.14	15,029	7,031	5,825	2,173	17,085	9,125	6,941	1,019
Meter Retrofit	2,365	1.236	10,021	9,213	N/A	808	13,386	8,988	3,398	N/A
Clip-On	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Market										
ERA Spec	-4,104	0.831	24,334	16,000	5,128	3,206	20,230	9,583	9,768	970
BEAMA Spec	-1,660	0.919	20,388	12,064	5,128	3,197	18,728	9,546	8,212	970
Dumb+Smart	2,497	1.18	13,765	6,726	5,128	1,911	16,262	8,691	6,602	970
Meter Retrofit	2,621	1.286	9,172	8,763	N/A	408	11,793	8,561	3,232	N/A
Clip-On	1,249	1.759	1,644	1,338	N/A	306	2,893	2,893	N/A	N/A

Roll-Out Option/ Technologies	PLC NPV (£mil)	B/C Ratio	Total Costs (£mil)	Asset, Install, O&M Costs (£mil)	Comms Costs (£mil)	Other Costs (£mil)	Total Benefits (£mil)	Consumer & CO2 Benefits (£mil)	Supplier Benefits (£mil)	Other Benefits (£mil)
Market with Tipping Point										
ERA Spec	-4,385	0.832	26,130	17,216	5,659	3,255	21,745	10,289	10,414	1,043
BEAMA Spec	-1,765	0.919	21,895	12,981	5,659	3,255	20,130	10,250	8,837	1,043
Dumb+Smart	2,711	1.18	14,765	7,241	5,659	1,865	17,476	9,329	7,104	1,043
Meter Retrofit	2,800	1.284	9,867	9,430	N/A	437	12,667	9,189	3,478	N/A
Clip-On	1,338	1.757	1,768	1,440	N/A	329	3,106	3,106	N/A	N/A
Market with Tipping Point Fast										
ERA Spec	-4,465	0.832	26,523	17,468	5,778	3,278	22,058	10,434	10,566	1,058
BEAMA Spec	-1,808	0.919	22,226	13,171	5,778	3,278	20,419	10,394	8,966	1,058
Dumb+Smart	2,733	1.18	14,993	7,346	5,778	1,868	17,726	9,460	7,208	1,058
Meter Retrofit	2,836	1.283	10,011	9,567	N/A	443	12,847	9,318	3,528	N/A
Clip-On	1,356	1.756	1,794	1,461	N/A	333	3,150	3,150	N/A	N/A

Notes: Comms are included only in the first three technologies, Regional Franchise does not apply for clip-ons,

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Appendix A Metering and Comms Technologies

A.1 Electricity Display Devices

For technical characteristics of these devices, we have looked at two brands that are already available in retail, the 'Electrisave' and 'Current Cost'. Both devices were given out to customers by several suppliers.

The transmitter of the device is usually powered by replaceable or non-replaceable batteries, while the display unit is powered either by batteries or the mains. According to the technical specifications of these devices, the accuracy of displayed consumption data is higher than 90% for most household users (1A to less than 3A), and higher than 95% for most SMEs (3A to 71A).

It should be noted that CDUs do not provide any kind of information back to the supplier. Also, because of their relative inaccuracy, they cannot be used for reliable metering, even if meter reads from the CDU were provided by the customer to the supplier. In essence, CDUs are not meters since they do not provide any kind of metering service.

However, CDUs can provide real time information on electricity use to the consumer, thus they can provide the feedback effect, which has been found to yield energy savings (e.g. see Darby).

Currently, there are no simple clip-on devices for gas meters, although external retrofit devices exist for both gas and electricity meters. These retrofit devices work either by using optical readers (that employ the optical character recognition technology that is commonly used in scanners), magnetic field sensors or electronic pulse readers. The accuracy of these devices is as good as normal meters. However, few have ever been installed in the UK.

A.2 Modular Metering Solutions

'Modular' metering is a generic term that can describe the 'dumb meter with smart box' metering solution. The basic idea behind this technology is that all the 'smart' characteristics of the meter are not contained within the meter itself, but are located elsewhere i.e. in a comms box or a 'smart' box that communicates with a comms box within the household. Modularity allows for increased flexibility in provision of metering solutions because it separates the three key characteristics embedded in SM i.e. metering, managing data and communicating, to separate modules that can be updated or withdrawn, depending on innovation and/or customer needs. For instance, if the comms technology becomes obsolete, the modular system does not require changing the whole metering infrastructure but only the comms modules; or if customers require a function that is not currently in the system, then suppliers can adapt only part of the metering system. Therefore, this technology bears less technology risks than 'metercentric' solutions that contain all technology within the meter.

Error! Reference source not found. presents schematically two possible technology options with dumb meters and comms that provide AMR and feedback from the supplier back to the consumer, although it is not conclusive of all modular metering technologies we have identified. The solution in the figure resembles 'Edelia' solution, that we have located at the website of BERR[4]. However, upon our research in the industry we have discovered several others like the 'Meter Mimic'[5], 'Meter-Pod'[6] and 'Elect Trans'.

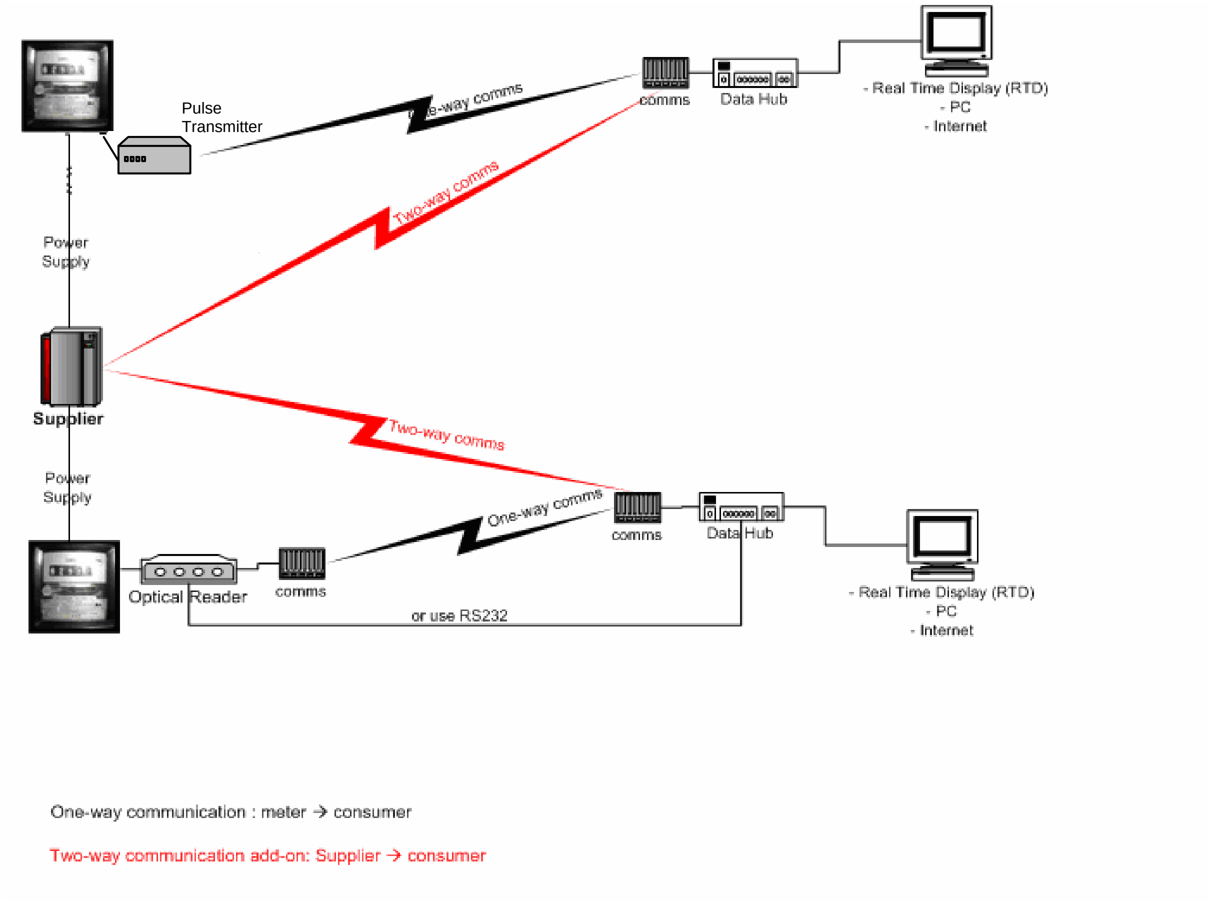
It is very important to note that almost all modular technologies offer integrated solutions for metering of electricity, gas and water data. This is crucial, since current policies on smart meters do not include water data metering.

Another crucial aspect of modular metering technologies is that they can be 'hosted' to existing smart boxes in the household, like those offered by BT, Tiscali or Virgin, that combine several comms related services. From our industry overview, we were informed that such integration of technologies is currently discussed between comms services providers and makers of modular metering technologies.

Such integration presents two significant opportunities: first is that it can lower significantly costs for smart-metering since it requires a small amount of extra capex for communicating with the meter, it does not require installation (at least Edelia and Meter Mimic are Plug-n-Play) and mitigates (if not eliminates) the risk of stranded technology costs. Second it can ensure that data will be transferred securely back to suppliers. Dedicated smart boxes can be unplugged and therefore interrupt the transmission of data back to the supplier; however integrating metering data transfer with existing smart boxes can overcome this problem, since without the box plugged the customer would be left without telephone, internet and TV.

[4] http://www.berr.gov.uk/files/file37310.pdf
[5] http://www.cgm-ltd.com/
[6] www.pilotsystems.com

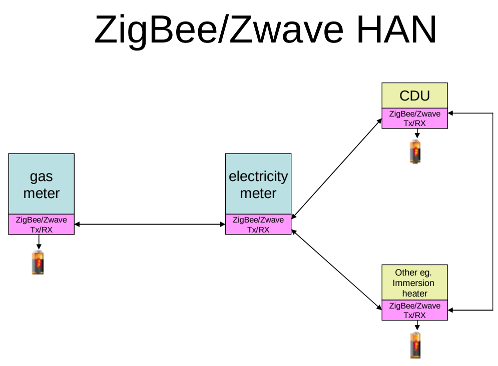
Figure 10-1 Dumb Meter with Smart Box – Electricity and Gas



A.3 Architecture of HAN

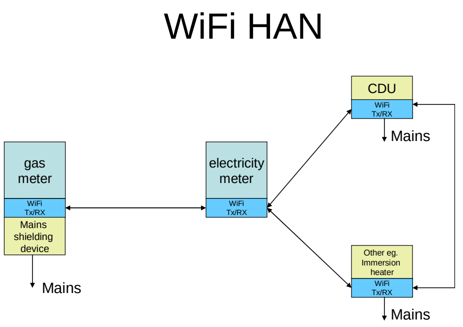
Using ZigBee/Zwave battery operation of the household devices could be realistically achieved. Each meter or home that needs to be controlled has an integrated ZigBee/Zwave device and a battery. Research is ongoing into low power communication techniques for ZigBee devices. [10] A schematic representation is given in Figure 10-2.

Figure 10-2 ZigBee/Zwave device for all meters and controlled devices



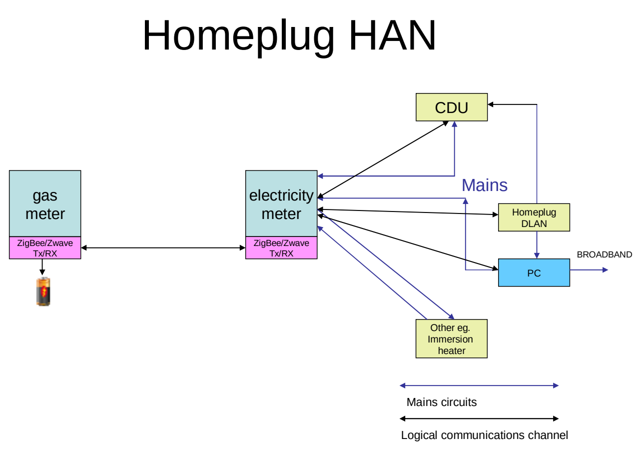
Where a WiFIi HAN is used this requires the same number of devices but these require to be mains powered, as shown in Figure 10-3

Figure 10-3 WiFi HAN connected to the mains



In the case of homeplug the number of ZigBee/Zwave device needed is reduced, but the homeplug device is required, as can be seen in Figure 10-4. These are currently available eg Zyxel P660HWP which retails at about £100.

Figure 10-4 HAN with homeplug



In the above figure, only the gas and electric meters need a low power wireless device as all other communications is carried out by the homeplug and mains cable technology through the home.

During this search we investigated the state of development of integrated communications devices in the white goods market. The rationale being that if the white goods manufacturers had decided on a particular standard then this was an optimum choice for the devices in the meters. Relevant standards in the white goods area were uncovered and noted [17,18,19,20].

There is currently no published evidence of the production or imminent market launch of white goods containing integrated communications devices. Our inquiry shows that consortiums of manufacturers and research institutions worldwide are in the process of product development within broader programmes such as ‘the digital home’, support for the elderly, and health informatics. Examples include:

- Easyline+ (Ambient Assisted Living in the Ageing Society) aims to develop prototypes near to market of advanced white goods to support elderly persons with or without disabilities to have a longer independent life by compensating for their loss of physical and/or cognitive abilities. Technologies include Neuronal Networks, Zigbee, and RFID sensors. *Siemens Business Services GMBH & Co. OHG* is the main industry participant [13].

- *Haier* is working with *Helicomm* to integrate IEEE 802.15.4 and ZigBee wireless communications into products and has an ongoing co-operation with *Ericsson* to develop home electrical appliances using Bluetooth technology. Haier is currently in talks with *Sanyo* and *Samsung* over the co-development of network-enabled digital appliance operations[14].

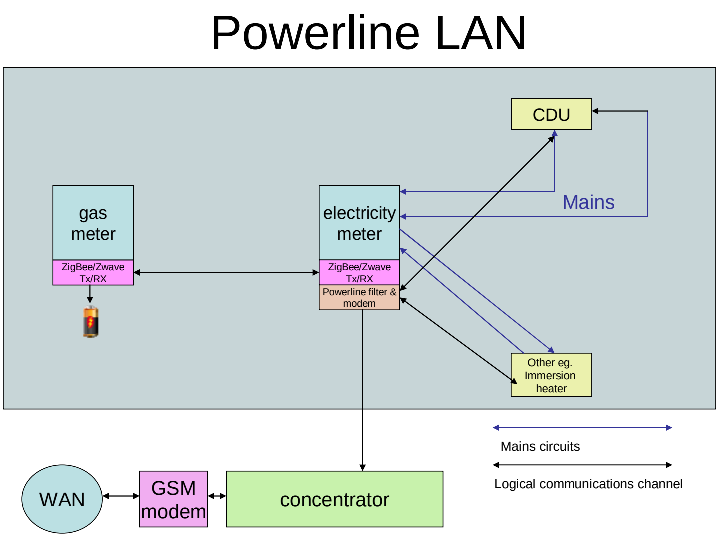
- The ESTIA Consortium asserts that developing household appliances that are suitable for connection in home systems will need to consider that the power line network and wireless such as Zigbee, Bluetooth, and WiFi are most suitable for communication [15]. Industry participants include *Alcatel Sel*, *Bosch/Siemens/Hausgeraete-/B/S/H*, *Thales*, *Gorenje*, *Siemens*, *Teletel*, and *Keletron*.

- The PHENOM project is linked to a number of other *Philips Research* projects on Ambient Intelligence, which jointly participate in the Eureka-ITEA project, AMBIENCE. *PHENOM* aims at creating a home environment that is aware of the identity, location and intention of its users, and that eventually is capable of butler-like behaviour. The project involves 802.11b wireless LAN and RFID technology.[16]

A.4 LAN Technical Issues

In Figure 10-5 power line inserts an extra hop between homes and a point in the power distributors network. At the concentration point the data is connected into the WAN ie. a third party network (eg BT, O2 etc.) The benefit of this is that the third party networks do not have to reach every home.

Figure 10-5 LAN with powerline and GSM

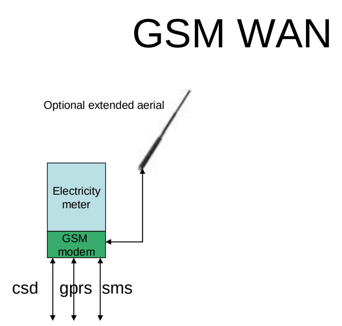


In the case of GSM, where for every point of connection a mobile number, a SIM and a modem is required, there can be some cost reductions. In low volumes mobile operators charge a purchase cost for each SIM and a monthly SIM rental. Powerline in this case reduces the number of SIMs, and hence purchase and rental costs, the number mobile numbers and hence modems. This is purchased at the cost of installing and maintaining concentrators. A low power wireless device is still required for communications between the gas and electric meter (HAN), and a powerline modem with a filter is required for each home. Wireless mesh could be used in a similar way to concentrate traffic prior to hand-off to a third party provider.

A.5 Home Equipment to support various WAN options

If a GSM modem is required, this will support CSD/GPRS/SMS. The implication is that the utility can use a mixture of SMS (for meter reads and tariff changes) and GPRS (for software upgrades). An optional antenna extension can be made available to extend coverage to basements and interiors of large blocks. SMS will have penetration is some basements as the power level required is so much lower than for GPRS. Figure 10-6 presents how a GSM modem can be combined with WAN.

Figure 10-6 GSM Modem integrated in electricity meter



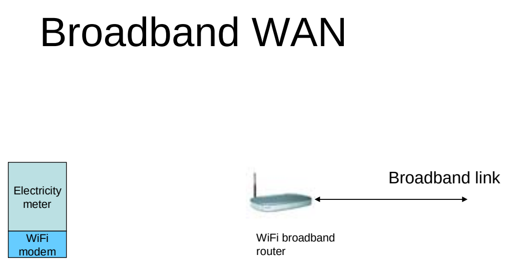
Current broadband implementations use one of:

- USB modem
- Ethernet router (usually 2-port, sometimes 4-port)
- WiFi router.

The USB modem can't support connection to the meter, the Ethernet option requires internal wiring to the electricity meter. The WiFi router is therefore currently the best option.

Zwave/ZigBee enabled routers would be ideal and there are low cost chipsets available [5], although these would not support metering (further work needs to be done on ZigBee and Zwave to support metering). A ZigBee/Zwave router would not only support the meters and CDU but also could support a wider HAN network.

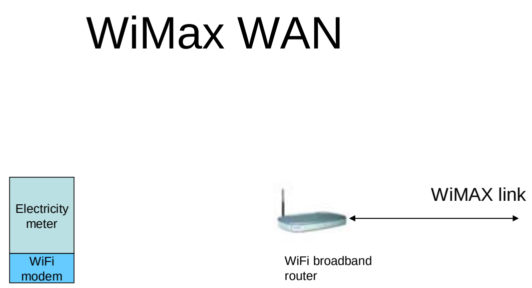
Figure 10-7 Broadband with WAN



In Figure 10-7 a WiFi transmitter/receiver must be attached to the electricity meter and a WiFi router provided to enable broadband to be connected.

Wimax routers for the home are just becoming available, they generally support WiFi and WiMax, with WiFi being used within the home for HAN, and WiMax facing out to the WAN [12]. It is likely that in future PCs etc. will be shipped with WiMax modems and so there is an option to integrate WiMax modems. No costs are currently available.

Figure 10-8 Wimax with WAN



In Figure 10-8, a WiFi transmitter/receiver must be attached to the electricity meter and a WiFi router provided to enable WiMaX to be connected.

A.6 Application Protocols

To understand how the application relates to the communication that supports it the OSI reference architecture is a good starting point [4]. This describes how two end points communicate over a network and is summarised in Table 10-2 ISO OSI 7-layer model.

The model describes any communication as divided into a set of layers each supporting different functions. The objective of the model was to encourage applications to be developed which were not tied to one particular communications method. Owing to the uncertainty in the future of WAN comms both in the 21CN and 2G vs 3G arenas and that not all homes will be able to have the same communications method this is essential. The goal for suppliers is to ensure that the meter reading, tariff setting applications etc, as well as any monitoring or maintenance applications are defined carefully so that for example TCP/IP may be used or alternately SMS or GPRS.

Table 10-2 ISO OSI 7-layer model

OSI Model			
	Data unit	**Layer**	**Function**
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segments	4. Transport	End-to-end connections and reliability (TCP)
Media layers	Packets	3. Network	Path determination and logical addressing (IP)
	Frames	2. Data link	Physical addressing (MAC & LLC)
	Bits	1. Physical	Media, signal and binary transmission

There are several application protocols in use:

- DLMS (device language messaging specification)
- Mbus (message bus)
- Smartbus etc

There are two options when specifying the application protocol interface, one is to standardise the API at the meter, the other is to allow proprietary interfaces at the meter and to use protocol converters at the data collector. If ,proprietary applications are allowed this will add capital cost in the development of the data collector and more importantly annual operational costs and any upgrade costs will be higher throughout the SM lifetime. If the proprietary applications all demand different communications technologies, this will make dealing with customer churn more problematic and costly for the utility supplier. Table 10-3 Characteristics of application protocols summarises the main characteristics of application protocols.

Table 10-3 Characteristics of application protocols

	Advantages	Disadvantages	Future Work
DLMS	International standard IEC TC 13 and CEN TC 294 Operates over optical or electrical ports, over leased line PSTN or GSM. Others possible as application layer is separated from lower layers. Can operate over TCP/IP and UDP/IP	Connection oriented, so overhead bits are higher, usage charges over 3rd party networks will be higher	Needs standard to be extended to support smart metering
Mbus	International standard RFC 3259 Supports multi-cast and UDP/IP (port number 47000) supports IP v4 and IP v6	Is a standard for AMR, needs extension to support smart meters	Needs standard to be extended to support smart metering

Appendix B Statistical Analysis and Results

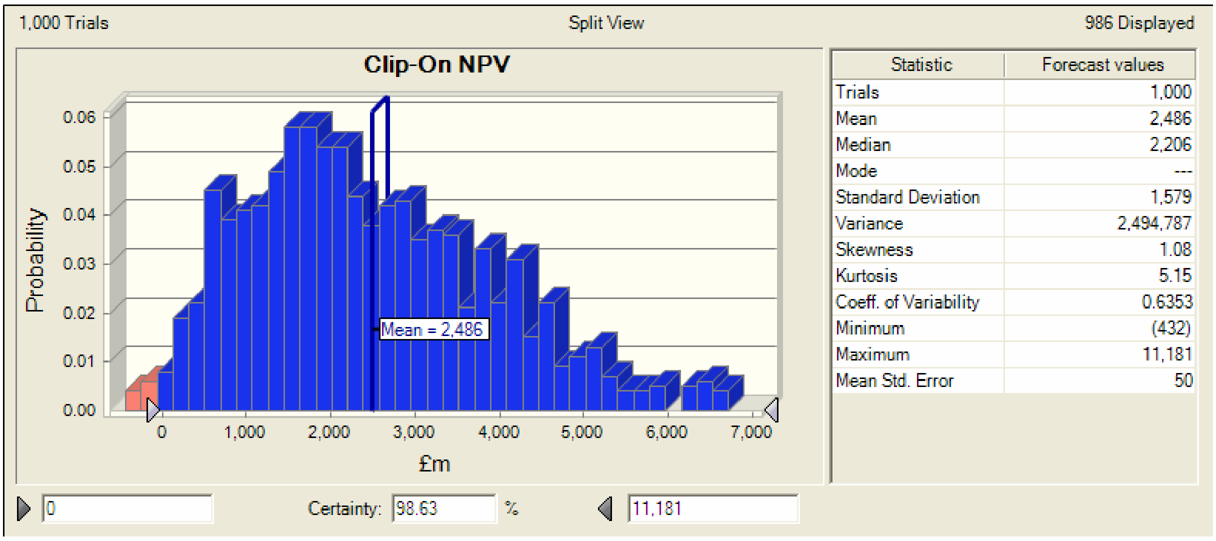
In this Appendix, we provide full results and graphs from the Monte-Carlo simulations. Results were obtained from the model with included values for optimism bias, dual fuel efficiencies and 100% pass-through for costs, benefits and stranding. Results are given per technology option, roll-out options and comms option. All figures below show probability graphs from simulation experiments. Right below the graphs, we provide certainty percentages that the NPV forecast is either positive or negative. Next to each graph, we provide a summary table of the statistical results from simulations.

In addition, we provide indicative results per technology and roll-out option for Hybrid 2, without including optimism bias so as to make results comparable with other studies that have not corrected for biases. Finally, we also provide results for stranding costs.

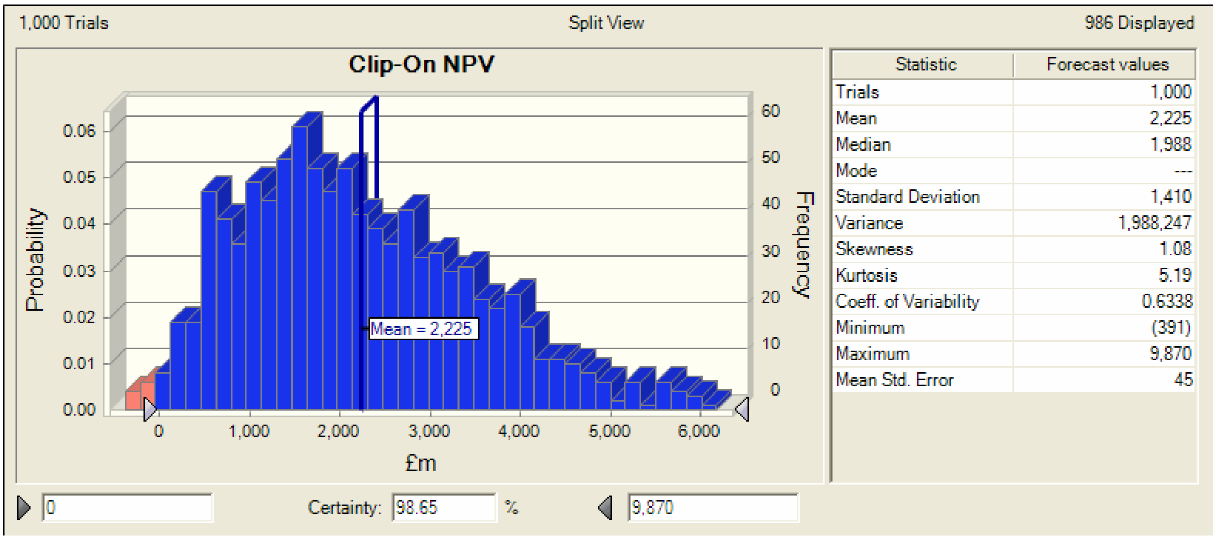
B.1 GB PLC Results

B.1.1 Clip-Ons

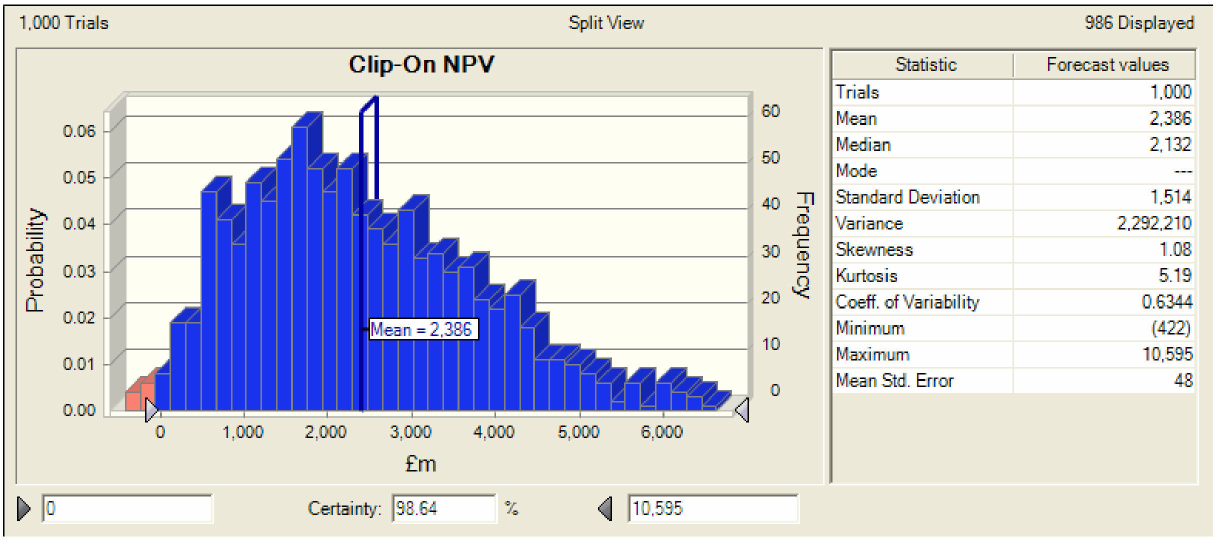
B.i Clip-Ons – New, Replacement and Voluntary



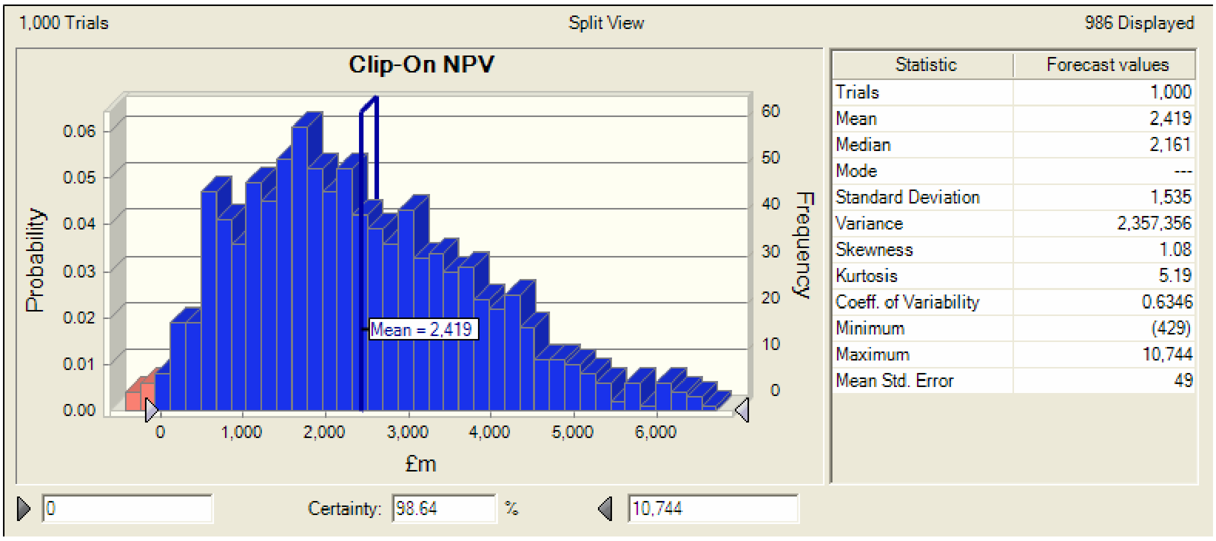
B.ii Clip-Ons – Market



B.iii Clip-Ons – Market Tip

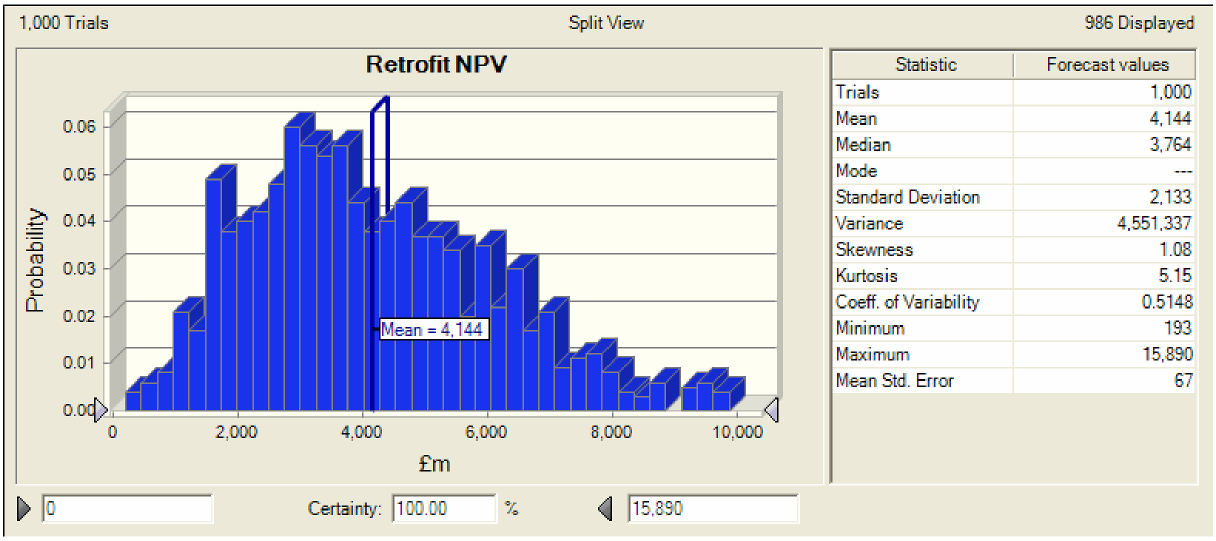


B.iv Clip-Ons – Market Tip Fast

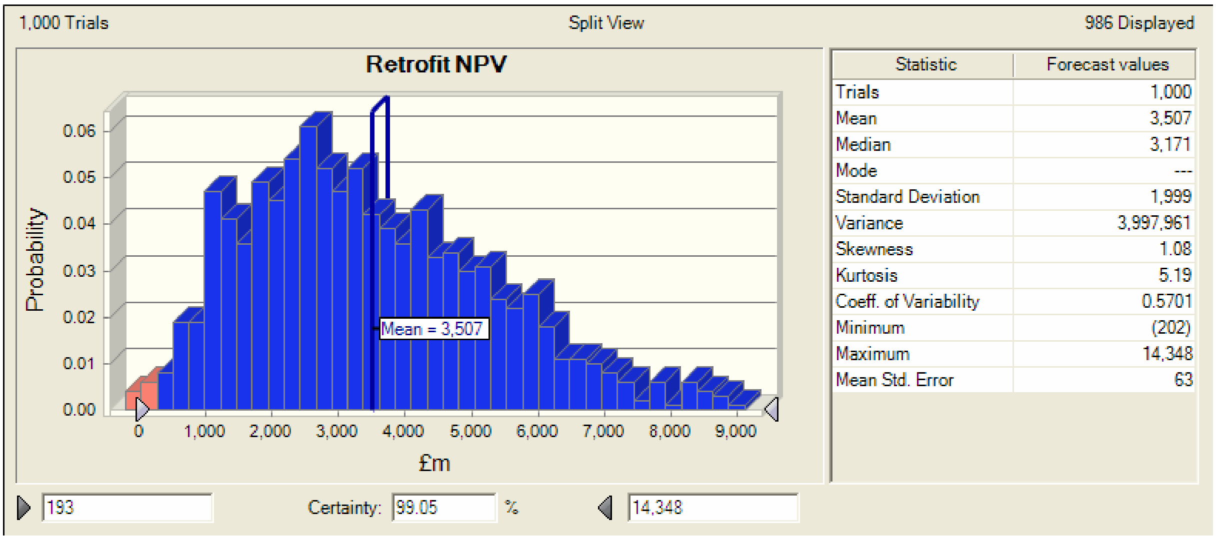


B.1.2 Meter Retrofit

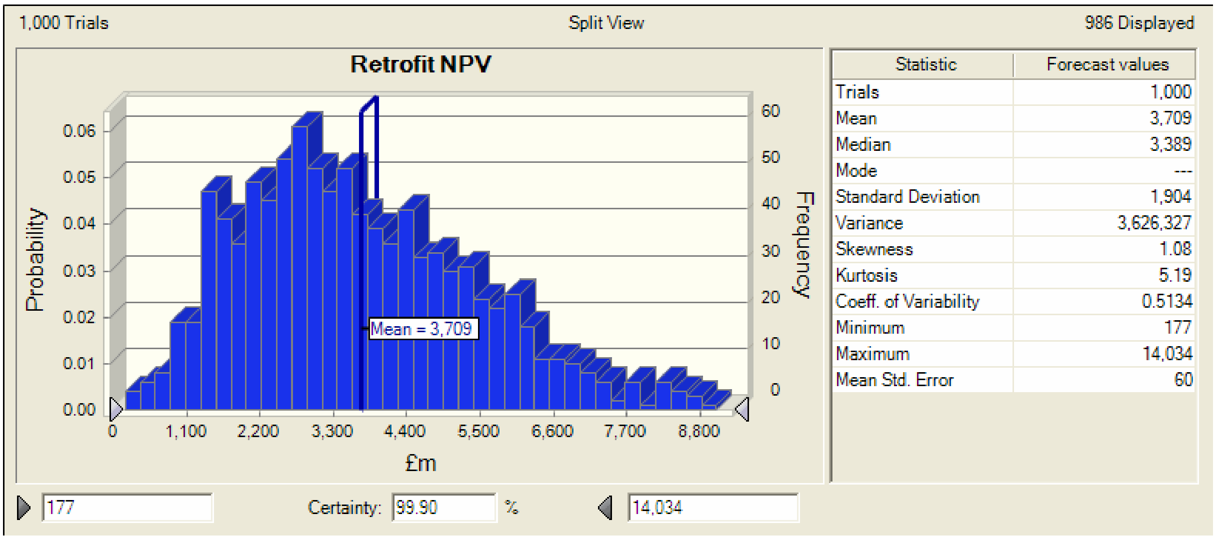
B.i Meter Retrofit – New, Replacement and Voluntary



B.ii Meter Retrofit – Regional Franchise

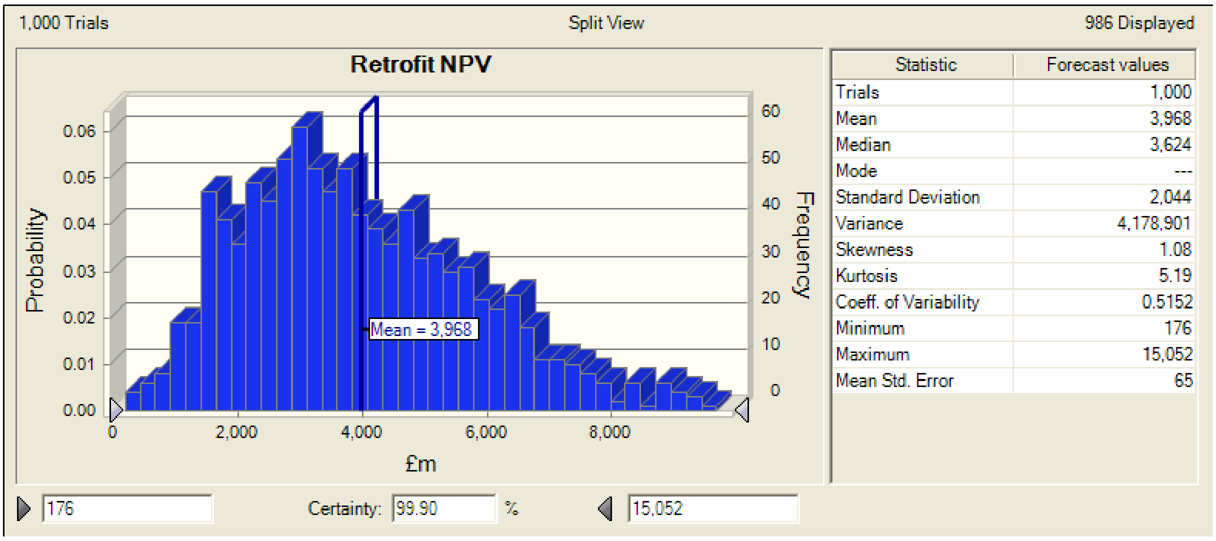


B.iii Meter Retrofit – Market



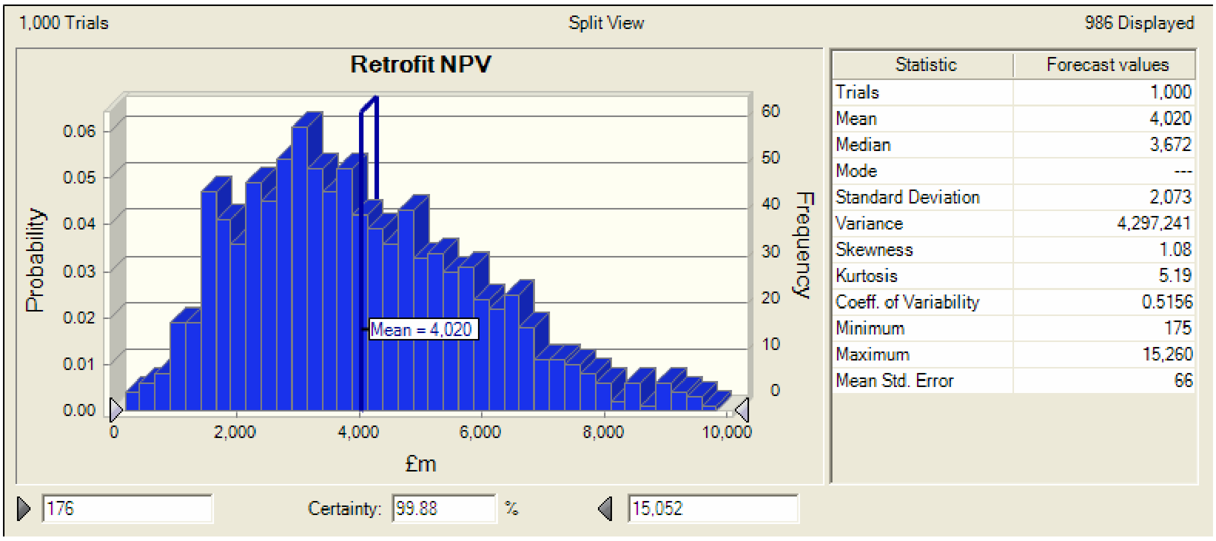
Statistic	Forecast values
Trials	1,000
Mean	3,709
Median	3,389
Mode	---
Standard Deviation	1,904
Variance	3,626,327
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5134
Minimum	177
Maximum	14,034
Mean Std. Error	60

B.iv Meter Retrofit – Market Tip



Statistic	Forecast values
Trials	1,000
Mean	3,968
Median	3,624
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5152
Minimum	176
Maximum	15,052
Mean Std. Error	65

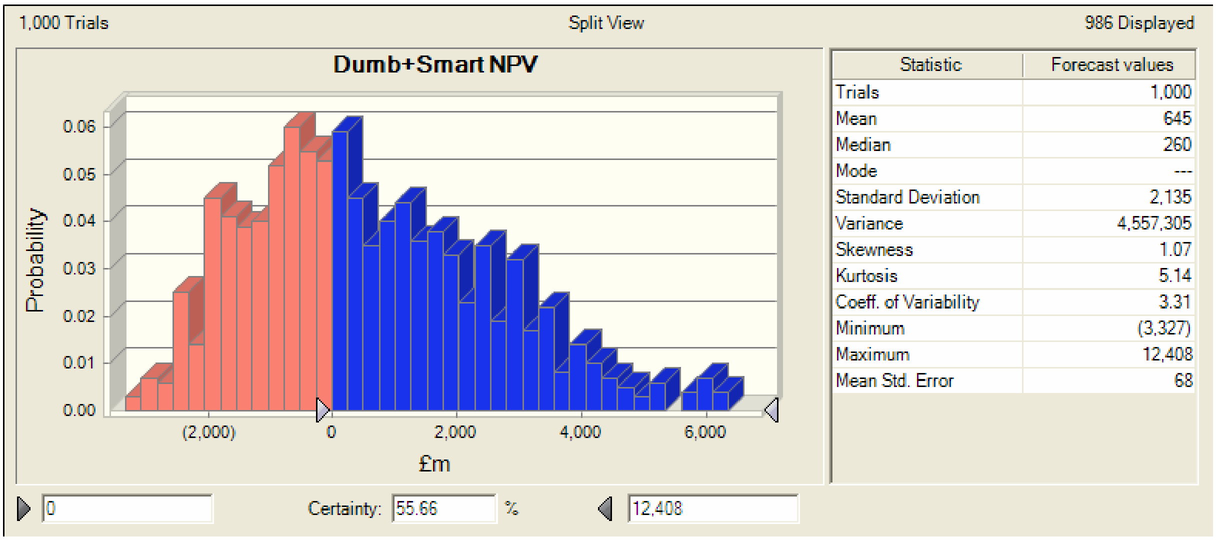
B.v Meter Retrofit – Market Tip Fast



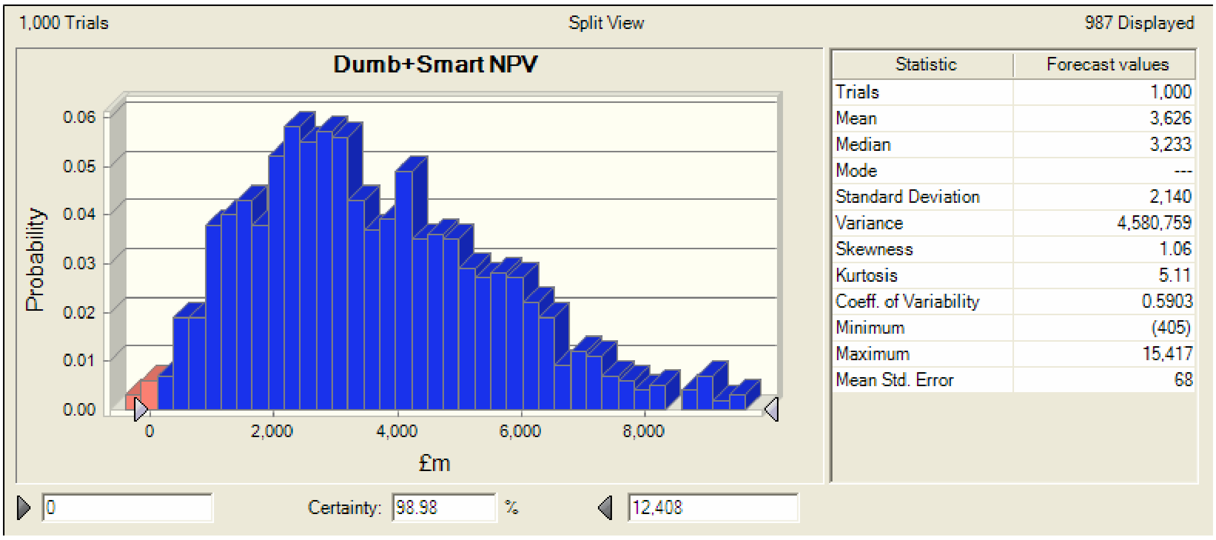
Statistic	Forecast values
Trials	1,000
Mean	4,020
Median	3,672
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5156
Minimum	175
Maximum	15,260
Mean Std. Error	66

B.1.3 Dumb Meter and Smart Box

B.i D+S - New, Replacement and Voluntary and PLC

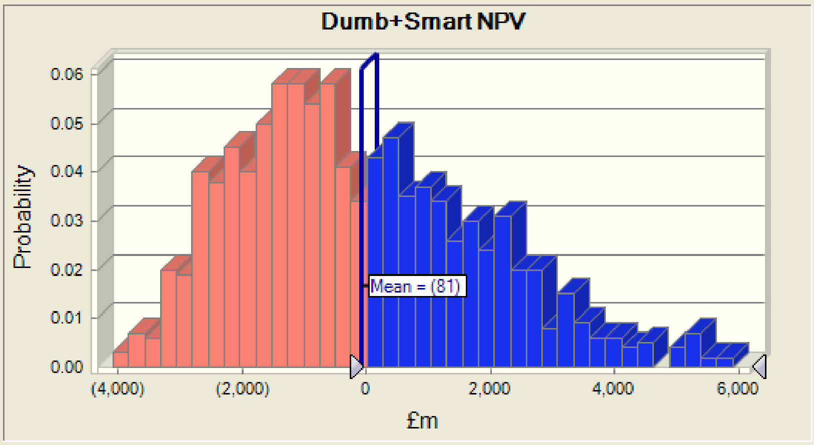


B.ii D+S - New, Replacement and Voluntary and Broadband



B.iii D+S - New, Replacement and Voluntary and WiMax

1,000 Trials | Split View | 986 Displayed

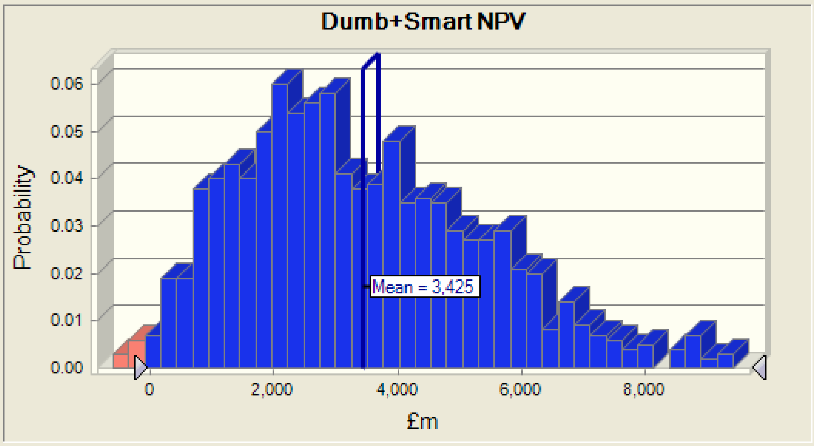


Statistic	Forecast values
Trials	1,000
Mean	(81)
Median	(476)
Mode	---
Standard Deviation	2,138
Variance	4,569,105
Skewness	1.07
Kurtosis	5.12
Coeff. of Variability	-26.40
Minimum	(4,085)
Maximum	11,698
Mean Std. Error	68

0 Certainty: 42.98 % 12,408

B.iv D+S - New, Replacement and Voluntary and 3G

1,000 Trials | Split View | 987 Displayed

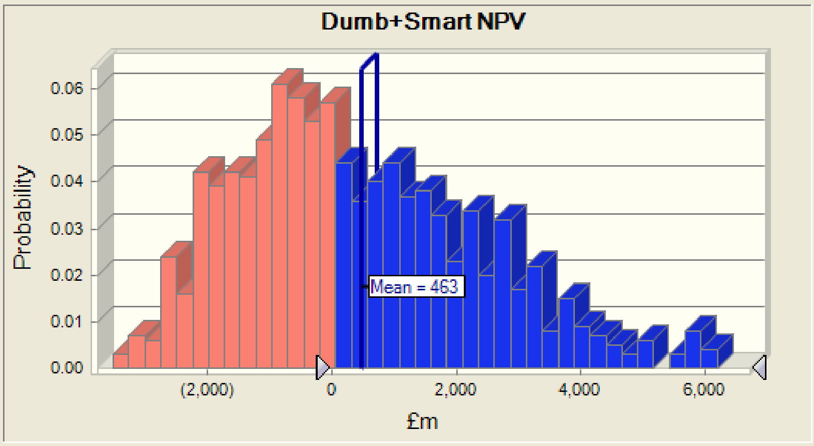


Statistic	Forecast values
Trials	1,000
Mean	3,425
Median	3,029
Mode	---
Standard Deviation	2,140
Variance	4,577,846
Skewness	1.07
Kurtosis	5.11
Coeff. of Variability	0.6247
Minimum	(599)
Maximum	15,214
Mean Std. Error	68

0 Certainty: 98.36 % 12,408

B.v D+S - New, Replacement and Voluntary and Hybrid 1

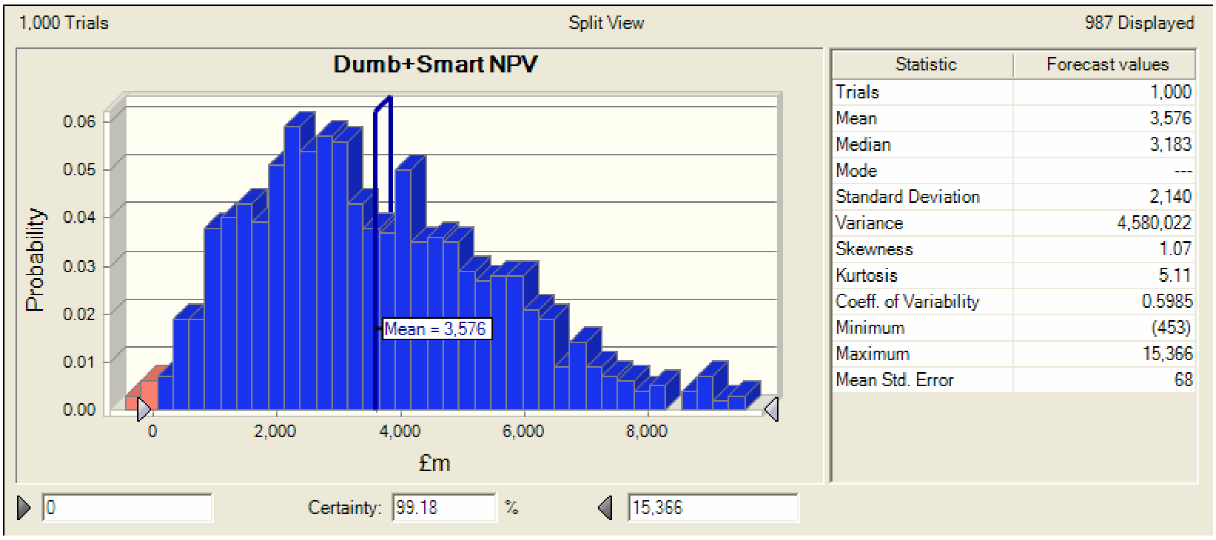
1,000 Trials | Split View | 986 Displayed



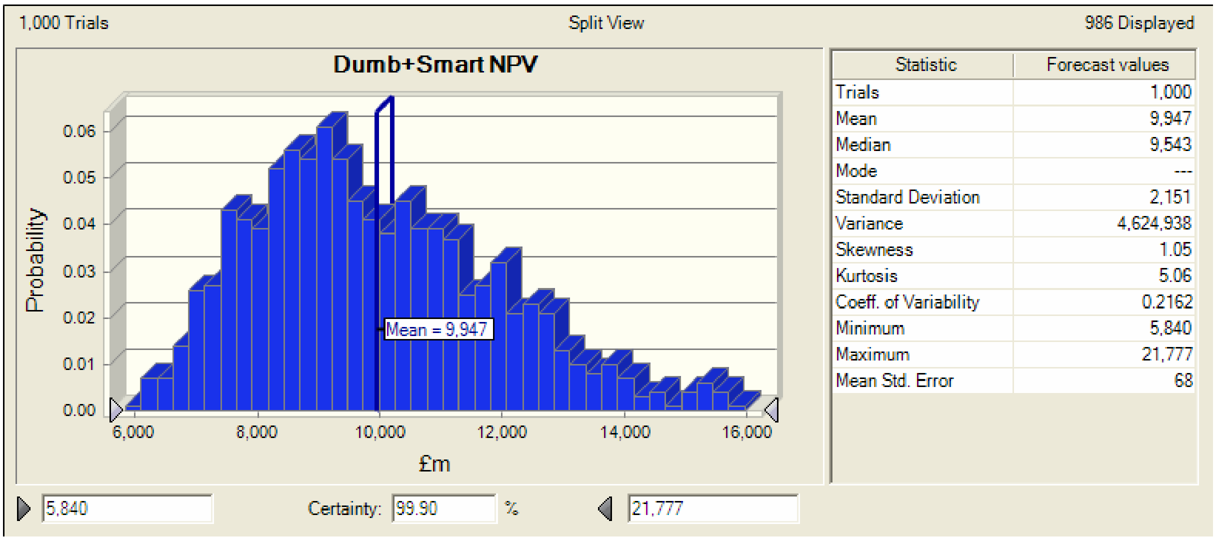
Statistic	Forecast values
Trials	1,000
Mean	463
Median	80
Mode	---
Standard Deviation	2,135
Variance	4,560,019
Skewness	1.07
Kurtosis	5.14
Coeff. of Variability	4.61
Minimum	(3,517)
Maximum	12,230
Mean Std. Error	68

0 Certainty: 51.26 % 12,408

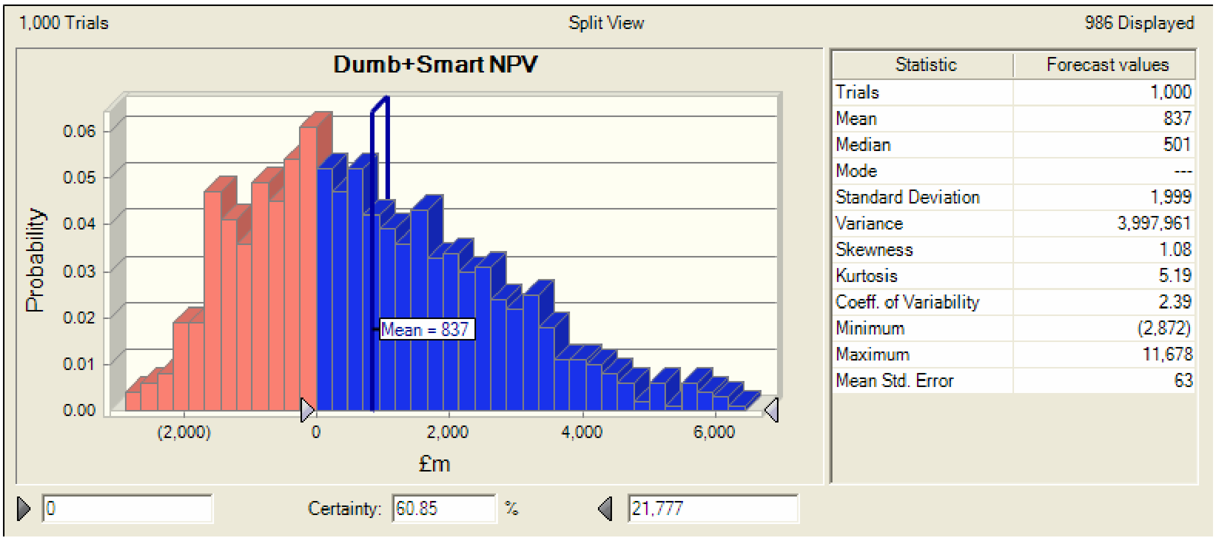
B.vi D+S - New, Replacement and Voluntary and Hybrid 2



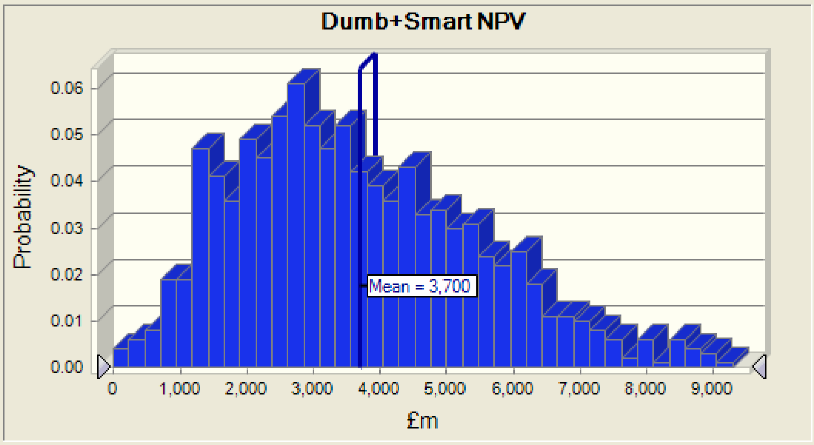
B.vii D+S - New, Replacement and Voluntary without comms



B.viii D+S – Regional Franchise and PLC

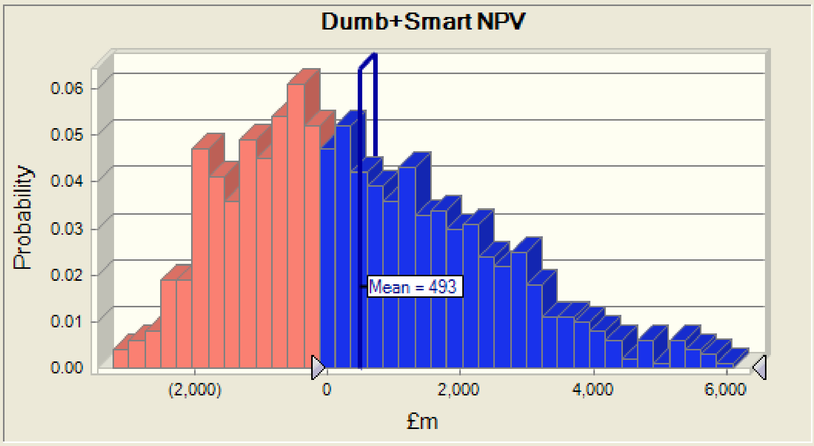


B.ix D+S - Regional Franchise and Broadband



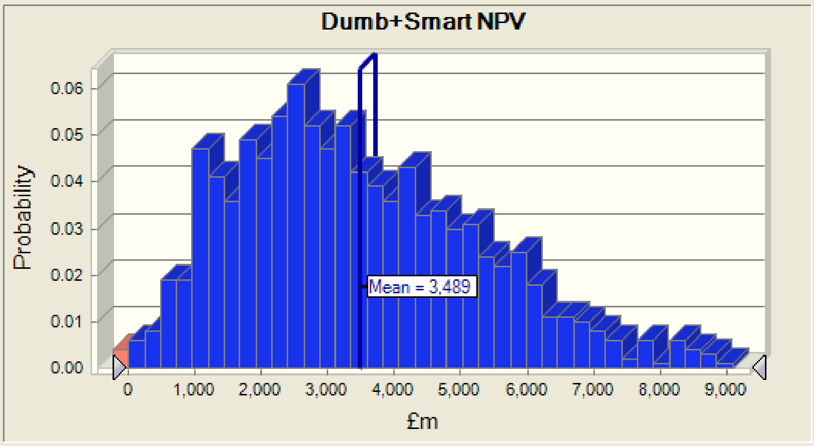
Statistic	Forecast values
Trials	1,000
Mean	3,700
Median	3,364
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5404
Minimum	(9)
Maximum	14,541
Mean Std. Error	63

B.x D+S - Regional Franchise and WiMax



Statistic	Forecast values
Trials	1,000
Mean	493
Median	157
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	4.05
Minimum	(3,216)
Maximum	11,334
Mean Std. Error	63

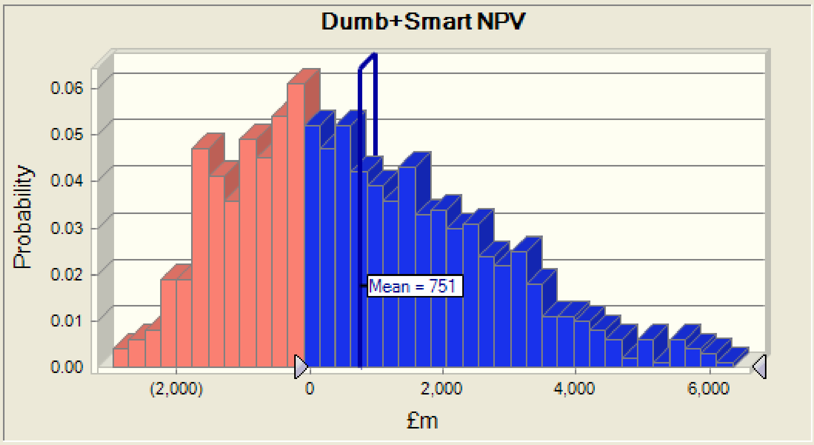
B.xi D+S - Regional Franchise and 3G



Statistic	Forecast values
Trials	1,000
Mean	3,489
Median	3,153
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5730
Minimum	(219)
Maximum	14,330
Mean Std. Error	63

B.xii D+S - Regional Franchise and Hybrid 1

1,000 Trials | Split View | 986 Displayed

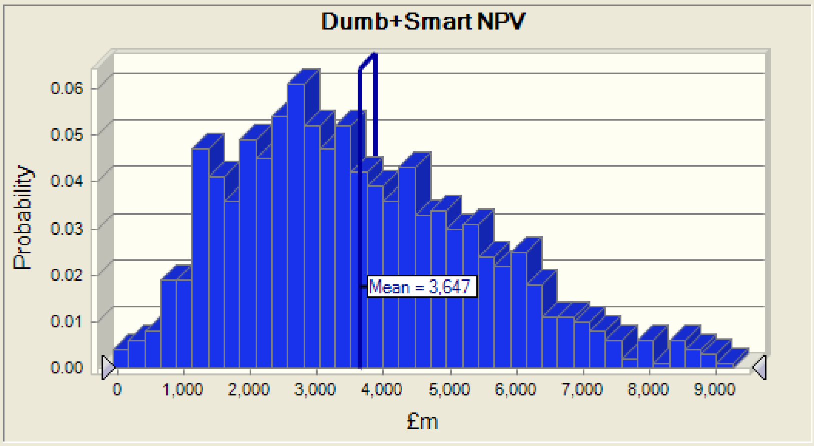


Statistic	Forecast values
Trials	1,000
Mean	751
Median	415
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	2.66
Minimum	(2,958)
Maximum	11,592
Mean Std. Error	63

0 Certainty: 58.57 % 11,592

B.xiii D+S - Regional Franchise and Hybrid 2

1,000 Trials | Split View | 986 Displayed

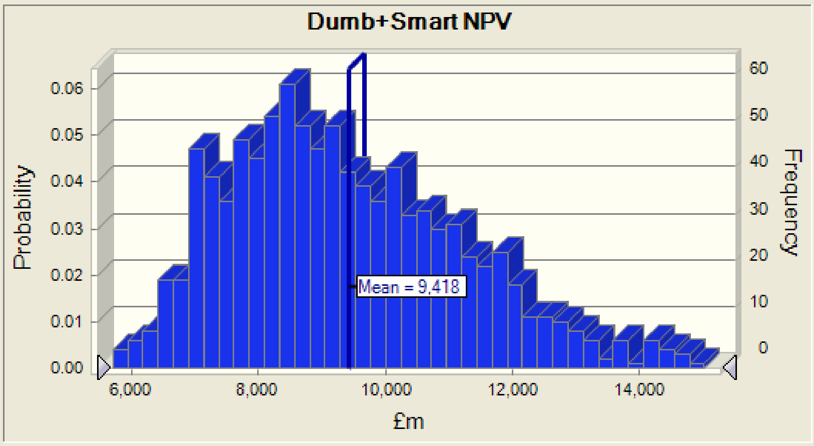


Statistic	Forecast values
Trials	1,000
Mean	3,647
Median	3,311
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5482
Minimum	(62)
Maximum	14,488
Mean Std. Error	63

0 Certainty: 99.82 % 14,488

B.xiv D+S - Regional Franchise without comms

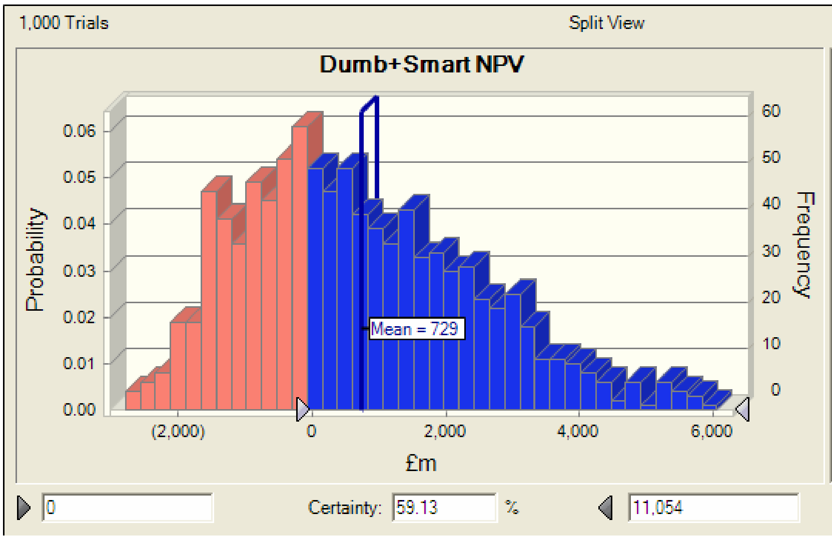
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	9,418
Median	9,082
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2123
Minimum	5,709
Maximum	20,259
Mean Std. Error	63

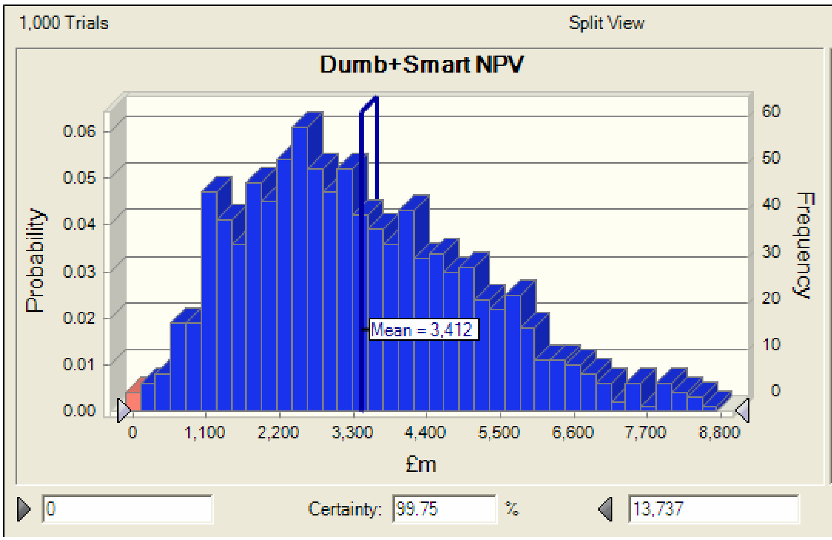
5,709 Certainty: 99.90 % 20,259

B.xv D+S – Market and PLC



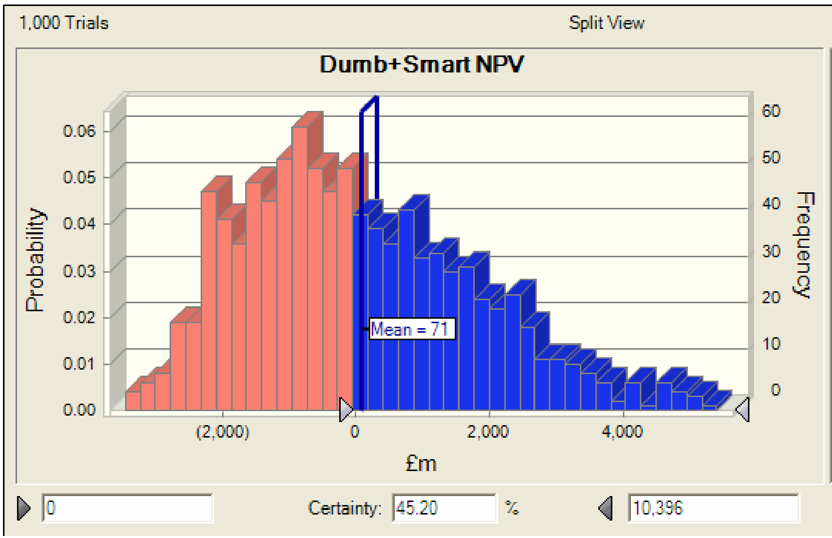
Statistic	Forecast values
Trials	1,000
Mean	729
Median	409
Mode	---
Standard Deviation	1,904
Variance	3,626,327
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	2.61
Minimum	(2,803)
Maximum	11,054
Mean Std. Error	60

B.xvi D+S - Market and Broadband



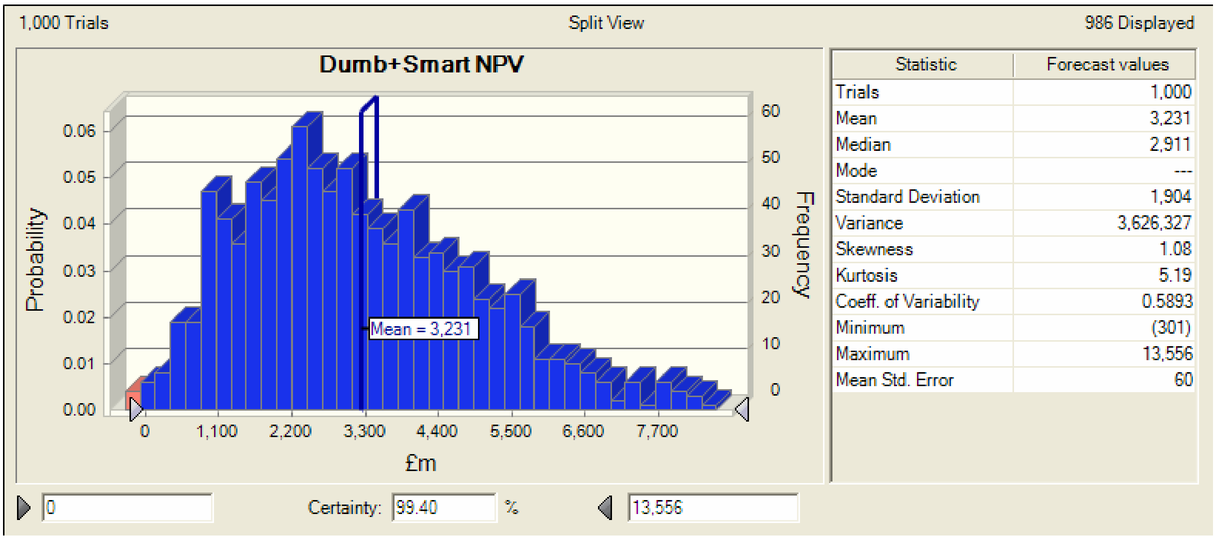
Statistic	Forecast values
Trials	1,000
Mean	3,412
Median	3,092
Mode	---
Standard Deviation	1,904
Variance	3,626,327
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5582
Minimum	(121)
Maximum	13,737
Mean Std. Error	60

B.xvii D+S - Market and WiMax

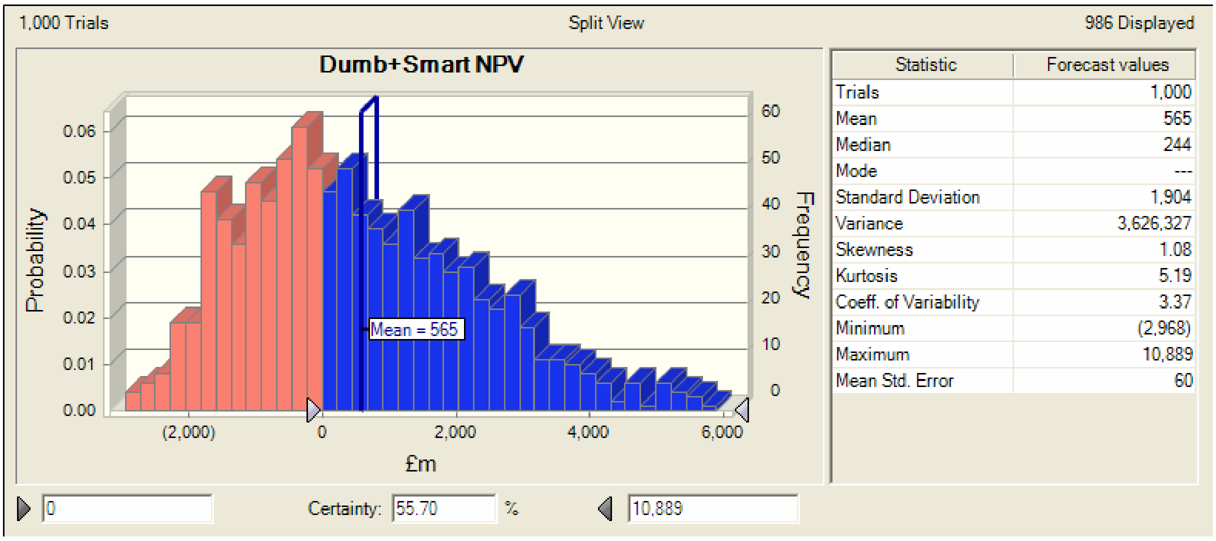


Statistic	Forecast values
Trials	1,000
Mean	71
Median	(249)
Mode	---
Standard Deviation	1,904
Variance	3,626,327
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	26.81
Minimum	(3,461)
Maximum	10,396
Mean Std. Error	60

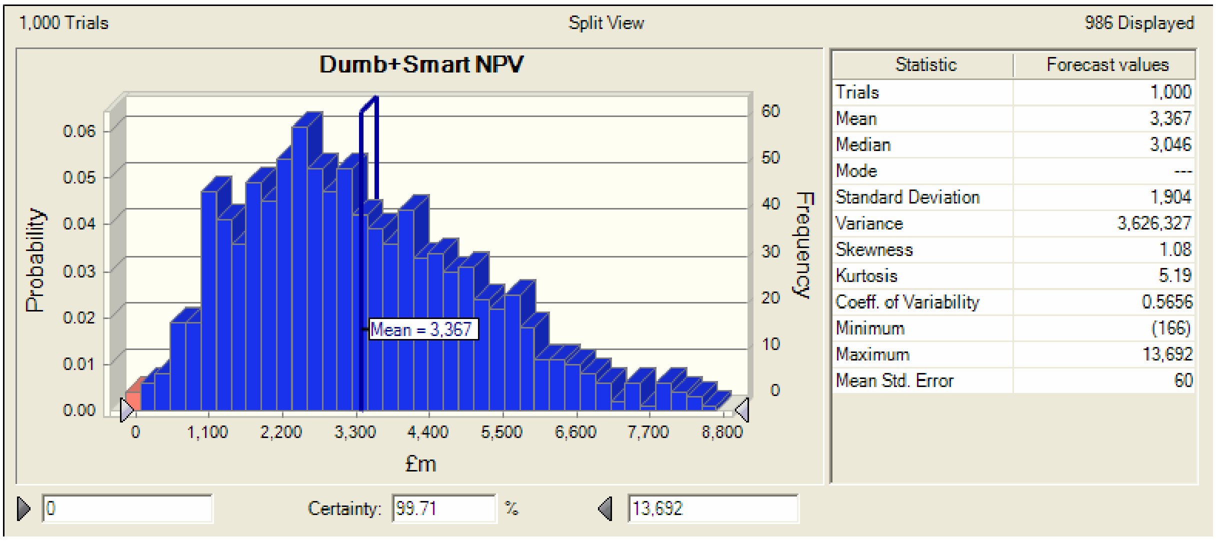
B.xviii D+S - Market and 3G



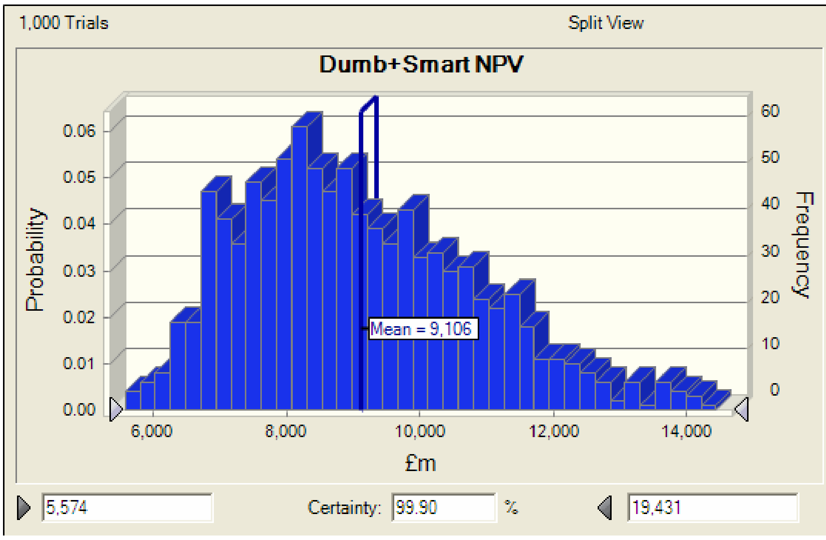
B.xix D+S - Market and Hybrid 1



B.xx D+S - Market and Hybrid 2

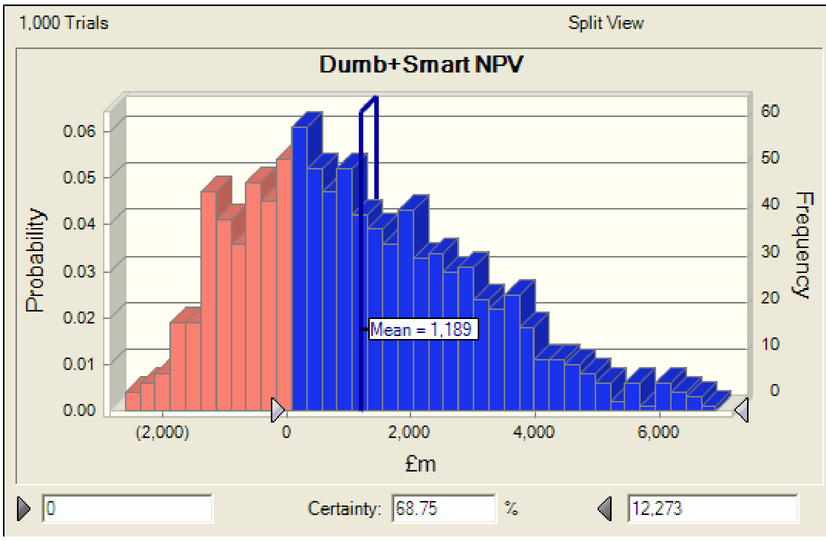


B.xxi D+S - Market without comms



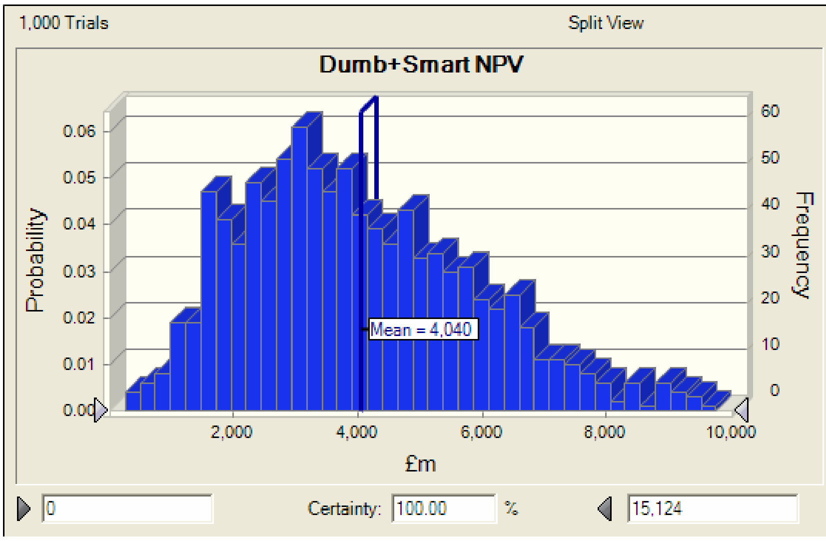
Statistic	Forecast values
Trials	1,000
Mean	9,106
Median	8,786
Mode	---
Standard Deviation	1,904
Variance	3,626,327
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2091
Minimum	5,574
Maximum	19,431
Mean Std. Error	60

B.xxii D+S – Market Tip and PLC



Statistic	Forecast values
Trials	1,000
Mean	1,189
Median	845
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	1.72
Minimum	(2,603)
Maximum	12,273
Mean Std. Error	65

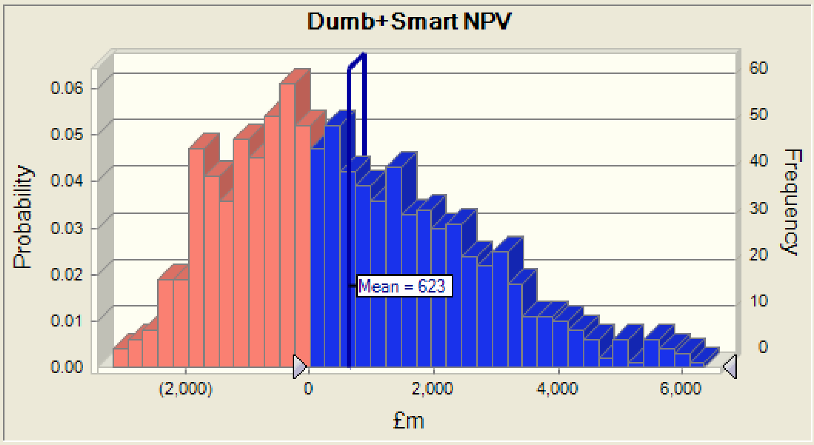
B.xxiii D+S – Market Tip and Broadband



Statistic	Forecast values
Trials	1,000
Mean	4,040
Median	3,697
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5060
Minimum	248
Maximum	15,124
Mean Std. Error	65

B.xxiv D+S - Market Tip and WiMax

1,000 Trials | Split View | 986 Displayed

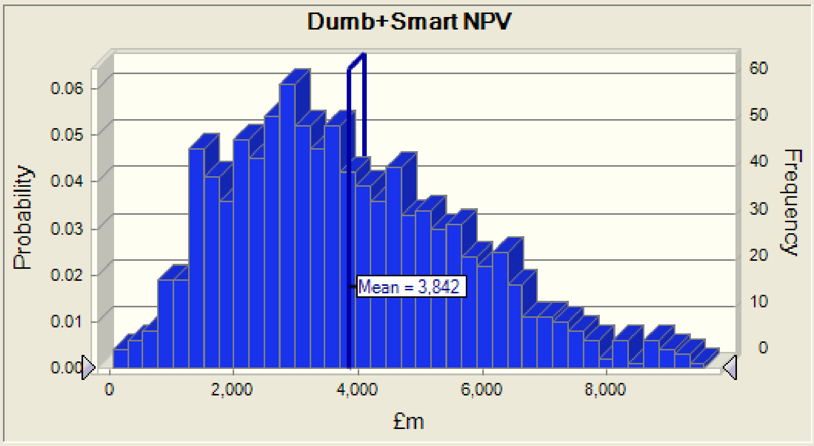


Statistic	Forecast values
Trials	1,000
Mean	623
Median	280
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	3.28
Minimum	(3,169)
Maximum	11,707
Mean Std. Error	65

0 Certainty: 55.89 % 11,707

B.xxv D+S - Market Tip and 3G

1,000 Trials | Split View | 986 Displayed

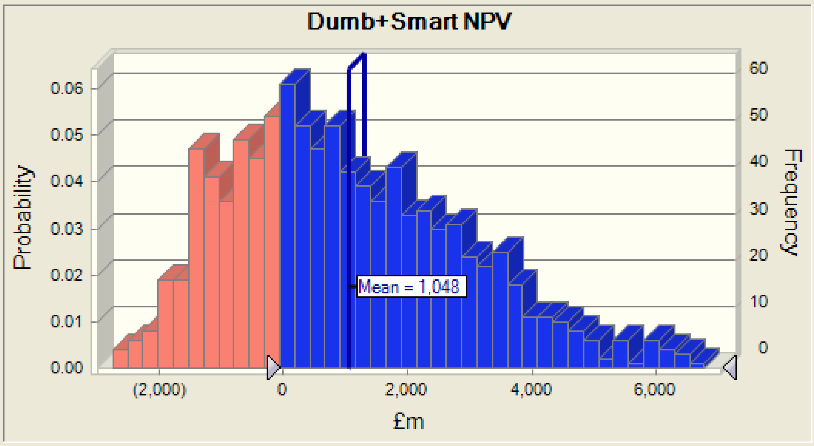


Statistic	Forecast values
Trials	1,000
Mean	3,842
Median	3,498
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5321
Minimum	50
Maximum	14,926
Mean Std. Error	65

0 Certainty: 100.00 % 14,926

B.xxvi D+S - Market Tip and Hybrid 1

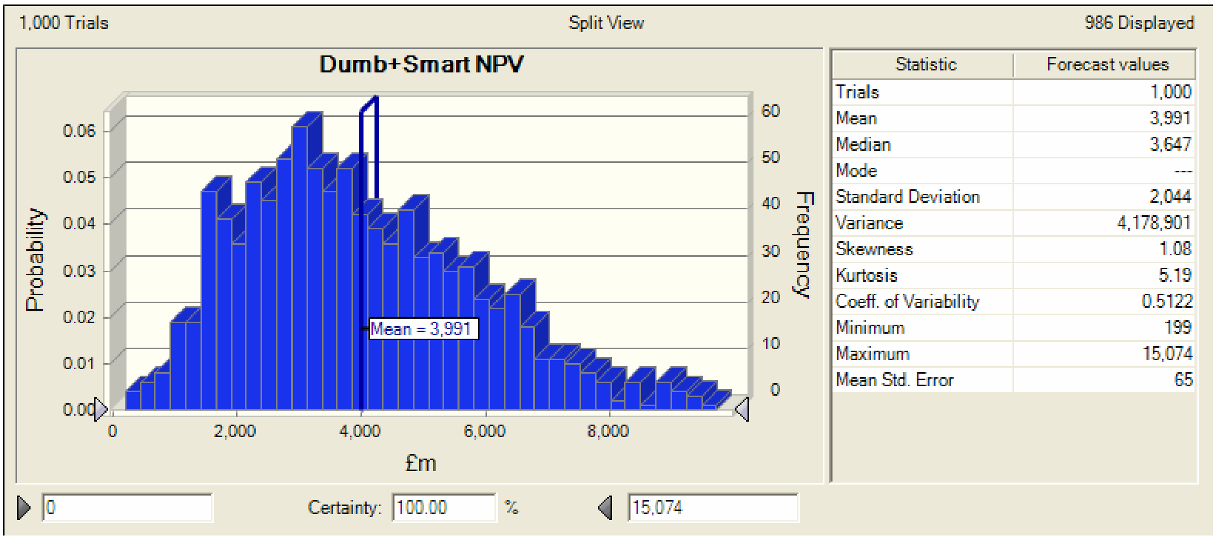
1,000 Trials | Split View | 986 Displayed



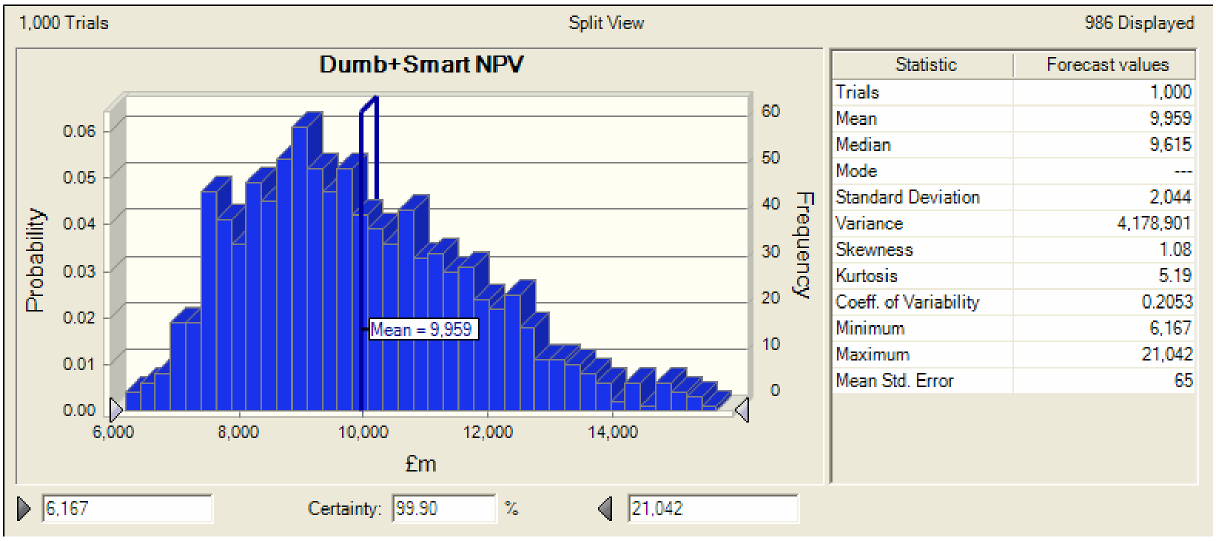
Statistic	Forecast values
Trials	1,000
Mean	1,048
Median	704
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	1.95
Minimum	(2,744)
Maximum	12,131
Mean Std. Error	65

0 Certainty: 65.36 % 12,131

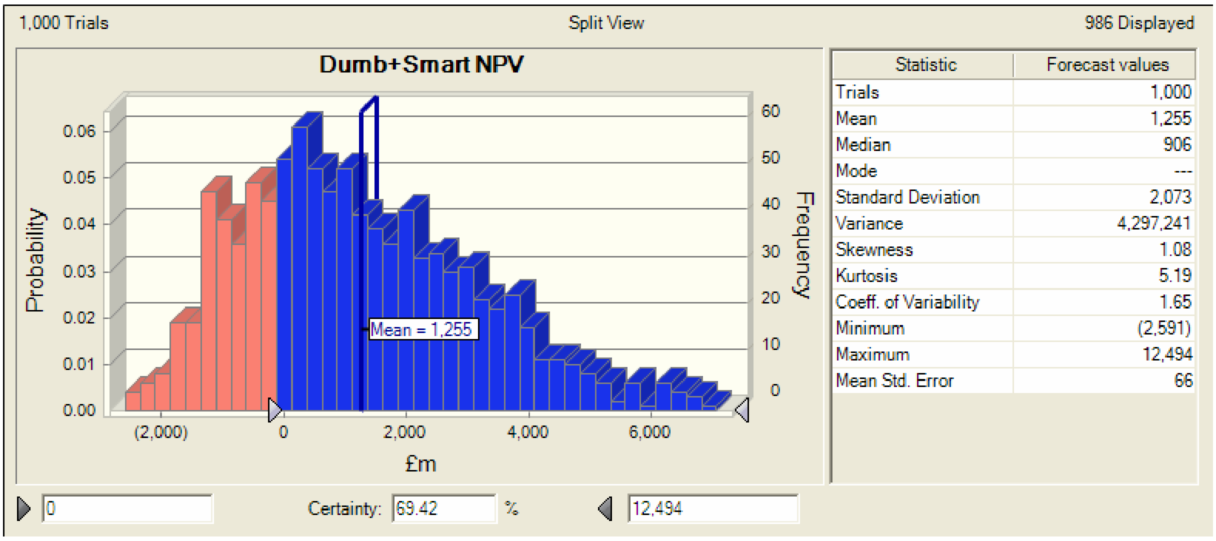
B.xxvii D+S - Market Tip and Hybrid 2



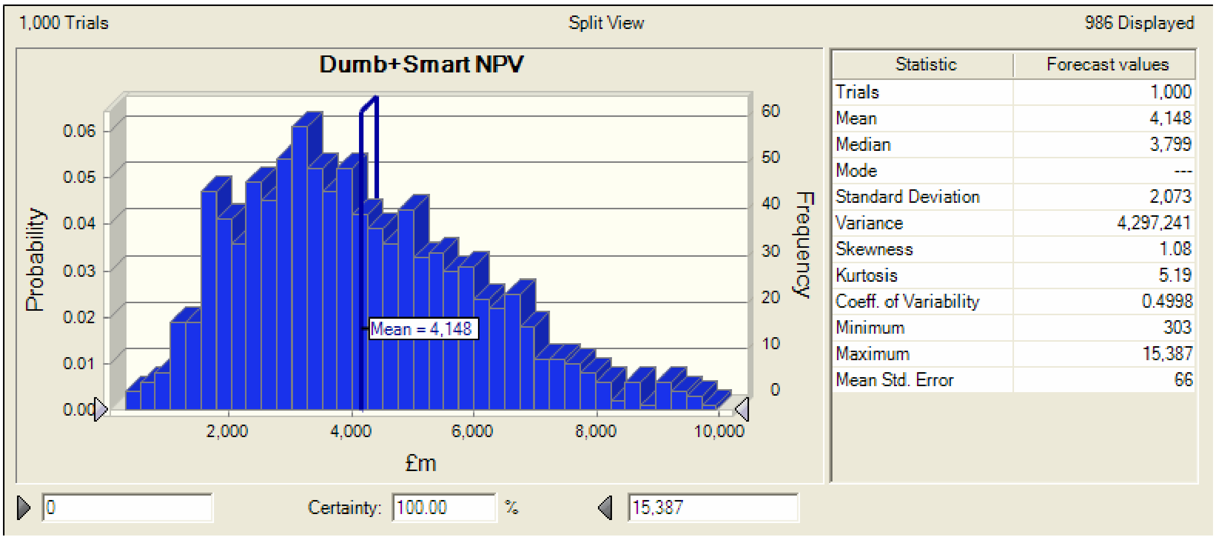
B.xxviii D+S - Market Tip without comms



B.xxix D+S – Market Tip Fast and PLC

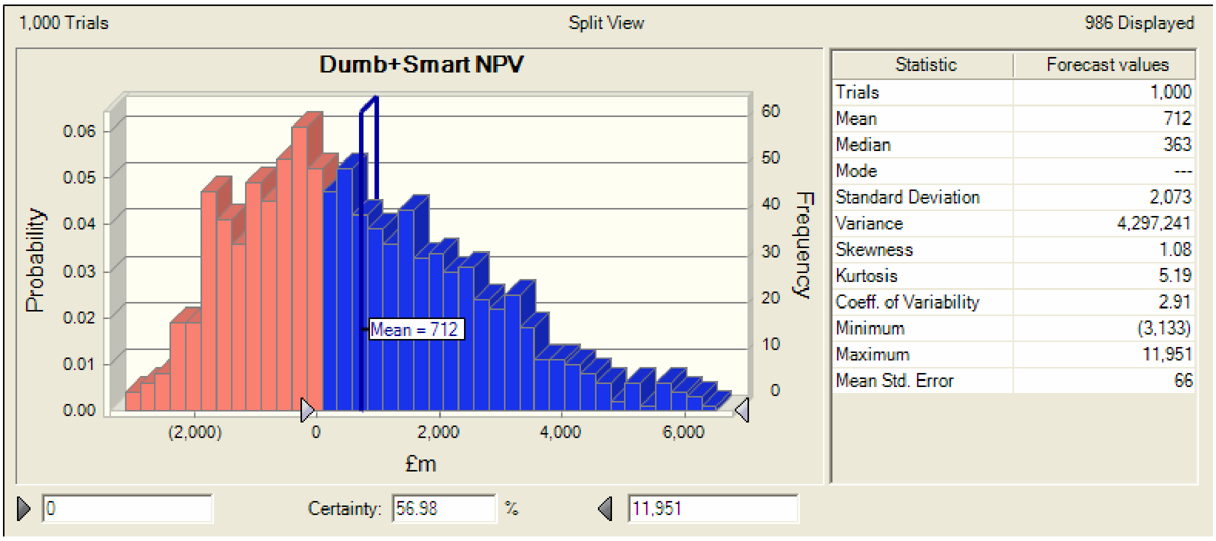


B.xxx D+S – Market Tip Fast and Broadband



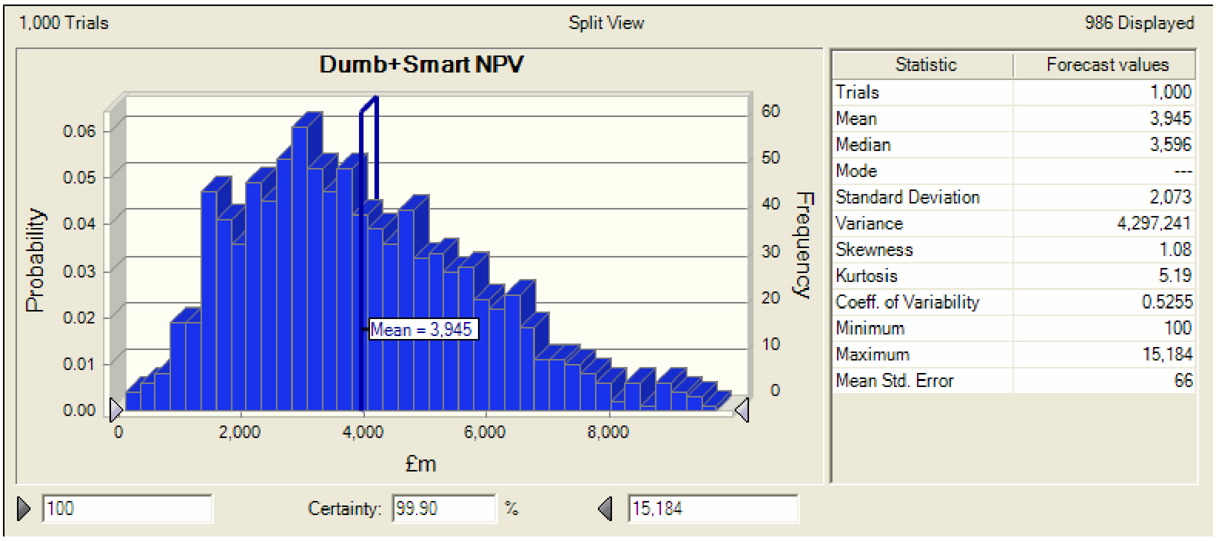
Statistic	Forecast values
Trials	1,000
Mean	4,148
Median	3,799
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.4998
Minimum	303
Maximum	15,387
Mean Std. Error	66

B.xxxi D+S - Market Tip Fast and WiMax



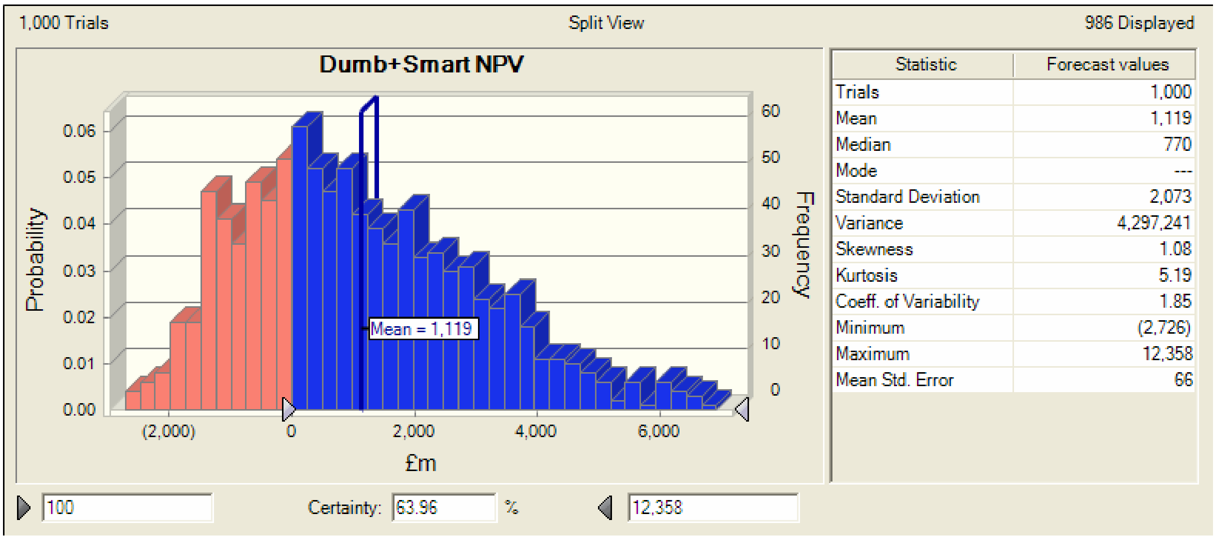
Statistic	Forecast values
Trials	1,000
Mean	712
Median	363
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	2.91
Minimum	(3,133)
Maximum	11,951
Mean Std. Error	66

B.xxxii D+S - Market Tip Fast and 3G

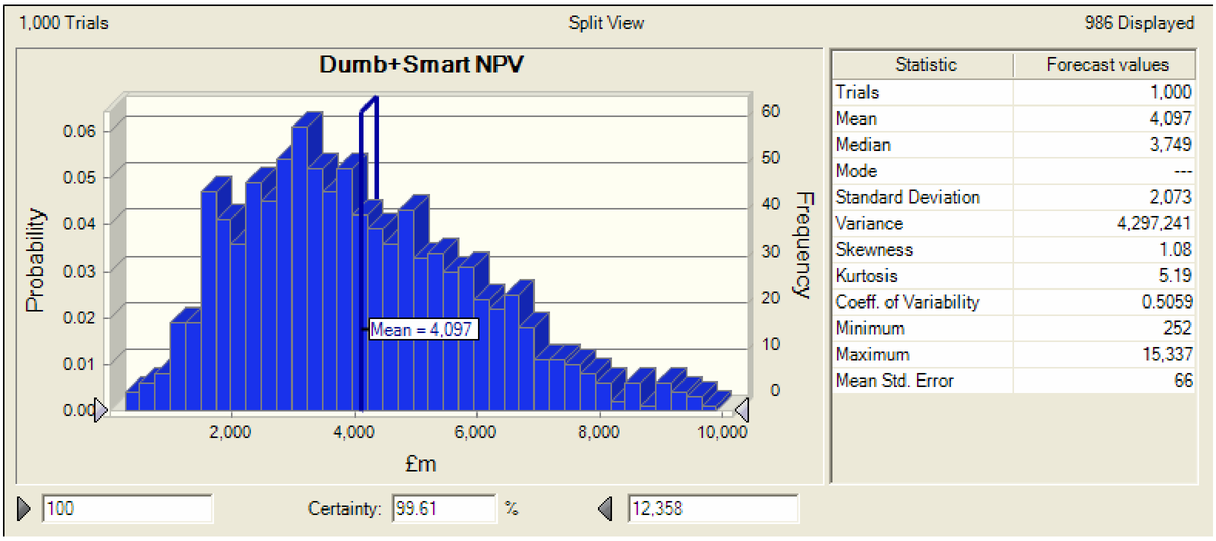


Statistic	Forecast values
Trials	1,000
Mean	3,945
Median	3,596
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.5255
Minimum	100
Maximum	15,184
Mean Std. Error	66

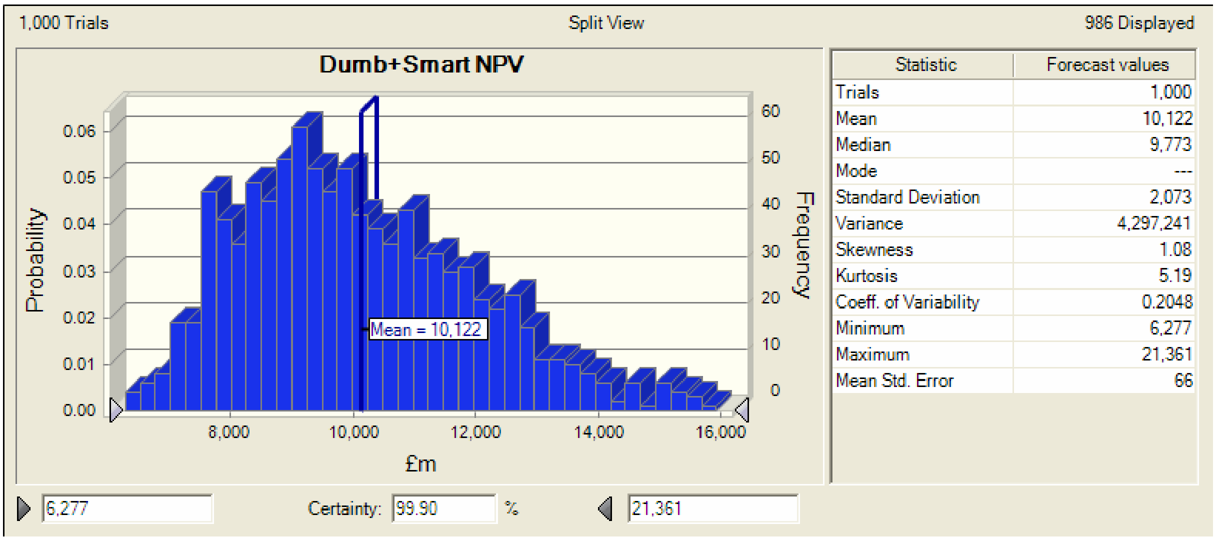
B.xxxiii D+S - Market Tip Fast and Hybrid 1



B.xxxiv D+S - Market Tip Fast and Hybrid 2

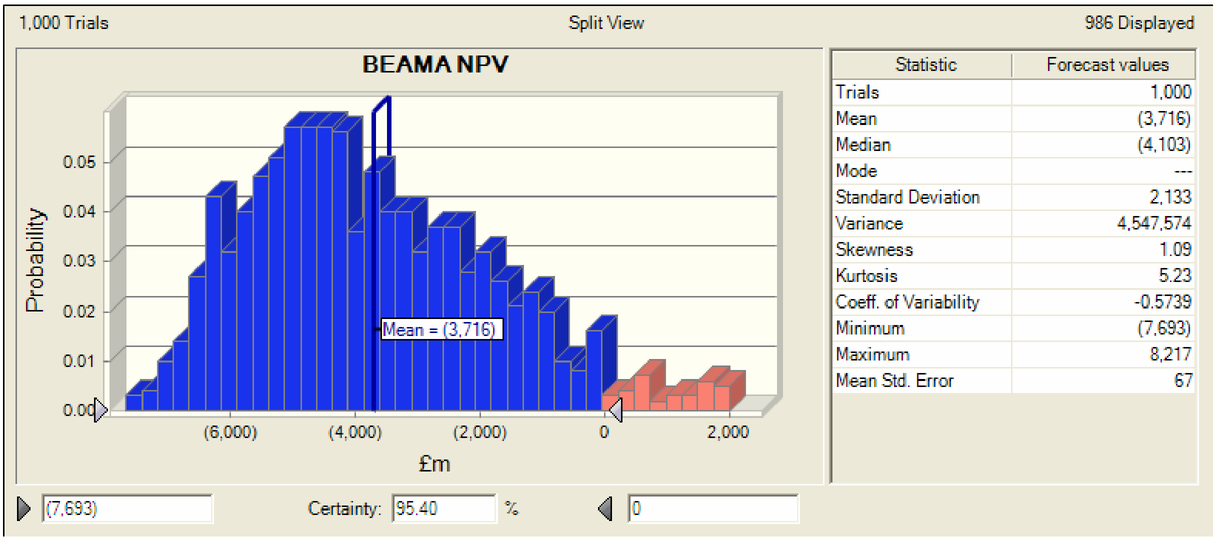


B.xxxv D+S - Market Tip Fast without comms

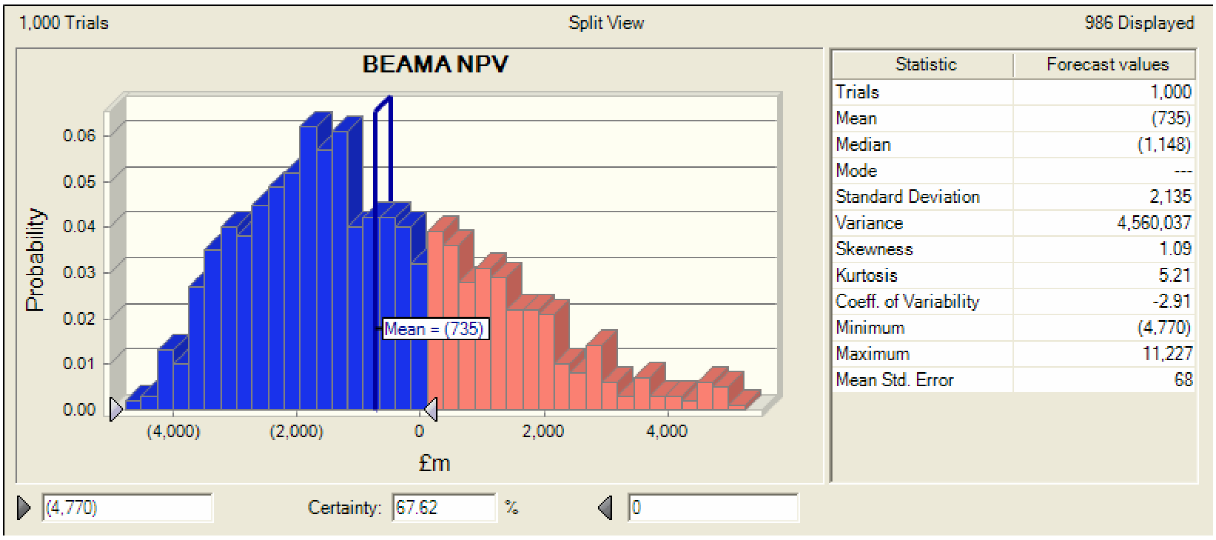


B.1.4 BEAMA Specification

B.i BEAMA - New, Replacement and Voluntary and PLC

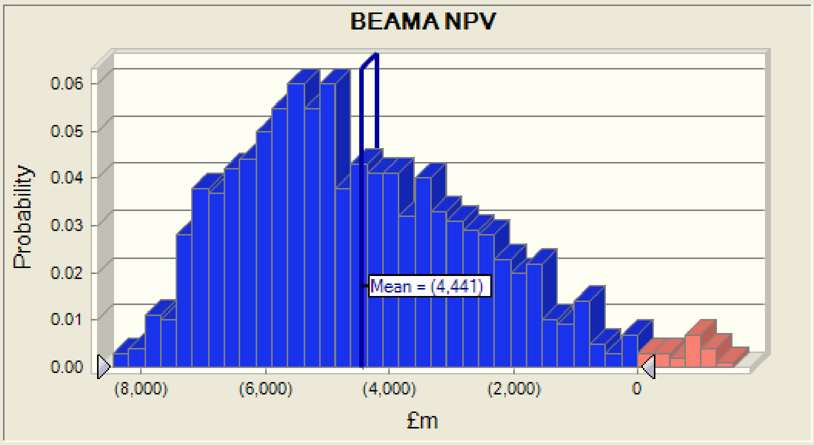


B.ii BEAMA - New, Replacement and Voluntary and Broadband



B.iii BEAMA - New, Replacement and Voluntary and WiMax

1,000 Trials | Split View | 986 Displayed

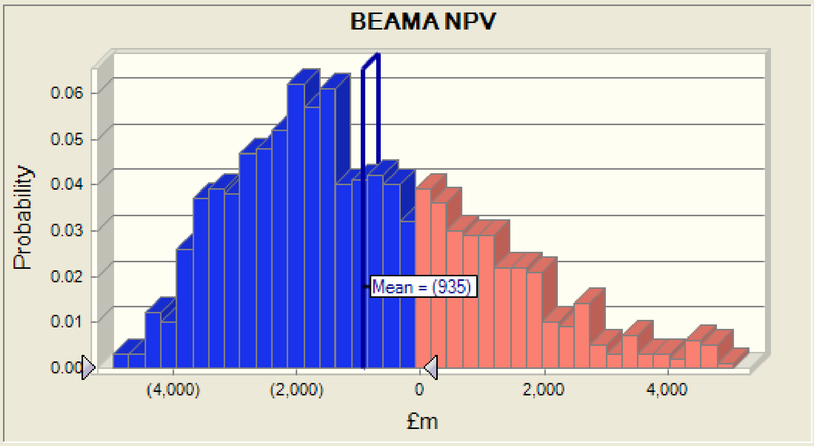


Statistic	Forecast values
Trials	1,000
Mean	(4,441)
Median	(4,850)
Mode	---
Standard Deviation	2,134
Variance	4,553,357
Skewness	1.09
Kurtosis	5.22
Coeff. of Variability	-0.4805
Minimum	(8,450)
Maximum	7,507
Mean Std. Error	67

(8,450) Certainty: 96.58 % 0

B.iv BEAMA - New, Replacement and Voluntary and 3G

1,000 Trials | Split View | 986 Displayed

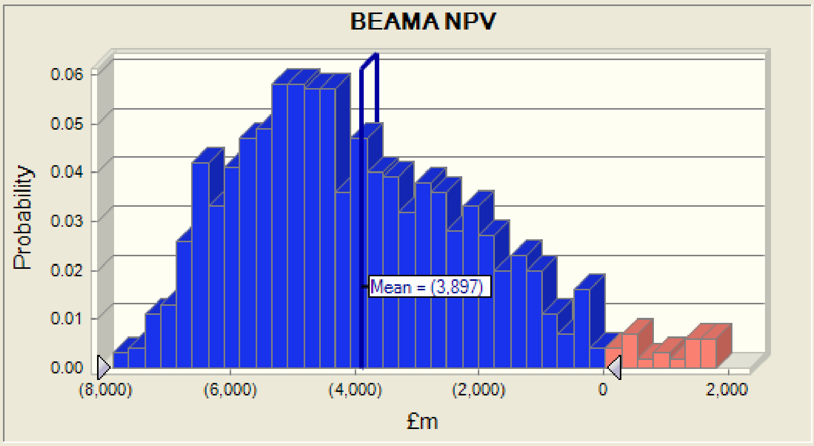


Statistic	Forecast values
Trials	1,000
Mean	(935)
Median	(1,346)
Mode	---
Standard Deviation	2,135
Variance	4,558,301
Skewness	1.09
Kurtosis	5.22
Coeff. of Variability	-2.28
Minimum	(4,965)
Maximum	11,023
Mean Std. Error	68

(8,450) Certainty: 70.51 % 0

B.v BEAMA - New, Replacement and Voluntary and Hybrid 1

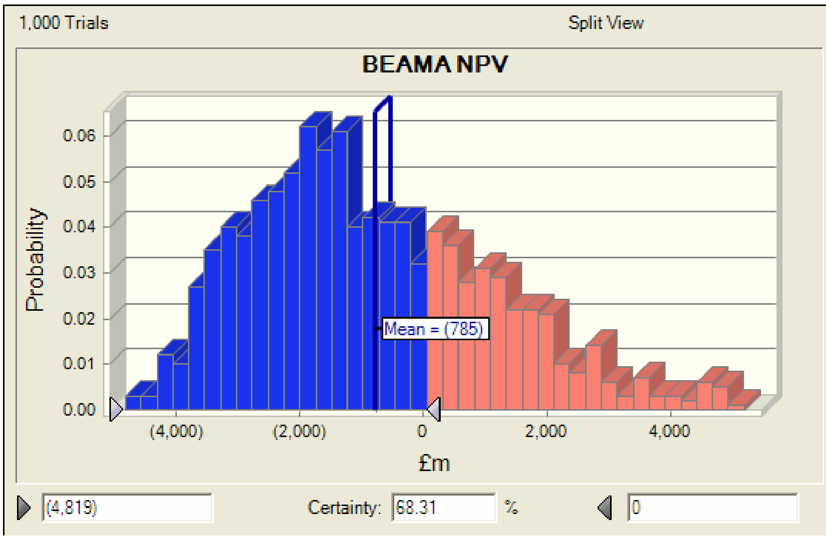
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(3,897)
Median	(4,294)
Mode	---
Standard Deviation	2,133
Variance	4,548,784
Skewness	1.09
Kurtosis	5.23
Coeff. of Variability	-0.5473
Minimum	(7,882)
Maximum	8,040
Mean Std. Error	67

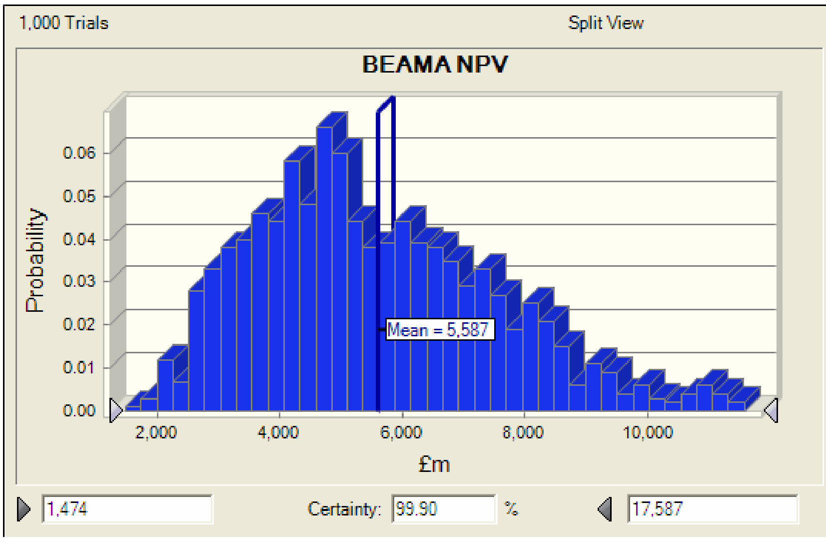
(7,882) Certainty: 95.56 % 0

B.vi BEAMA - New, Replacement and Voluntary and Hybrid 2



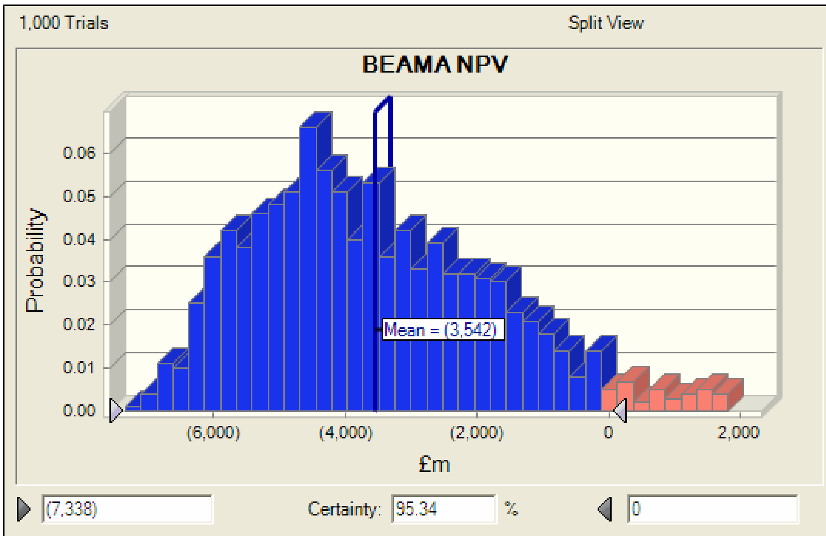
Statistic	Forecast values
Trials	1,000
Mean	(785)
Median	(1,198)
Mode	---
Standard Deviation	2,135
Variance	4,559,594
Skewness	1.09
Kurtosis	5.21
Coeff. of Variability	-2.72
Minimum	(4,819)
Maximum	11,176
Mean Std. Error	68

B.vii BEAMA - New, Replacement and Voluntary without comms



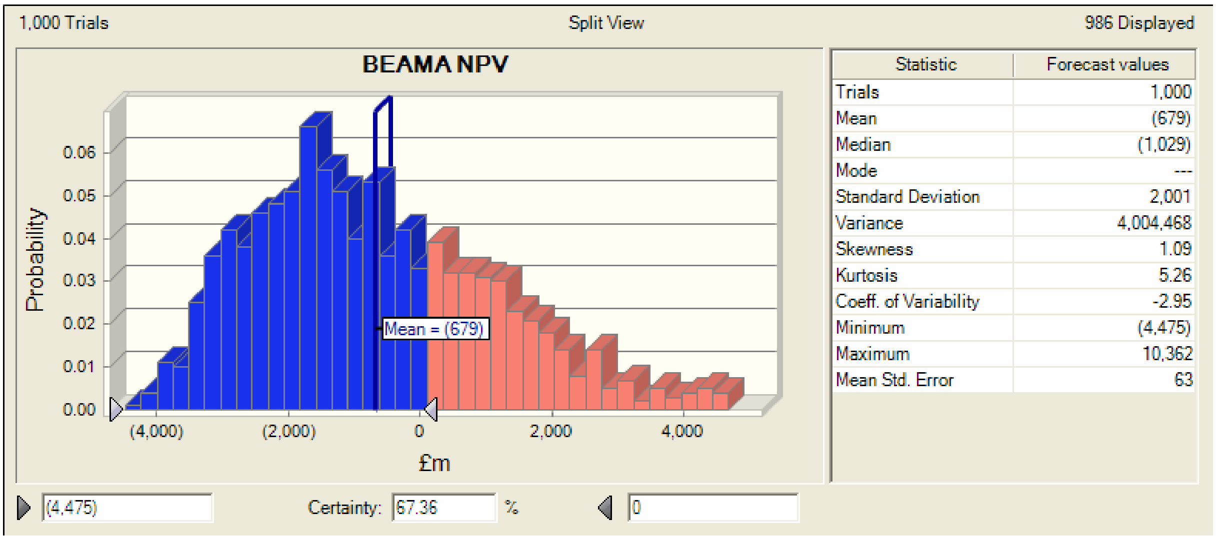
Statistic	Forecast values
Trials	1,000
Mean	5,587
Median	5,206
Mode	---
Standard Deviation	2,142
Variance	4,589,608
Skewness	1.08
Kurtosis	5.18
Coeff. of Variability	0.3834
Minimum	1,474
Maximum	17,587
Mean Std. Error	68

B.viii BEAMA – Regional Franchise and PLC

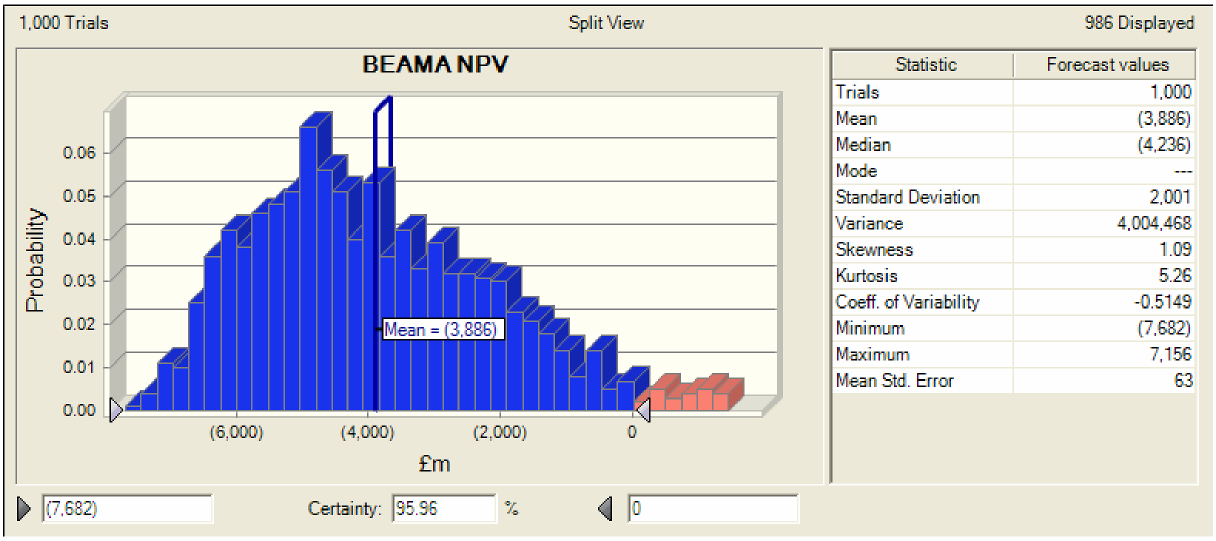


Statistic	Forecast values
Trials	1,000
Mean	(3,542)
Median	(3,892)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.5649
Minimum	(7,338)
Maximum	7,500
Mean Std. Error	63

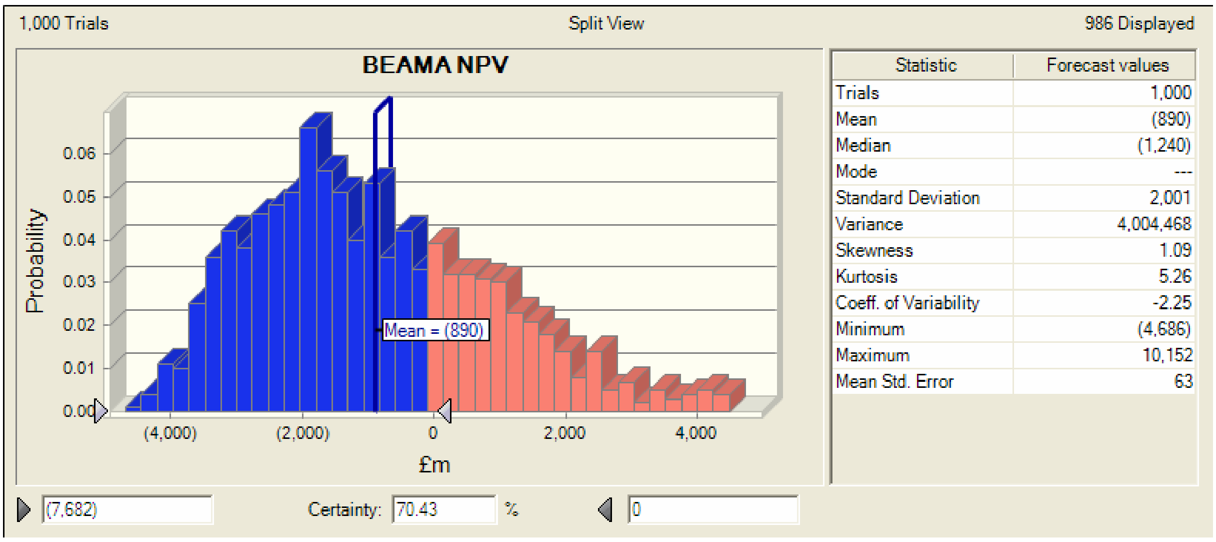
B.ix BEAMA - Regional Franchise and Broadband



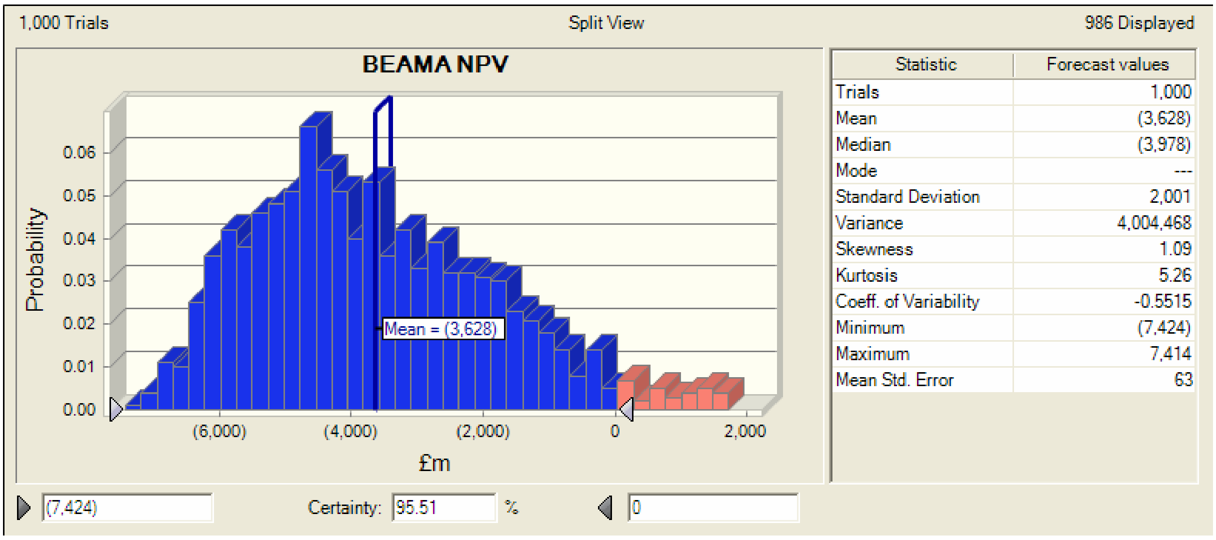
B.x BEAMA - Regional Franchise and WiMax



B.xi BEAMA - Regional Franchise and 3G

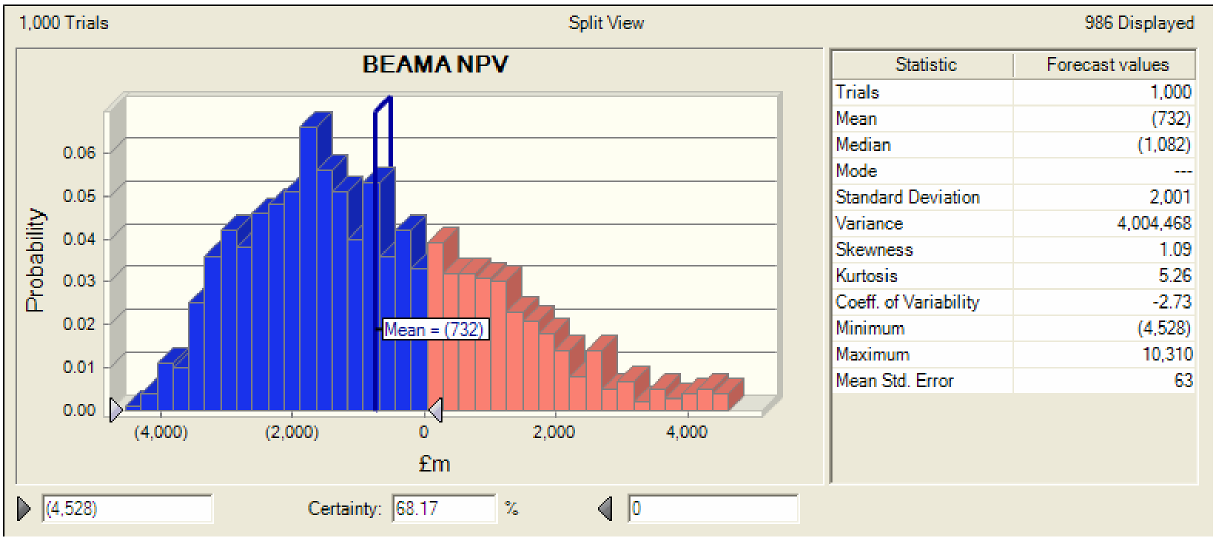


B.xii BEAMA - Regional Franchise and Hybrid 1



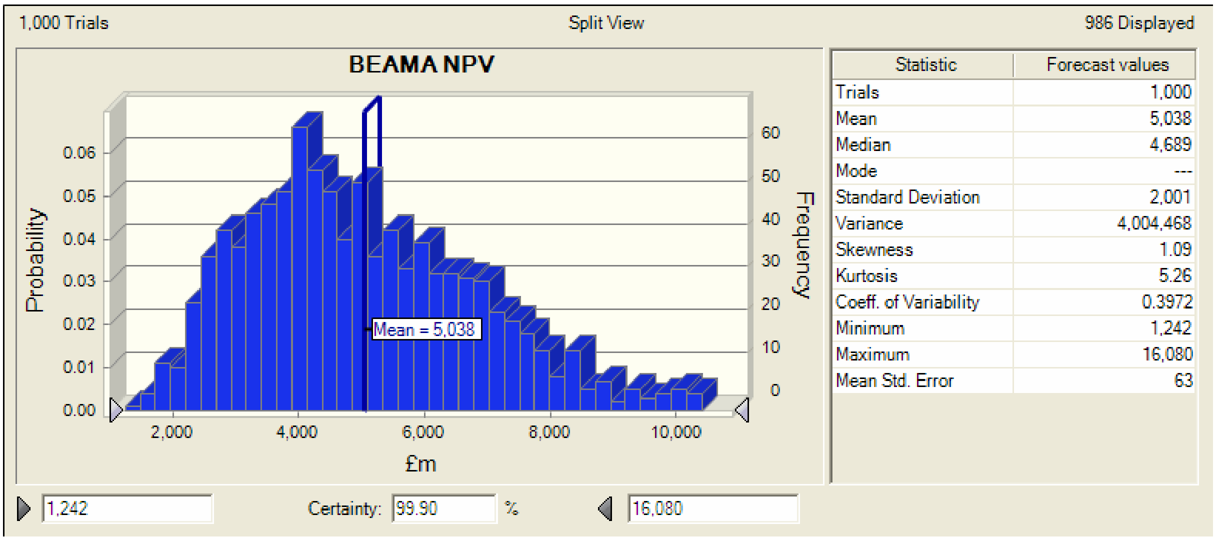
Statistic	Forecast values
Trials	1,000
Mean	(3,628)
Median	(3,978)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.5515
Minimum	(7,424)
Maximum	7,414
Mean Std. Error	63

B.xiii BEAMA - Regional Franchise and Hybrid 2



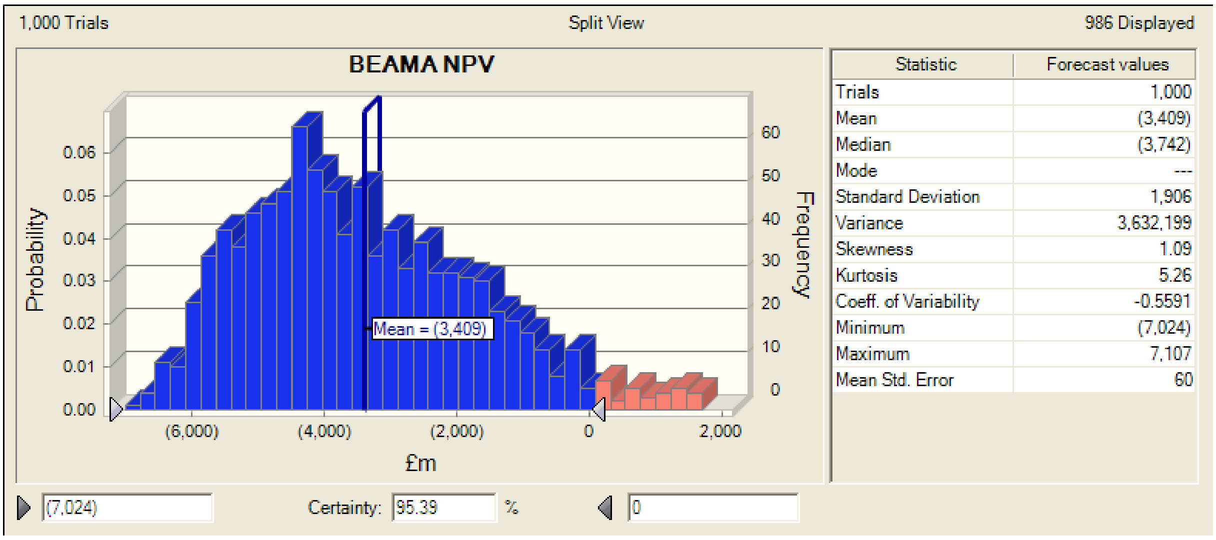
Statistic	Forecast values
Trials	1,000
Mean	(732)
Median	(1,082)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-2.73
Minimum	(4,528)
Maximum	10,310
Mean Std. Error	63

B.xiv BEAMA - Regional Franchise without comms

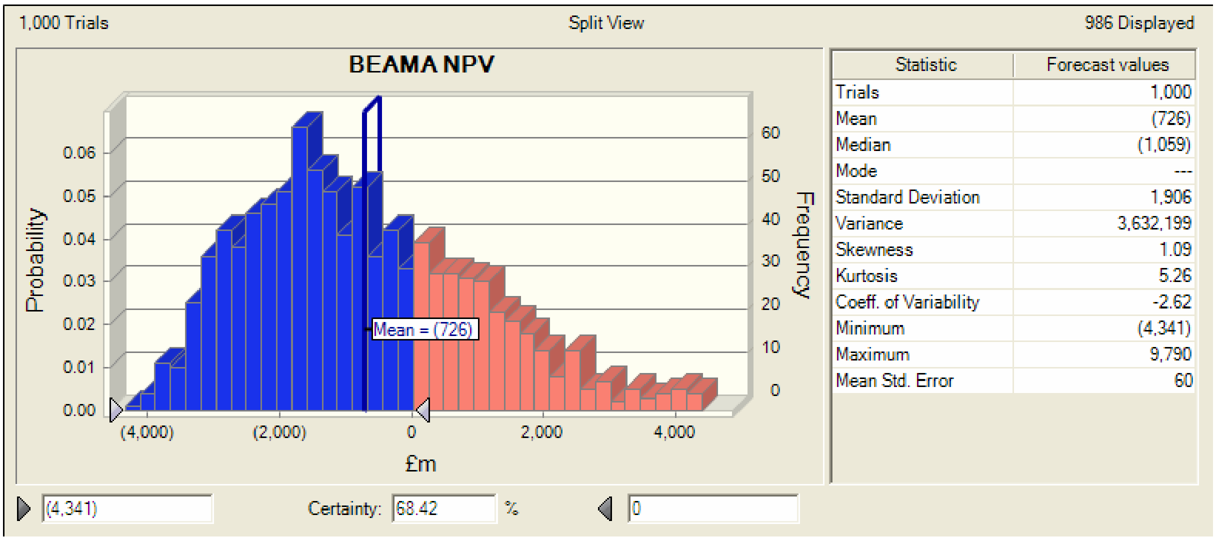


Statistic	Forecast values
Trials	1,000
Mean	5,038
Median	4,689
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	0.3972
Minimum	1,242
Maximum	16,080
Mean Std. Error	63

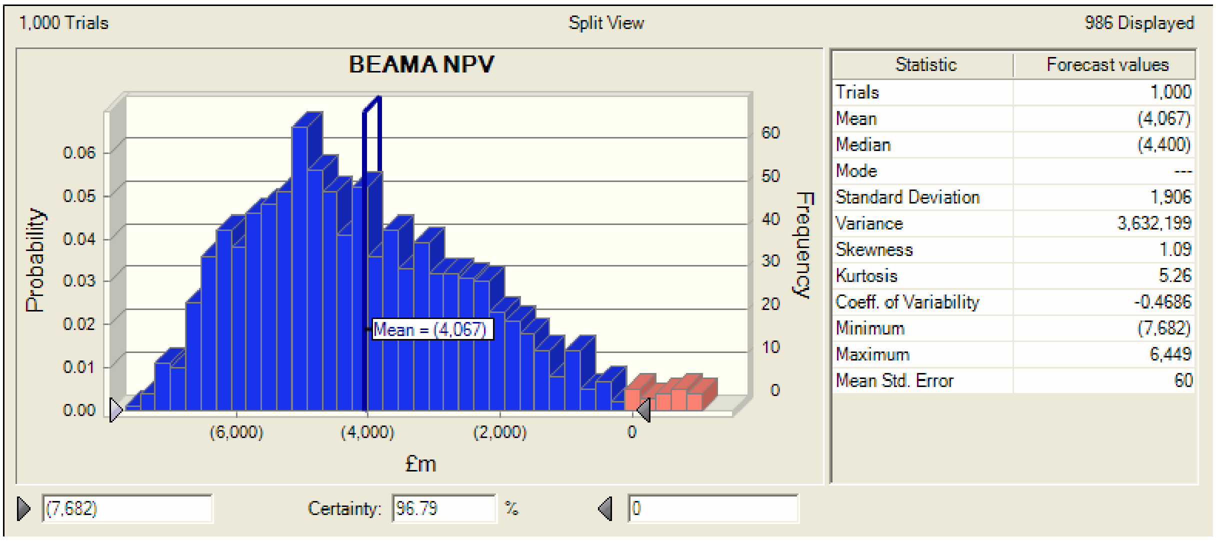
B.xv BEAMA – Market and PLC



B.xvi BEAMA - Market and Broadband

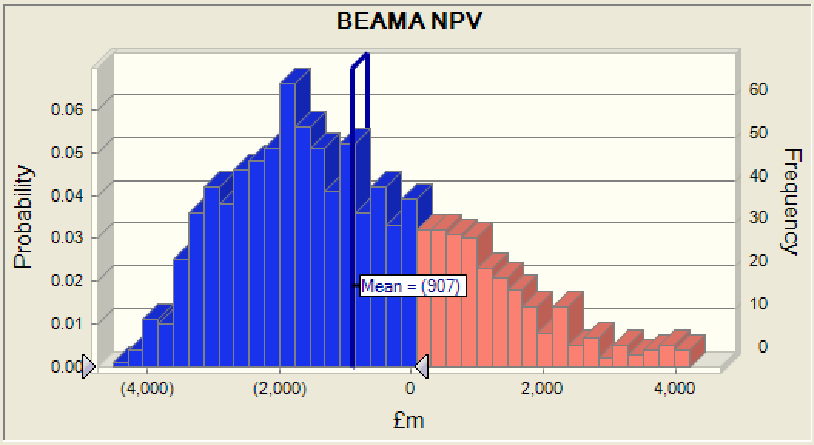


B.xvii BEAMA - Market and WiMax



B.xviii BEAMA - Market and 3G

1,000 Trials | Split View | 986 Displayed

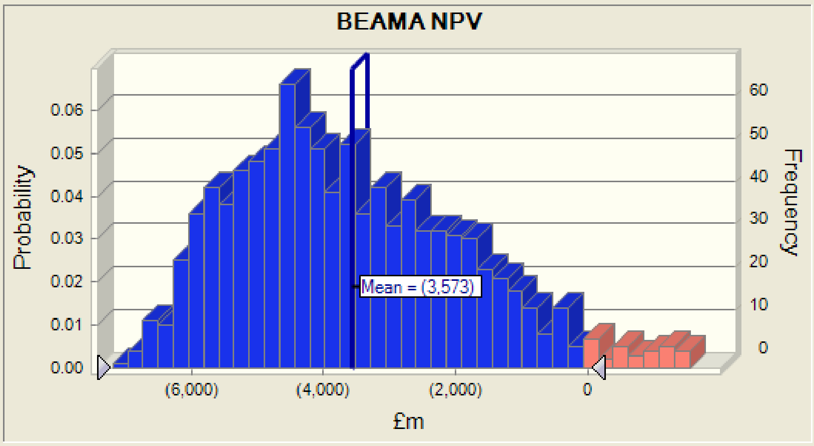


Statistic	Forecast values
Trials	1,000
Mean	(907)
Median	(1,240)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-2.10
Minimum	(4,522)
Maximum	9,609
Mean Std. Error	60

(4,522) Certainty: 71.44 % 0

B.xix BEAMA - Market and Hybrid 1

1,000 Trials | Split View | 986 Displayed

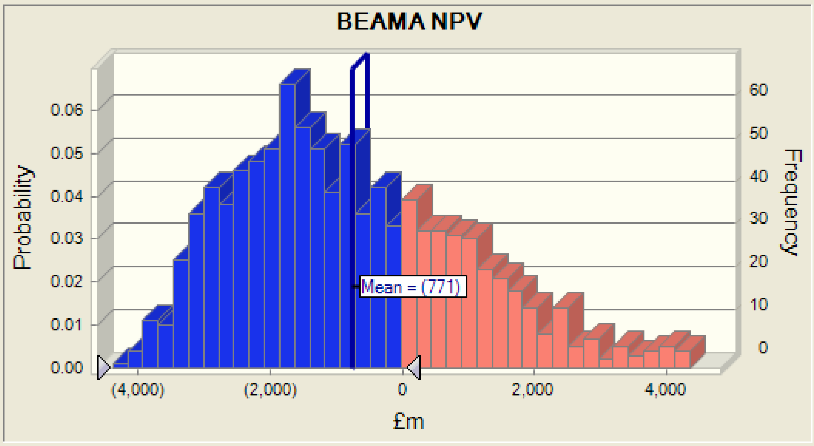


Statistic	Forecast values
Trials	1,000
Mean	(3,573)
Median	(3,906)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.5334
Minimum	(7,188)
Maximum	6,943
Mean Std. Error	60

(7,188) Certainty: 95.57 % 0

B.xx BEAMA - Market and Hybrid 2

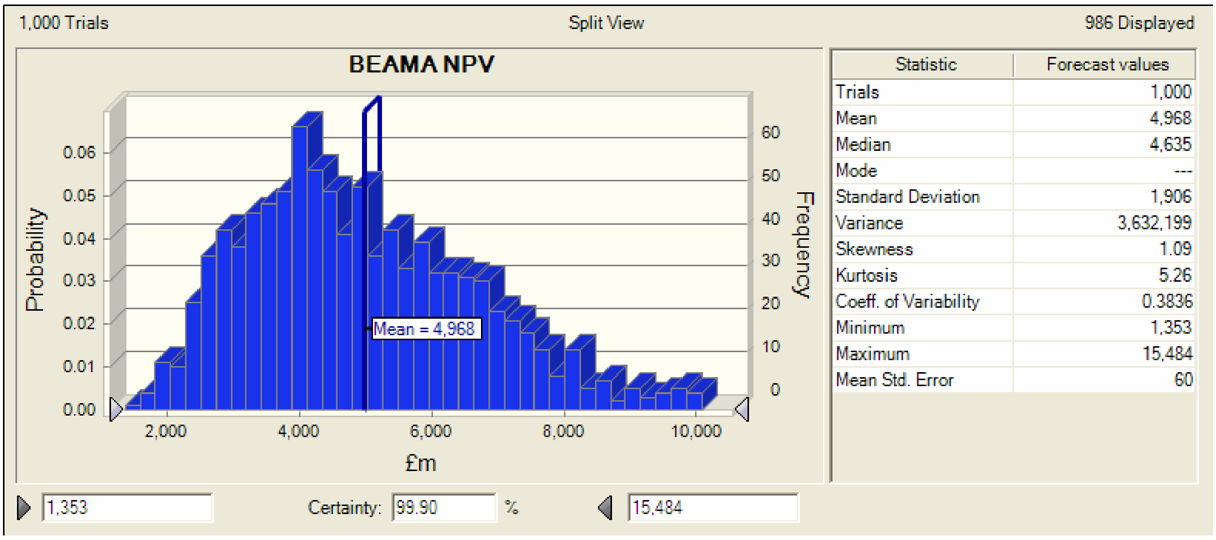
1,000 Trials | Split View | 986 Displayed



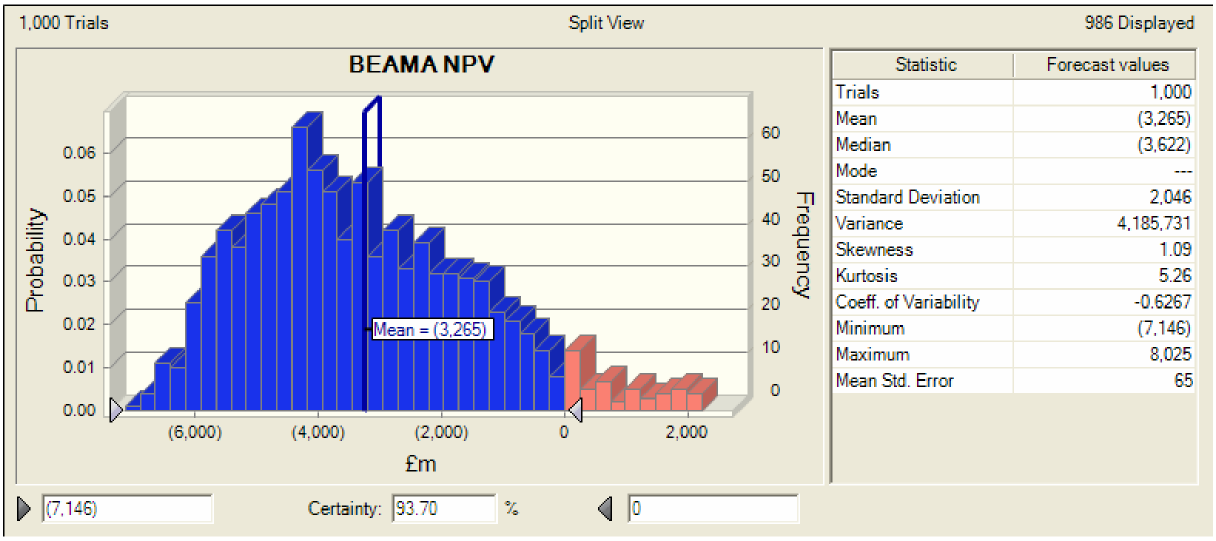
Statistic	Forecast values
Trials	1,000
Mean	(771)
Median	(1,104)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-2.47
Minimum	(4,386)
Maximum	9,745
Mean Std. Error	60

(4,386) Certainty: 69.23 % 0

B.xxi BEAMA - Market without comms

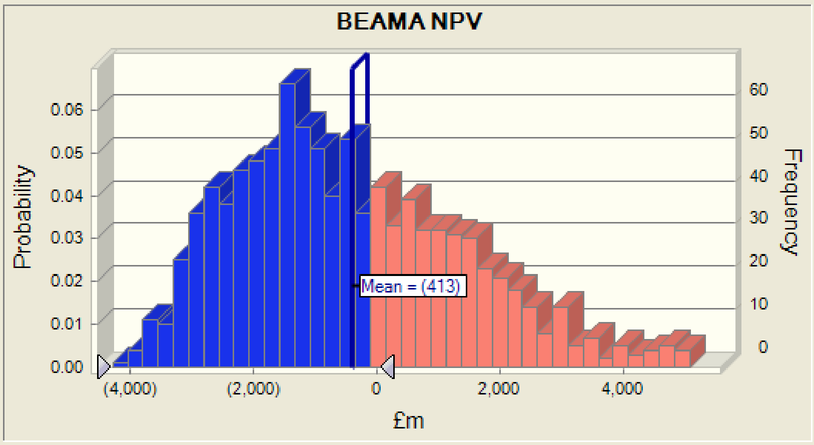


B.xxii BEAMA – Market Tip and PLC



B.xxiii BEAMA – Market Tip and Broadband

1,000 Trials | Split View | 986 Displayed

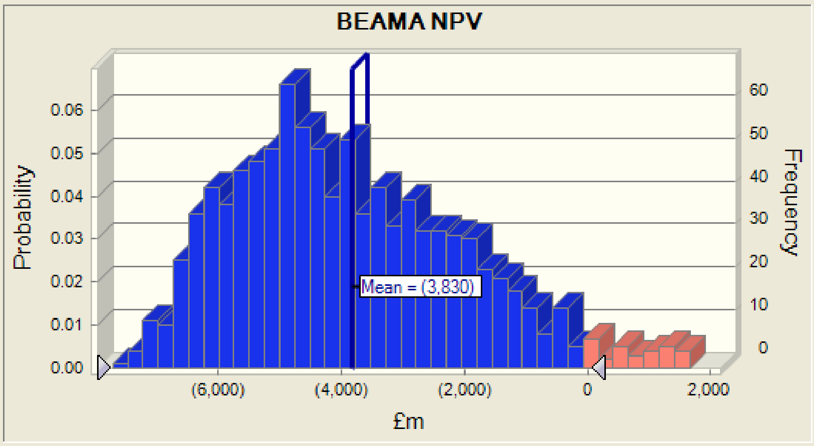


Statistic	Forecast values
Trials	1,000
Mean	(413)
Median	(771)
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-4.95
Minimum	(4,294)
Maximum	10,876
Mean Std. Error	65

(4,294) Certainty: 63.20 % 0

B.xxiv BEAMA - Market Tip and WiMax

1,000 Trials | Split View | 986 Displayed

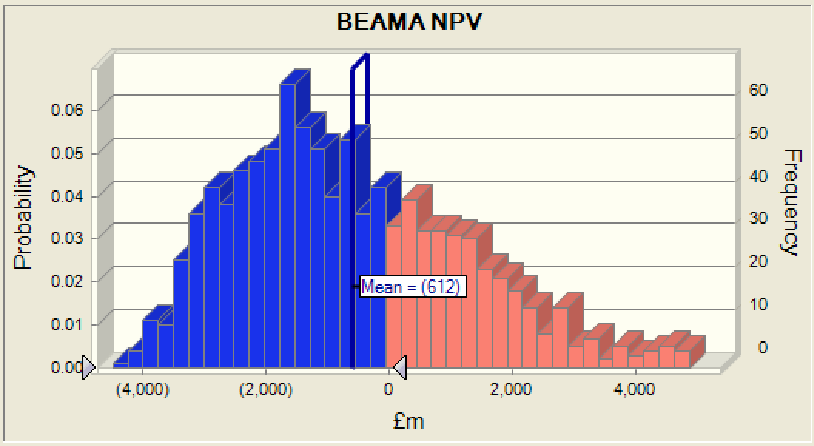


Statistic	Forecast values
Trials	1,000
Mean	(3,830)
Median	(4,188)
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.5341
Minimum	(7,711)
Maximum	7,459
Mean Std. Error	65

(7,711) Certainty: 95.57 % 0

B.xxv BEAMA - Market Tip and 3G

1,000 Trials | Split View | 986 Displayed

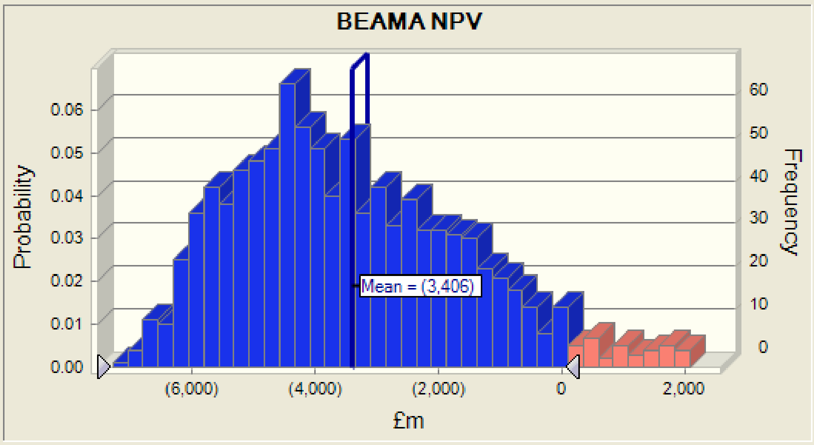


Statistic	Forecast values
Trials	1,000
Mean	(612)
Median	(969)
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-3.34
Minimum	(4,493)
Maximum	10,677
Mean Std. Error	65

(10,677) Certainty: 66.71 % 0

B.xxvi BEAMA - Market Tip and Hybrid 1

1,000 Trials | Split View | 986 Displayed

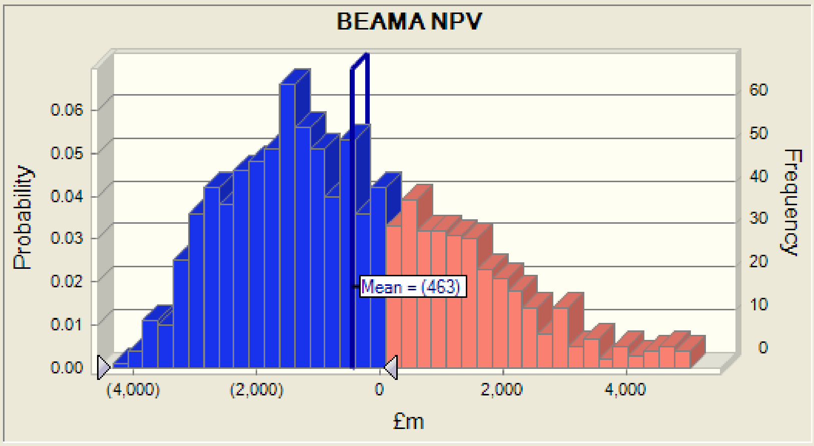


Statistic	Forecast values
Trials	1,000
Mean	(3,406)
Median	(3,764)
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.6006
Minimum	(7,287)
Maximum	7,883
Mean Std. Error	65

(7,287) Certainty: 94.45 % 0

B.xxvii BEAMA - Market Tip and Hybrid 2

1,000 Trials | Split View | 986 Displayed

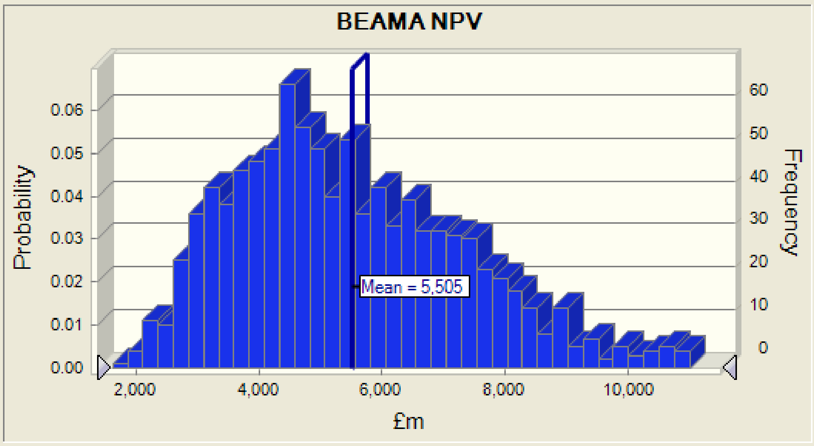


Statistic	Forecast values
Trials	1,000
Mean	(463)
Median	(821)
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-4.42
Minimum	(4,344)
Maximum	10,826
Mean Std. Error	65

(4,344) Certainty: 63.59 % 0

B.xxviii BEAMA - Market Tip without comms

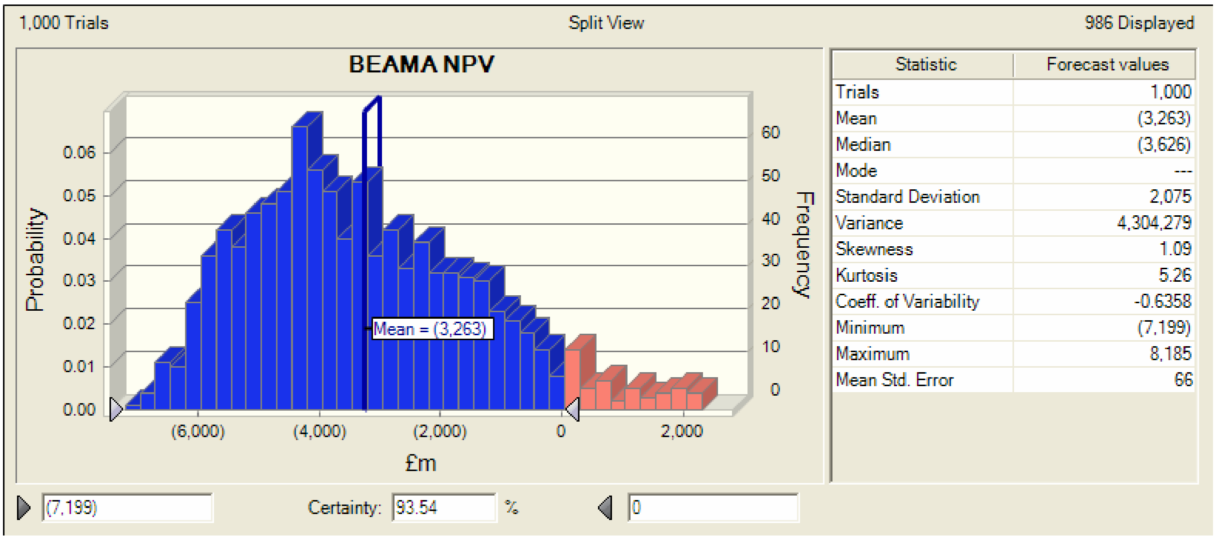
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	5,505
Median	5,147
Mode	---
Standard Deviation	2,046
Variance	4,185,731
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	0.3717
Minimum	1,624
Maximum	16,794
Mean Std. Error	65

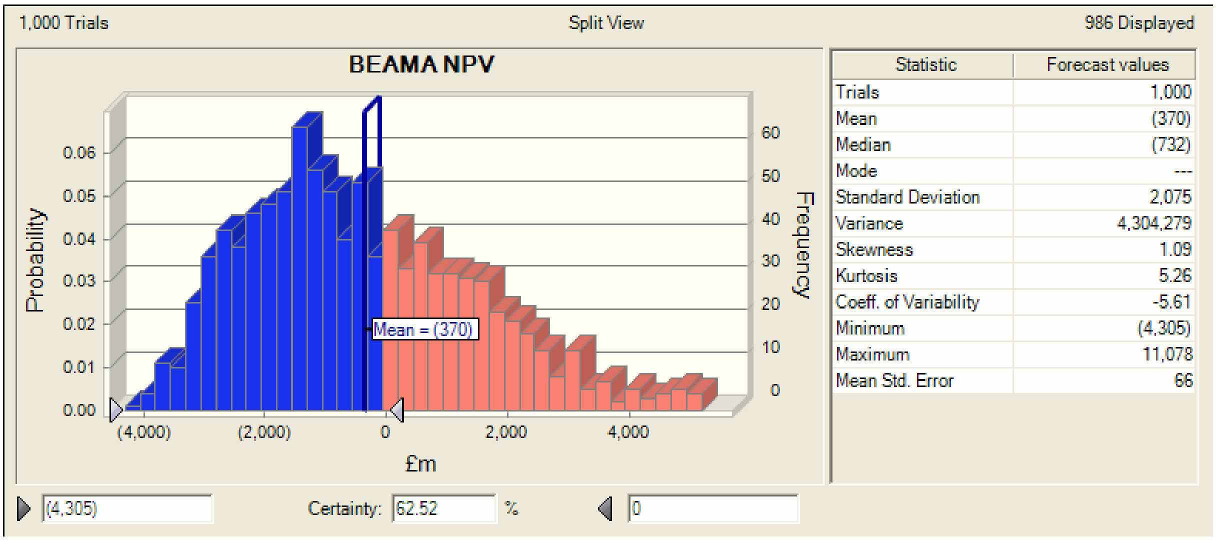
1,624 Certainty: 99.90 % 16,794

B.xxix BEAMA – Market Tip Fast and PLC



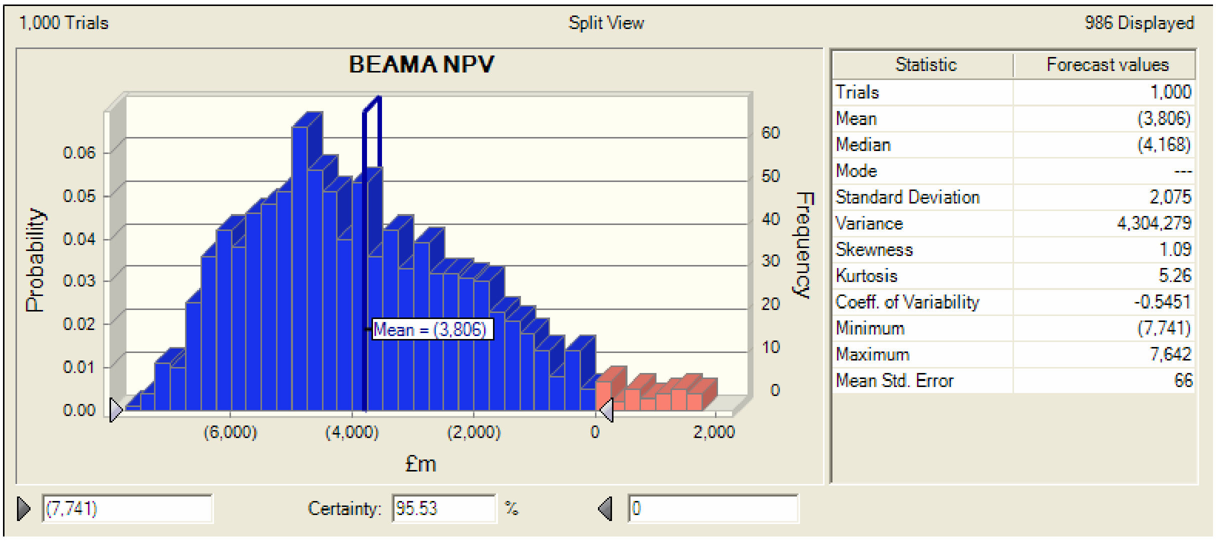
Statistic	Forecast values
Trials	1,000
Mean	(3,263)
Median	(3,626)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.6358
Minimum	(7,199)
Maximum	8,185
Mean Std. Error	66

B.xxx BEAMA – Market Tip Fast and Broadband



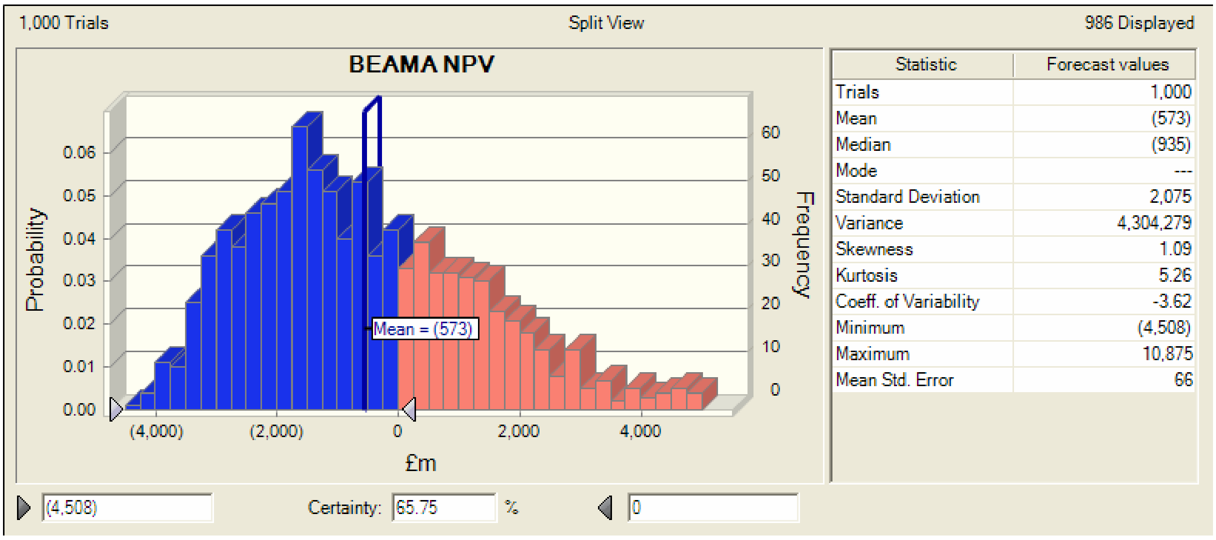
Statistic	Forecast values
Trials	1,000
Mean	(370)
Median	(732)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-5.61
Minimum	(4,305)
Maximum	11,078
Mean Std. Error	66

B.xxxi BEAMA - Market Tip Fast and WiMax

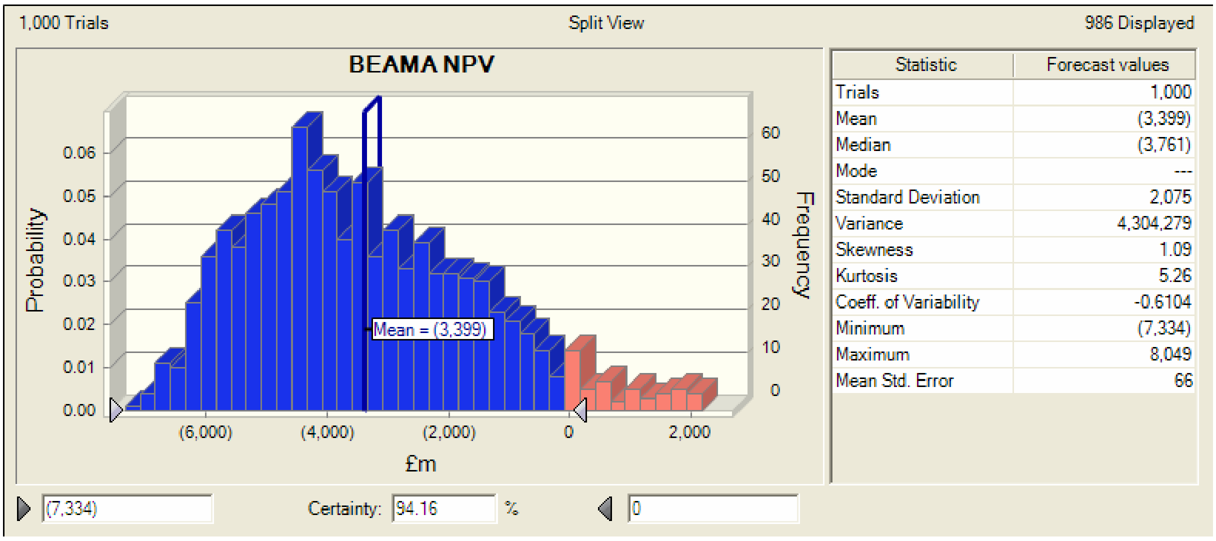


Statistic	Forecast values
Trials	1,000
Mean	(3,806)
Median	(4,168)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.5451
Minimum	(7,741)
Maximum	7,642
Mean Std. Error	66

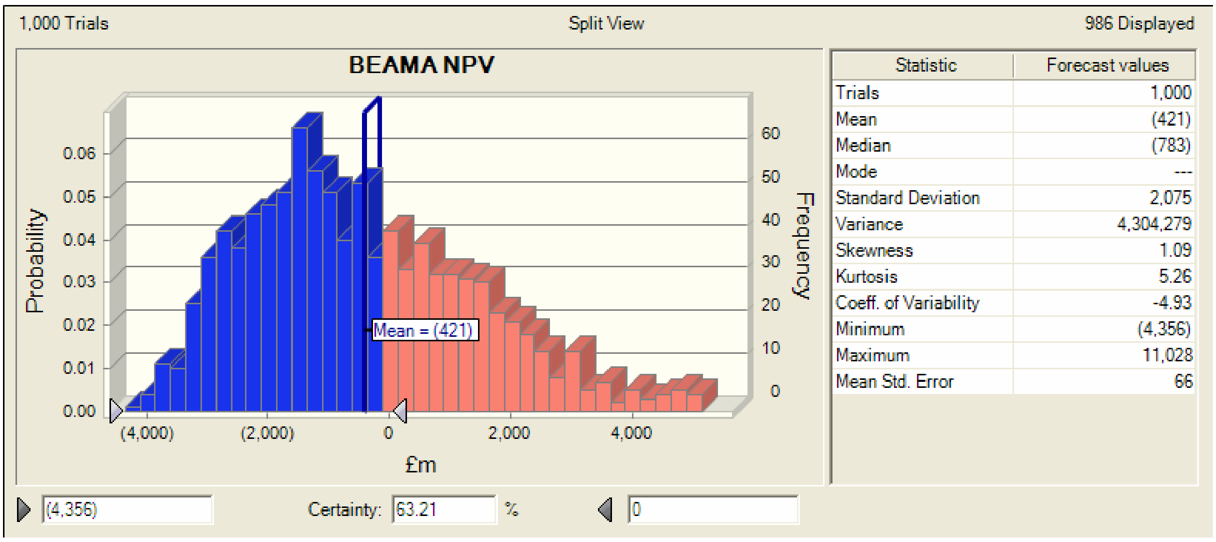
B.xxxii BEAMA - Market Tip Fast and 3G



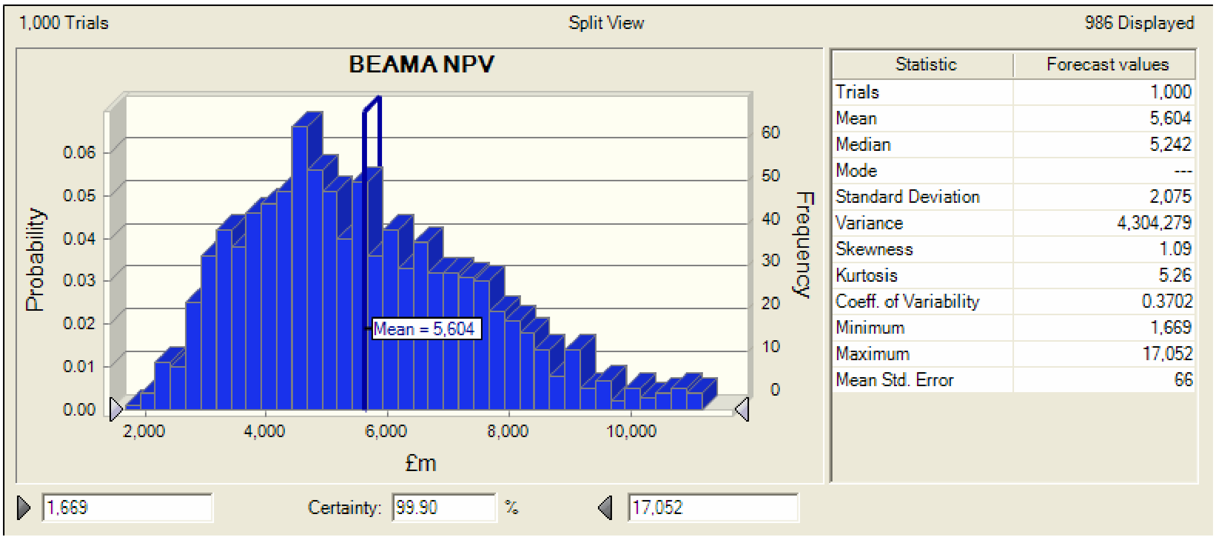
B.xxxiii BEAMA - Market Tip Fast and Hybrid 1



B.xxxiv BEAMA - Market Tip Fast and Hybrid 2

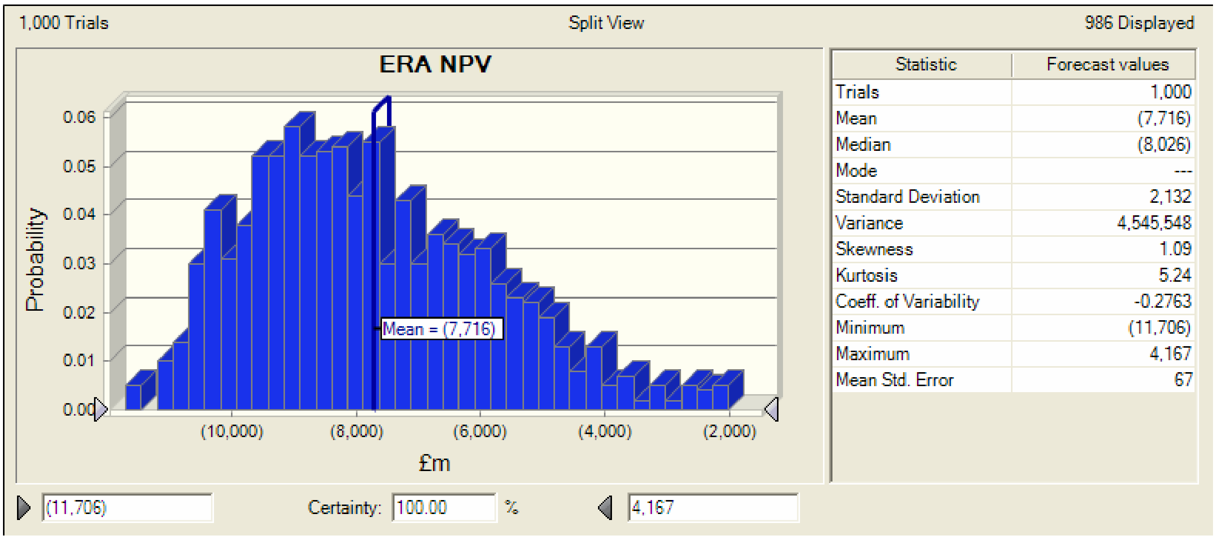


B.xxxv BEAMA - Market Tip Fast without comms



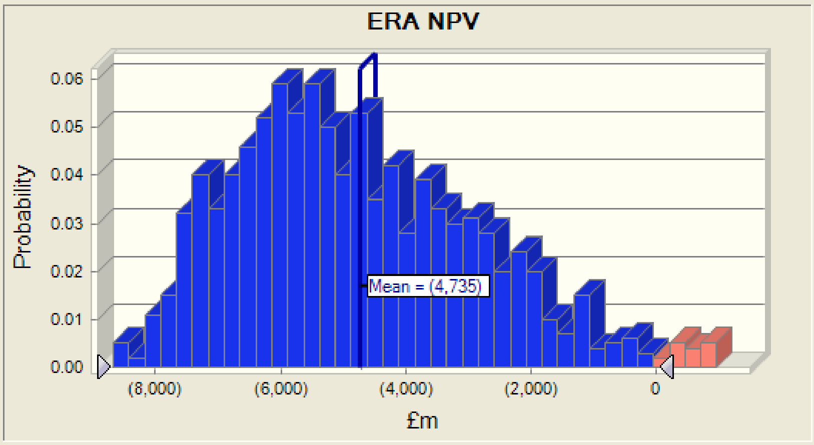
B.1.5 ERA Specification

B.i ERA - New, Replacement and Voluntary and PLC



B.ii ERA - New, Replacement and Voluntary and Broadband

1,000 Trials | Split View | 986 Displayed

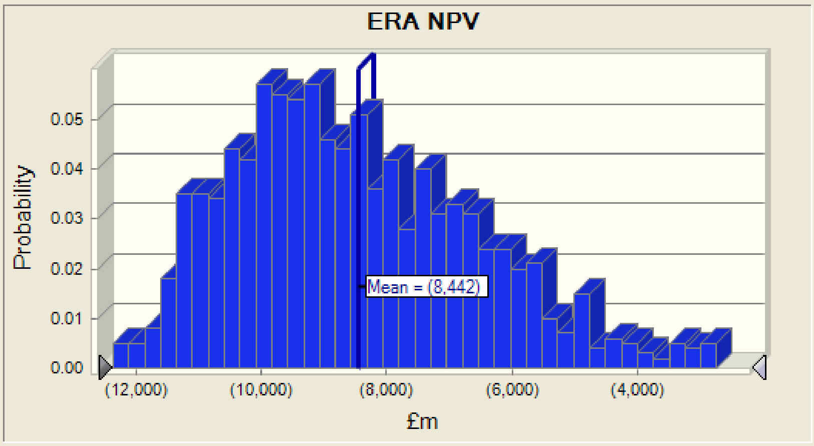


Statistic	Forecast values
Trials	1,000
Mean	(4,735)
Median	(5,102)
Mode	---
Standard Deviation	2,132
Variance	4,544,312
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.4502
Minimum	(8,675)
Maximum	7,176
Mean Std. Error	67

(8,675) Certainty: 96.93 % 0

B.iii ERA - New, Replacement and Voluntary and WiMax

1,000 Trials | Split View | 986 Displayed

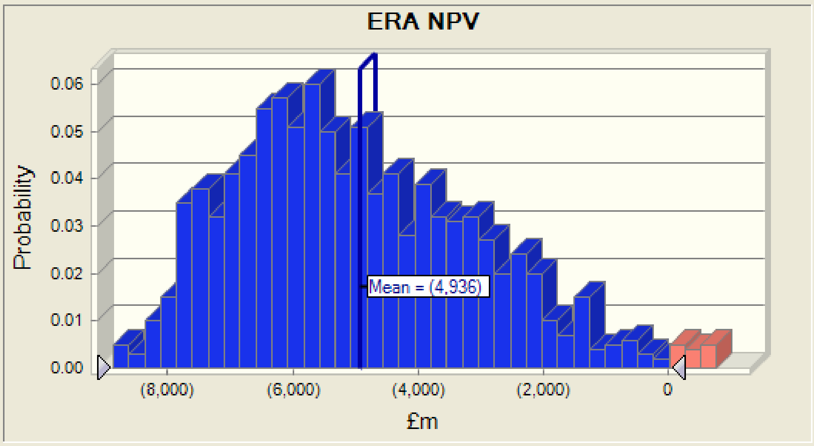


Statistic	Forecast values
Trials	1,000
Mean	(8,442)
Median	(8,773)
Mode	---
Standard Deviation	2,132
Variance	4,543,830
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.2525
Minimum	(12,355)
Maximum	3,457
Mean Std. Error	67

(12,332) Certainty: 99.81 % 3,457

B.iv ERA - New, Replacement and Voluntary and 3G

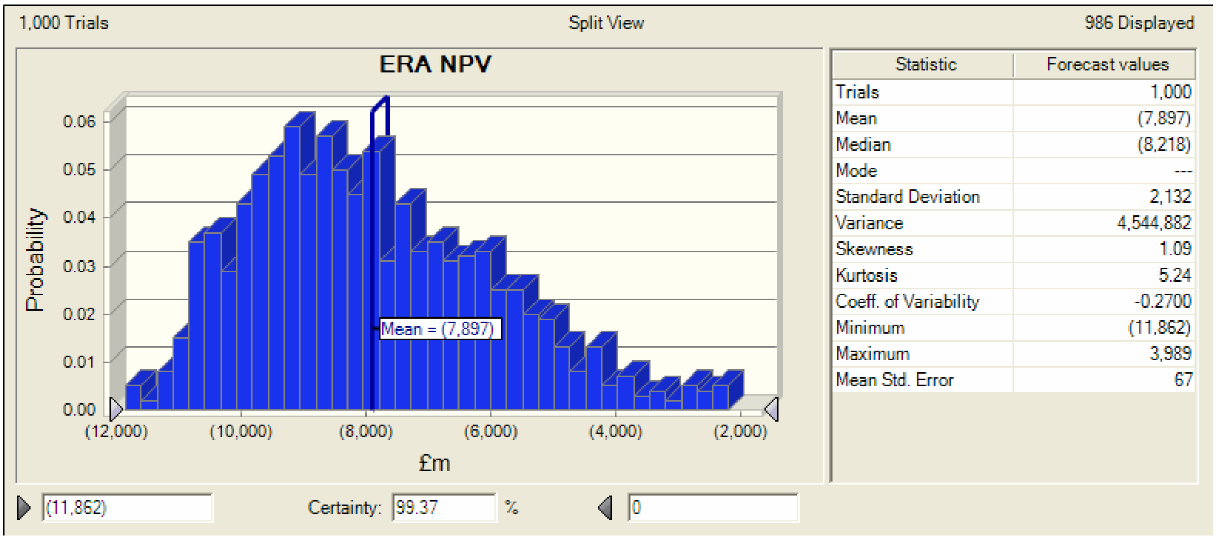
1,000 Trials | Split View | 986 Displayed



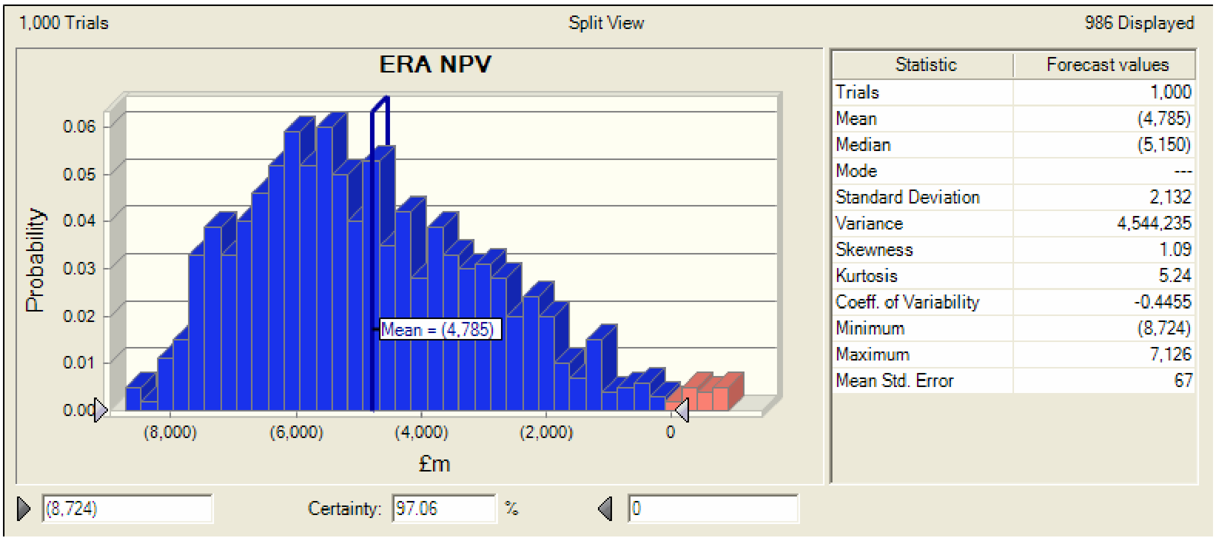
Statistic	Forecast values
Trials	1,000
Mean	(4,936)
Median	(5,296)
Mode	---
Standard Deviation	2,132
Variance	4,544,043
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.4319
Minimum	(8,870)
Maximum	6,973
Mean Std. Error	67

(8,870) Certainty: 97.12 % 0

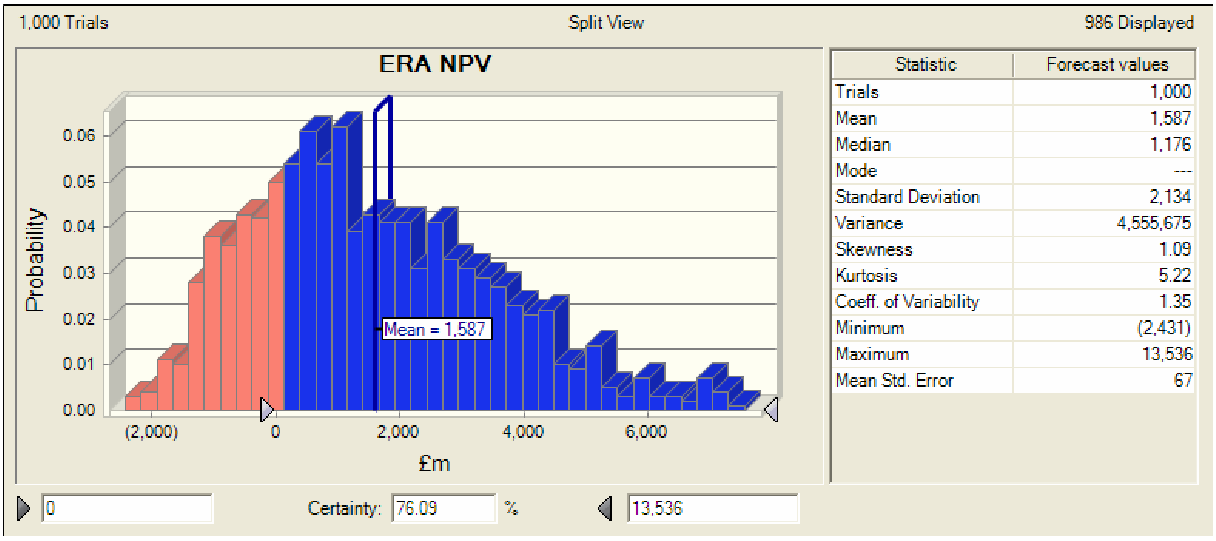
B.v ERA - New, Replacement and Voluntary and Hybrid 1



B.vi ERA - New, Replacement and Voluntary and Hybrid 2

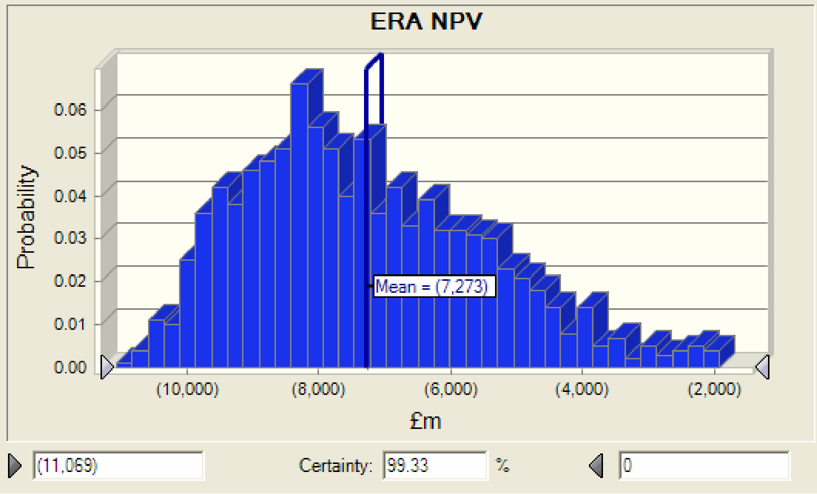


B.vii ERA - New, Replacement and Voluntary without comms



B.viii ERA – Regional Franchise and PLC

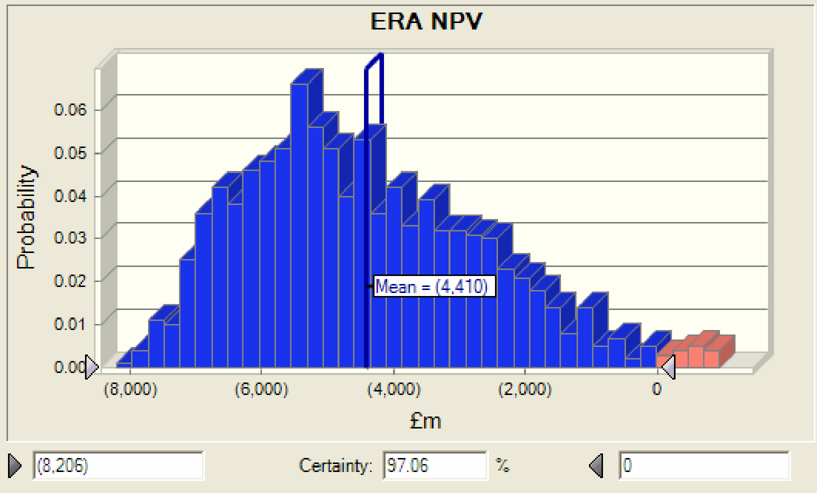
1,000 Trials — Split View — 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(7,273)
Median	(7,622)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2752
Minimum	(11,069)
Maximum	3,769
Mean Std. Error	63

B.ix ERA - Regional Franchise and Broadband

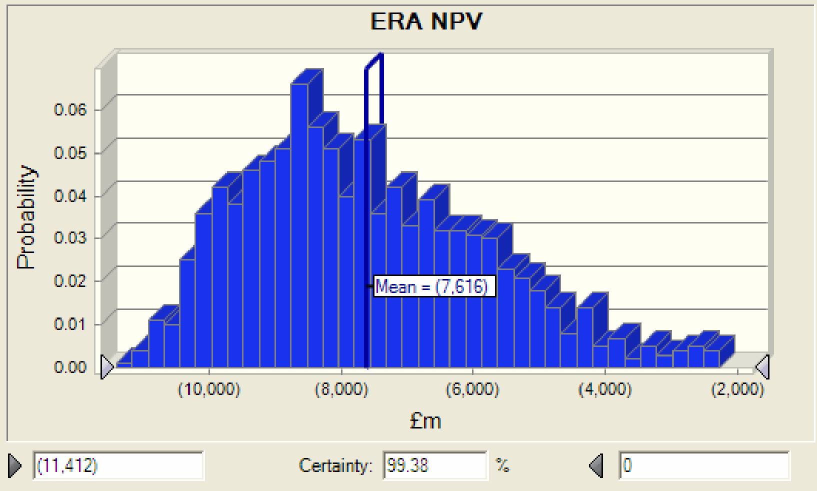
1,000 Trials — Split View — 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(4,410)
Median	(4,759)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4538
Minimum	(8,206)
Maximum	6,632
Mean Std. Error	63

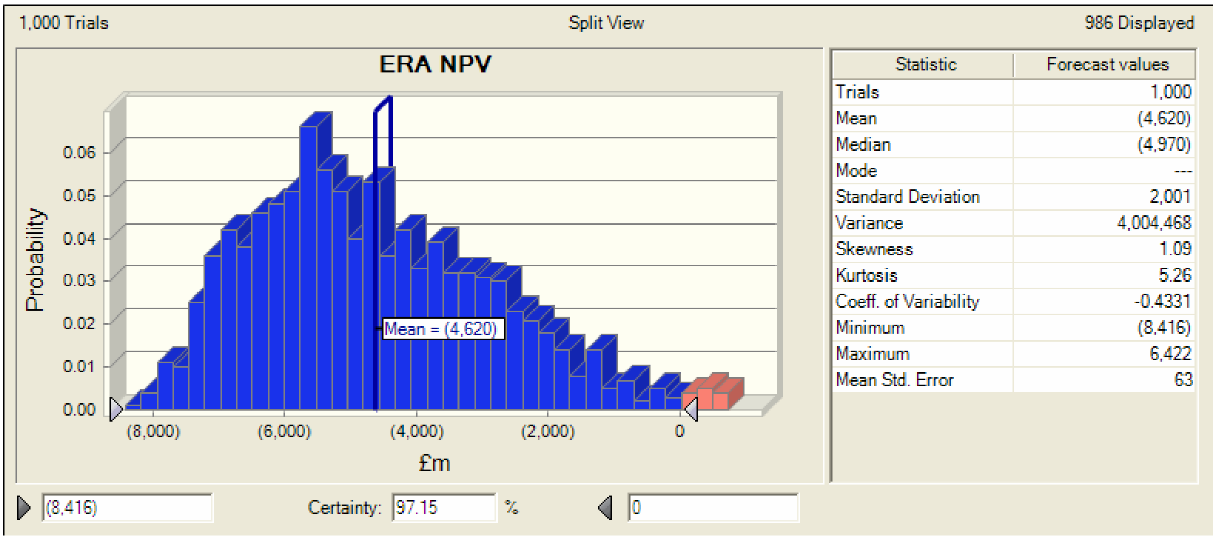
B.x ERA - Regional Franchise and WiMax

1,000 Trials — Split View — 986 Displayed

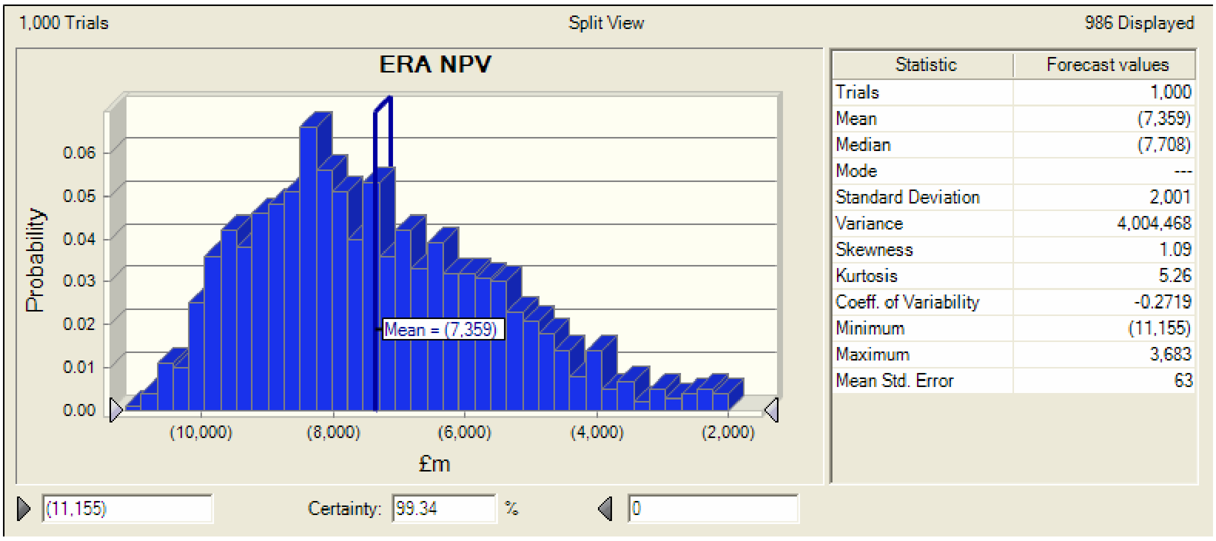


Statistic	Forecast values
Trials	1,000
Mean	(7,616)
Median	(7,966)
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2627
Minimum	(11,412)
Maximum	3,426
Mean Std. Error	63

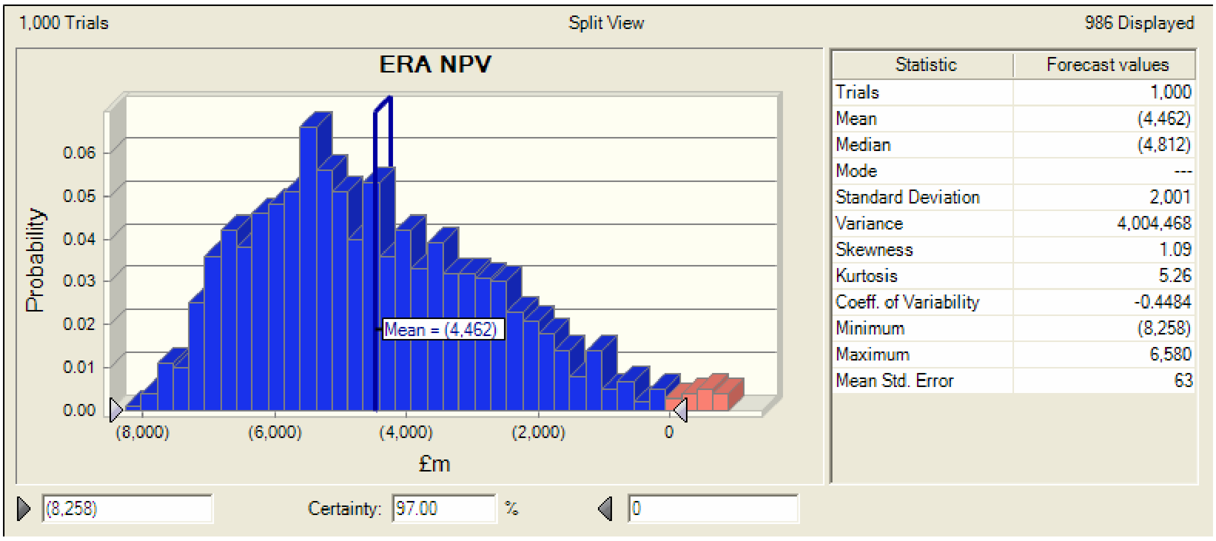
B.xi ERA - Regional Franchise and 3G



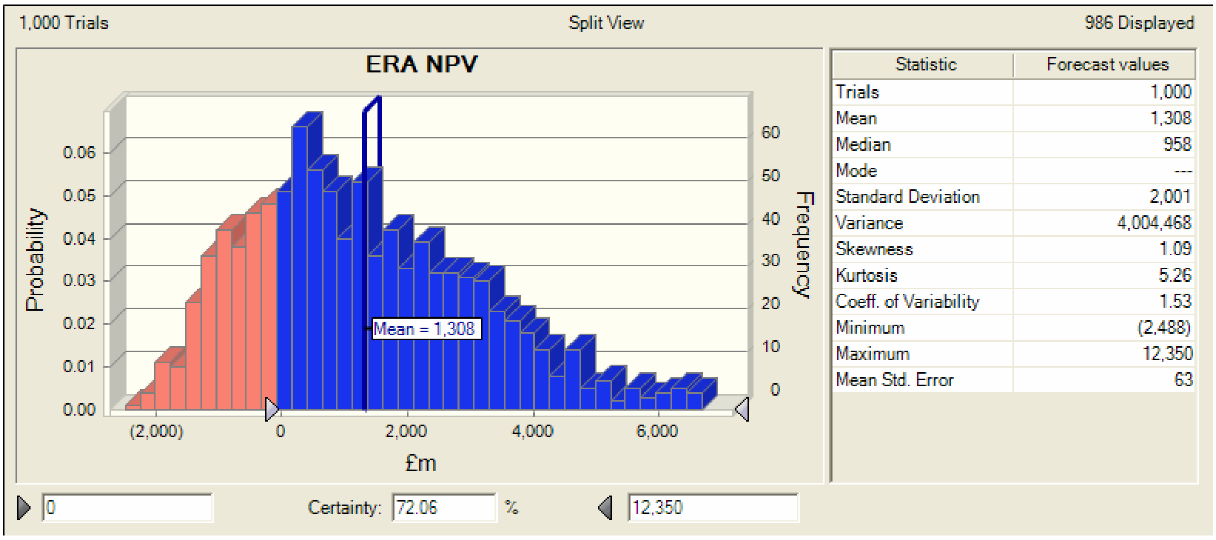
B.xii ERA - Regional Franchise and Hybrid 1



B.xiii ERA - Regional Franchise and Hybrid 2

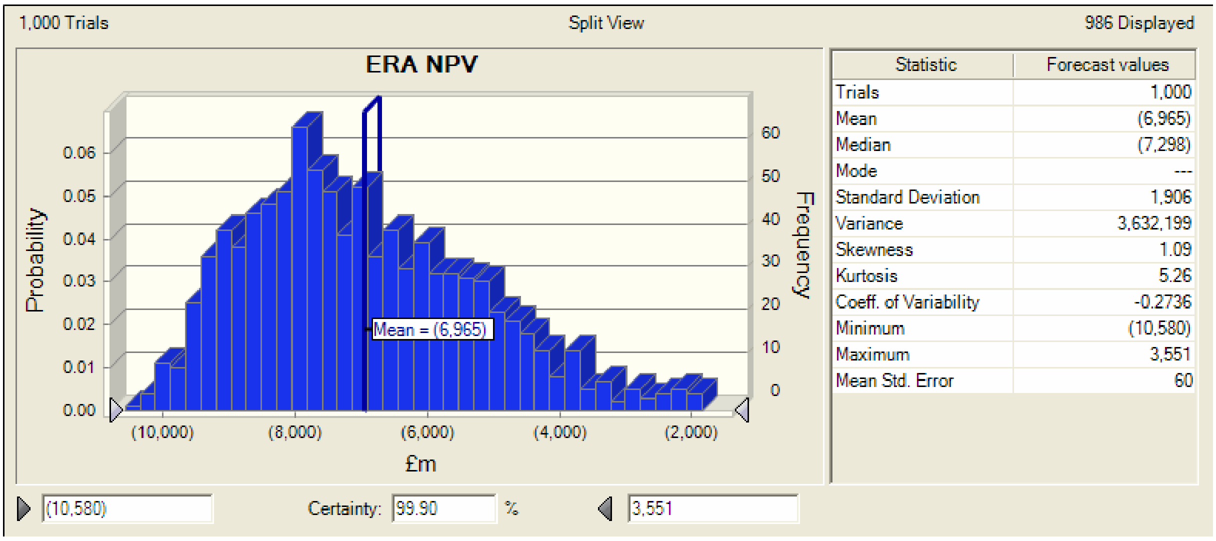


B.xiv ERA - Regional Franchise without comms



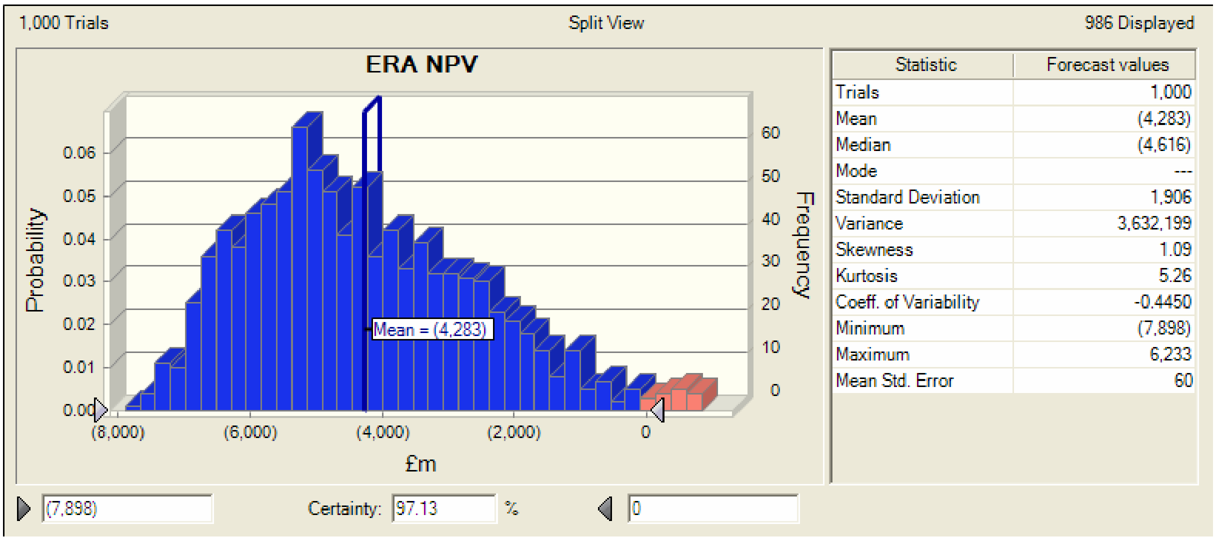
Statistic	Forecast values
Trials	1,000
Mean	1,308
Median	958
Mode	---
Standard Deviation	2,001
Variance	4,004,468
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	1.53
Minimum	(2,488)
Maximum	12,350
Mean Std. Error	63

B.xv ERA – Market and PLC



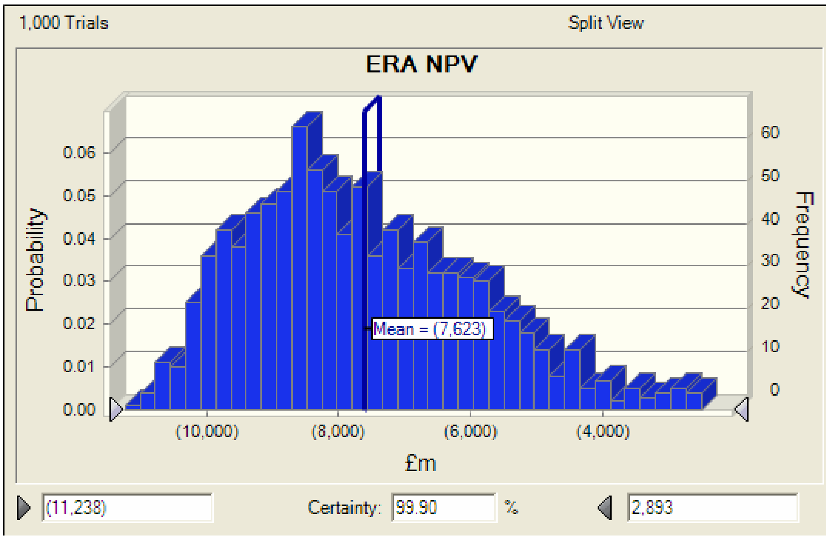
Statistic	Forecast values
Trials	1,000
Mean	(6,965)
Median	(7,298)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2736
Minimum	(10,580)
Maximum	3,551
Mean Std. Error	60

B.xvi ERA - Market and Broadband



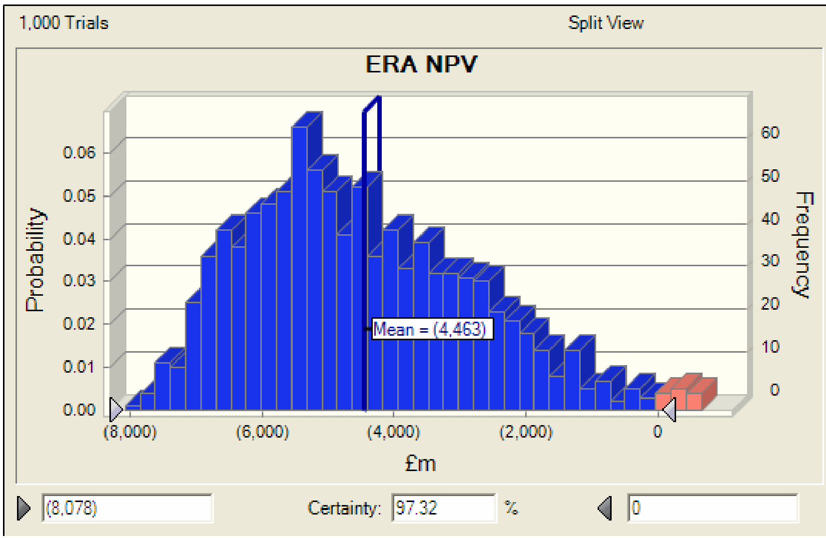
Statistic	Forecast values
Trials	1,000
Mean	(4,283)
Median	(4,616)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4450
Minimum	(7,898)
Maximum	6,233
Mean Std. Error	60

B.xvii ERA - Market and WiMax



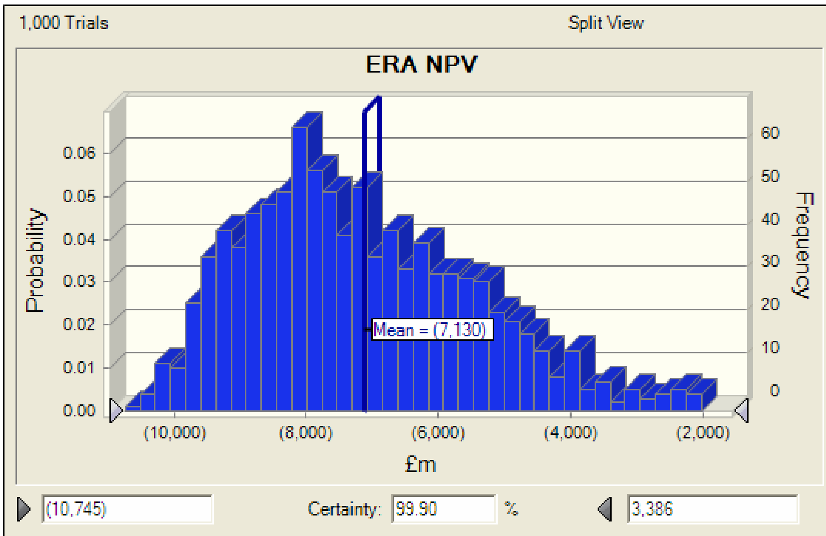
Statistic	Forecast values
Trials	1,000
Mean	(7,623)
Median	(7,956)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2500
Minimum	(11,238)
Maximum	2,893
Mean Std. Error	60

B.xviii ERA - Market and 3G



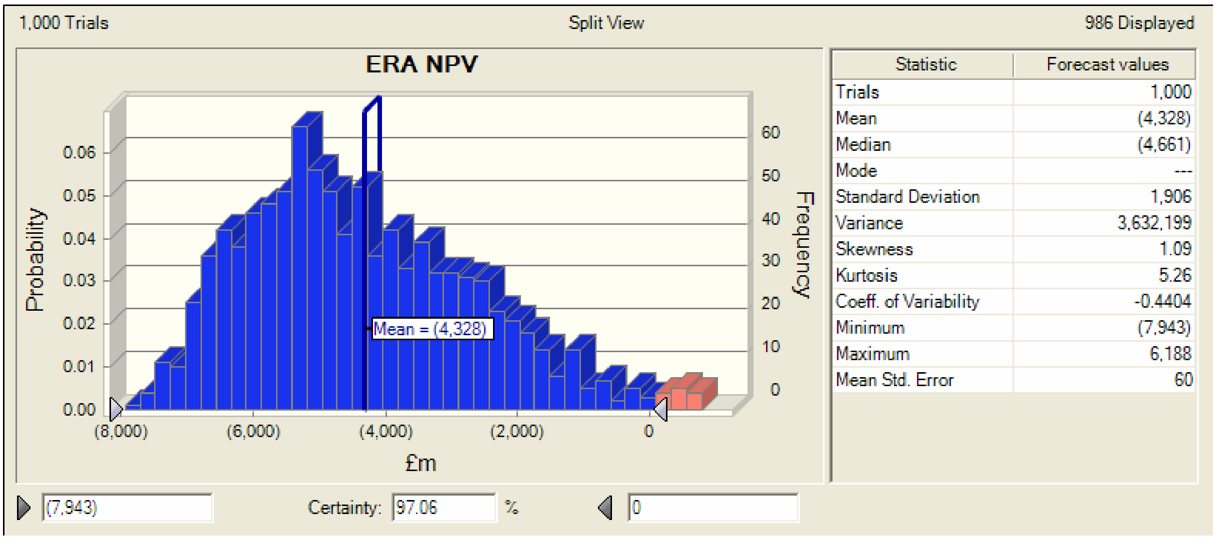
Statistic	Forecast values
Trials	1,000
Mean	(4,463)
Median	(4,796)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4270
Minimum	(8,078)
Maximum	6,053
Mean Std. Error	60

B.xix ERA - Market and Hybrid 1

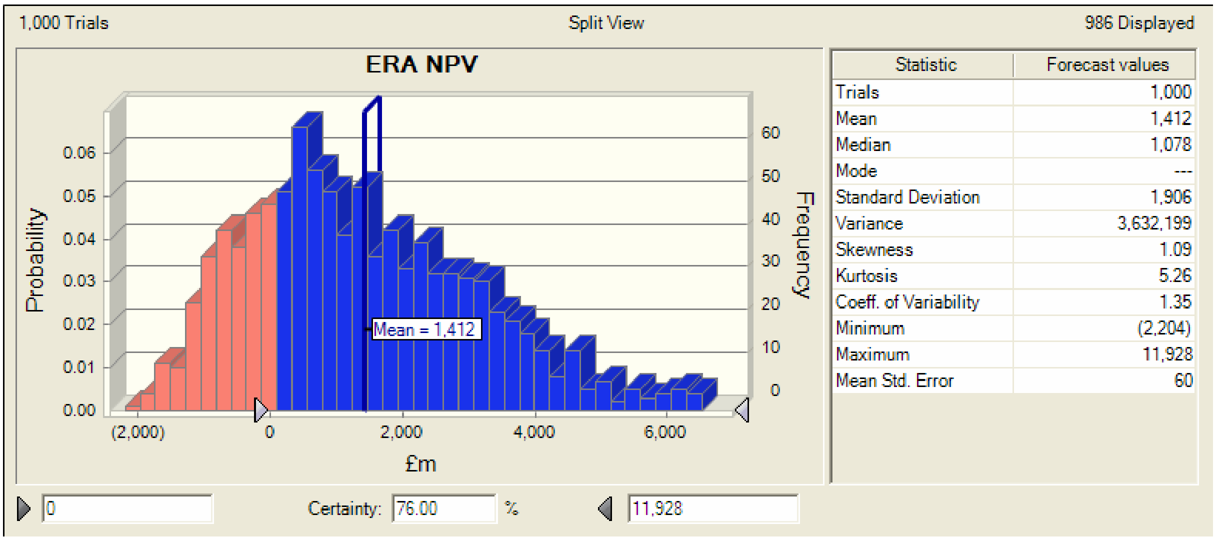


Statistic	Forecast values
Trials	1,000
Mean	(7,130)
Median	(7,463)
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2673
Minimum	(10,745)
Maximum	3,386
Mean Std. Error	60

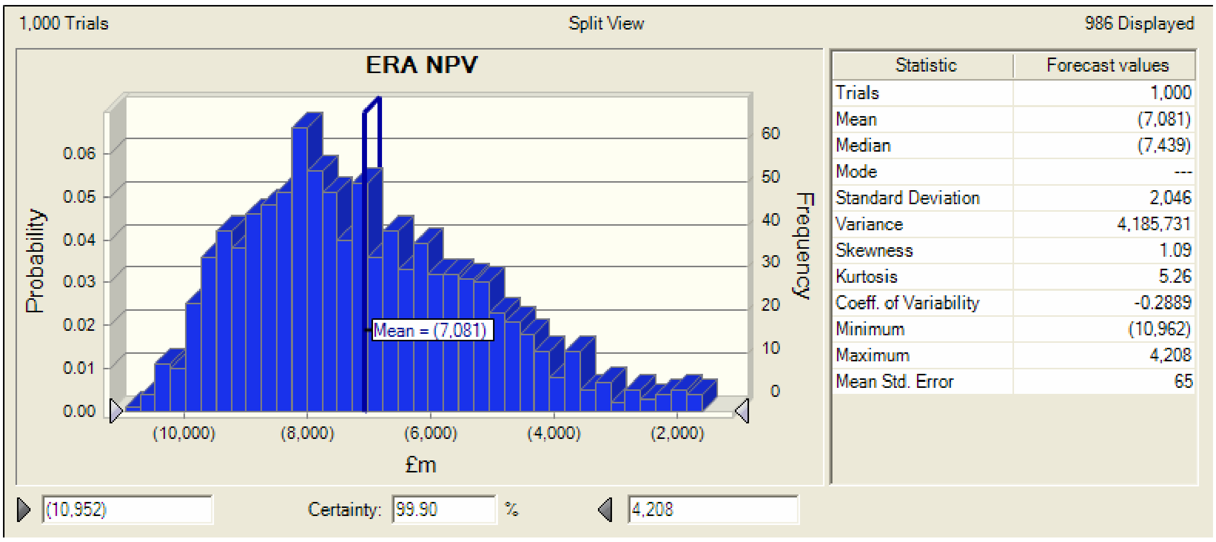
B.xx ERA - Market and Hybrid 2



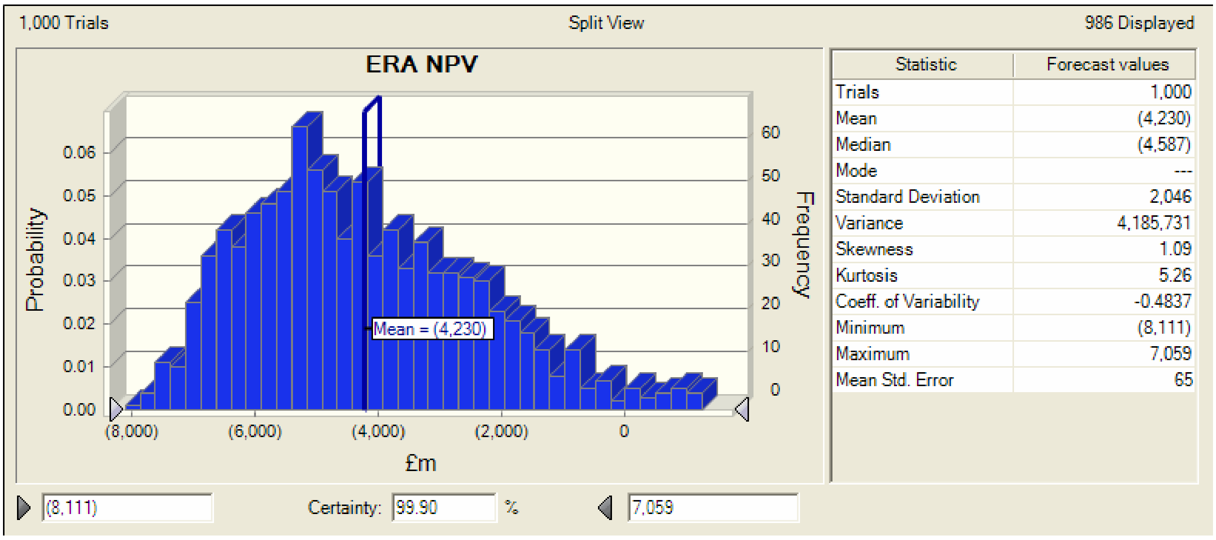
B.xxi ERA - Market without comms



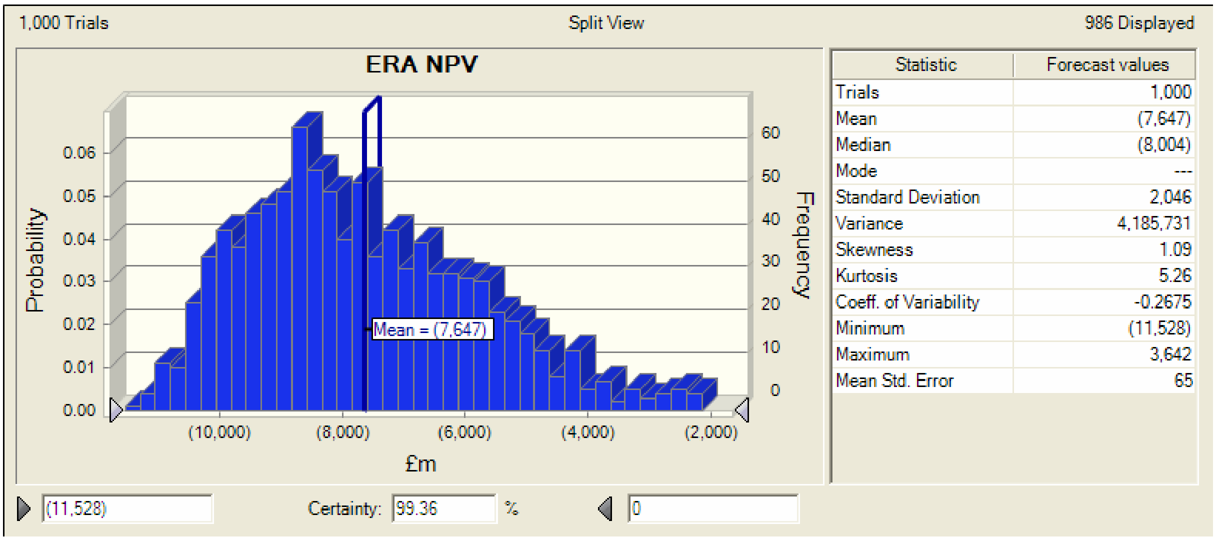
B.xxii ERA – Market Tip and PLC



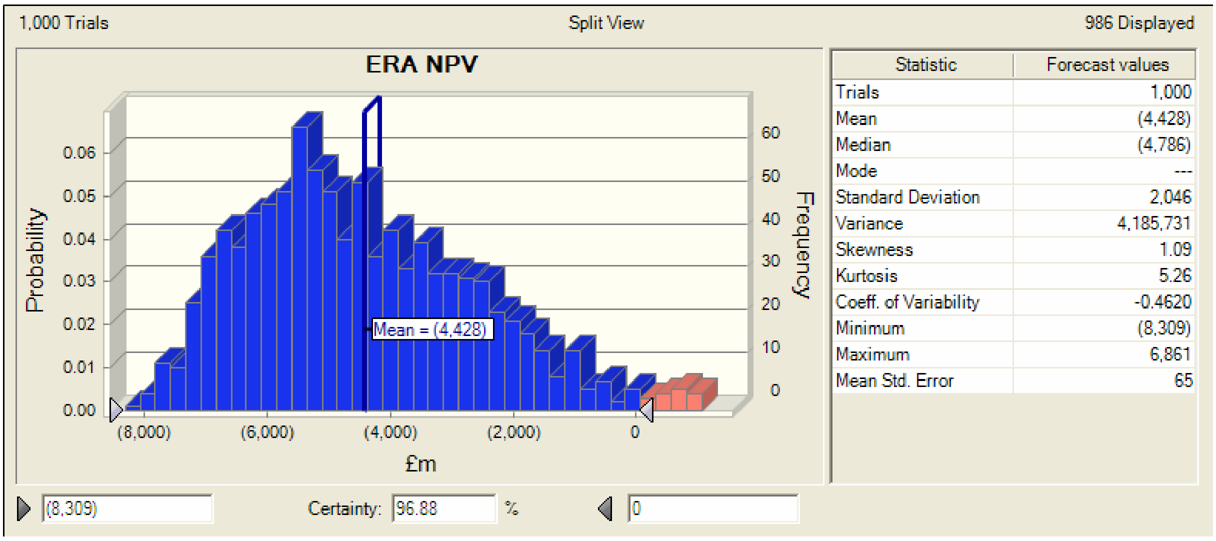
B.xxiii ERA – Market Tip and Broadband



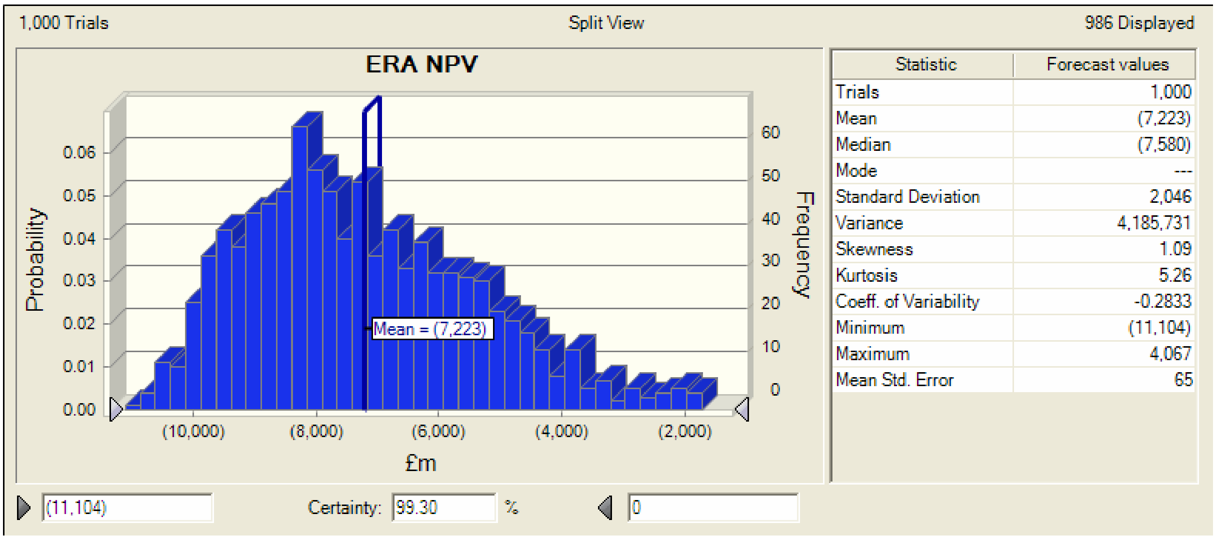
B.xxiv ERA - Market Tip and WiMax



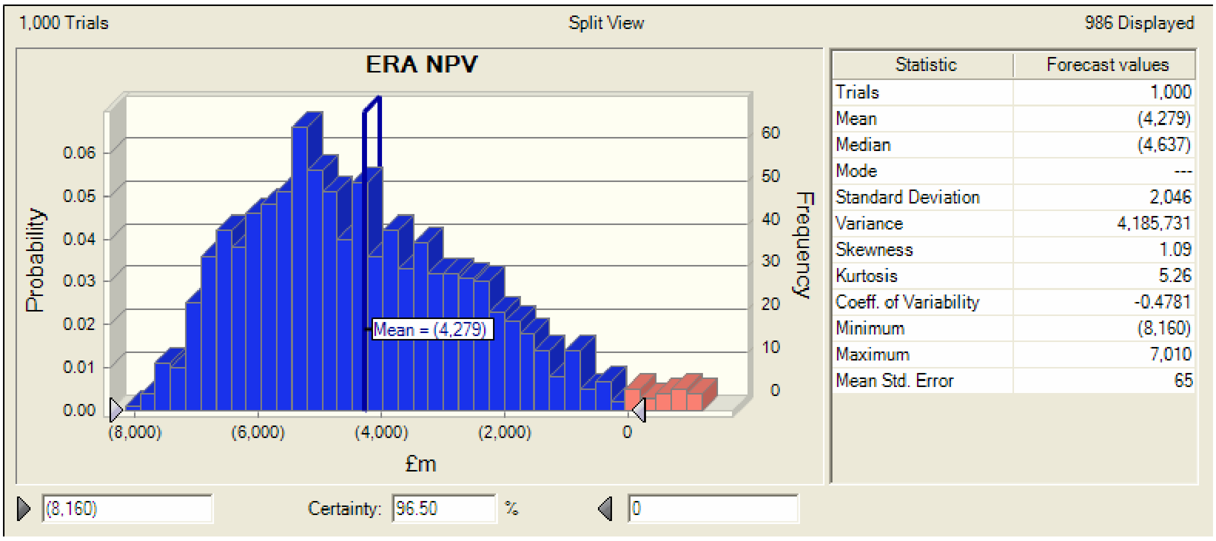
B.xxv ERA - Market Tip and 3G



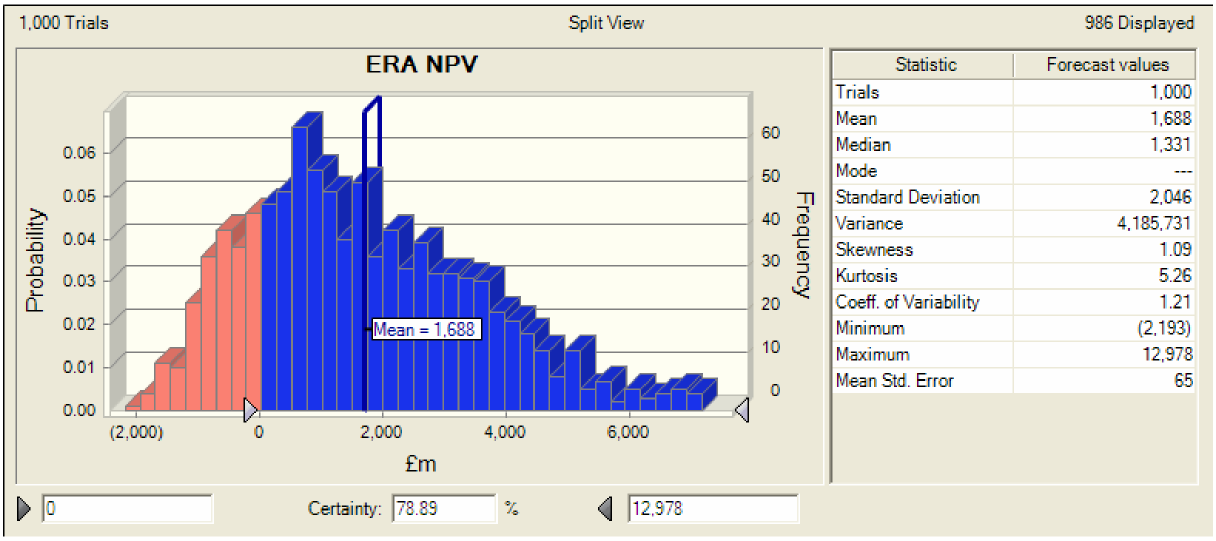
B.xxvi ERA - Market Tip and Hybrid 1



B.xxvii ERA - Market Tip and Hybrid 2

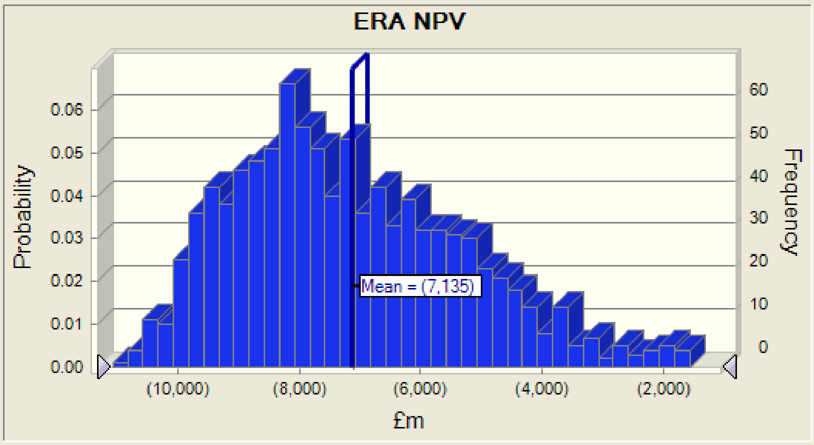


B.xxviii ERA - Market Tip without comms



B.xxix ERA – Market Tip Fast and PLC

1,000 Trials | Split View | 986 Displayed

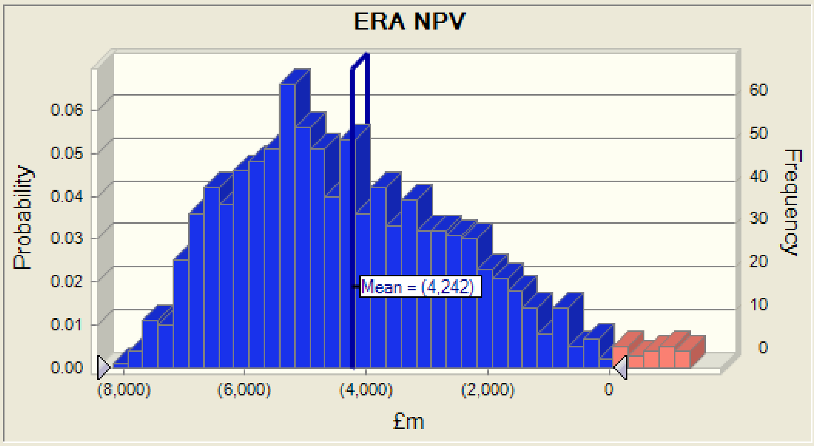


Statistic	Forecast values
Trials	1,000
Mean	(7,135)
Median	(7,498)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2908
Minimum	(11,071)
Maximum	4,313
Mean Std. Error	66

(11,071) Certainty: 99.27 % 0

B.xxx ERA – Market Tip Fast and Broadband

1,000 Trials | Split View | 986 Displayed

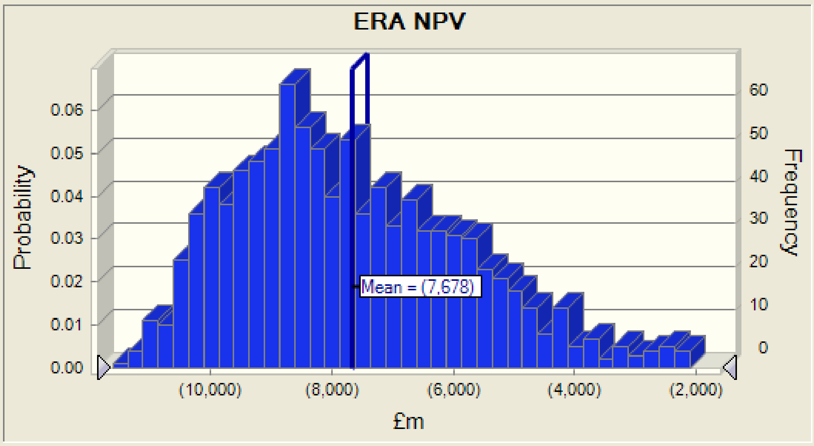


Statistic	Forecast values
Trials	1,000
Mean	(4,242)
Median	(4,604)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4891
Minimum	(8,178)
Maximum	7,206
Mean Std. Error	66

(8,178) Certainty: 96.46 % 0

B.xxxi ERA - Market Tip Fast and WiMax

1,000 Trials | Split View | 986 Displayed

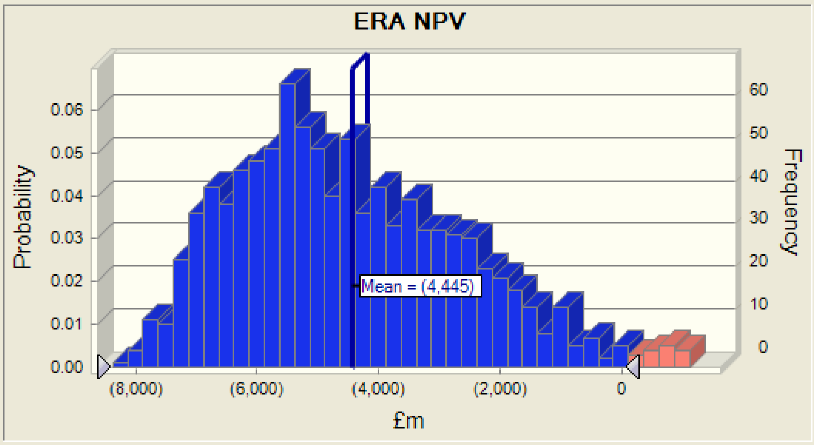


Statistic	Forecast values
Trials	1,000
Mean	(7,678)
Median	(8,040)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2702
Minimum	(11,614)
Maximum	3,770
Mean Std. Error	66

(11,614) Certainty: 99.35 % 0

B.xxxii ERA - Market Tip Fast and 3G

1,000 Trials | Split View | 986 Displayed

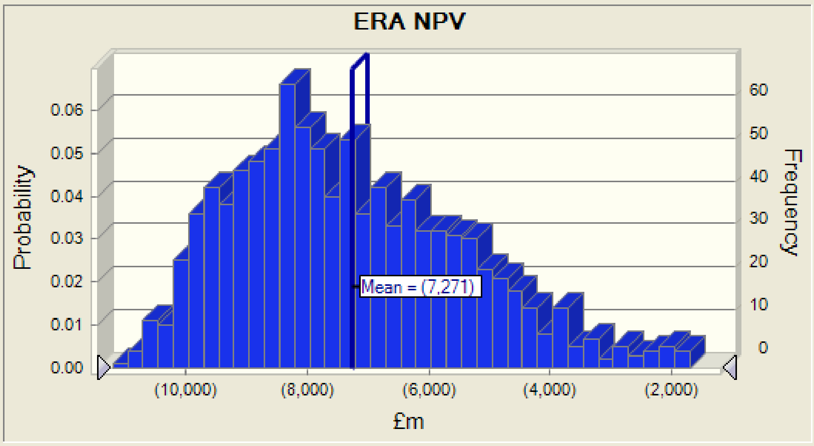


Statistic	Forecast values
Trials	1,000
Mean	(4,445)
Median	(4,807)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4668
Minimum	(8,381)
Maximum	7,003
Mean Std. Error	66

(8,381) Certainty: 96.82 % 0

B.xxxiii ERA - Market Tip Fast and Hybrid 1

1,000 Trials | Split View | 986 Displayed

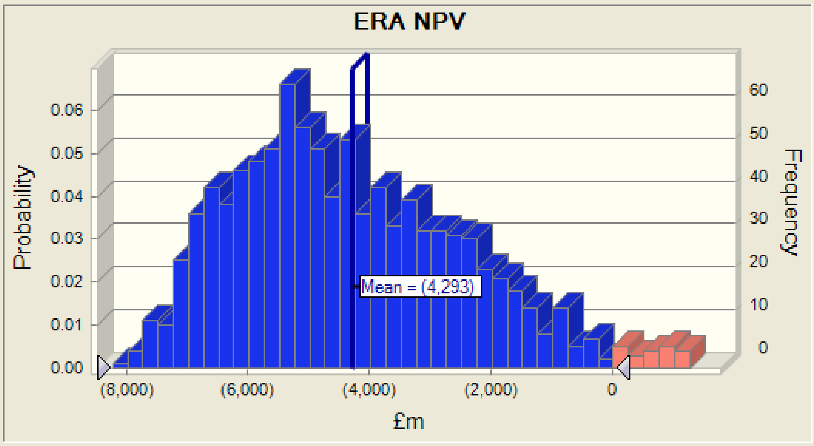


Statistic	Forecast values
Trials	1,000
Mean	(7,271)
Median	(7,633)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.2853
Minimum	(11,207)
Maximum	4,177
Mean Std. Error	66

(11,207) Certainty: 99.29 % 0

B.xxxiv ERA - Market Tip Fast and Hybrid 2

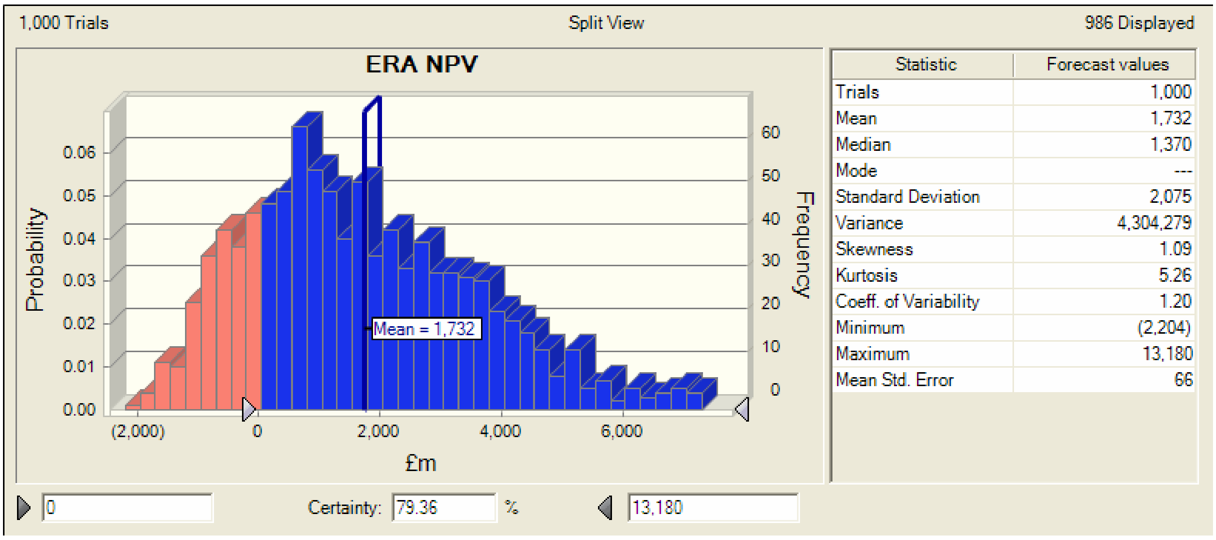
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(4,293)
Median	(4,655)
Mode	---
Standard Deviation	2,075
Variance	4,304,279
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	-0.4833
Minimum	(8,228)
Maximum	7,155
Mean Std. Error	66

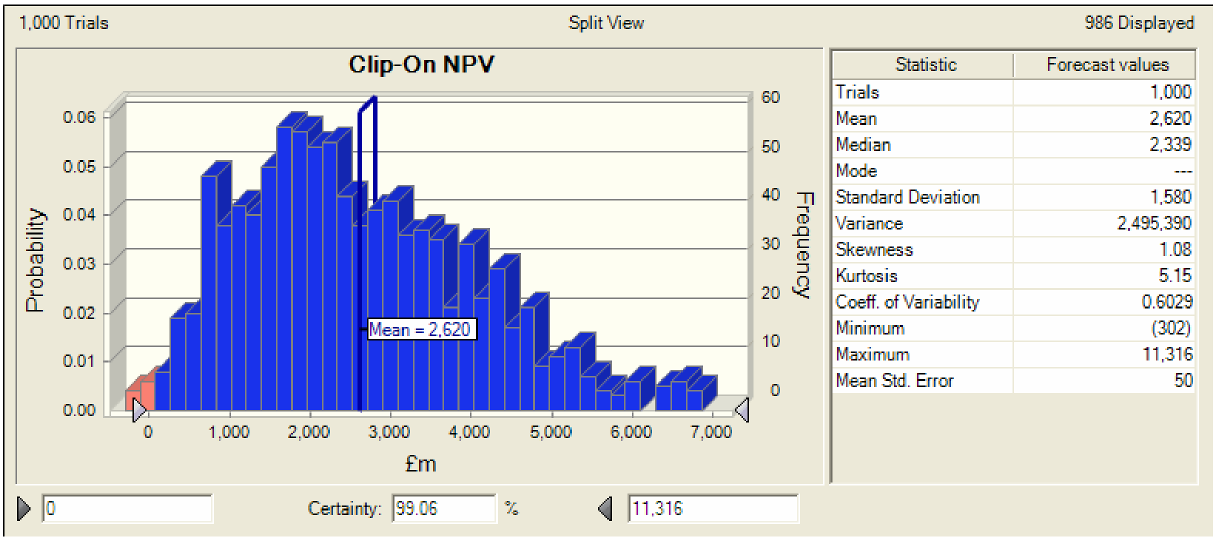
(8,228) Certainty: 96.48 % 0

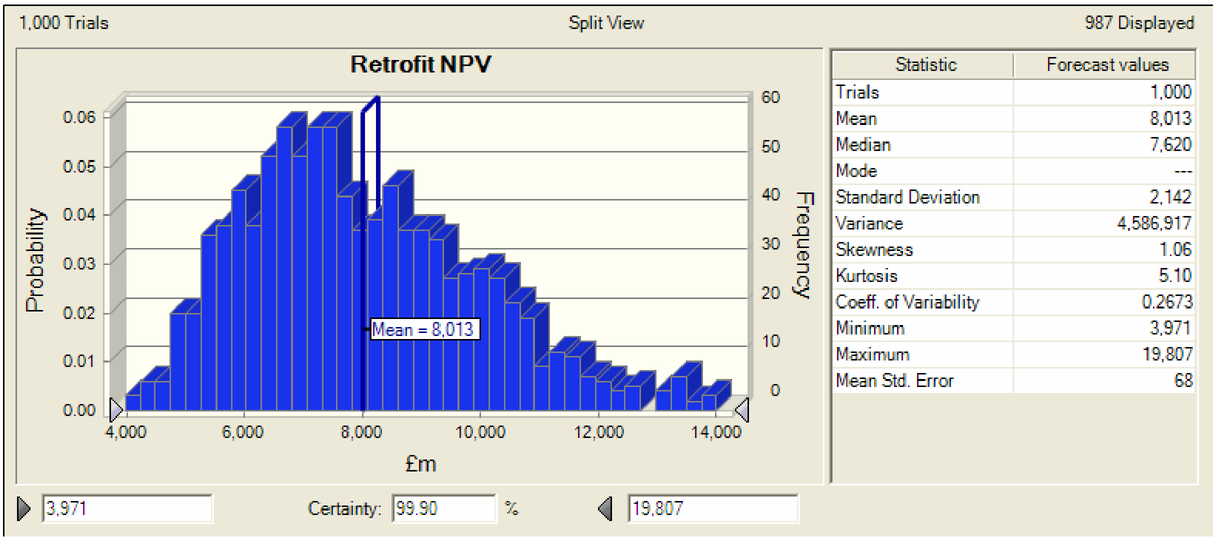
B.xxxv ERA - Market Tip Fast without comms

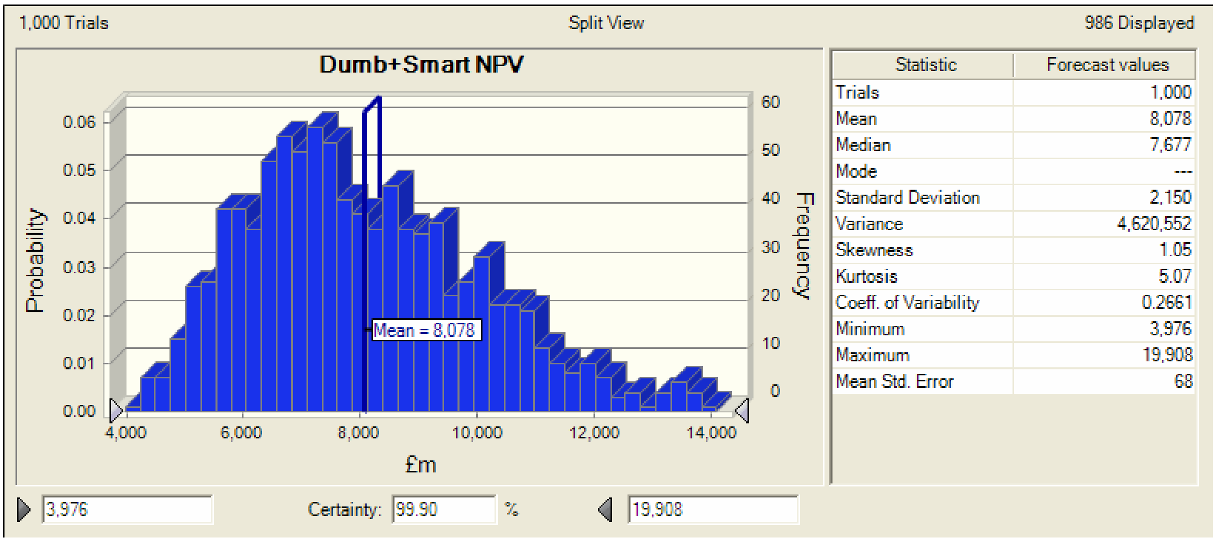


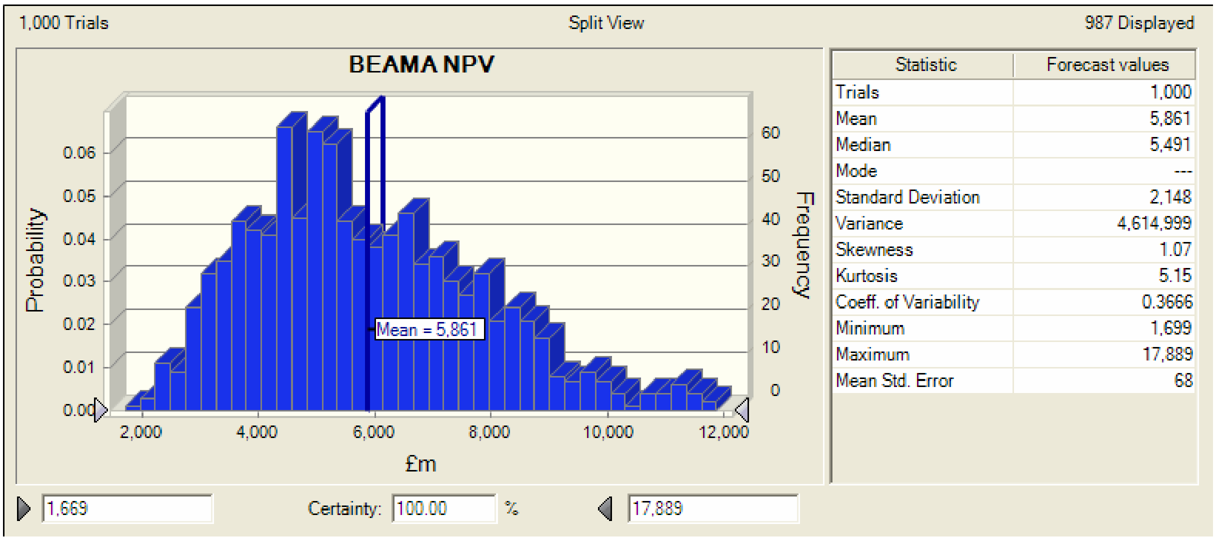
B.1.6 Indicative Results for Hybrid 2 without Optimism Bias

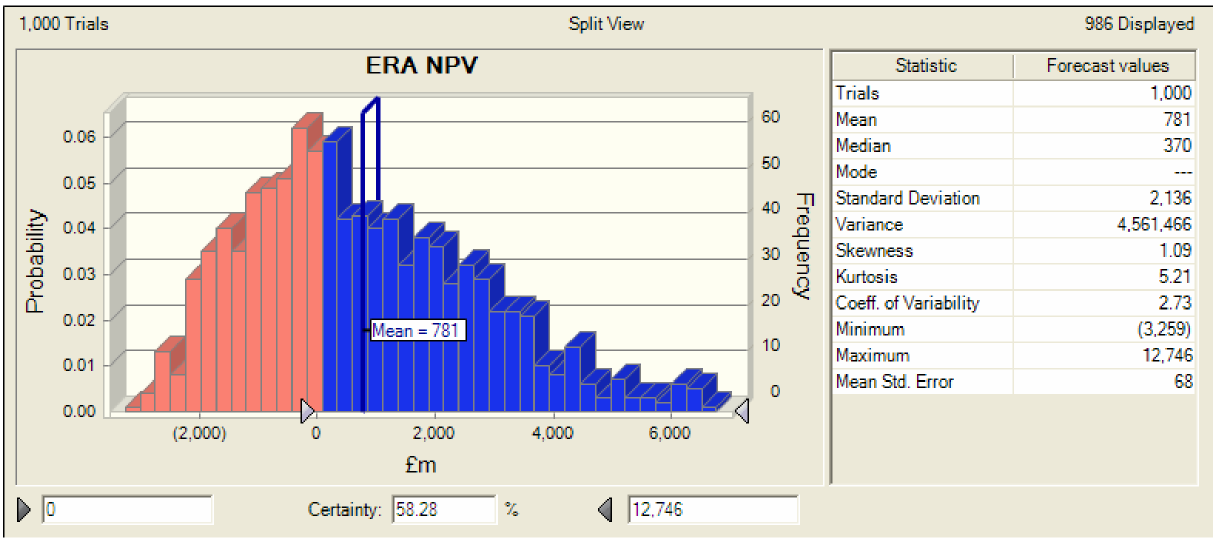
B.i New, Replacement and Voluntary




1,000 Trials
Split View
987 Displayed
Retrofit NPV
Probability
Frequency
£m
Mean = 8,013
Statistic | Forecast values
Trials 1,000
Mean 8,013
Median 7,620
Mode ---
Standard Deviation 2,142
Variance 4,586,917
Skewness 1.06
Kurtosis 5.10
Coeff. of Variability 0.2673
Minimum 3,971
Maximum 19,807
Mean Std. Error 68
3,971
Certainty: 99.90 %
19,807

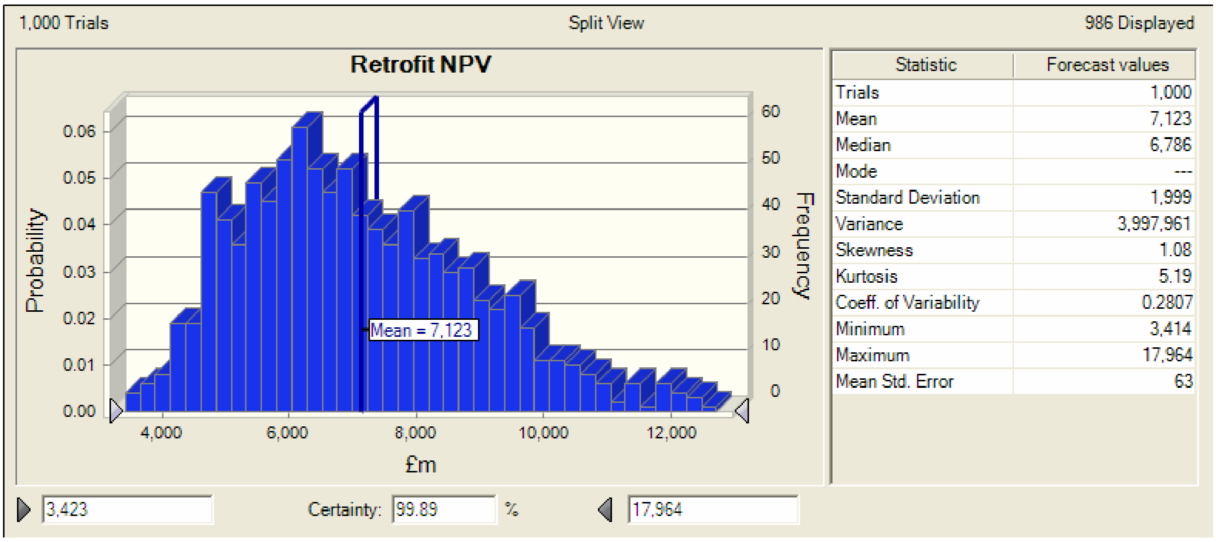

1,000 Trials
Split View
986 Displayed
Dumb+Smart NPV
Probability
Frequency
£m
Mean = 8,078
Statistic | Forecast values
Trials 1,000
Mean 8,078
Median 7,677
Mode ---
Standard Deviation 2,150
Variance 4,620,552
Skewness 1.05
Kurtosis 5.07
Coeff. of Variability 0.2661
Minimum 3,976
Maximum 19,908
Mean Std. Error 68
3,976
Certainty: 99.90 %
19,908


1,000 Trials
Split View
987 Displayed
BEAMA NPV
Probability
Frequency
£m
Mean = 5,861
Statistic | Forecast values
Trials 1,000
Mean 5,861
Median 5,491
Mode ---
Standard Deviation 2,148
Variance 4,614,999
Skewness 1.07
Kurtosis 5.15
Coeff. of Variability 0.3666
Minimum 1,699
Maximum 17,889
Mean Std. Error 68
1,669
Certainty: 100.00 %
17,889

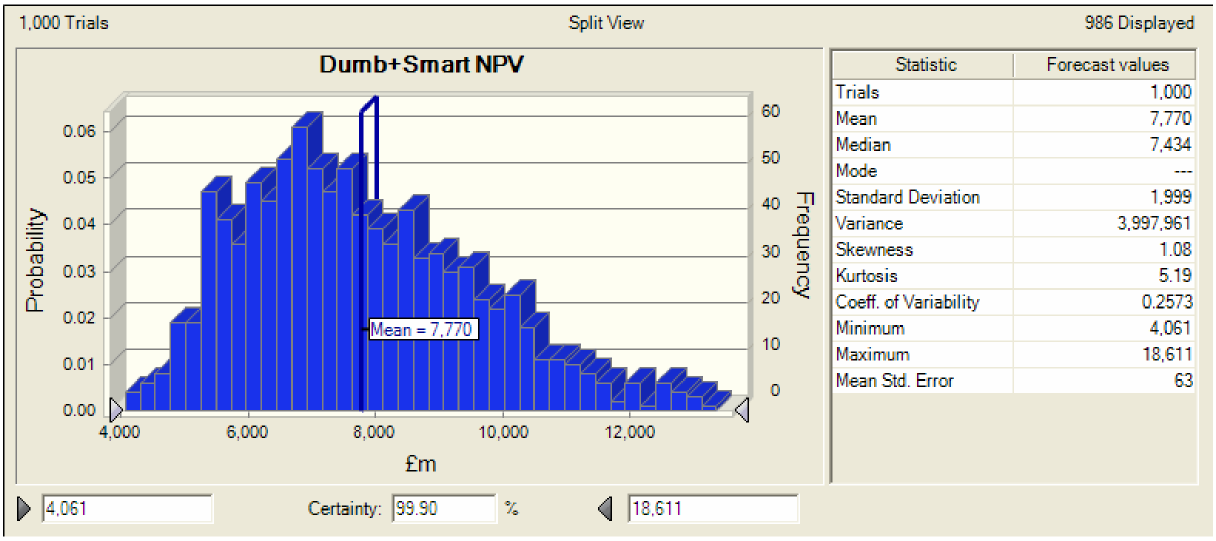


Statistic	Forecast values
Trials	1,000
Mean	781
Median	370
Mode	---
Standard Deviation	2,136
Variance	4,561,466
Skewness	1.09
Kurtosis	5.21
Coeff. of Variability	2.73
Minimum	(3,259)
Maximum	12,746
Mean Std. Error	68

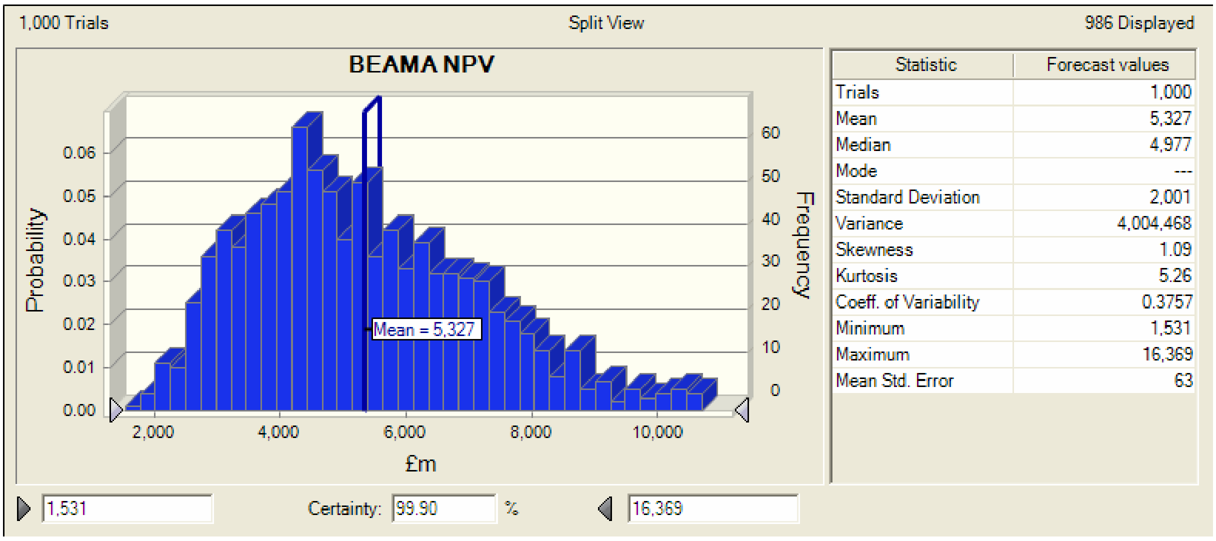
B.ii Regional Franchise

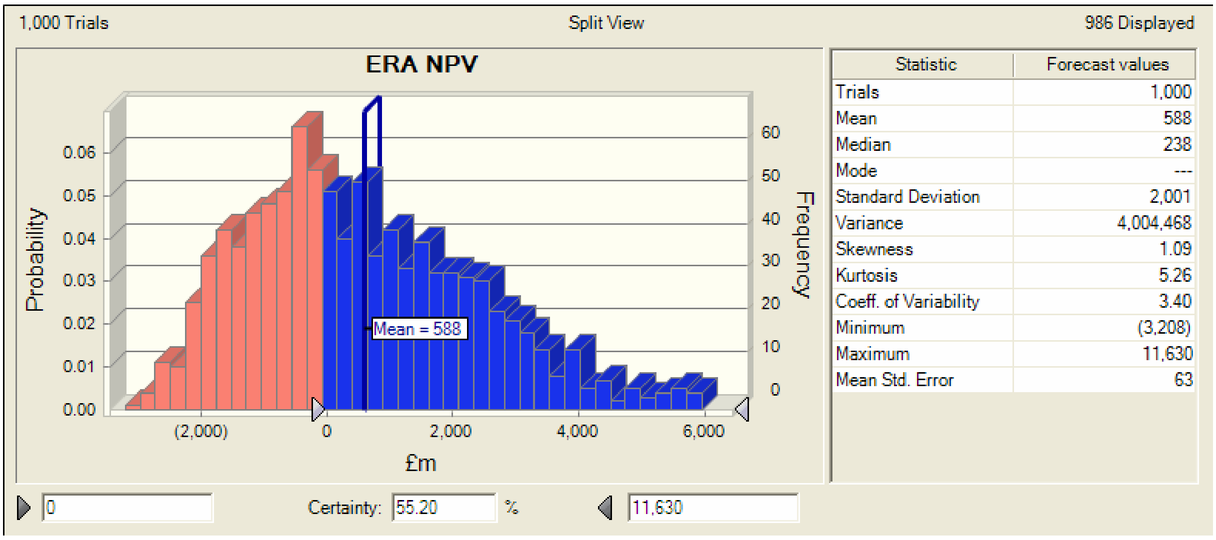


Statistic	Forecast values
Trials	1,000
Mean	7,123
Median	6,786
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2807
Minimum	3,414
Maximum	17,964
Mean Std. Error	63

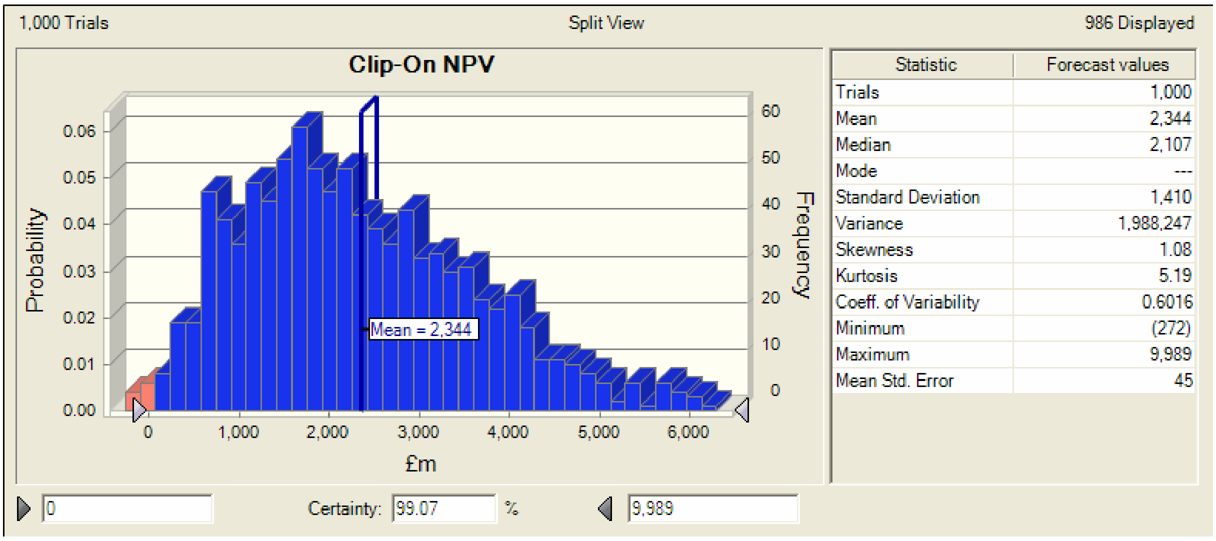


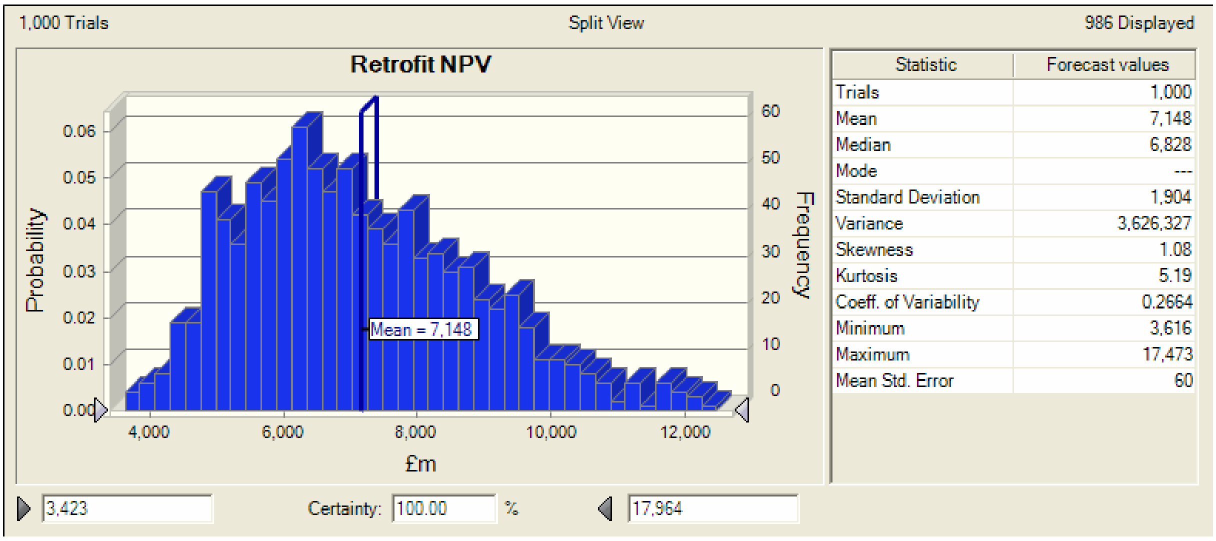
Statistic	Forecast values
Trials	1,000
Mean	7,770
Median	7,434
Mode	---
Standard Deviation	1,999
Variance	3,997,961
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2573
Minimum	4,061
Maximum	18,611
Mean Std. Error	63

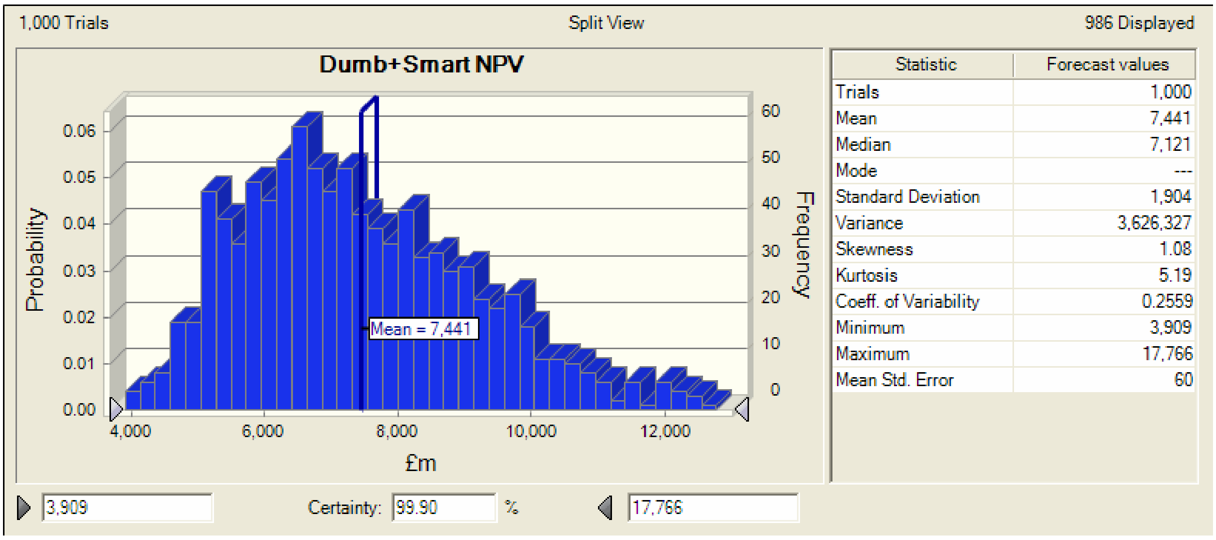

1,000 Trials
Split View
986 Displayed
BEAMA NPV
Probability
Frequency
£m
Mean = 5,327
Statistic | Forecast values
Trials 1,000
Mean 5,327
Median 4,977
Mode ---
Standard Deviation 2,001
Variance 4,004,468
Skewness 1.09
Kurtosis 5.26
Coeff. of Variability 0.3757
Minimum 1,531
Maximum 16,369
Mean Std. Error 63
1,531
Certainty: 99.90 %
16,369

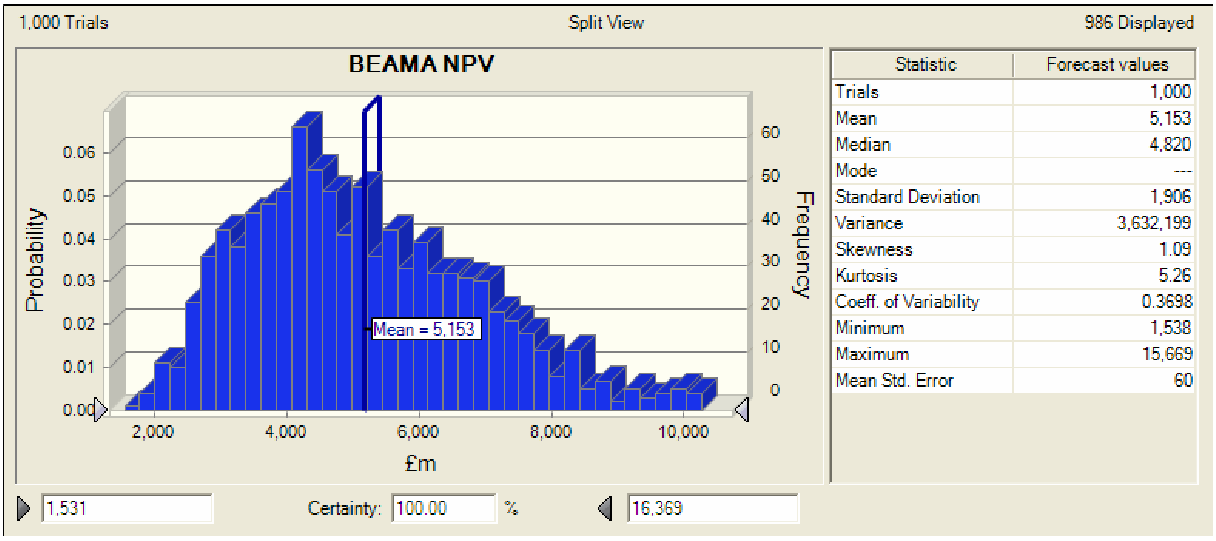

1,000 Trials
Split View
986 Displayed
ERA NPV
Probability
Frequency
£m
Mean = 588
Statistic | Forecast values
Trials 1,000
Mean 588
Median 238
Mode ---
Standard Deviation 2,001
Variance 4,004,468
Skewness 1.09
Kurtosis 5.26
Coeff. of Variability 3.40
Minimum (3,208)
Maximum 11,630
Mean Std. Error 63
0
Certainty: 55.20 %
11,630

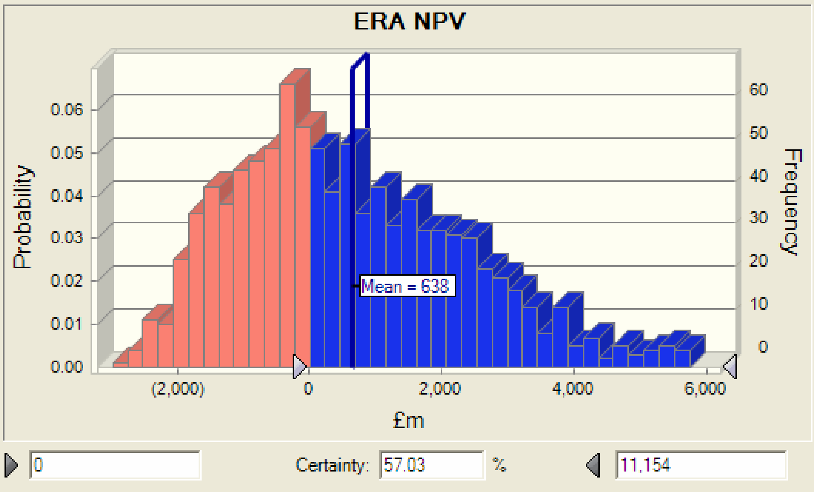
B.iii Market


1,000 Trials
Split View
986 Displayed
Clip-On NPV
Probability
Frequency
£m
Mean = 2,344
Statistic | Forecast values
Trials 1,000
Mean 2,344
Median 2,107
Mode ---
Standard Deviation 1,410
Variance 1,988,247
Skewness 1.08
Kurtosis 5.19
Coeff. of Variability 0.6016
Minimum (272)
Maximum 9,989
Mean Std. Error 45
0
Certainty: 99.07 %
9,989


1,000 Trials
Split View
986 Displayed
Retrofit NPV
Probability
Frequency
Mean = 7,148
£m
Statistic | Forecast values
Trials 1,000
Mean 7,148
Median 6,828
Mode ---
Standard Deviation 1,904
Variance 3,626,327
Skewness 1.08
Kurtosis 5.19
Coeff. of Variability 0.2664
Minimum 3,616
Maximum 17,473
Mean Std. Error 60
3,423
Certainty: 100.00 %
17,964

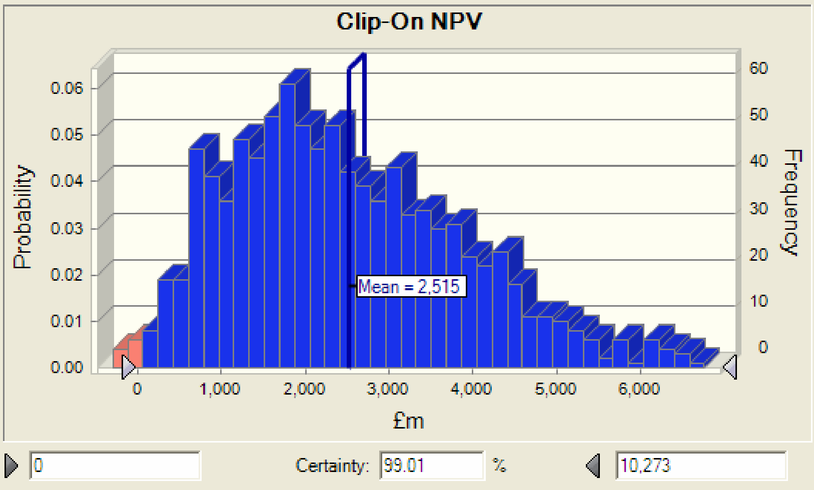

1,000 Trials
Split View
986 Displayed
Dumb+Smart NPV
Probability
Frequency
Mean = 7,441
£m
Statistic | Forecast values
Trials 1,000
Mean 7,441
Median 7,121
Mode ---
Standard Deviation 1,904
Variance 3,626,327
Skewness 1.08
Kurtosis 5.19
Coeff. of Variability 0.2559
Minimum 3,909
Maximum 17,766
Mean Std. Error 60
3,909
Certainty: 99.90 %
17,766


1,000 Trials
Split View
986 Displayed
BEAMA NPV
Probability
Frequency
Mean = 5,153
£m
Statistic | Forecast values
Trials 1,000
Mean 5,153
Median 4,820
Mode ---
Standard Deviation 1,906
Variance 3,632,199
Skewness 1.09
Kurtosis 5.26
Coeff. of Variability 0.3698
Minimum 1,538
Maximum 15,669
Mean Std. Error 60
1,531
Certainty: 100.00 %
16,369

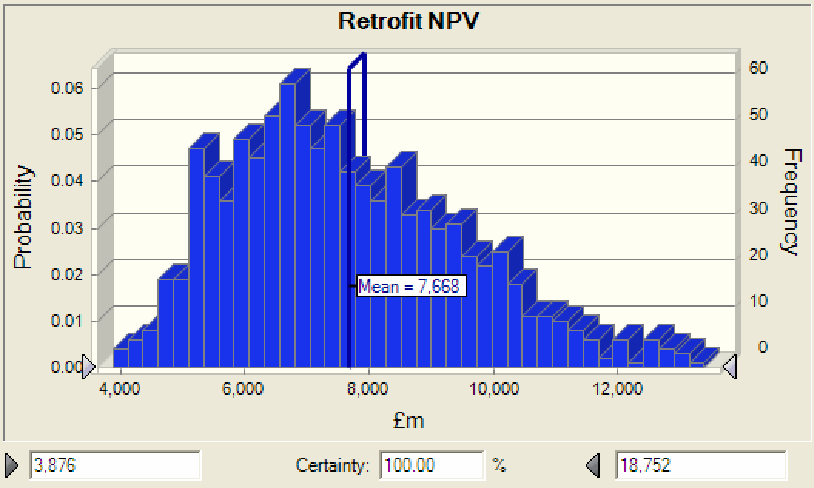


Statistic	Forecast values
Trials	1,000
Mean	638
Median	304
Mode	---
Standard Deviation	1,906
Variance	3,632,199
Skewness	1.09
Kurtosis	5.26
Coeff. of Variability	2.99
Minimum	(2,978)
Maximum	11,154
Mean Std. Error	60

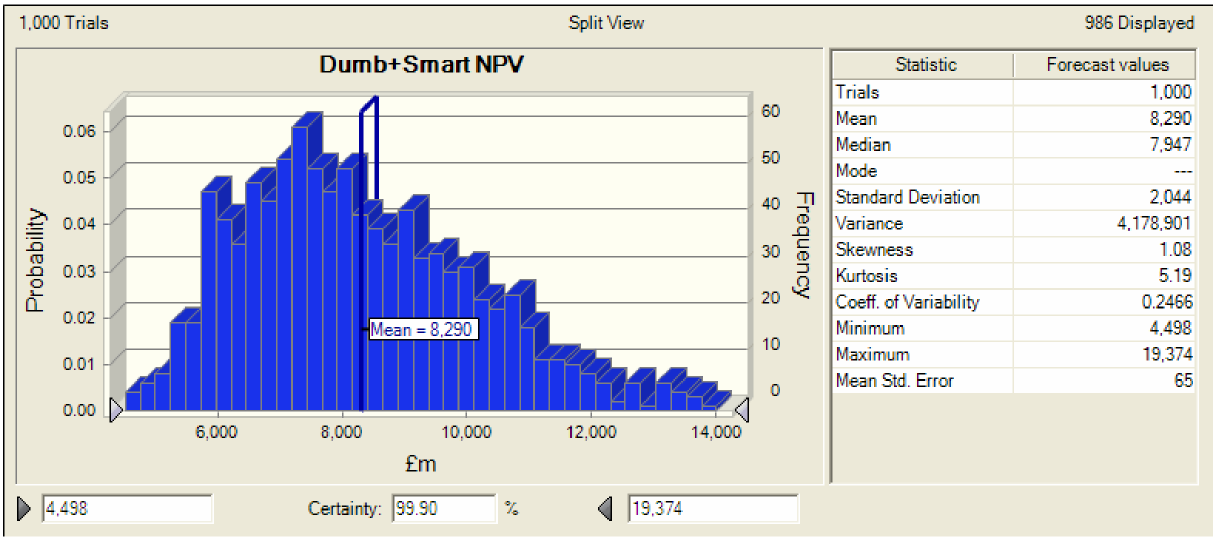
B.iv Market Tip Point

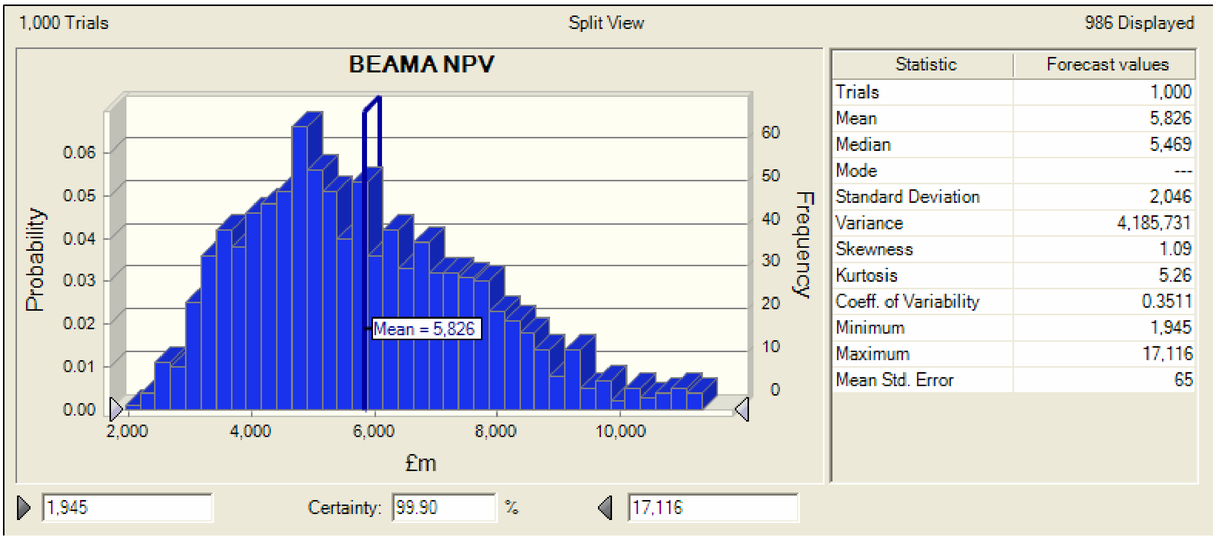


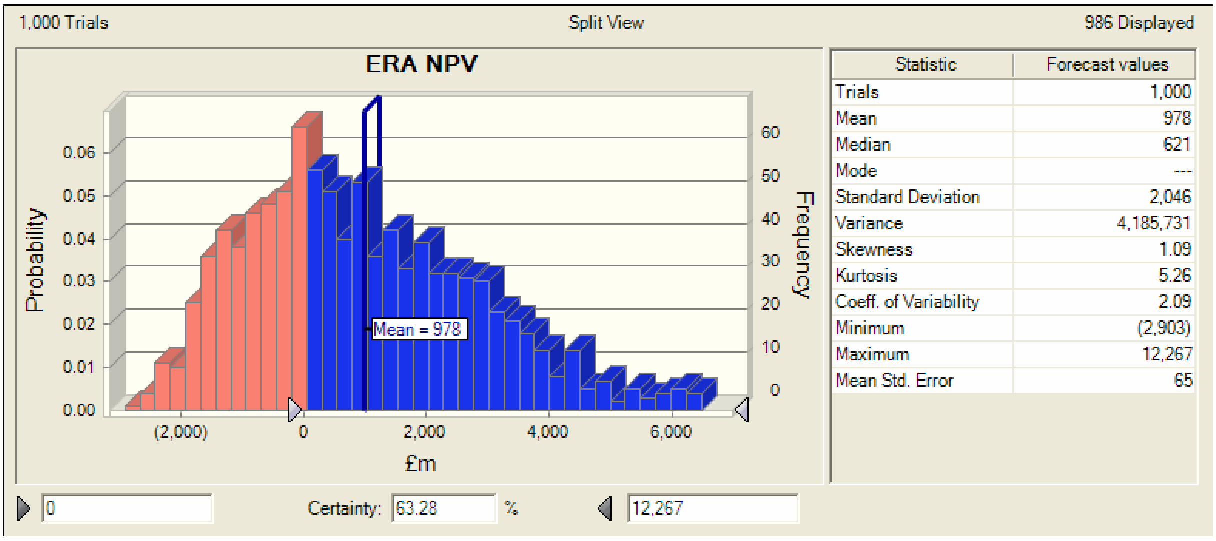
Statistic	Forecast values
Trials	1,000
Mean	2,515
Median	2,260
Mode	---
Standard Deviation	1,514
Variance	2,292,210
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.6021
Minimum	(294)
Maximum	10,723
Mean Std. Error	48



Statistic	Forecast values
Trials	1,000
Mean	7,668
Median	7,324
Mode	---
Standard Deviation	2,044
Variance	4,178,901
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2666
Minimum	3,876
Maximum	18,752
Mean Std. Error	65

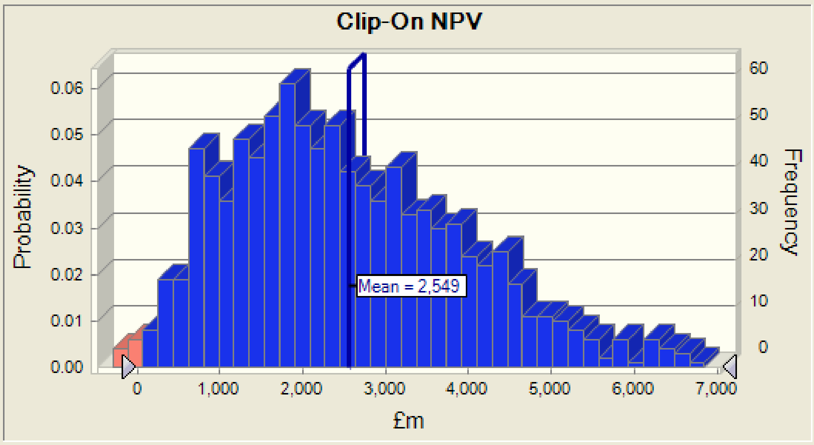

1,000 Trials
Split View
986 Displayed
Dumb+Smart NPV
Probability
Frequency
Mean = 8,290
£m
Statistic | Forecast values
Trials 1,000
Mean 8,290
Median 7,947
Mode ---
Standard Deviation 2,044
Variance 4,178,901
Skewness 1.08
Kurtosis 5.19
Coeff. of Variability 0.2466
Minimum 4,498
Maximum 19,374
Mean Std. Error 65
4,498
Certainty: 99.90 %
19,374


1,000 Trials
Split View
986 Displayed
BEAMA NPV
Probability
Frequency
Mean = 5,826
£m
Statistic | Forecast values
Trials 1,000
Mean 5,826
Median 5,469
Mode ---
Standard Deviation 2,046
Variance 4,185,731
Skewness 1.09
Kurtosis 5.26
Coeff. of Variability 0.3511
Minimum 1,945
Maximum 17,116
Mean Std. Error 65
1,945
Certainty: 99.90 %
17,116


1,000 Trials
Split View
986 Displayed
ERA NPV
Probability
Frequency
Mean = 978
£m
Statistic | Forecast values
Trials 1,000
Mean 978
Median 621
Mode ---
Standard Deviation 2,046
Variance 4,185,731
Skewness 1.09
Kurtosis 5.26
Coeff. of Variability 2.09
Minimum (2,903)
Maximum 12,267
Mean Std. Error 65
0
Certainty: 63.28 %
12,267

B.v Market Tip Fast

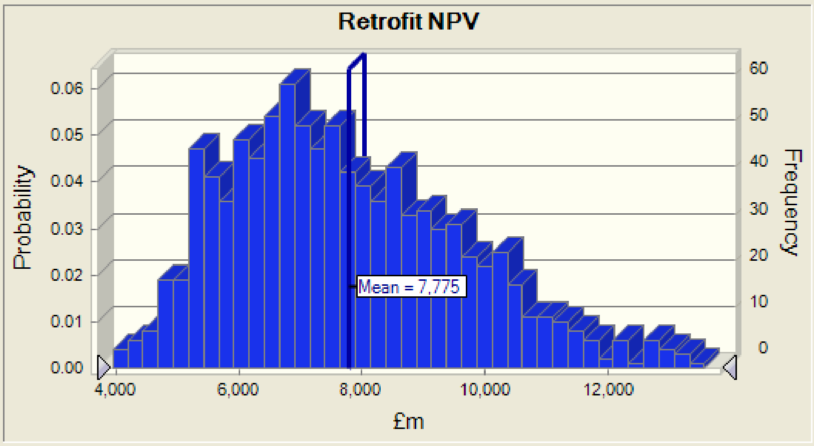
1,000 Trials Split View 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	2,549
Median	2,291
Mode	---
Standard Deviation	1,535
Variance	2,357,356
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.6022
Minimum	(299)
Maximum	10,874
Mean Std. Error	49

0 Certainty: 99.06 % 10,874

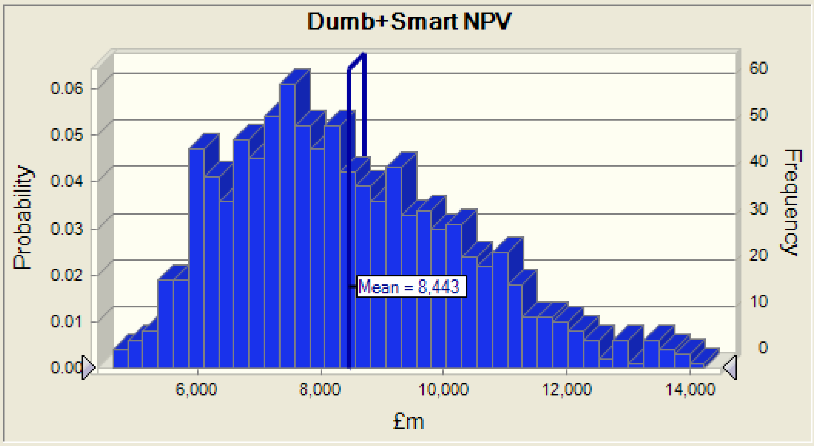
1,000 Trials Split View 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	7,775
Median	7,426
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2666
Minimum	3,929
Maximum	19,014
Mean Std. Error	66

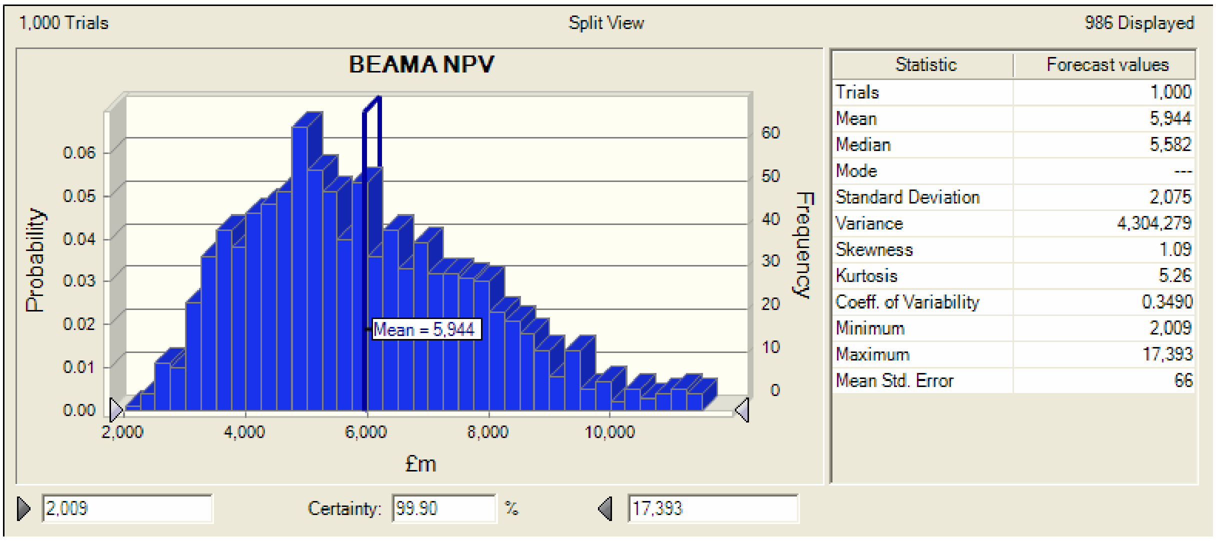
3,929 Certainty: 99.90 % 19,014

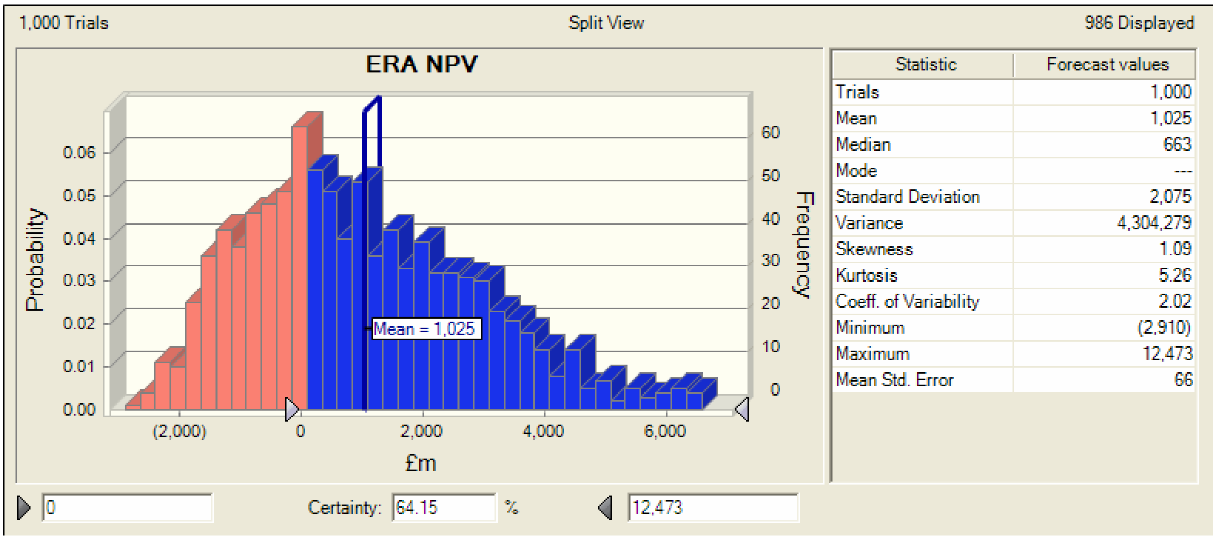
1,000 Trials Split View 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	8,443
Median	8,095
Mode	---
Standard Deviation	2,073
Variance	4,297,241
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.2455
Minimum	4,598
Maximum	19,683
Mean Std. Error	66

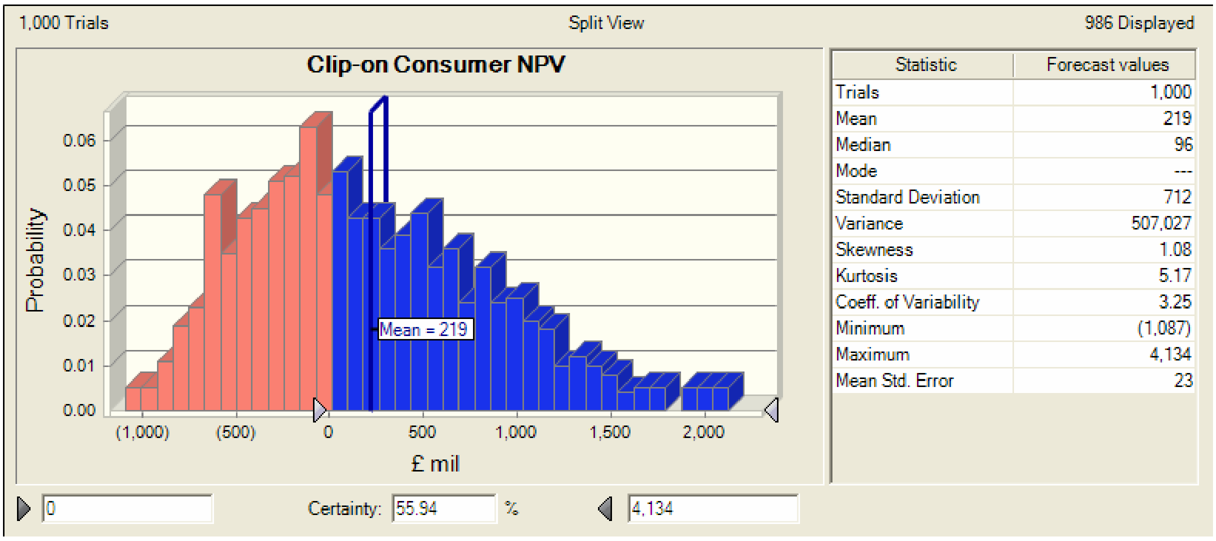
4,598 Certainty: 100.00 % 19,683



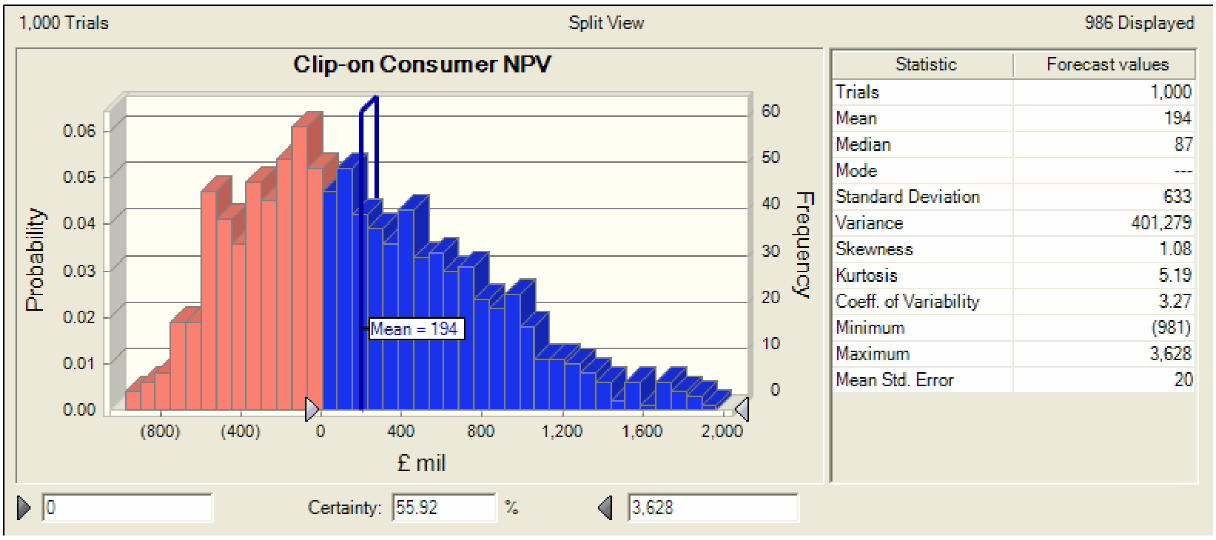


B.2 Consumers

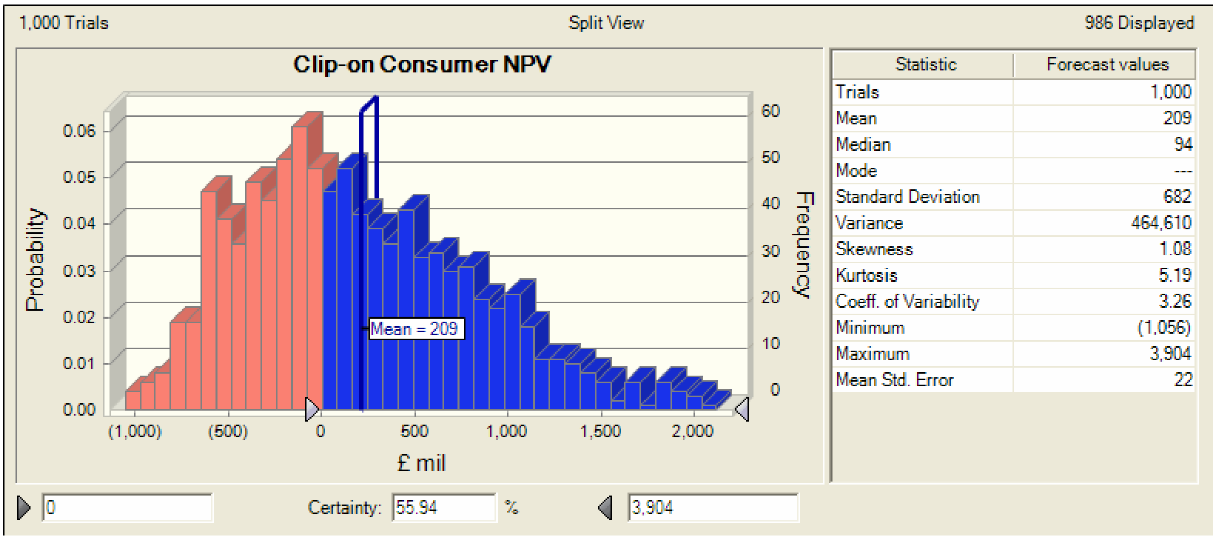
B.i Clip-Ons – New, Replacement and Voluntary



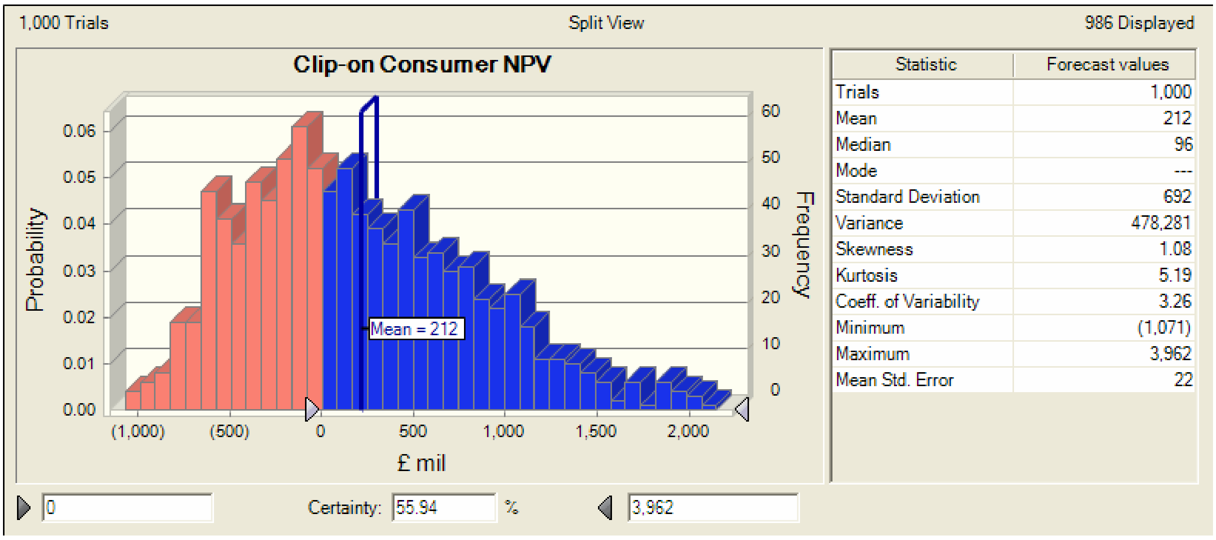
B.ii Clip-Ons – Market



B.iii Clip-Ons – Market Tip



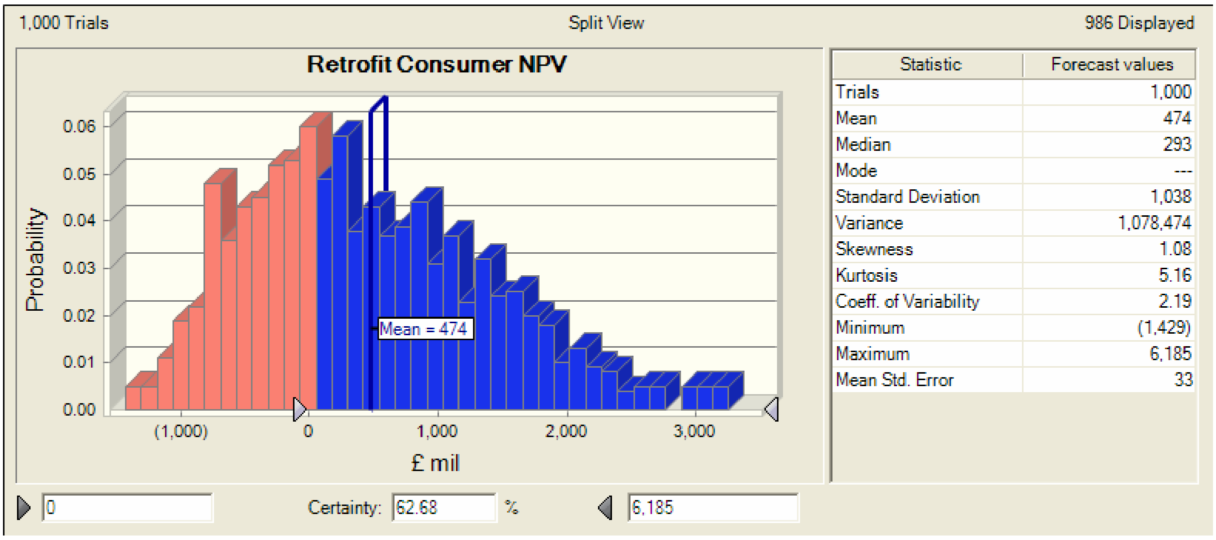
B.iv Clip-Ons – Market Tip Fast



Statistic	Forecast values
Trials	1,000
Mean	212
Median	96
Mode	---
Standard Deviation	692
Variance	478,281
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	3.26
Minimum	(1,071)
Maximum	3,962
Mean Std. Error	22

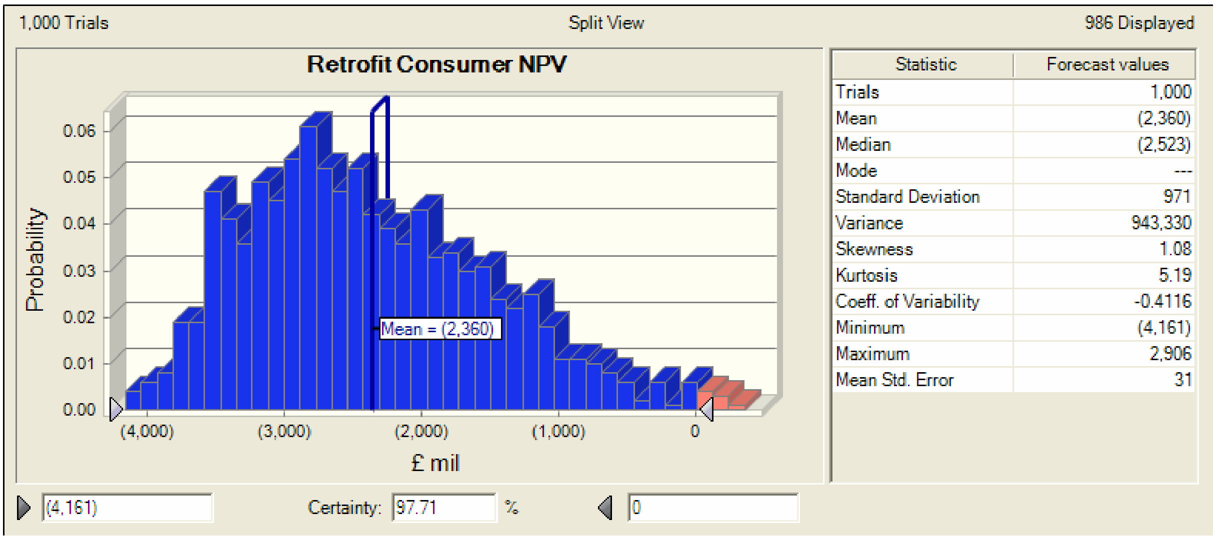
B.2.2 Meter Retrofit

B.i Meter Retrofit – New, Replacement and Voluntary



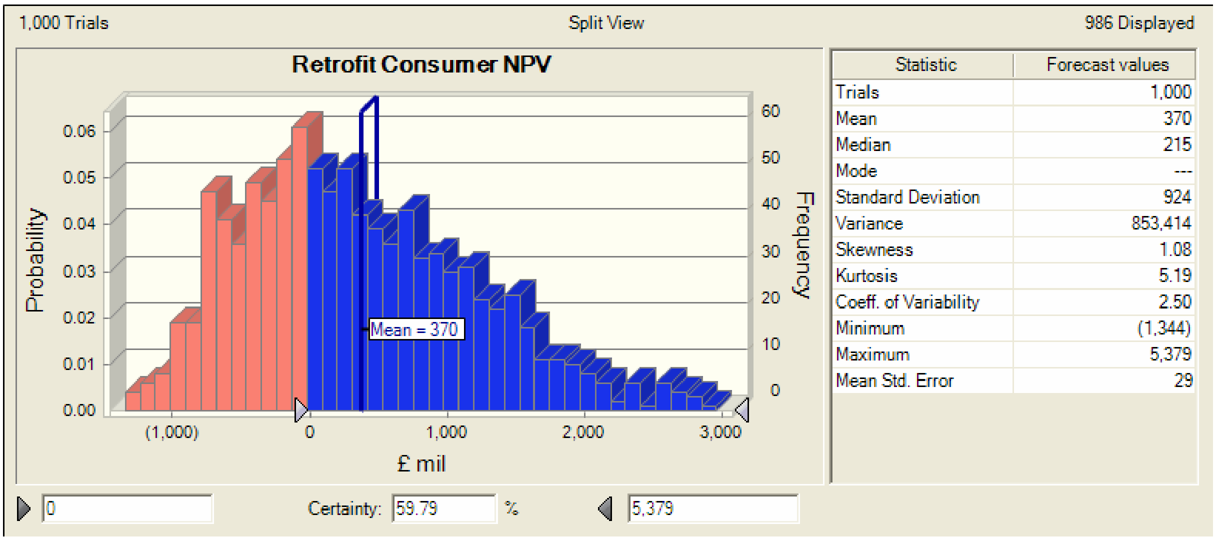
Statistic	Forecast values
Trials	1,000
Mean	474
Median	293
Mode	---
Standard Deviation	1,038
Variance	1,078,474
Skewness	1.08
Kurtosis	5.16
Coeff. of Variability	2.19
Minimum	(1,429)
Maximum	6,185
Mean Std. Error	33

B.ii Meter Retrofit – Regional Franchise



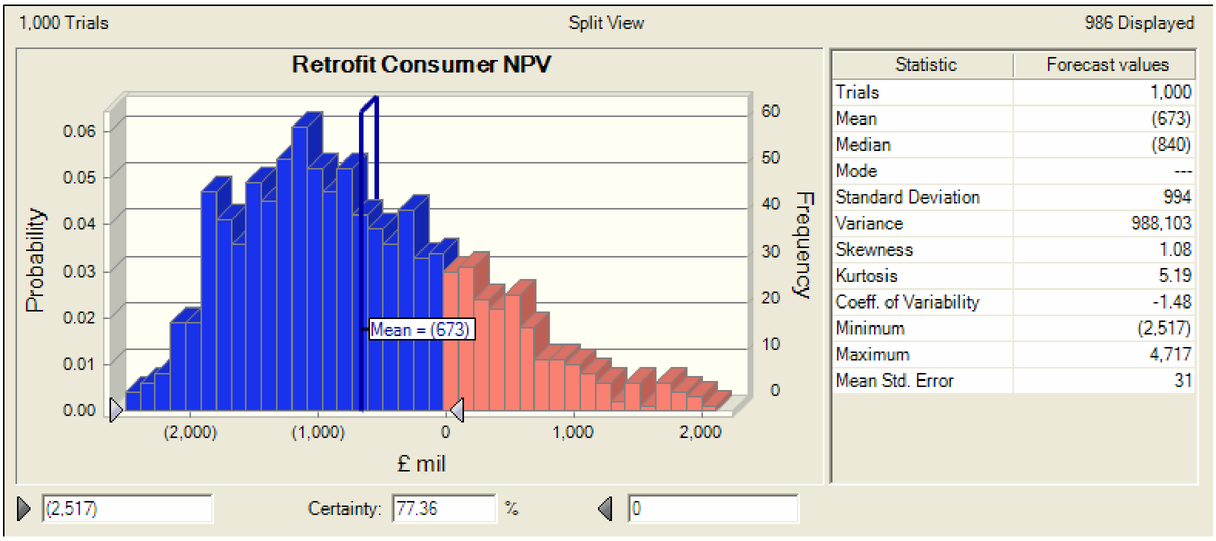
Statistic	Forecast values
Trials	1,000
Mean	(2,360)
Median	(2,523)
Mode	---
Standard Deviation	971
Variance	943,330
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.4116
Minimum	(4,161)
Maximum	2,906
Mean Std. Error	31

B.iii Meter Retrofit – Market



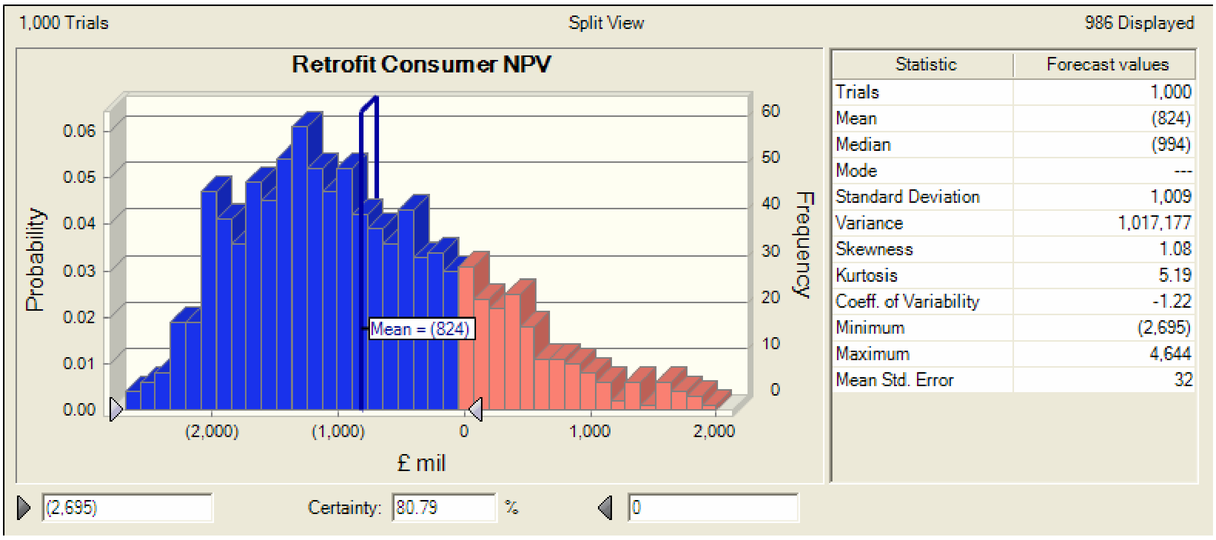
Statistic	Forecast values
Trials	1,000
Mean	370
Median	215
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	2.50
Minimum	(1,344)
Maximum	5,379
Mean Std. Error	29

B.iv Meter Retrofit – Market Tip



Statistic	Forecast values
Trials	1,000
Mean	(673)
Median	(840)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.48
Minimum	(2,517)
Maximum	4,717
Mean Std. Error	31

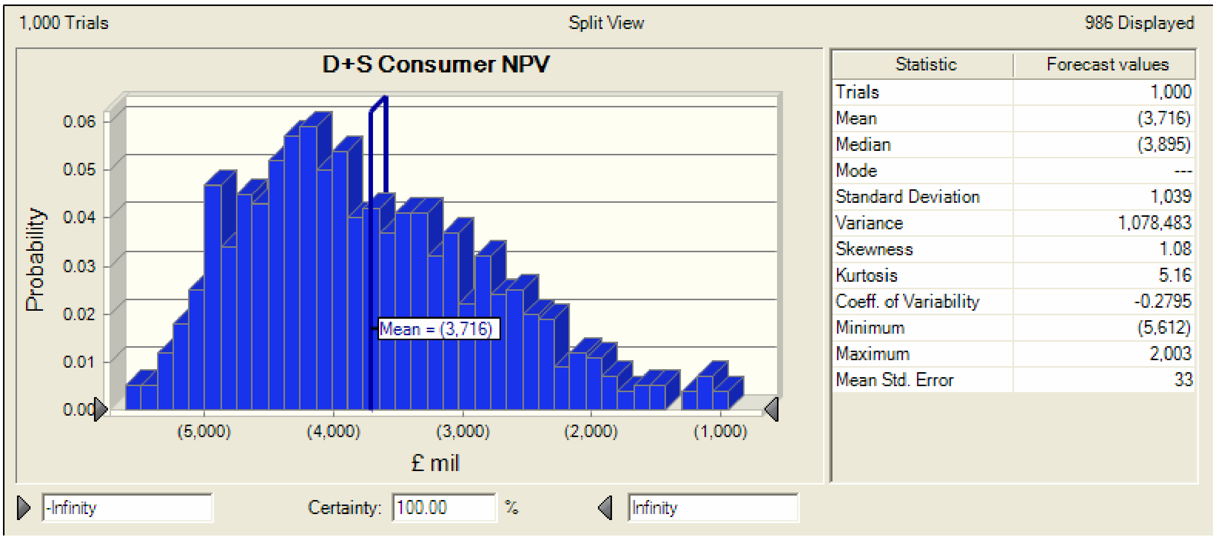
B.v Meter Retrofit – Market Tip Fast



Statistic	Forecast values
Trials	1,000
Mean	(824)
Median	(994)
Mode	---
Standard Deviation	1,009
Variance	1,017,177
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.22
Minimum	(2,695)
Maximum	4,644
Mean Std. Error	32

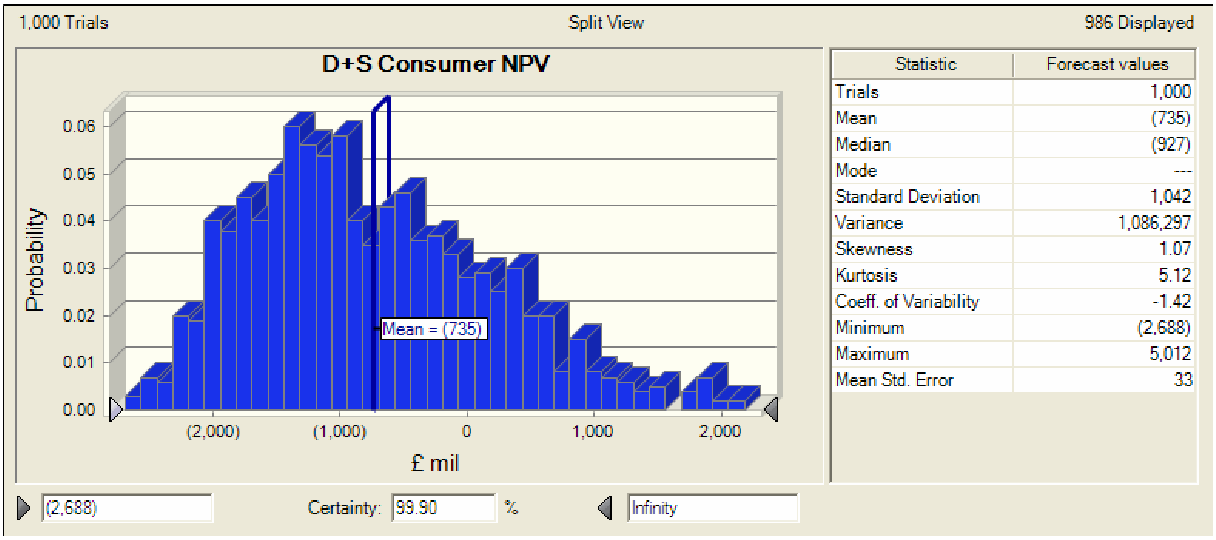
B.2.3 Dumb Meter and Smart Box

B.i D+S - New, Replacement and Voluntary and PLC



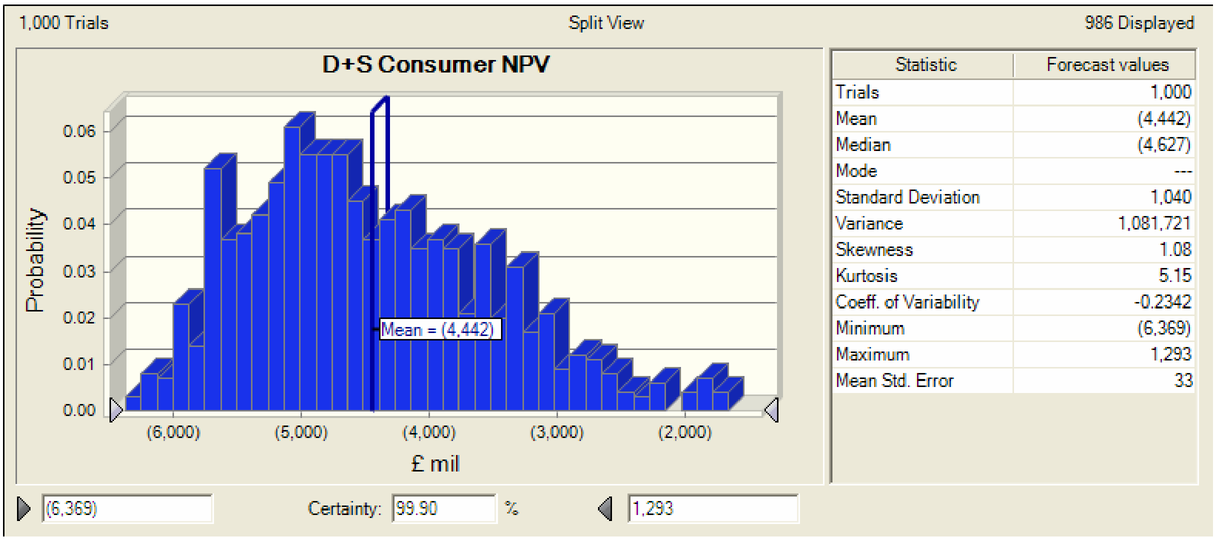
Statistic	Forecast values
Trials	1,000
Mean	(3,716)
Median	(3,895)
Mode	---
Standard Deviation	1,039
Variance	1,078,483
Skewness	1.08
Kurtosis	5.16
Coeff. of Variability	-0.2795
Minimum	(5,612)
Maximum	2,003
Mean Std. Error	33

B.ii D+S - New, Replacement and Voluntary and Broadband



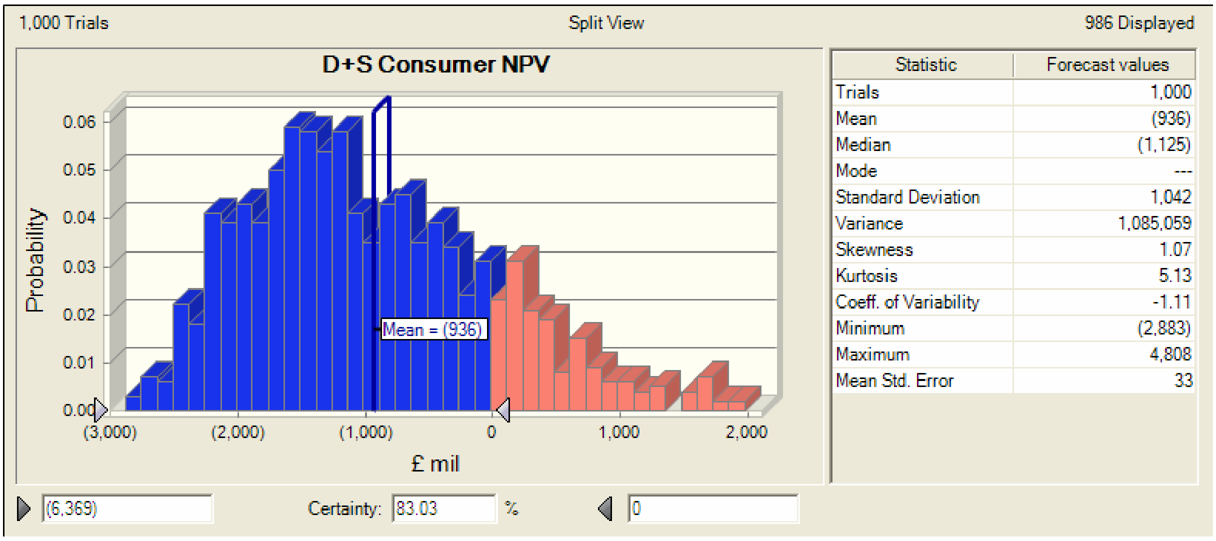
Statistic	Forecast values
Trials	1,000
Mean	(735)
Median	(927)
Mode	---
Standard Deviation	1,042
Variance	1,086,297
Skewness	1.07
Kurtosis	5.12
Coeff. of Variability	-1.42
Minimum	(2,688)
Maximum	5,012
Mean Std. Error	33

B.iii D+S - New, Replacement and Voluntary and WiMax



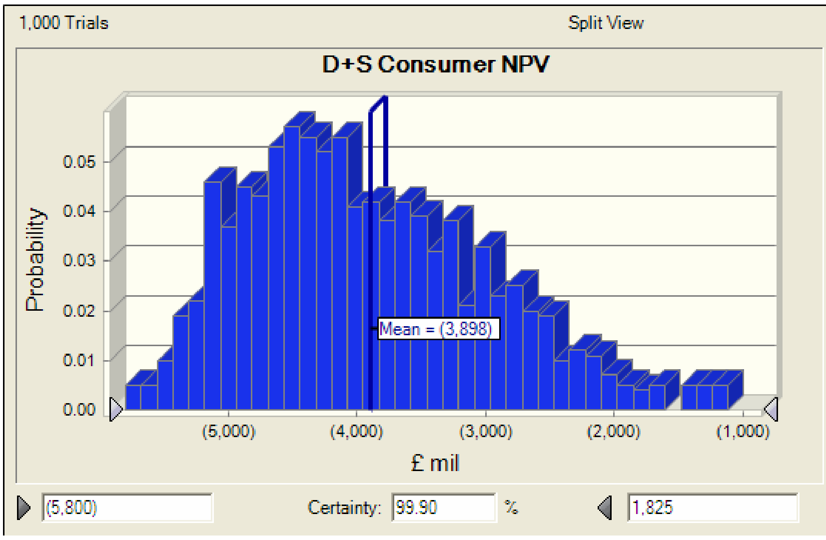
Statistic	Forecast values
Trials	1,000
Mean	(4,442)
Median	(4,627)
Mode	---
Standard Deviation	1,040
Variance	1,081,721
Skewness	1.08
Kurtosis	5.15
Coeff. of Variability	-0.2342
Minimum	(6,369)
Maximum	1,293
Mean Std. Error	33

B.iv D+S - New, Replacement and Voluntary and 3G



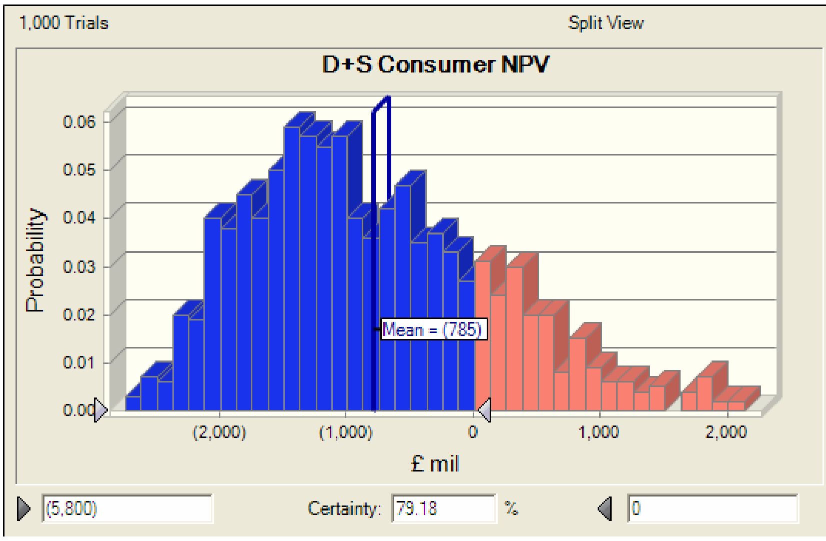
Statistic	Forecast values
Trials	1,000
Mean	(936)
Median	(1,125)
Mode	---
Standard Deviation	1,042
Variance	1,085,059
Skewness	1.07
Kurtosis	5.13
Coeff. of Variability	-1.11
Minimum	(2,883)
Maximum	4,808
Mean Std. Error	33

B.v D+S - New, Replacement and Voluntary and Hybrid 1



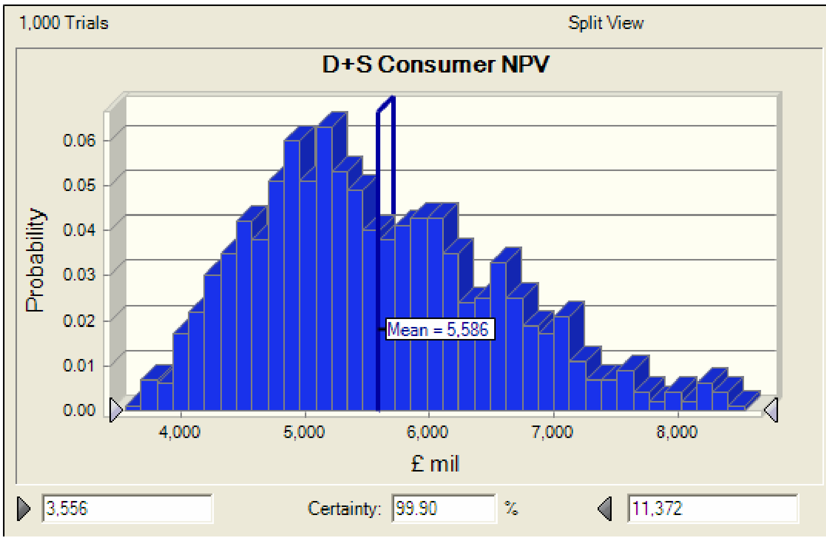
Statistic	Forecast values
Trials	1,000
Mean	(3,898)
Median	(4,077)
Mode	---
Standard Deviation	1,039
Variance	1,079,056
Skewness	1.08
Kurtosis	5.16
Coeff. of Variability	-0.2665
Minimum	(5,800)
Maximum	1,825
Mean Std. Error	33

B.vi D+S - New, Replacement and Voluntary and Hybrid 2



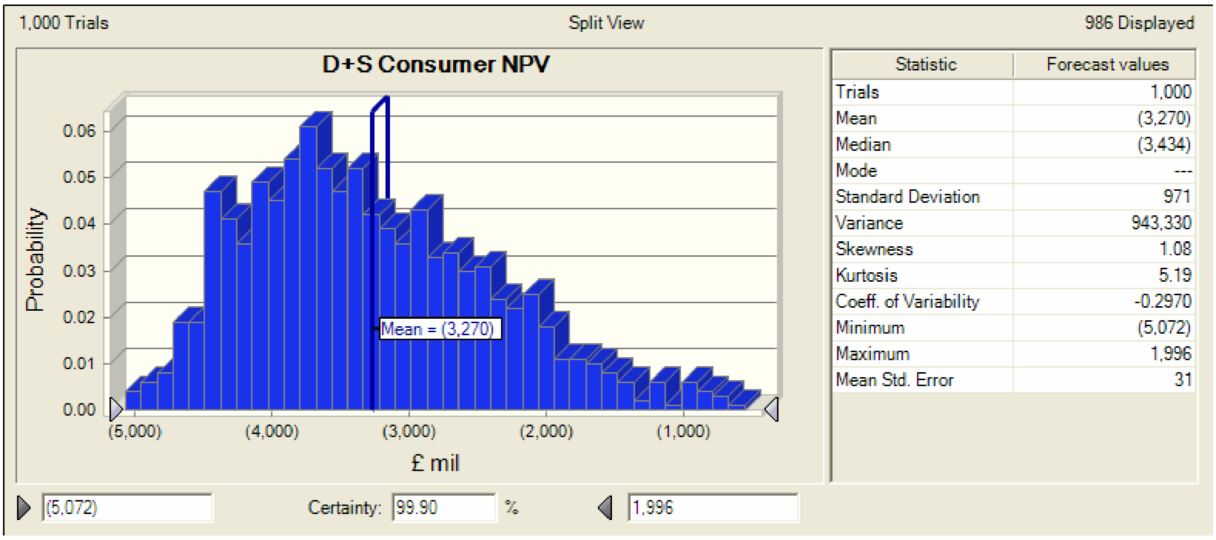
Statistic	Forecast values
Trials	1,000
Mean	(785)
Median	(977)
Mode	---
Standard Deviation	1,042
Variance	1,085,979
Skewness	1.07
Kurtosis	5.12
Coeff. of Variability	-1.33
Minimum	(2,737)
Maximum	4,961
Mean Std. Error	33

B.vii D+S - New, Replacement and Voluntary without comms

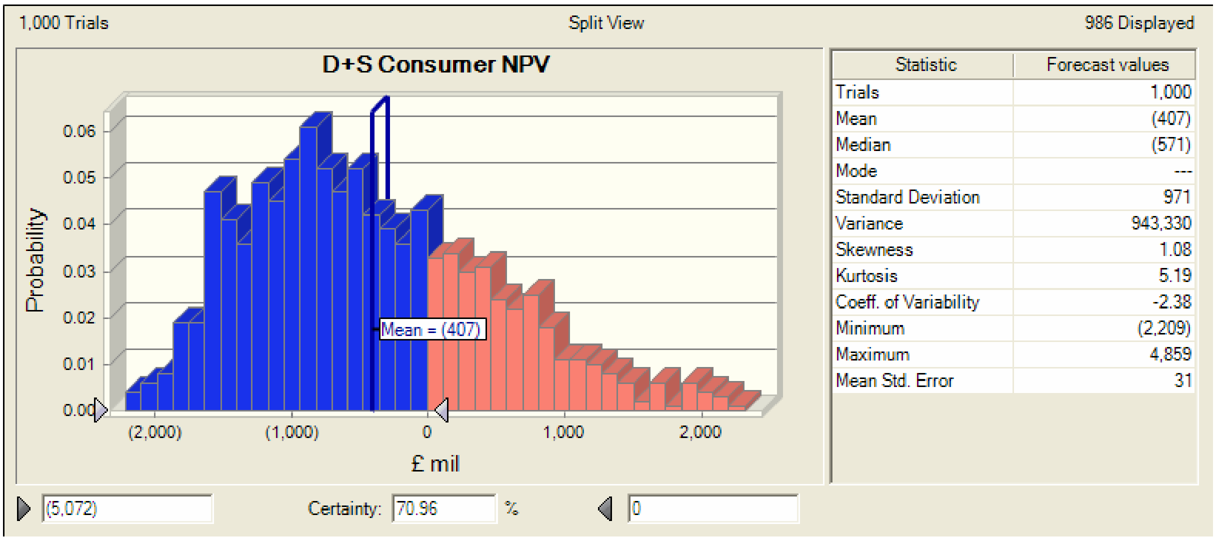


Statistic	Forecast values
Trials	1,000
Mean	5,586
Median	5,393
Mode	---
Standard Deviation	1,053
Variance	1,109,689
Skewness	1.04
Kurtosis	5.02
Coeff. of Variability	0.1886
Minimum	3,556
Maximum	11,372
Mean Std. Error	33

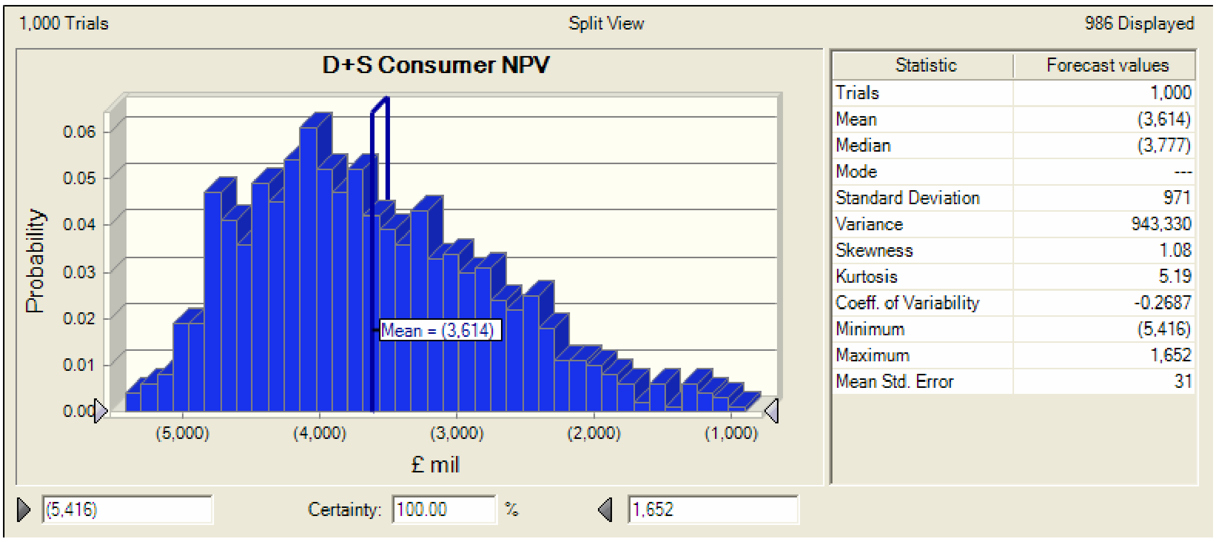
B.viii D+S – Regional Franchise and PLC



B.ix D+S - Regional Franchise and Broadband

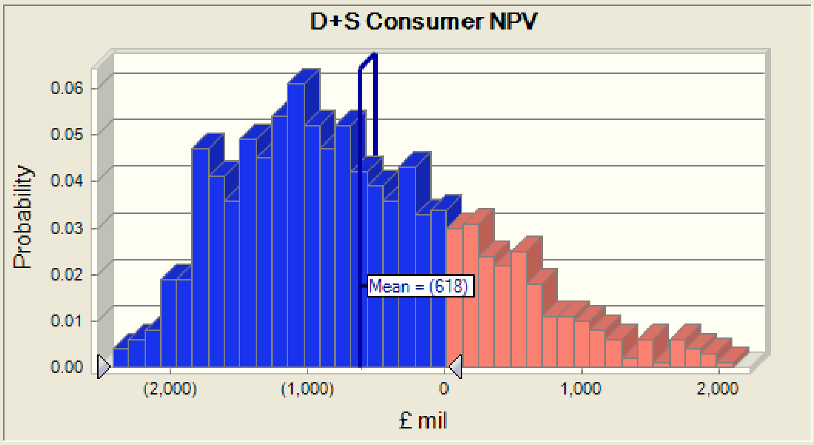


B.x D+S - Regional Franchise and WiMax



B.xi D+S - Regional Franchise and 3G

1,000 Trials | Split View | 986 Displayed

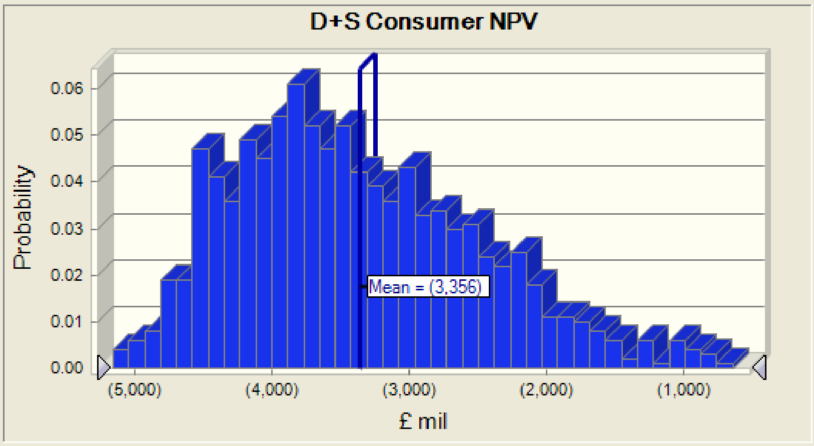


Statistic	Forecast values
Trials	1,000
Mean	(618)
Median	(781)
Mode	---
Standard Deviation	971
Variance	943,330
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.57
Minimum	(2,419)
Maximum	4,648
Mean Std. Error	31

(2,419) Certainty: 76.33 % 0

B.xii D+S - Regional Franchise and Hybrid 1

1,000 Trials | Split View | 986 Displayed

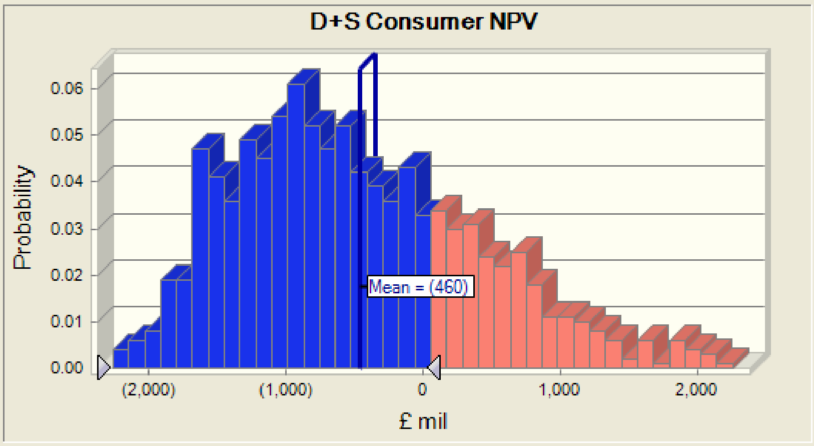


Statistic	Forecast values
Trials	1,000
Mean	(3,356)
Median	(3,519)
Mode	---
Standard Deviation	971
Variance	943,330
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.2894
Minimum	(5,158)
Maximum	1,910
Mean Std. Error	31

(5,158) Certainty: 99.90 % 1,910

B.xiii D+S - Regional Franchise and Hybrid 2

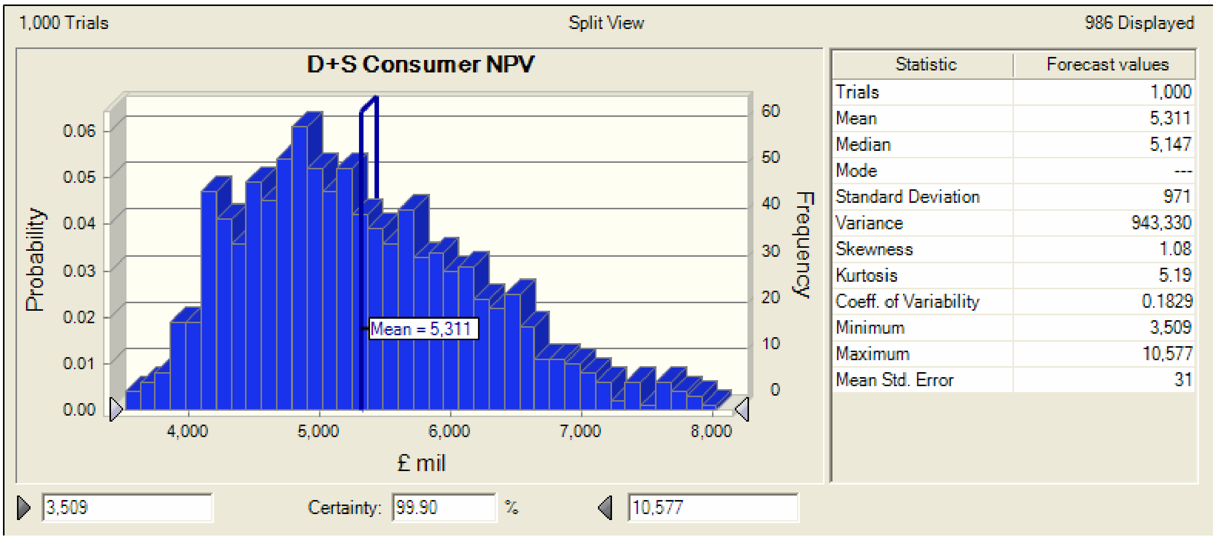
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(460)
Median	(623)
Mode	---
Standard Deviation	971
Variance	943,330
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-2.11
Minimum	(2,262)
Maximum	4,806
Mean Std. Error	31

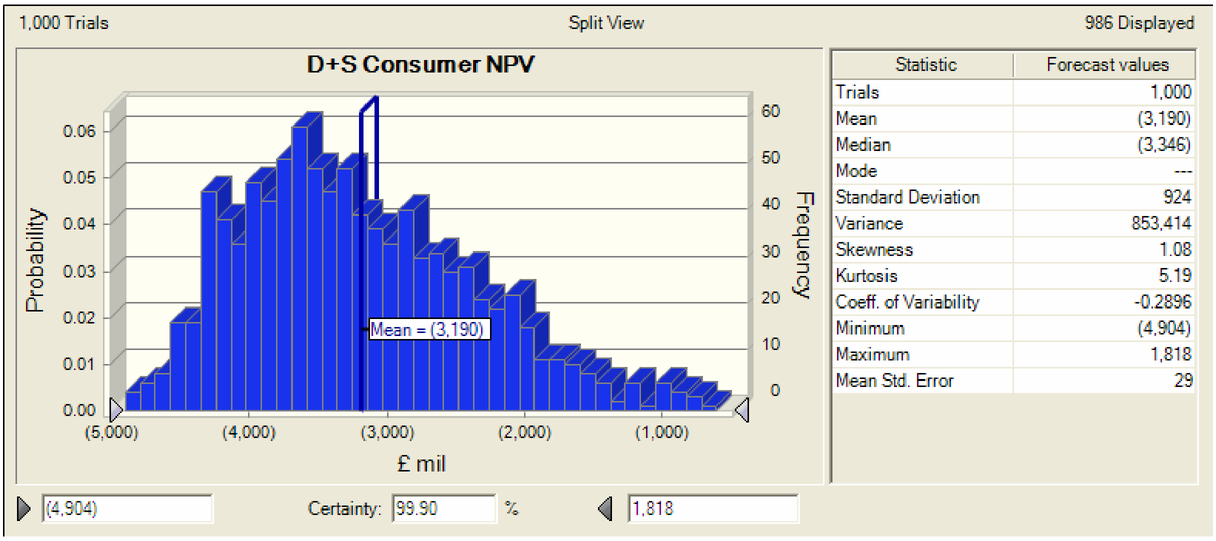
(2,262) Certainty: 71.69 % 0

B.xiv D+S - Regional Franchise without comms



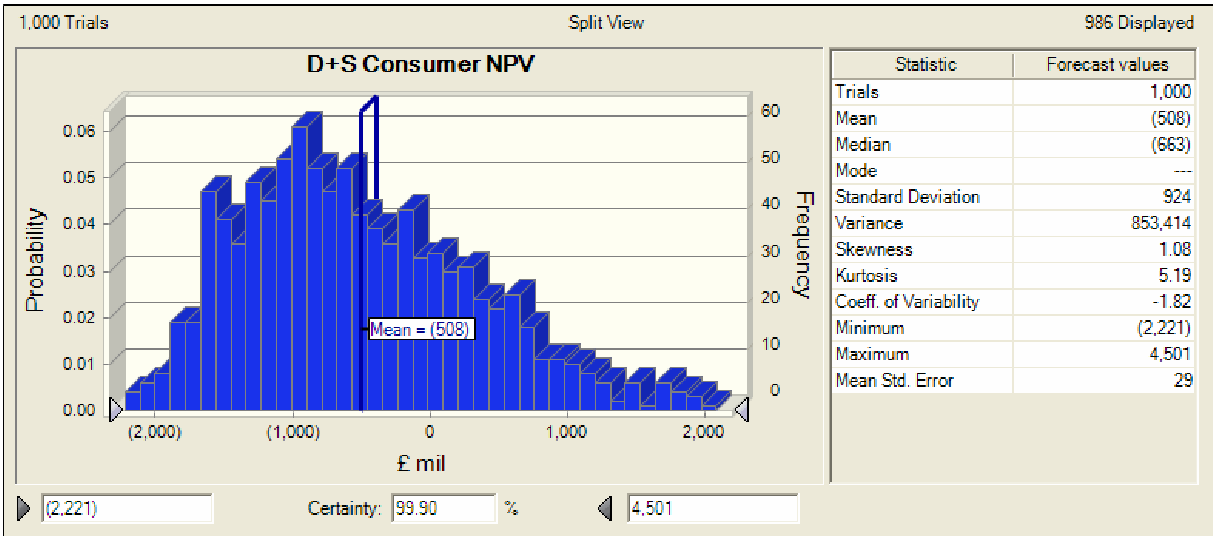
Statistic	Forecast values
Trials	1,000
Mean	5,311
Median	5,147
Mode	---
Standard Deviation	971
Variance	943,330
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.1829
Minimum	3,509
Maximum	10,577
Mean Std. Error	31

B.xv D+S – Market and PLC



Statistic	Forecast values
Trials	1,000
Mean	(3,190)
Median	(3,346)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.2896
Minimum	(4,904)
Maximum	1,818
Mean Std. Error	29

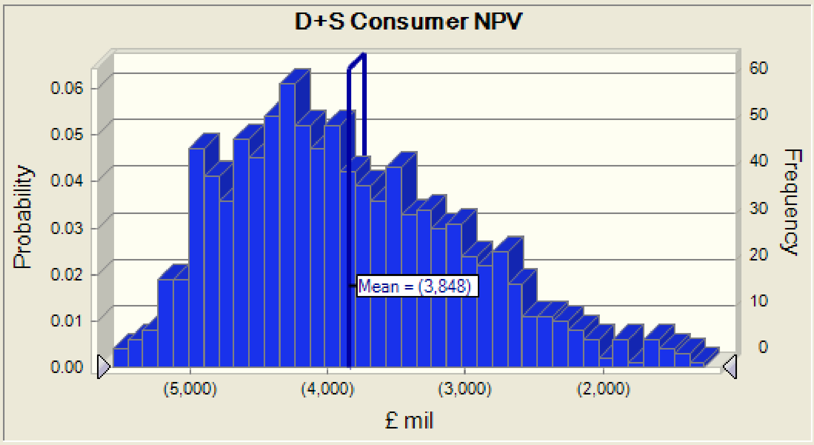
B.xvi D+S - Market and Broadband



Statistic	Forecast values
Trials	1,000
Mean	(508)
Median	(663)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.82
Minimum	(2,221)
Maximum	4,501
Mean Std. Error	29

B.xvii D+S - Market and WiMax

1,000 Trials | Split View | 986 Displayed

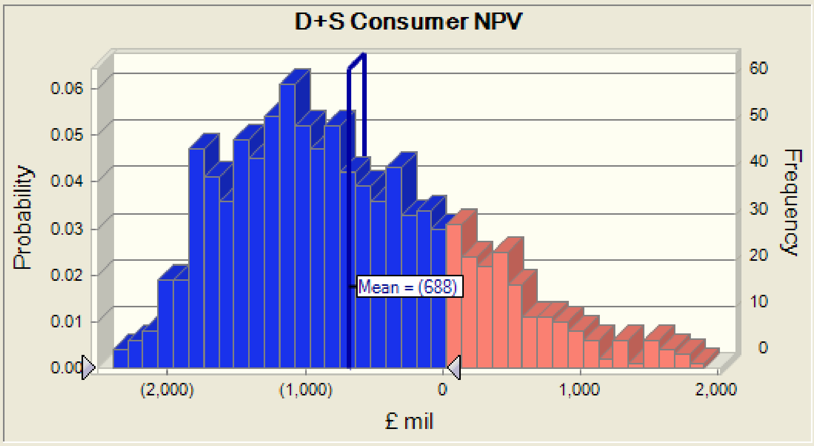


Statistic	Forecast values
Trials	1,000
Mean	(3,848)
Median	(4,004)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.2401
Minimum	(5,562)
Maximum	1,160
Mean Std. Error	29

(5,562) Certainty: 99.90 % 1,160

B.xviii D+S - Market and 3G

1,000 Trials | Split View | 986 Displayed

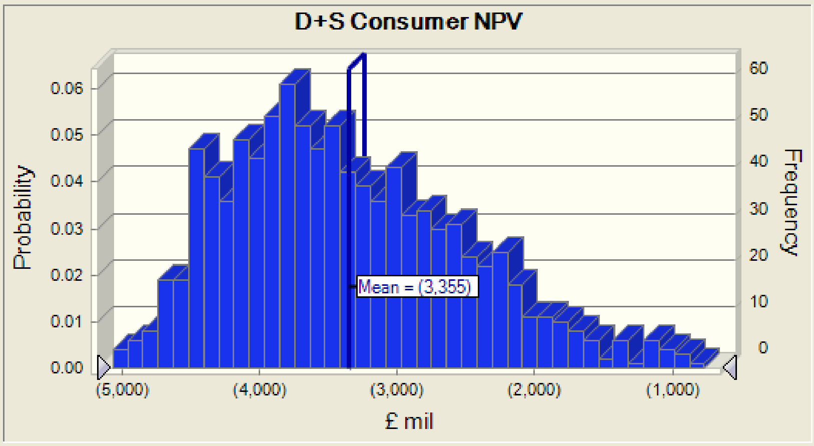


Statistic	Forecast values
Trials	1,000
Mean	(688)
Median	(843)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.34
Minimum	(2,402)
Maximum	4,321
Mean Std. Error	29

(2,402) Certainty: 79.11 % 0

B.xix D+S - Market and Hybrid 1

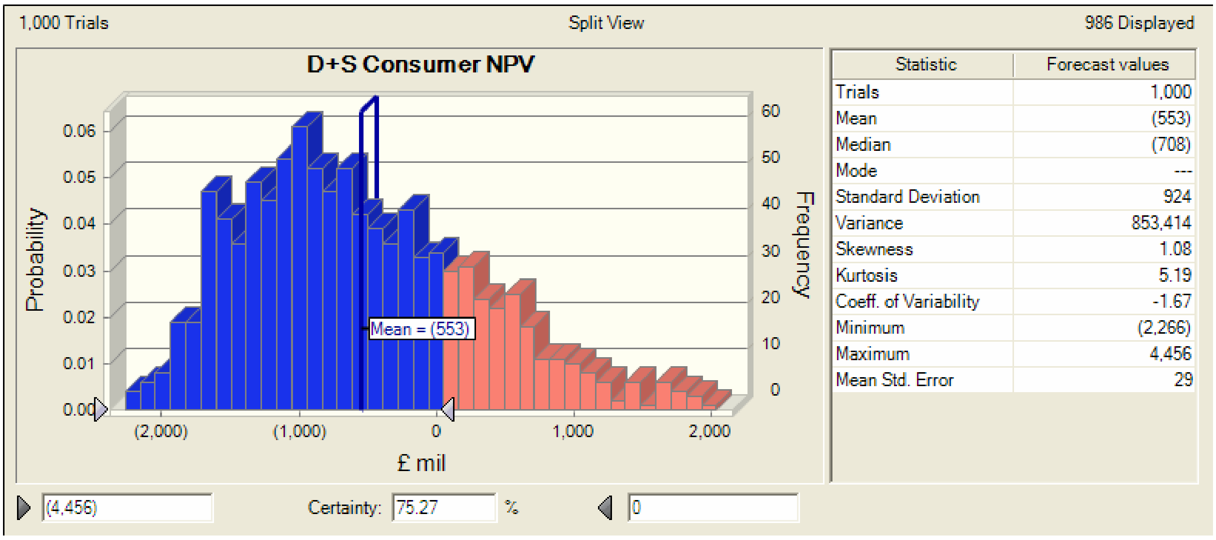
1,000 Trials | Split View | 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(3,355)
Median	(3,510)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.2754
Minimum	(5,068)
Maximum	1,654
Mean Std. Error	29

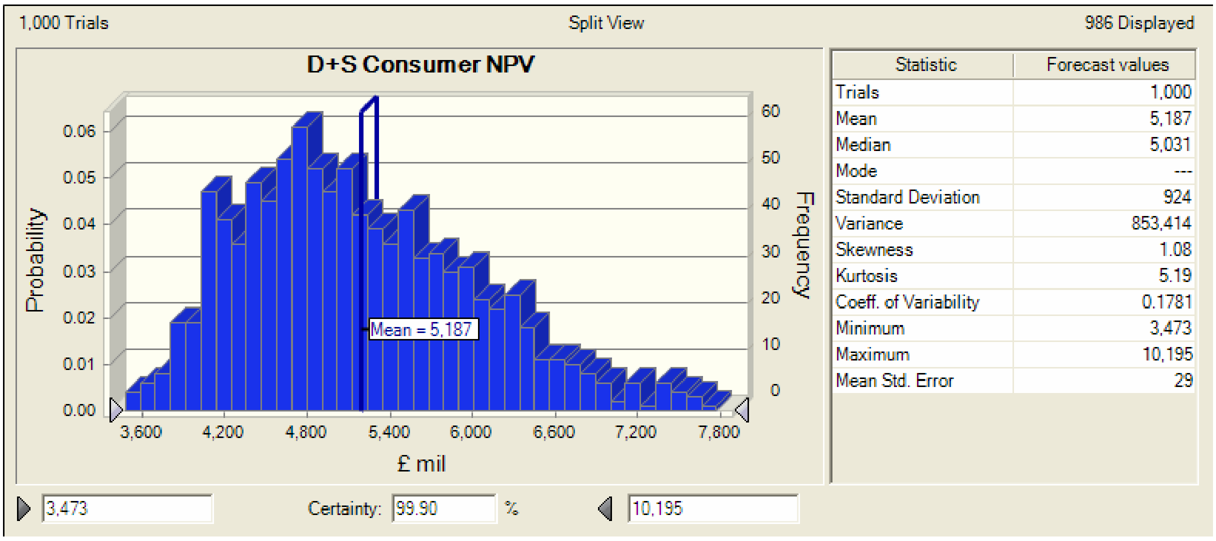
(5,068) Certainty: 99.33 % 0

B.xx D+S - Market and Hybrid 2



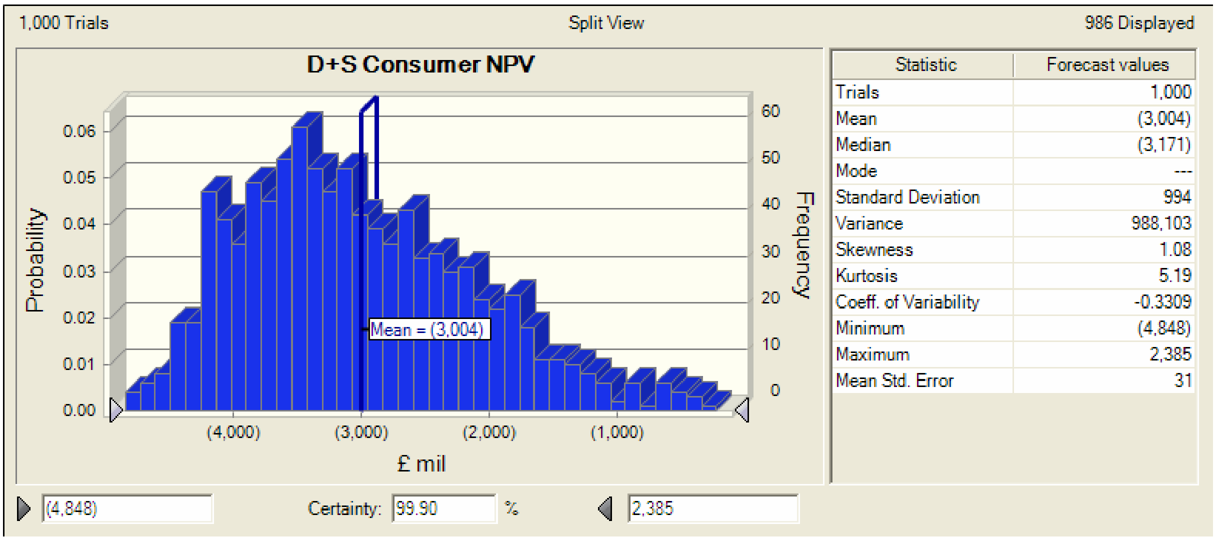
Statistic	Forecast values
Trials	1,000
Mean	(553)
Median	(708)
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-1.67
Minimum	(2,266)
Maximum	4,456
Mean Std. Error	29

B.xxi D+S - Market without comms



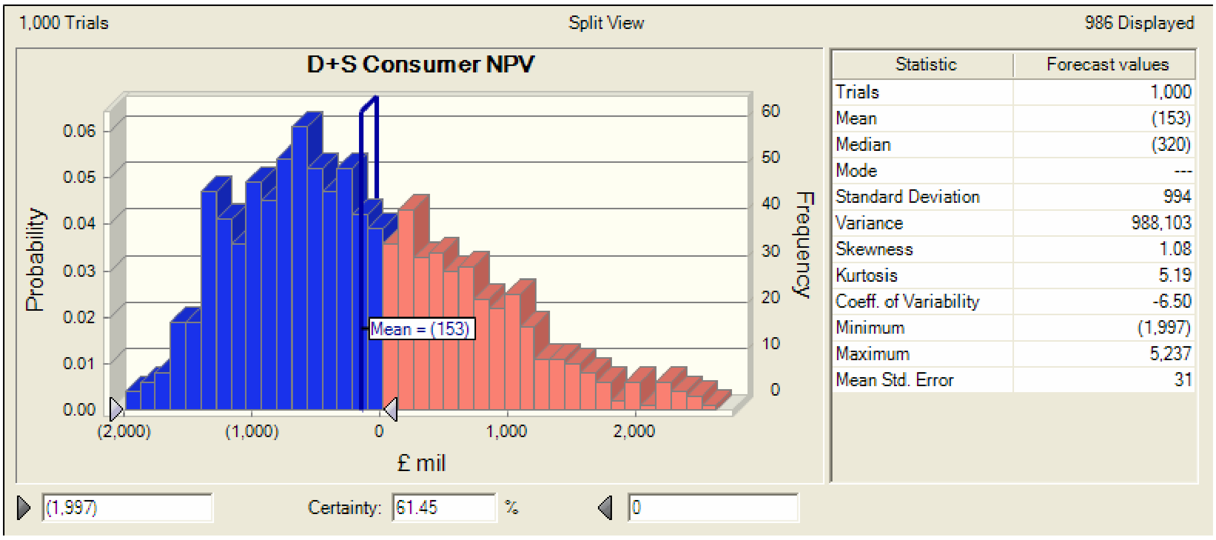
Statistic	Forecast values
Trials	1,000
Mean	5,187
Median	5,031
Mode	---
Standard Deviation	924
Variance	853,414
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.1781
Minimum	3,473
Maximum	10,195
Mean Std. Error	29

B.xxii D+S – Market Tip and PLC



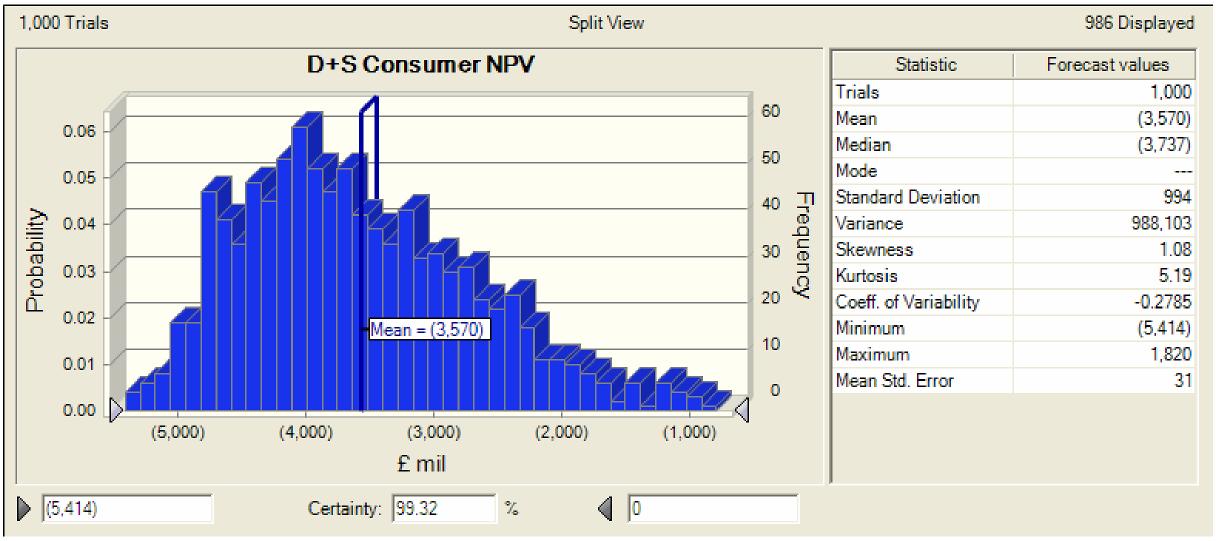
Statistic	Forecast values
Trials	1,000
Mean	(3,004)
Median	(3,171)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.3309
Minimum	(4,848)
Maximum	2,385
Mean Std. Error	31

B.xxiii D+S – Market Tip and Broadband



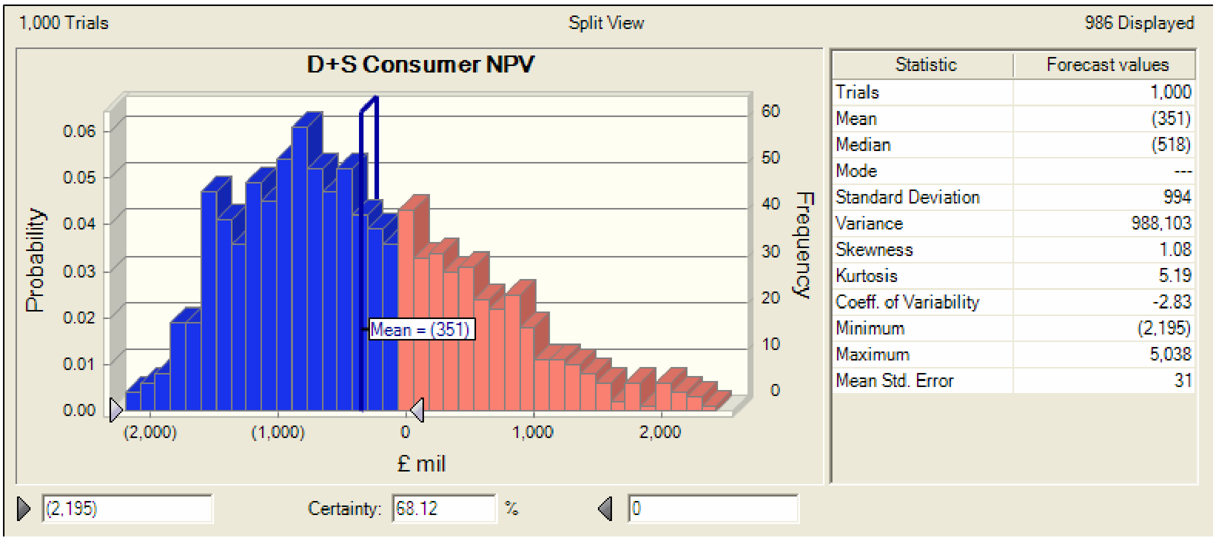
Statistic	Forecast values
Trials	1,000
Mean	(153)
Median	(320)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-6.50
Minimum	(1,997)
Maximum	5,237
Mean Std. Error	31

B.xxiv D+S - Market Tip and WiMax



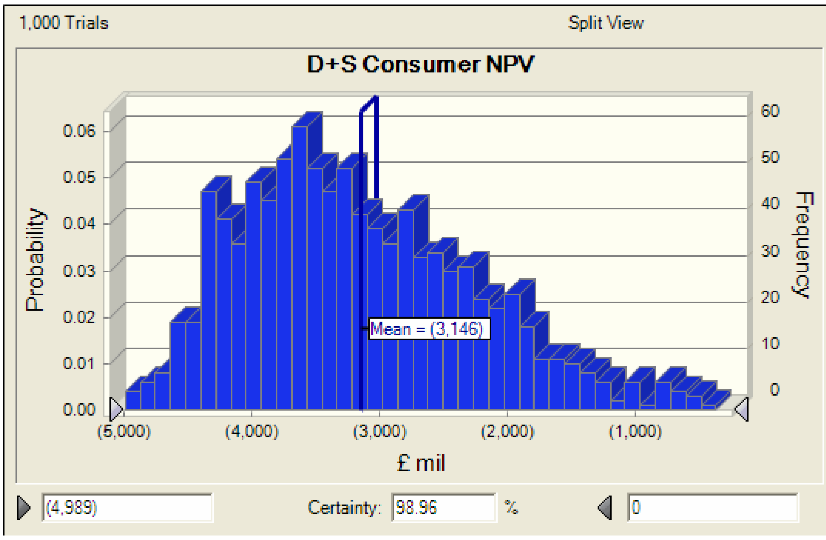
Statistic	Forecast values
Trials	1,000
Mean	(3,570)
Median	(3,737)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.2785
Minimum	(5,414)
Maximum	1,820
Mean Std. Error	31

B.xxv D+S - Market Tip and 3G



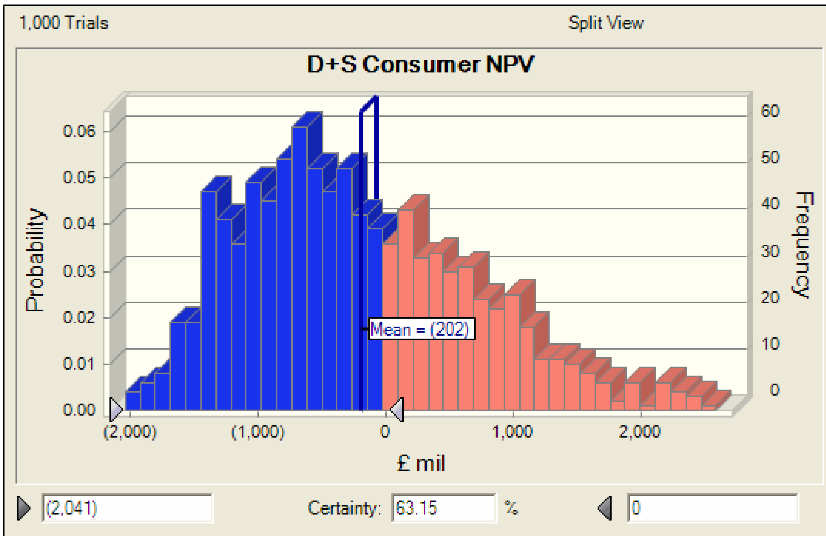
Statistic	Forecast values
Trials	1,000
Mean	(351)
Median	(518)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-2.83
Minimum	(2,195)
Maximum	5,038
Mean Std. Error	31

B.xxvi D+S - Market Tip and Hybrid 1



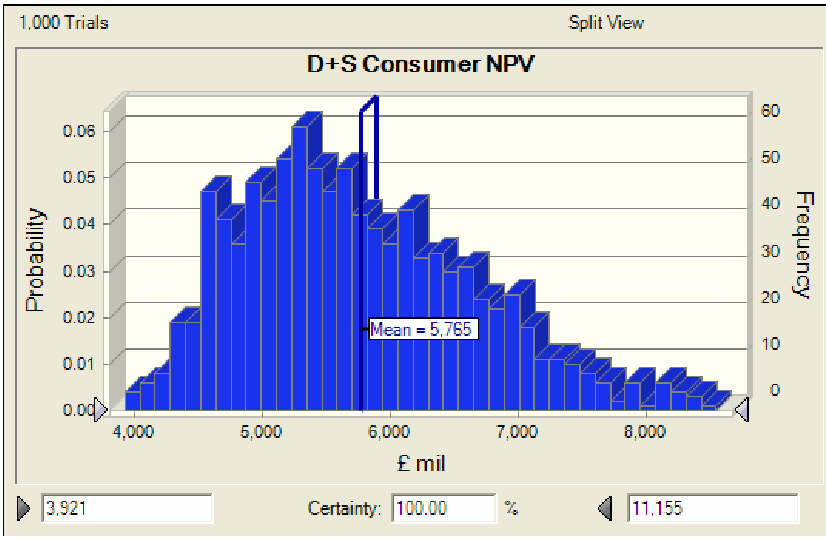
Statistic	Forecast values
Trials	1,000
Mean	(3,146)
Median	(3,313)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.3160
Minimum	(4,989)
Maximum	2,244
Mean Std. Error	31

B.xxvii D+S - Market Tip and Hybrid 2



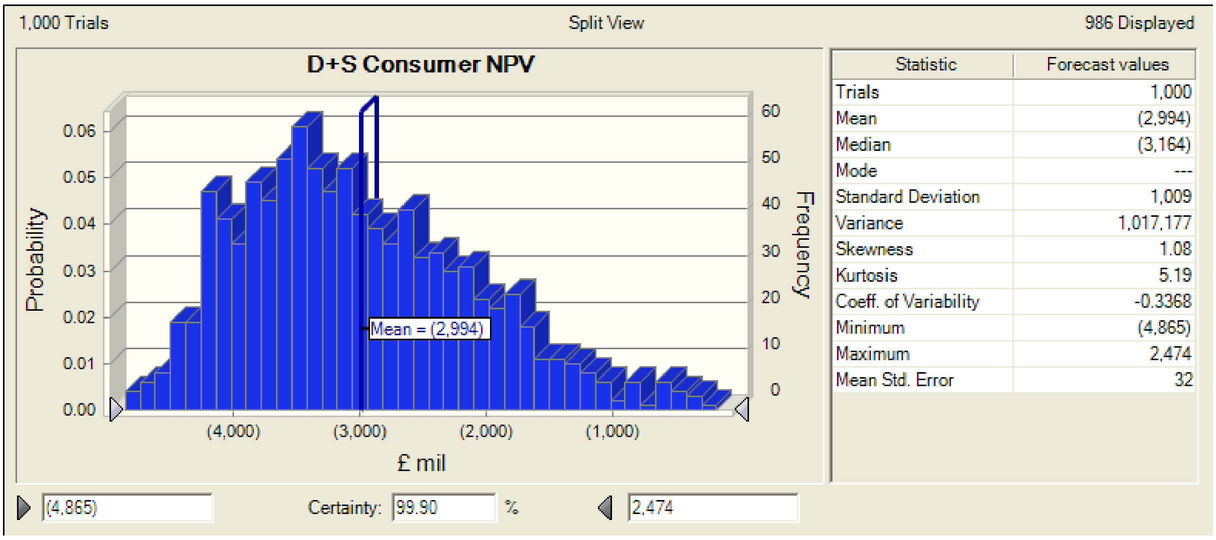
Statistic	Forecast values
Trials	1,000
Mean	(202)
Median	(370)
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-4.91
Minimum	(2,046)
Maximum	5,187
Mean Std. Error	31

B.xxviii D+S - Market Tip without comms

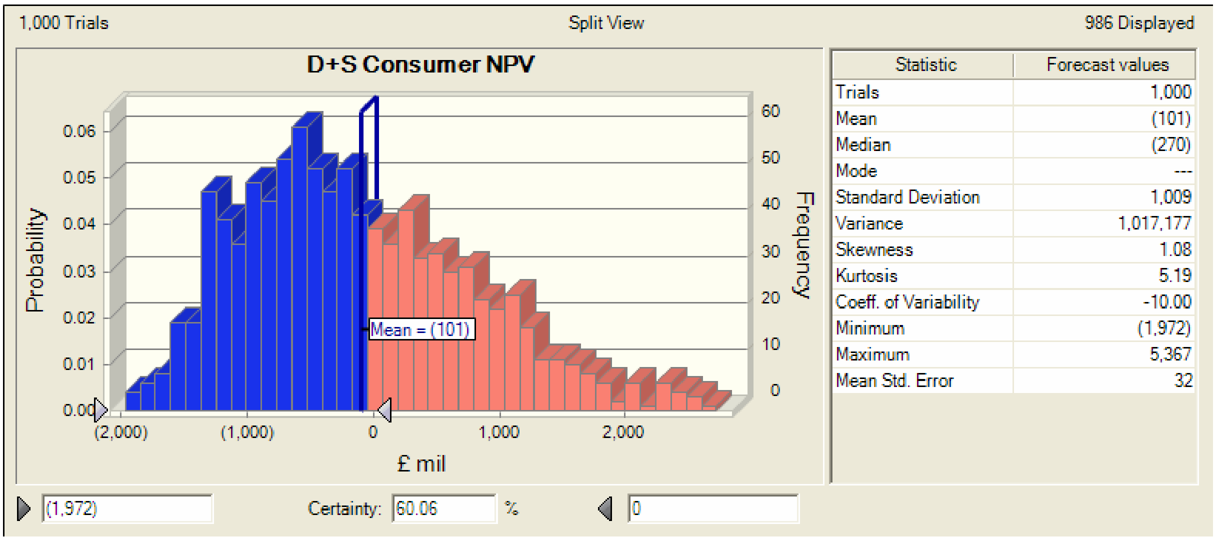


Statistic	Forecast values
Trials	1,000
Mean	5,765
Median	5,598
Mode	---
Standard Deviation	994
Variance	988,103
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	0.1724
Minimum	3,921
Maximum	11,155
Mean Std. Error	31

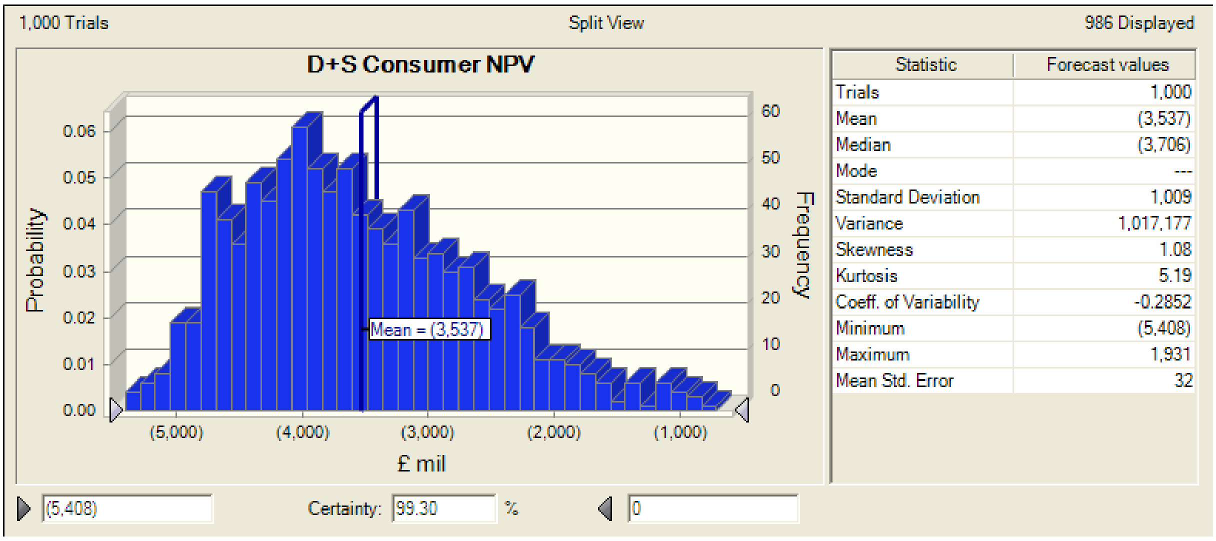
B.xxix D+S – Market Tip Fast and PLC



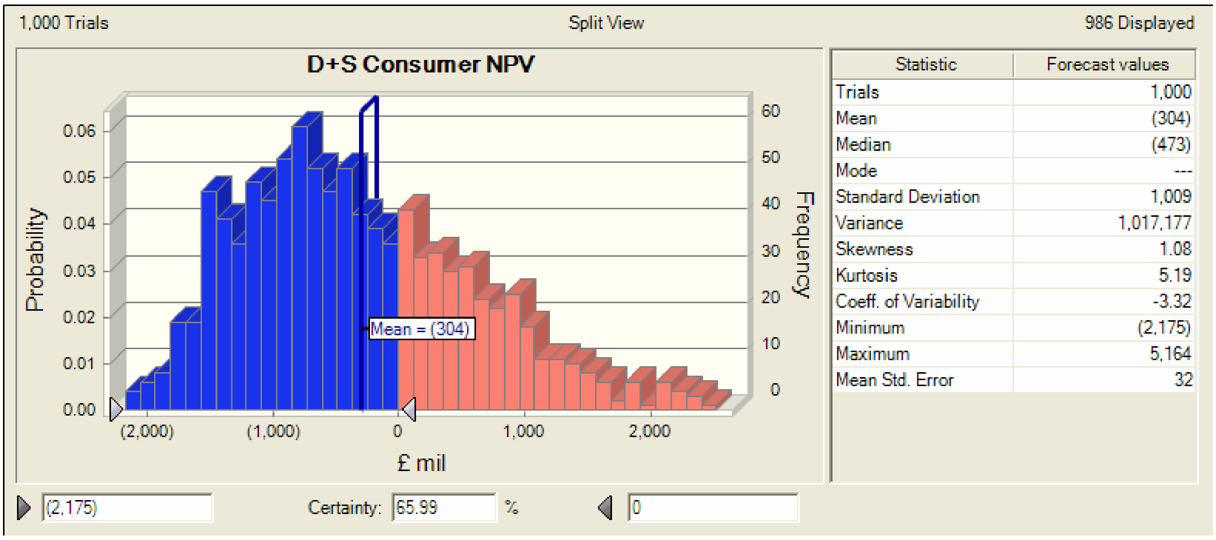
B.xxx D+S – Market Tip Fast and Broadband



B.xxxi D+S - Market Tip Fast and WiMax

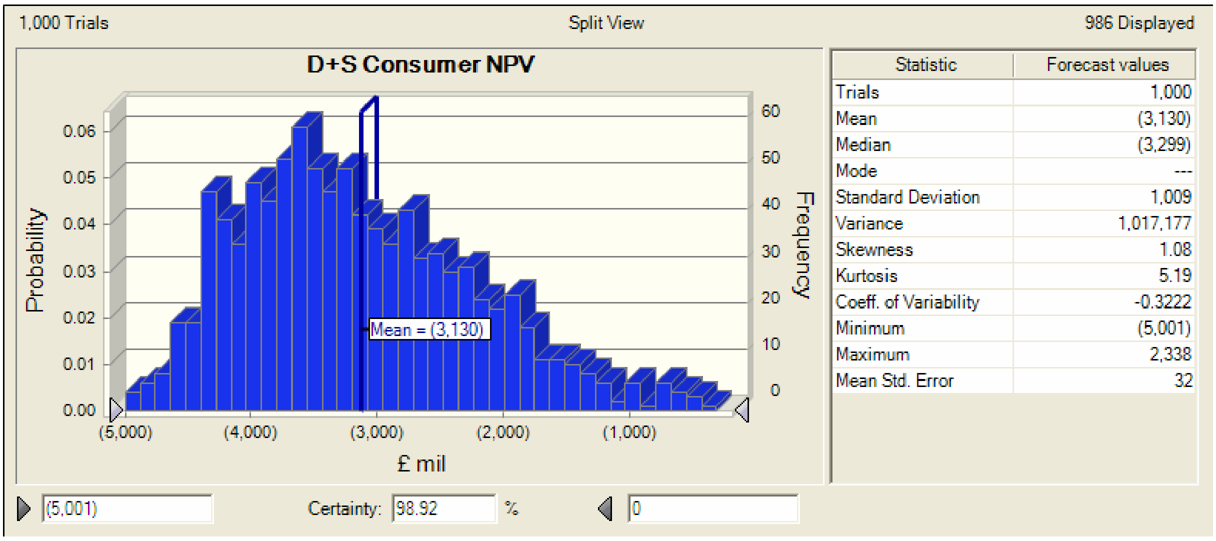


B.xxxii D+S - Market Tip Fast and 3G



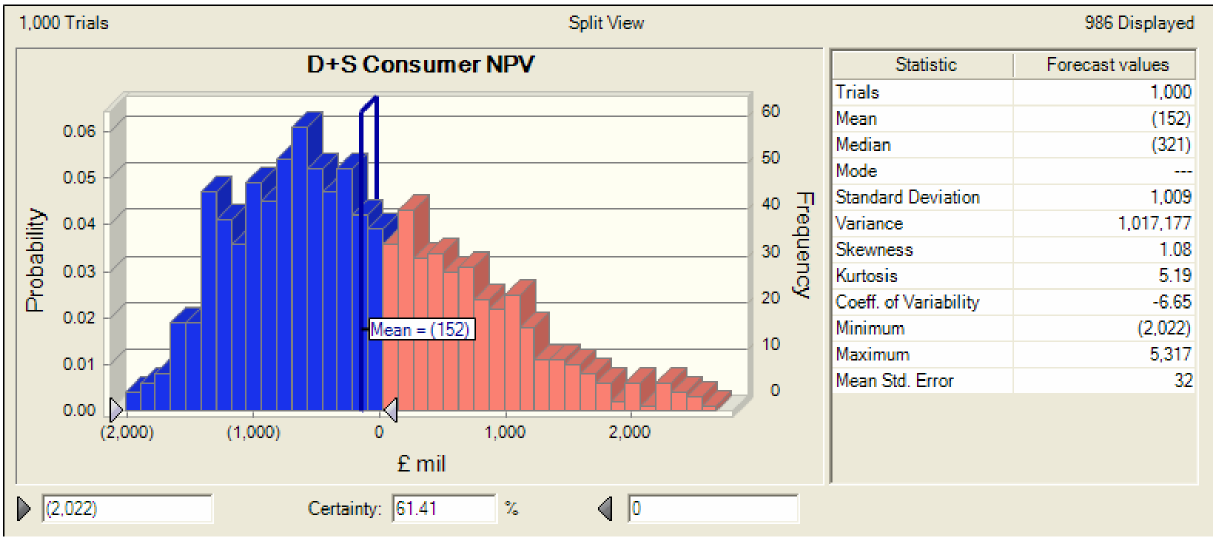
Statistic	Forecast values
Trials	1,000
Mean	(304)
Median	(473)
Mode	---
Standard Deviation	1,009
Variance	1,017,177
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-3.32
Minimum	(2,175)
Maximum	5,164
Mean Std. Error	32

B.xxxiii D+S - Market Tip Fast and Hybrid 1



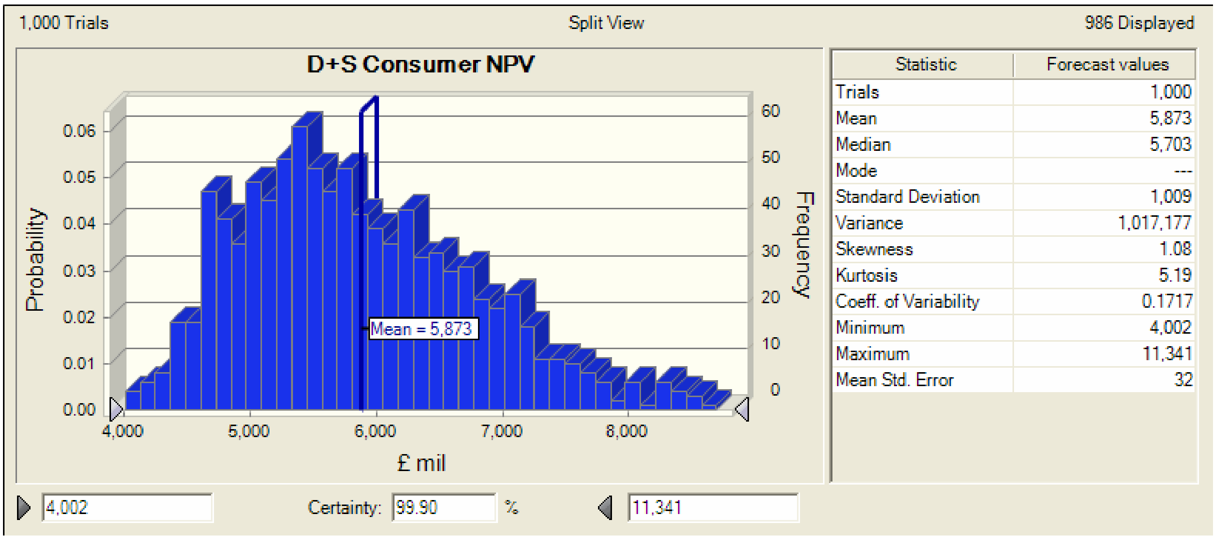
Statistic	Forecast values
Trials	1,000
Mean	(3,130)
Median	(3,299)
Mode	---
Standard Deviation	1,009
Variance	1,017,177
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-0.3222
Minimum	(5,001)
Maximum	2,338
Mean Std. Error	32

B.xxxiv D+S - Market Tip Fast and Hybrid 2



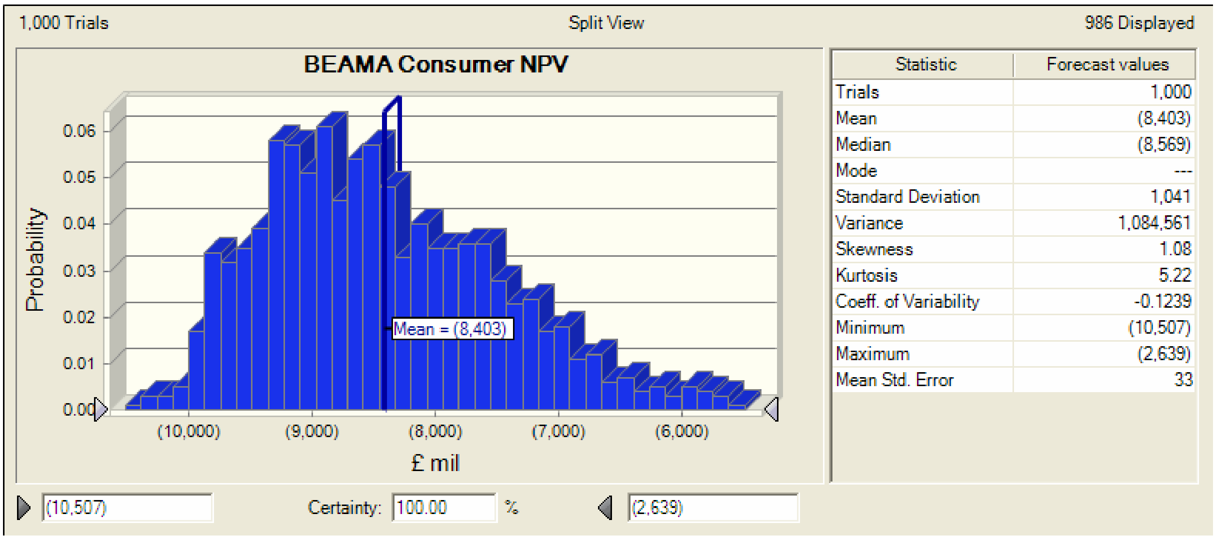
Statistic	Forecast values
Trials	1,000
Mean	(152)
Median	(321)
Mode	---
Standard Deviation	1,009
Variance	1,017,177
Skewness	1.08
Kurtosis	5.19
Coeff. of Variability	-6.65
Minimum	(2,022)
Maximum	5,317
Mean Std. Error	32

B.xxxv D+S - Market Tip Fast without comms

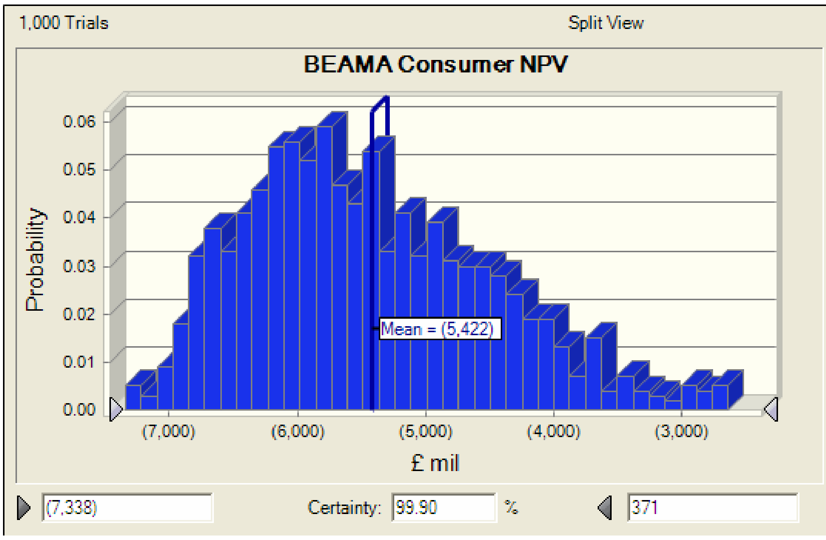


B.2.4 BEAMA Specification

B.i BEAMA - New, Replacement and Voluntary and PLC

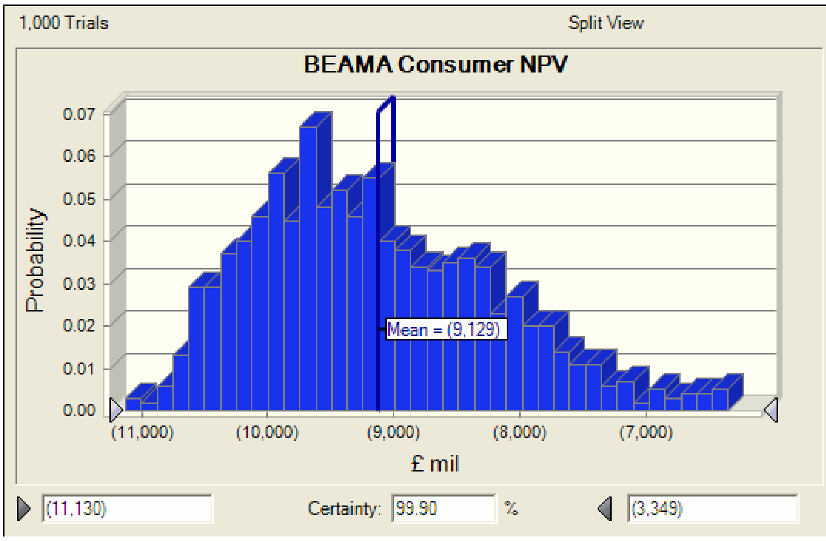


B.ii BEAMA - New, Replacement and Voluntary and Broadband



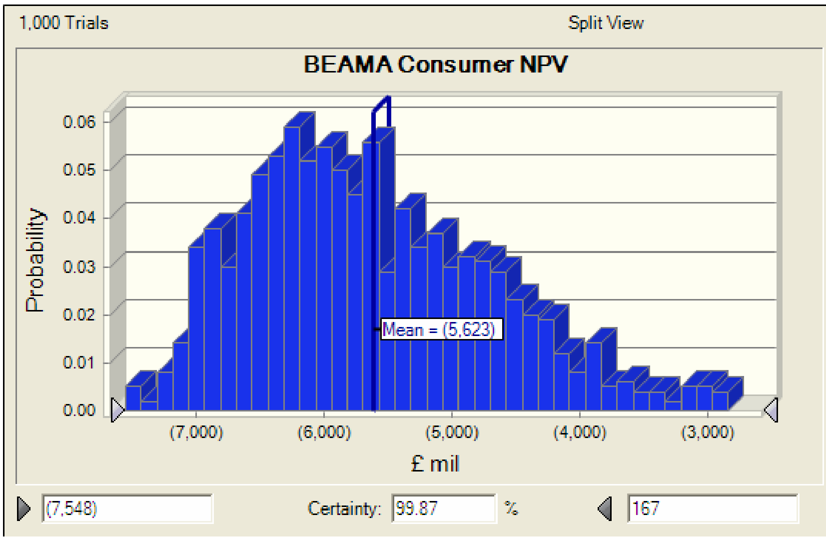
Statistic	Forecast values
Trials	1,000
Mean	(5,422)
Median	(5,581)
Mode	---
Standard Deviation	1,039
Variance	1,079,278
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.1916
Minimum	(7,338)
Maximum	371
Mean Std. Error	33

B.iii BEAMA - New, Replacement and Voluntary and WiMax



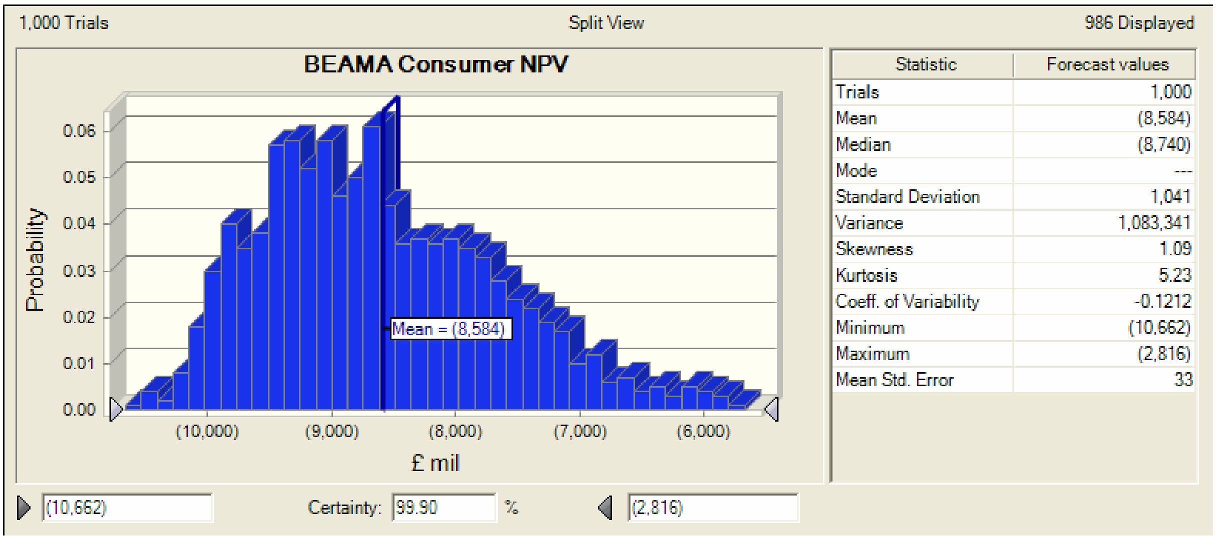
Statistic	Forecast values
Trials	1,000
Mean	(9,129)
Median	(9,278)
Mode	---
Standard Deviation	1,040
Variance	1,080,627
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.1139
Minimum	(11,130)
Maximum	(3,349)
Mean Std. Error	33

B.iv BEAMA - New, Replacement and Voluntary and 3G

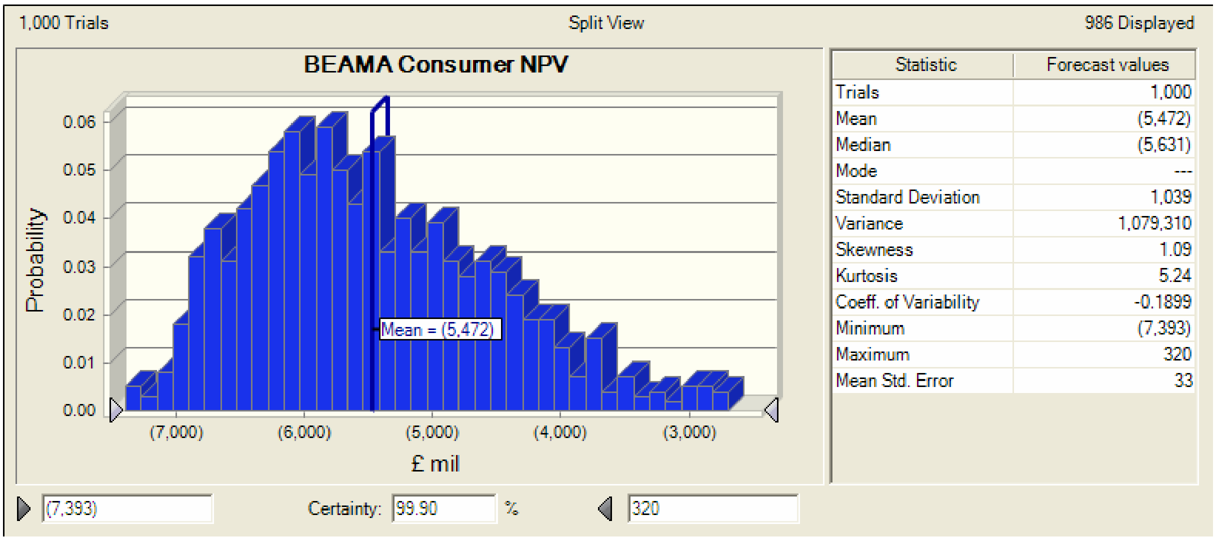


Statistic	Forecast values
Trials	1,000
Mean	(5,623)
Median	(5,779)
Mode	---
Standard Deviation	1,039
Variance	1,079,442
Skewness	1.09
Kurtosis	5.24
Coeff. of Variability	-0.1848
Minimum	(7,559)
Maximum	167
Mean Std. Error	33

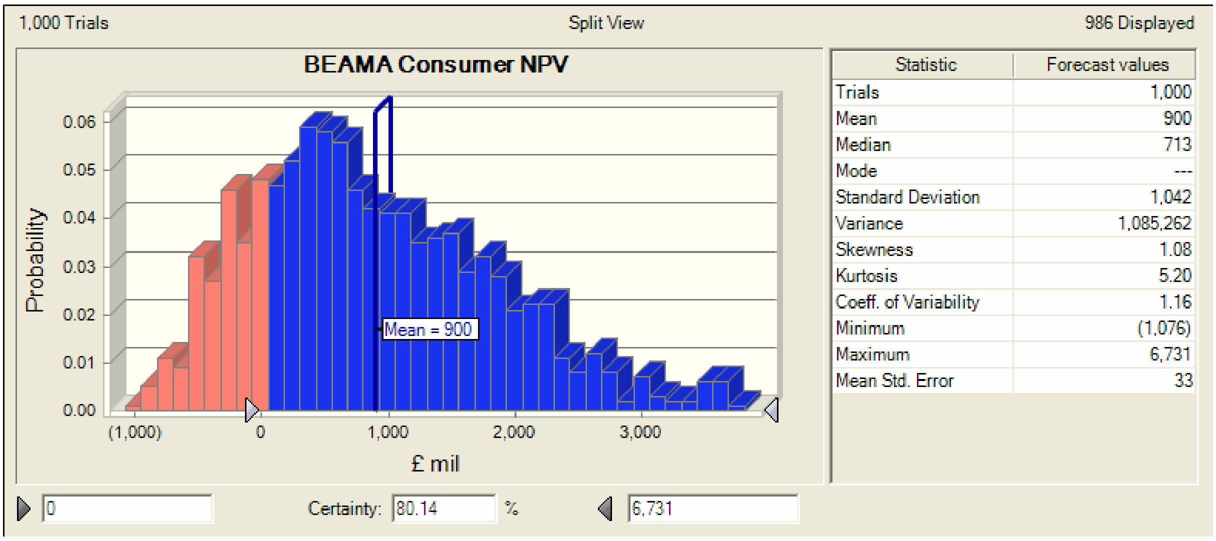
B.v BEAMA - New, Replacement and Voluntary and Hybrid 1



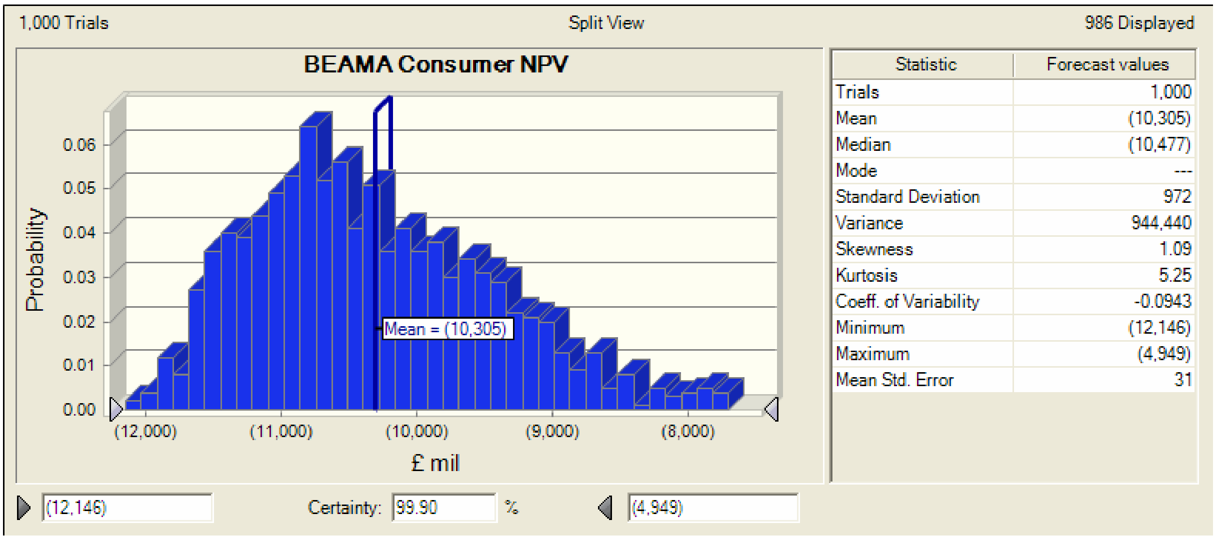
B.vi BEAMA - New, Replacement and Voluntary and Hybrid 2



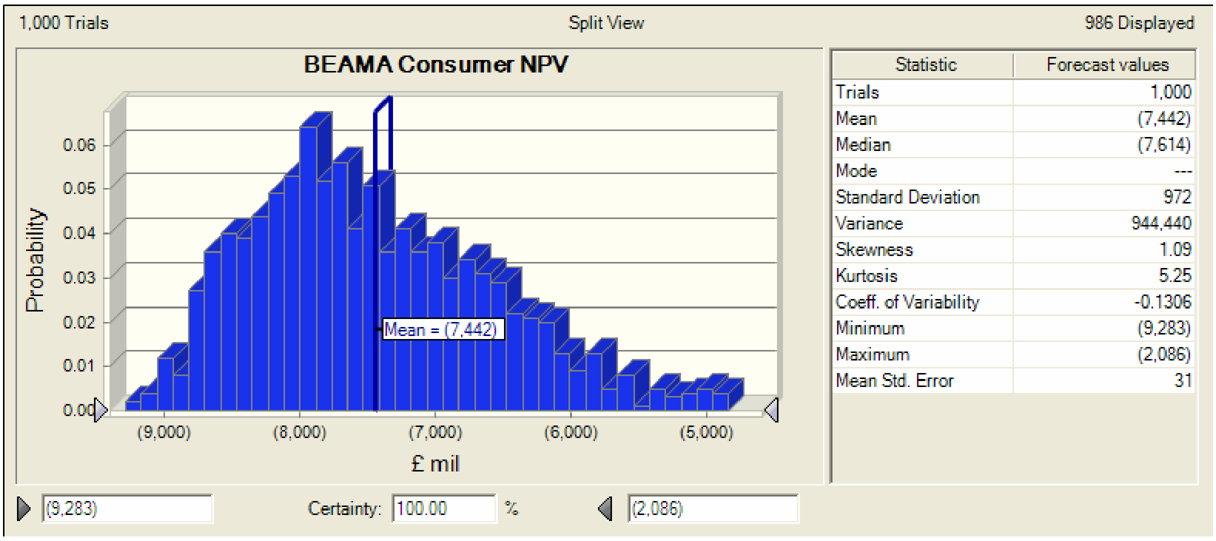
B.vii BEAMA - New, Replacement and Voluntary without comms



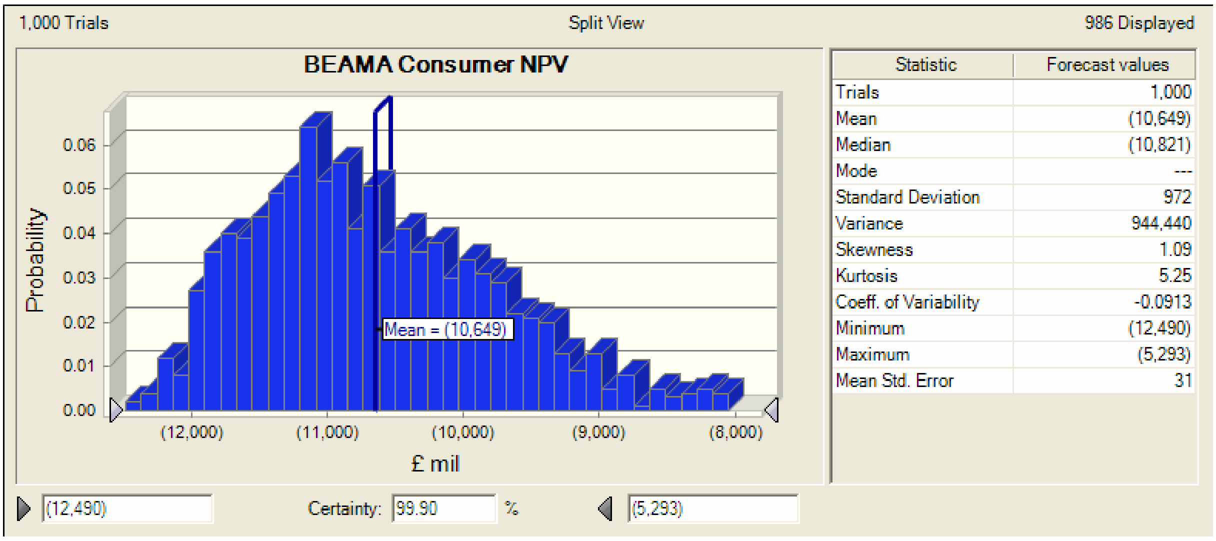
B.viii BEAMA – Regional Franchise and PLC



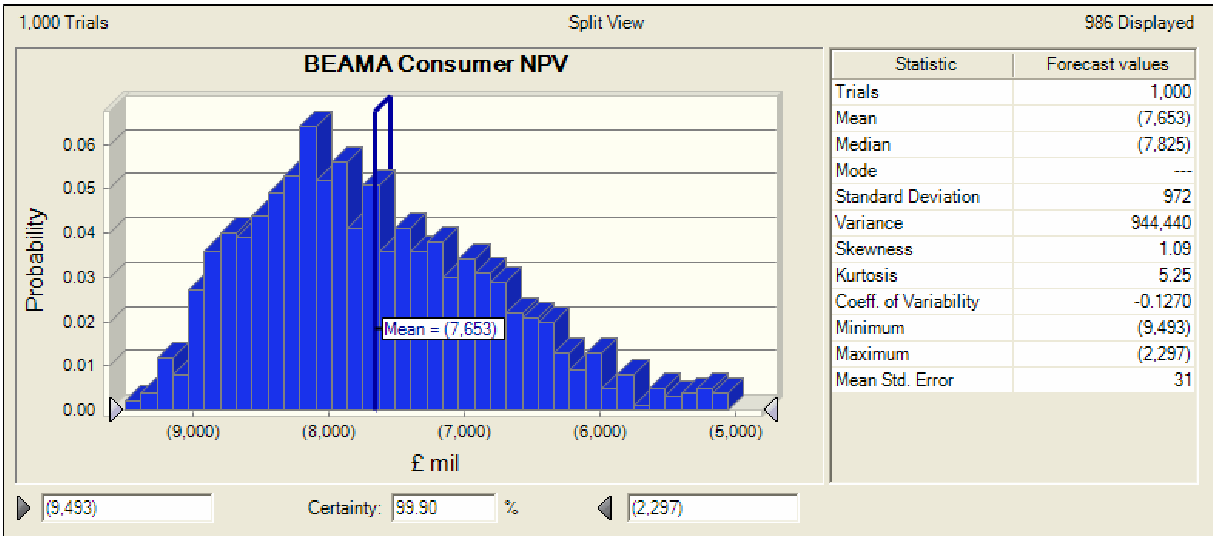
B.ix BEAMA - Regional Franchise and Broadband



B.x BEAMA - Regional Franchise and WiMax

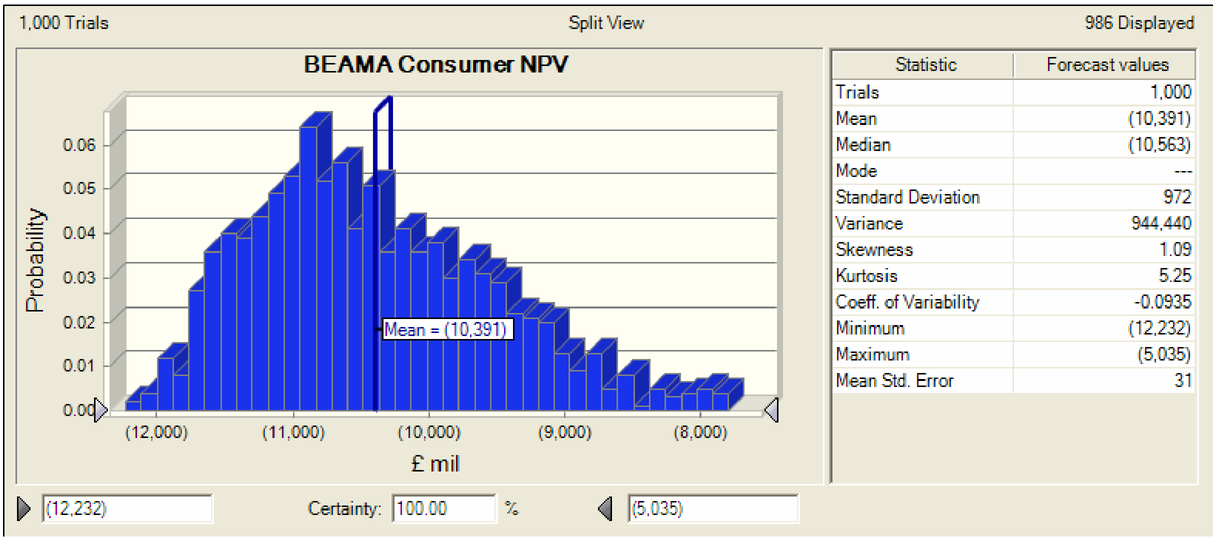


B.xi BEAMA - Regional Franchise and 3G



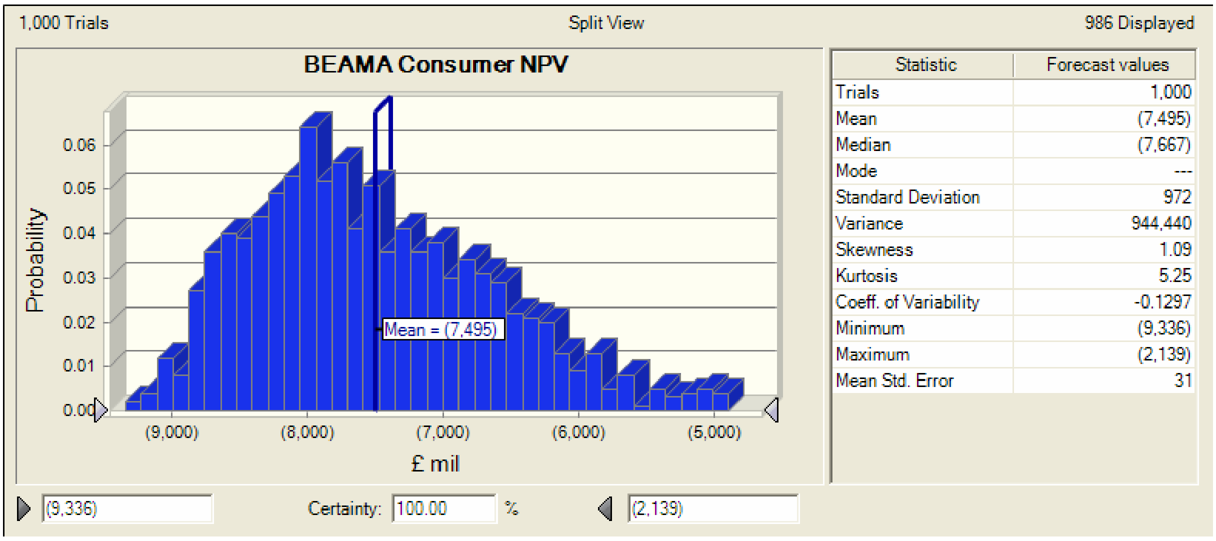
Statistic	Forecast values
Trials	1,000
Mean	(7,653)
Median	(7,825)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1270
Minimum	(9,493)
Maximum	(2,297)
Mean Std. Error	31

B.xii BEAMA - Regional Franchise and Hybrid 1



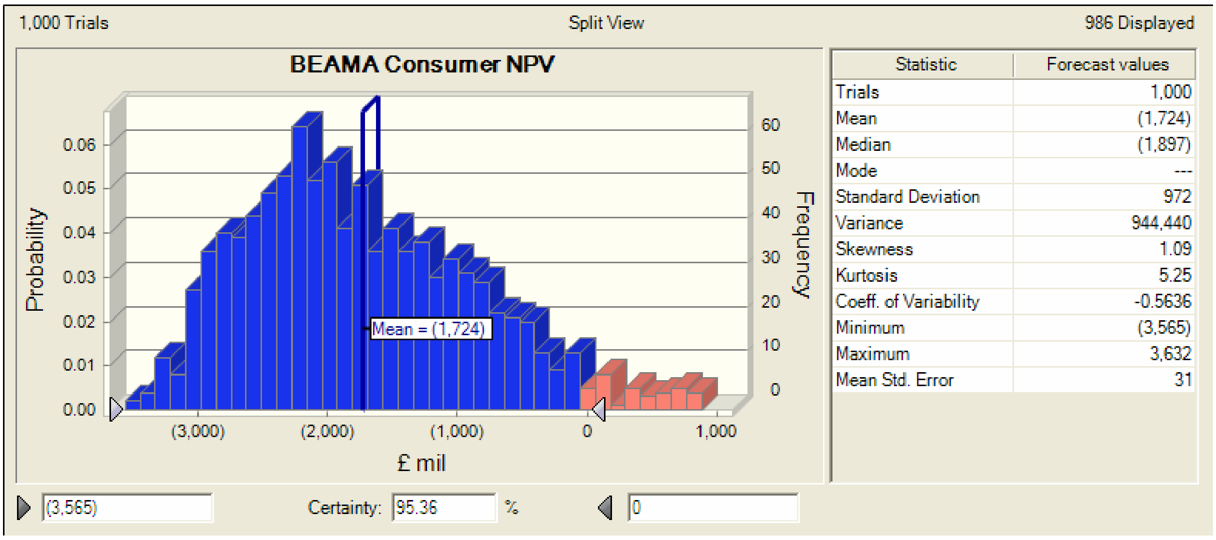
Statistic	Forecast values
Trials	1,000
Mean	(10,391)
Median	(10,563)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0935
Minimum	(12,232)
Maximum	(5,035)
Mean Std. Error	31

B.xiii BEAMA - Regional Franchise and Hybrid 2

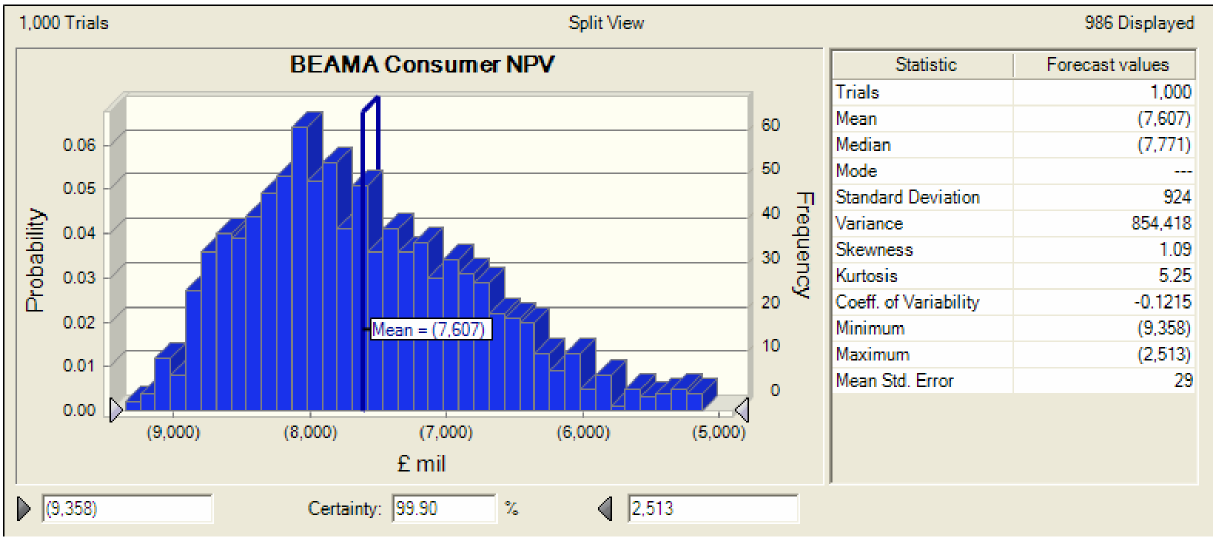


Statistic	Forecast values
Trials	1,000
Mean	(7,495)
Median	(7,667)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1297
Minimum	(9,336)
Maximum	(2,139)
Mean Std. Error	31

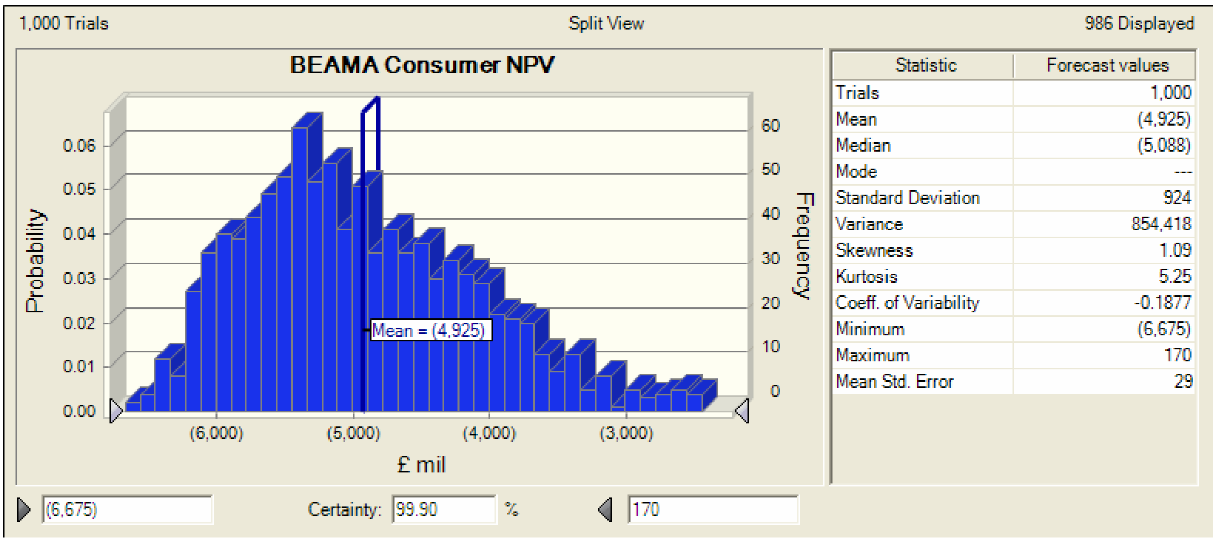
B.xiv BEAMA - Regional Franchise without comms



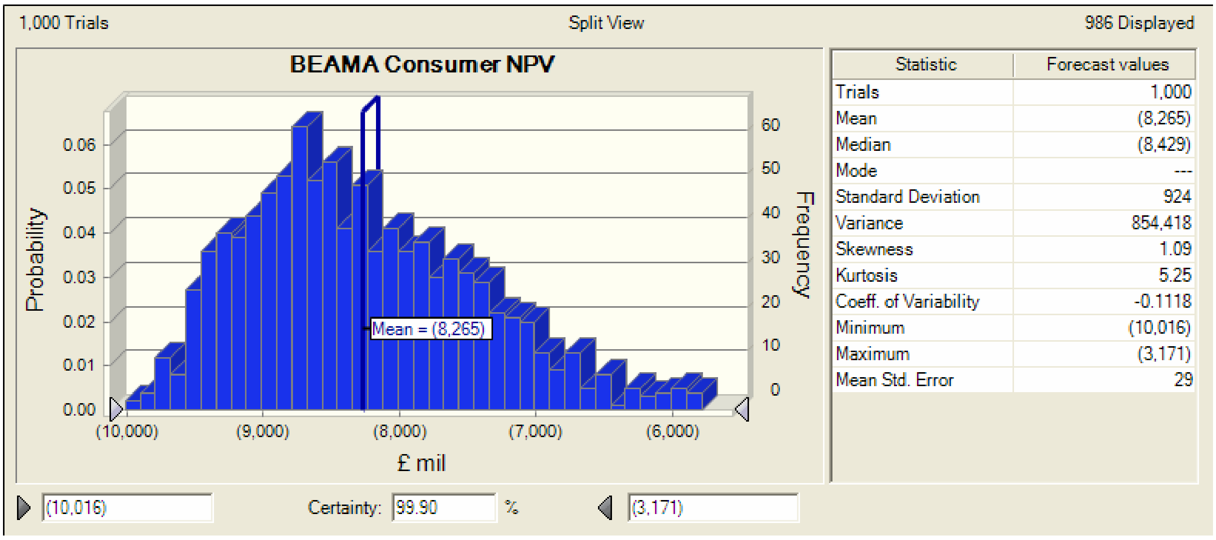
B.xv BEAMA – Market and PLC



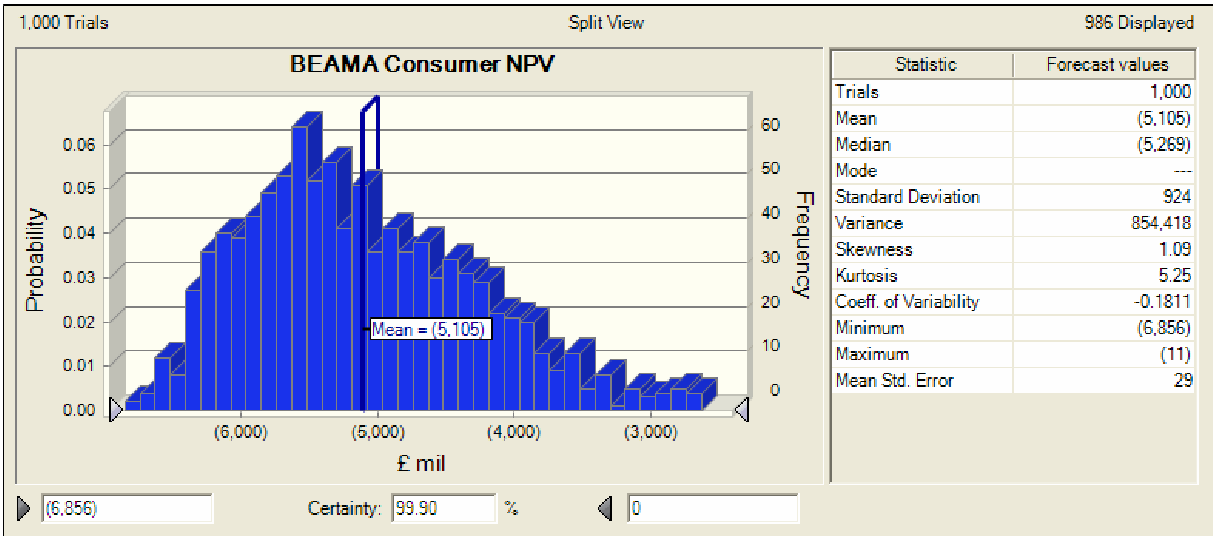
B.xvi BEAMA - Market and Broadband



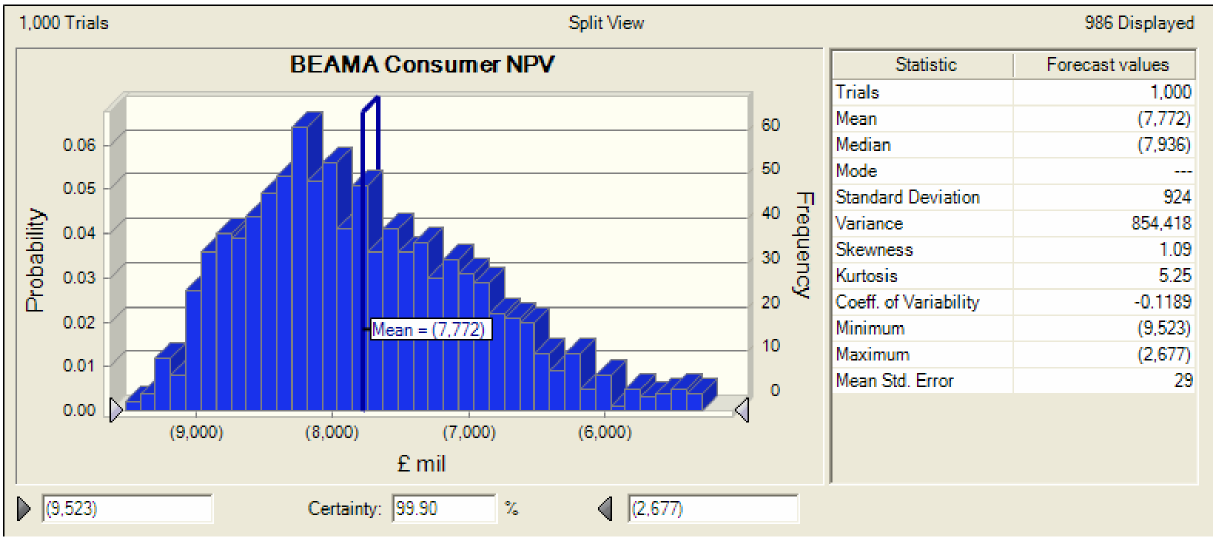
B.xvii BEAMA - Market and WiMax



B.xviii BEAMA - Market and 3G

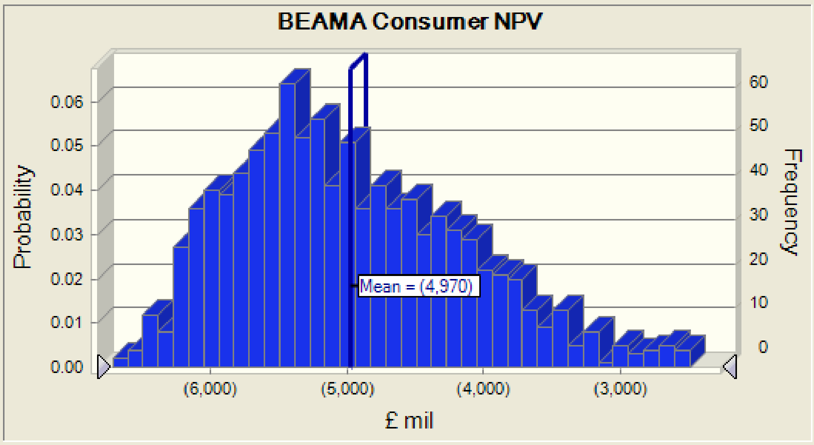


B.xix BEAMA - Market and Hybrid 1



B.xx BEAMA - Market and Hybrid 2

1,000 Trials Split View 986 Displayed

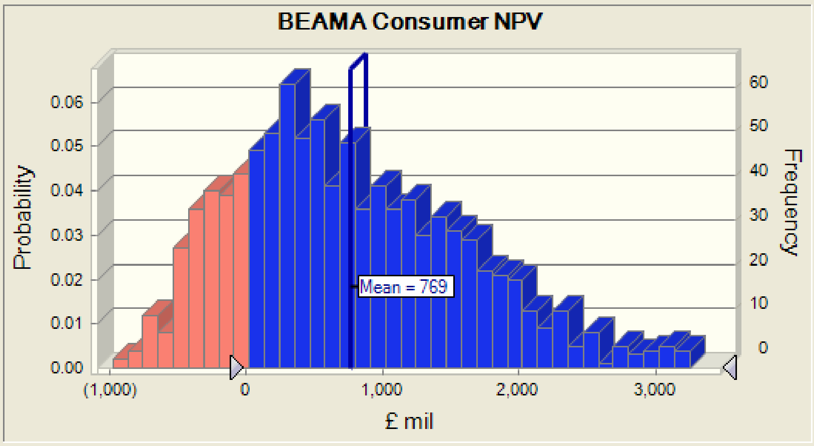


Statistic	Forecast values
Trials	1,000
Mean	(4,970)
Median	(5,134)
Mode	---
Standard Deviation	924
Variance	854,418
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1860
Minimum	(6,721)
Maximum	125
Mean Std. Error	29

(6,721) Certainty: 99.90 % 125

B.xxi BEAMA - Market without comms

1,000 Trials Split View 986 Displayed

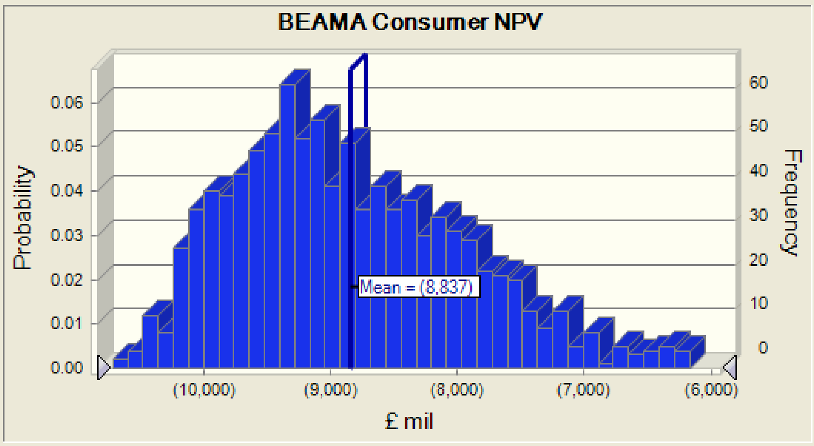


Statistic	Forecast values
Trials	1,000
Mean	769
Median	606
Mode	---
Standard Deviation	924
Variance	854,418
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	1.20
Minimum	(981)
Maximum	5,864
Mean Std. Error	29

0 Certainty: 79.27 % 5,864

B.xxii BEAMA – Market Tip and PLC

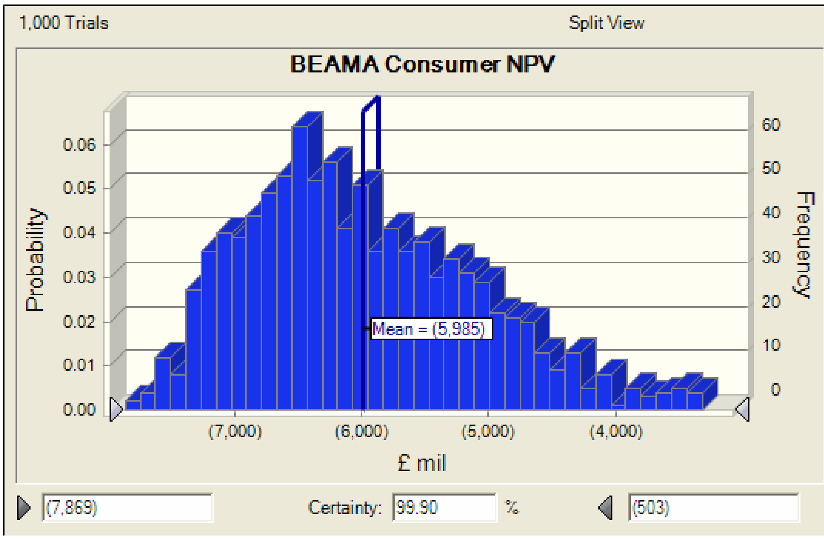
1,000 Trials Split View 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	(8,837)
Median	(9,013)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1126
Minimum	(10,720)
Maximum	(3,355)
Mean Std. Error	31

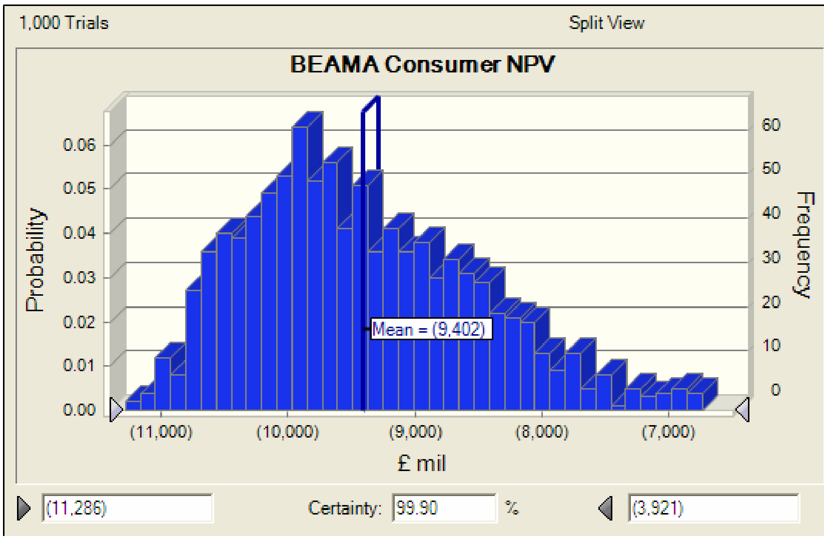
(10,720) Certainty: 99.90 % (3,355)

B.xxiii BEAMA – Market Tip and Broadband



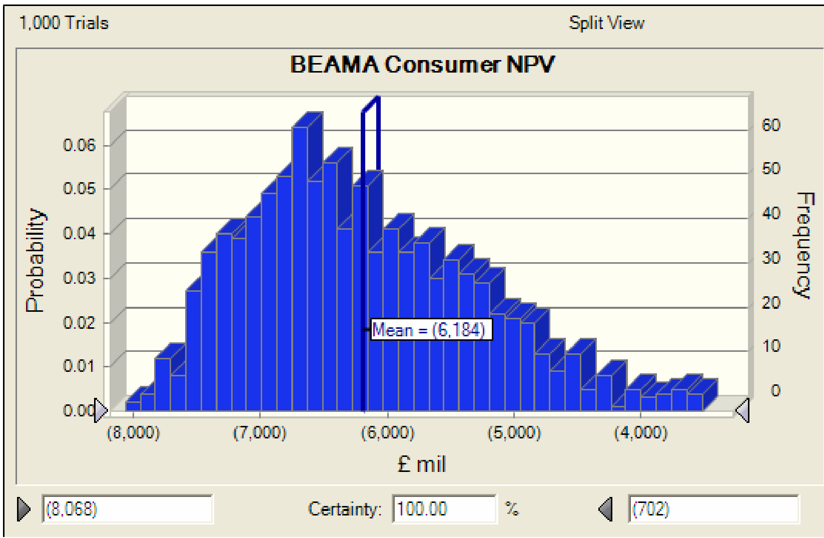
Statistic	Forecast values
Trials	1,000
Mean	(5,985)
Median	(6,162)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1662
Minimum	(7,869)
Maximum	(503)
Mean Std. Error	31

B.xxiv BEAMA - Market Tip and WiMax



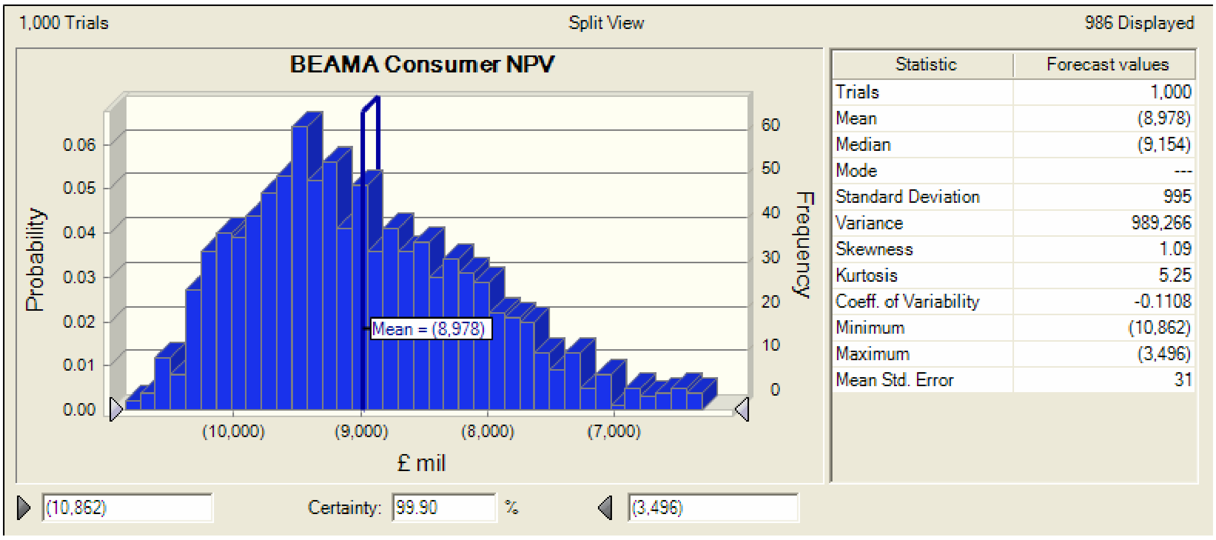
Statistic	Forecast values
Trials	1,000
Mean	(9,402)
Median	(9,579)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1058
Minimum	(11,286)
Maximum	(3,921)
Mean Std. Error	31

B.xxv BEAMA - Market Tip and 3G



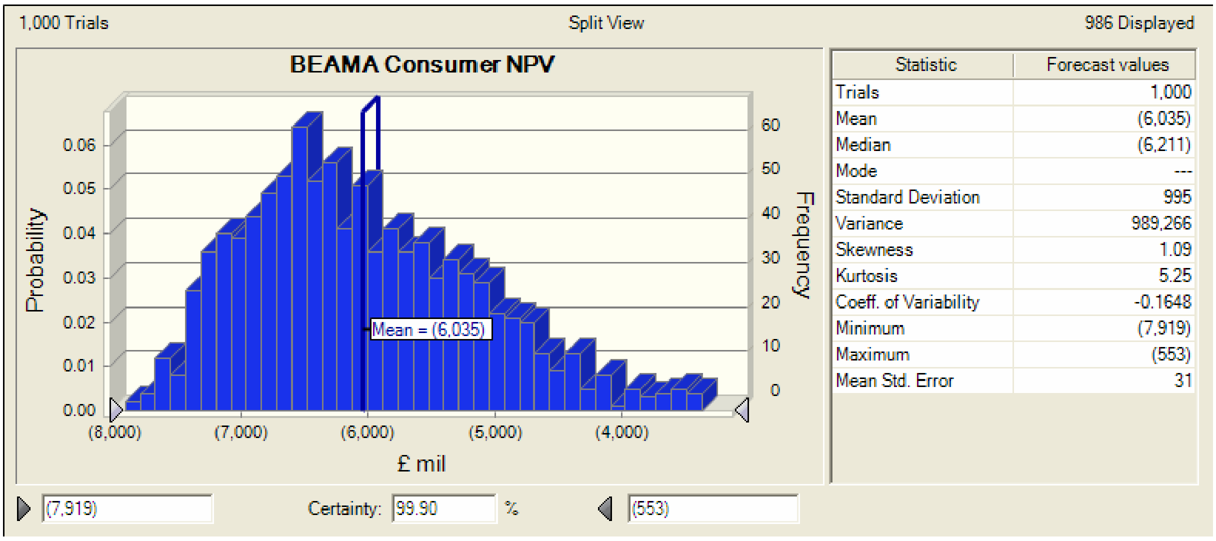
Statistic	Forecast values
Trials	1,000
Mean	(6,184)
Median	(6,360)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1608
Minimum	(8,068)
Maximum	(702)
Mean Std. Error	31

B.xxvi BEAMA - Market Tip and Hybrid 1



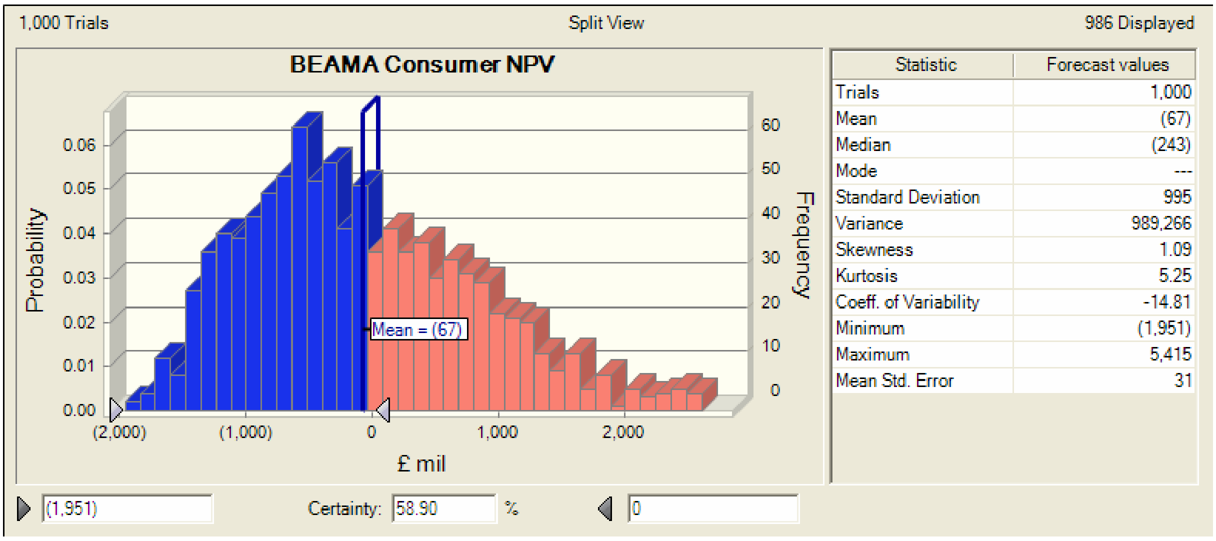
Statistic	Forecast values
Trials	1,000
Mean	(8,978)
Median	(9,154)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1108
Minimum	(10,862)
Maximum	(3,496)
Mean Std. Error	31

B.xxvii BEAMA - Market Tip and Hybrid 2



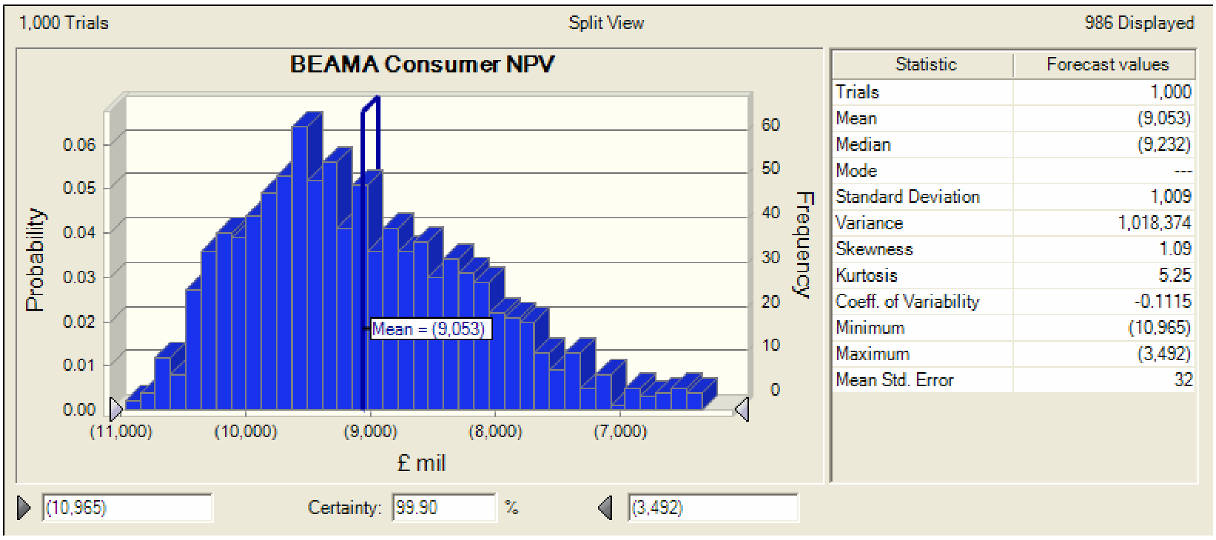
Statistic	Forecast values
Trials	1,000
Mean	(6,035)
Median	(6,211)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1648
Minimum	(7,919)
Maximum	(553)
Mean Std. Error	31

B.xxviii BEAMA - Market Tip without comms

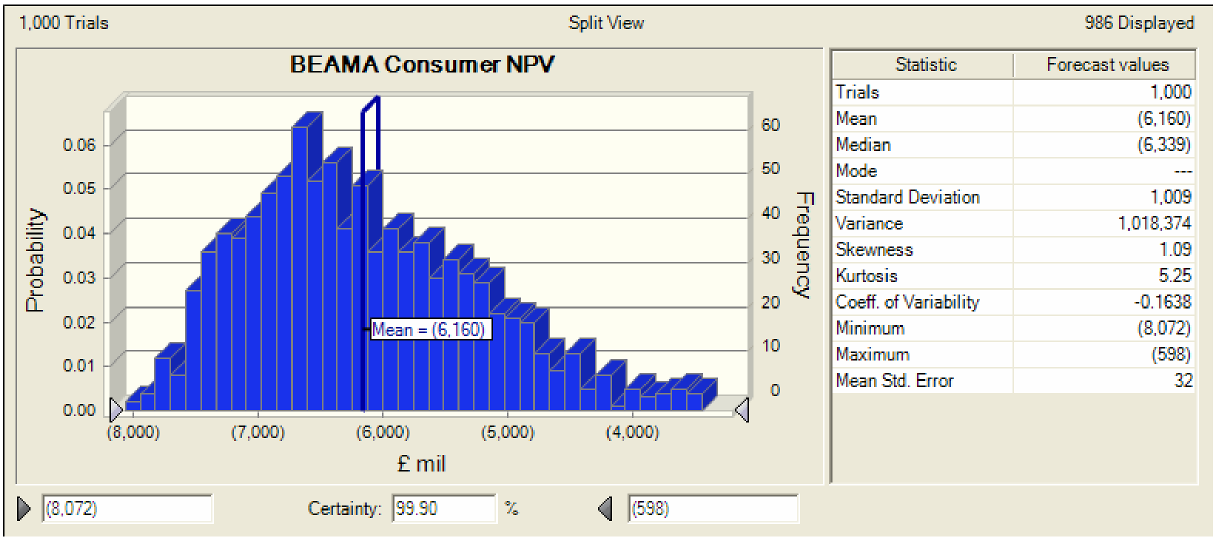


Statistic	Forecast values
Trials	1,000
Mean	(67)
Median	(243)
Mode	---
Standard Deviation	995
Variance	989,266
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-14.81
Minimum	(1,951)
Maximum	5,415
Mean Std. Error	31

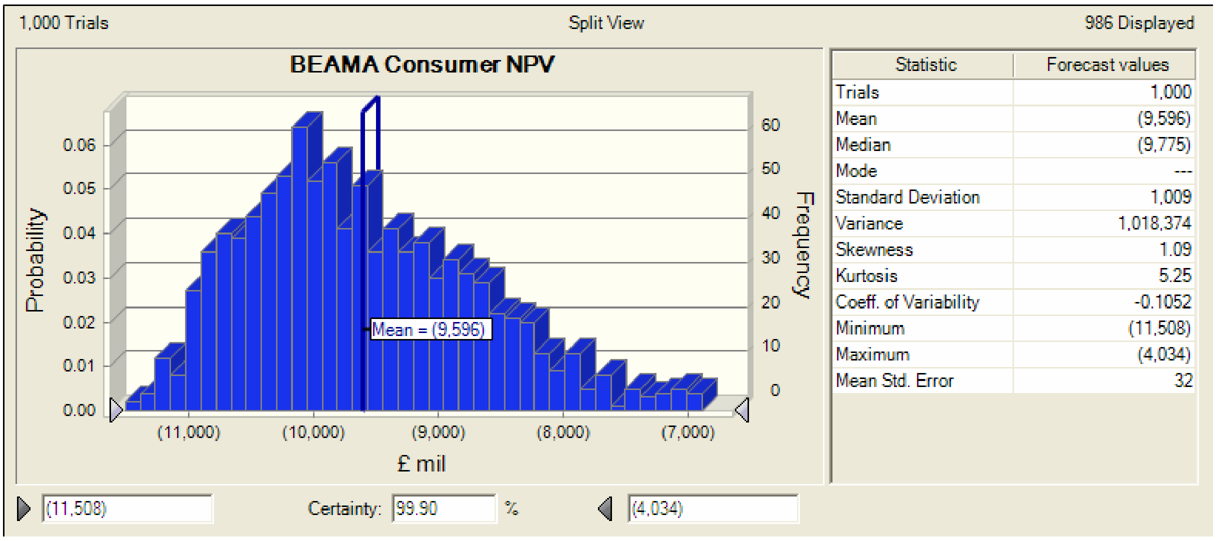
B.xxix BEAMA – Market Tip Fast and PLC



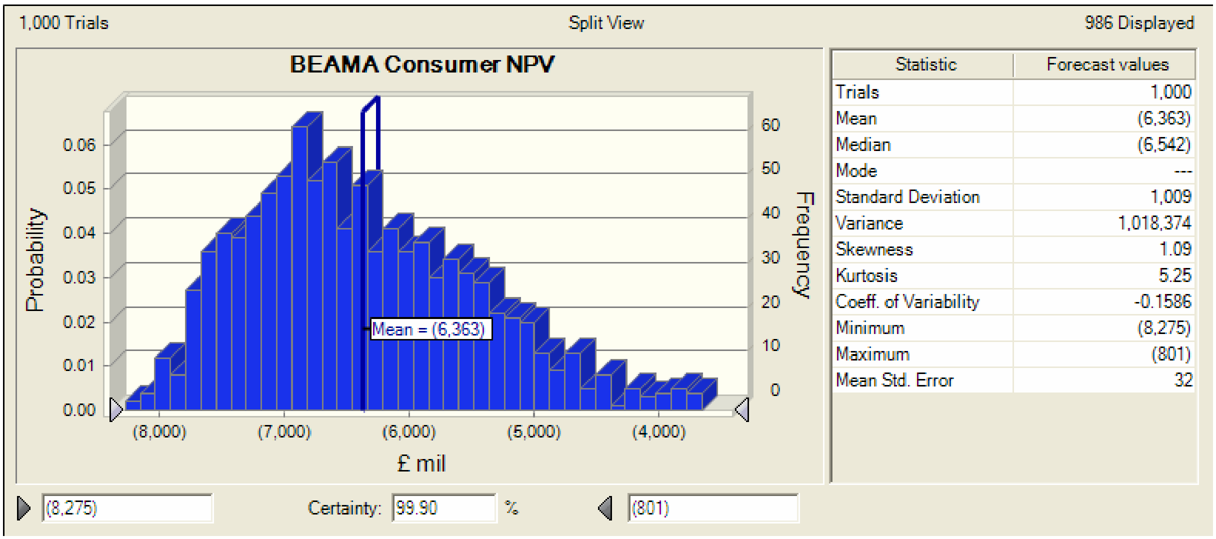
B.xxx BEAMA – Market Tip Fast and Broadband



B.xxxi BEAMA - Market Tip Fast and WiMax

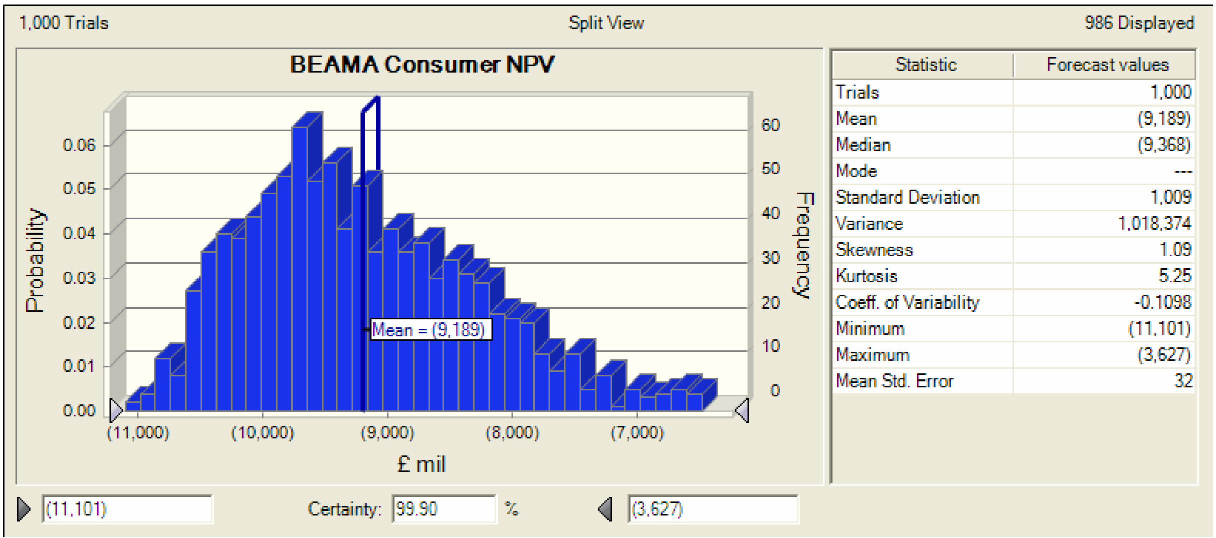


B.xxxii BEAMA - Market Tip Fast and 3G



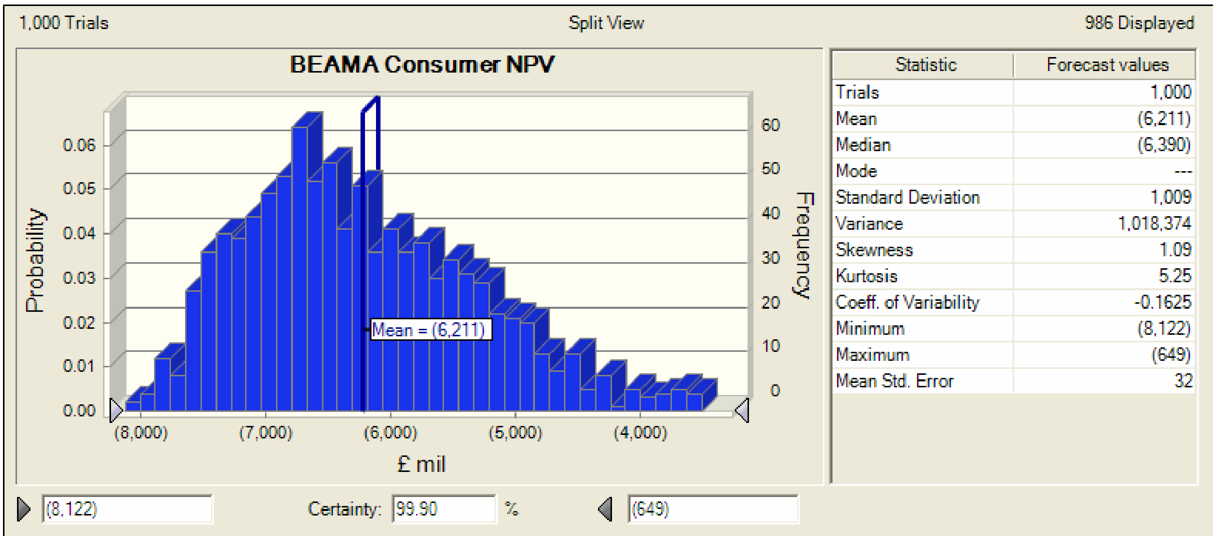
Statistic	Forecast values
Trials	1,000
Mean	(6,363)
Median	(6,542)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1586
Minimum	(8,275)
Maximum	(801)
Mean Std. Error	32

B.xxxiii BEAMA - Market Tip Fast and Hybrid 1



Statistic	Forecast values
Trials	1,000
Mean	(9,189)
Median	(9,368)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1098
Minimum	(11,101)
Maximum	(3,627)
Mean Std. Error	32

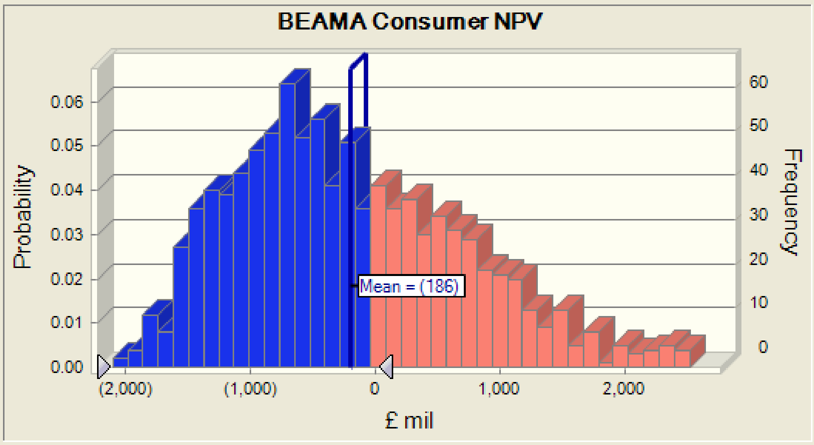
B.xxxiv BEAMA - Market Tip Fast and Hybrid 2



Statistic	Forecast values
Trials	1,000
Mean	(6,211)
Median	(6,390)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1625
Minimum	(8,122)
Maximum	(649)
Mean Std. Error	32

B.xxxv BEAMA - Market Tip Fast without comms

1,000 Trials | Split View | 986 Displayed



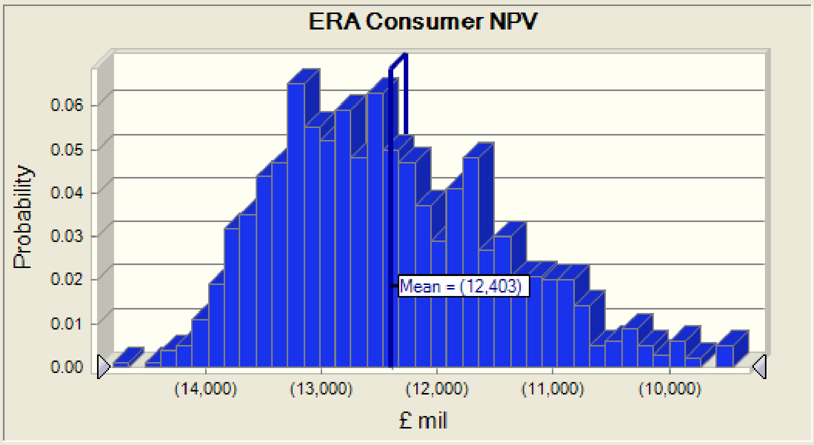
Statistic	Forecast values
Trials	1,000
Mean	(186)
Median	(365)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-5.42
Minimum	(2,098)
Maximum	5,376
Mean Std. Error	32

(2,098) Certainty: 62.61 % 0

B.2.5 ERA Specification

B.i ERA - New, Replacement and Voluntary and PLC

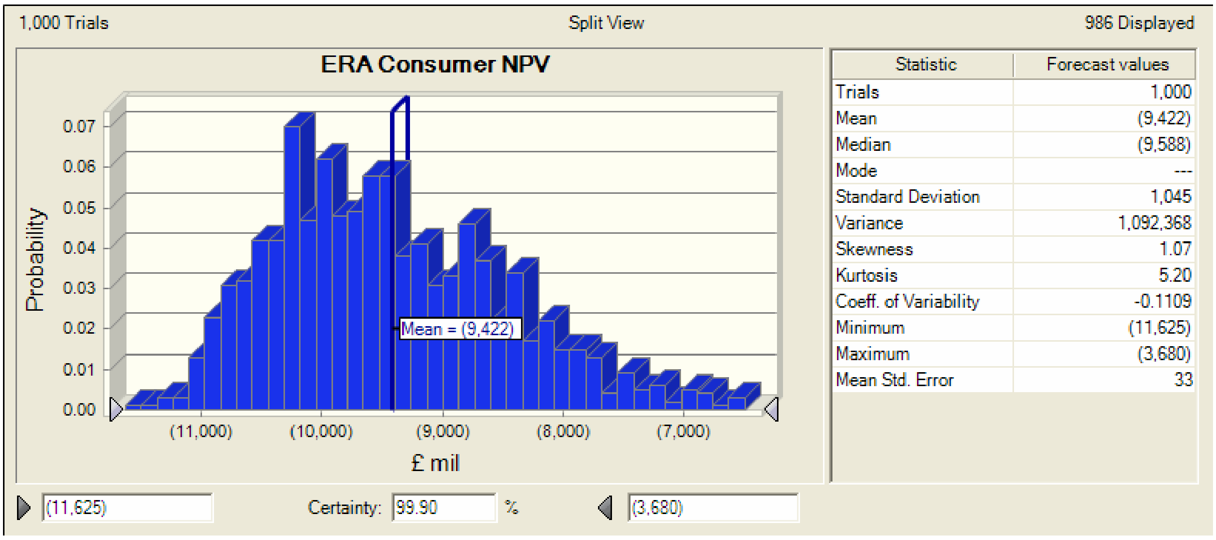
1,000 Trials | Split View | 987 Displayed



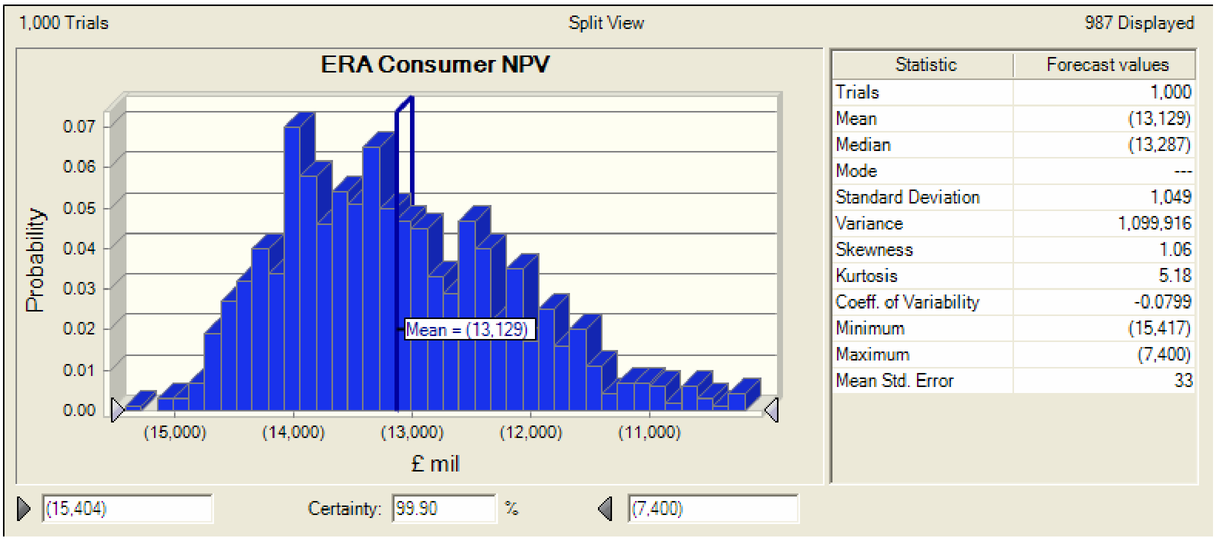
Statistic	Forecast values
Trials	1,000
Mean	(12,403)
Median	(12,563)
Mode	---
Standard Deviation	1,054
Variance	1,111,350
Skewness	1.04
Kurtosis	5.14
Coeff. of Variability	-0.0850
Minimum	(14,794)
Maximum	(6,690)
Mean Std. Error	33

(14,794) Certainty: 99.90 % (6,690)

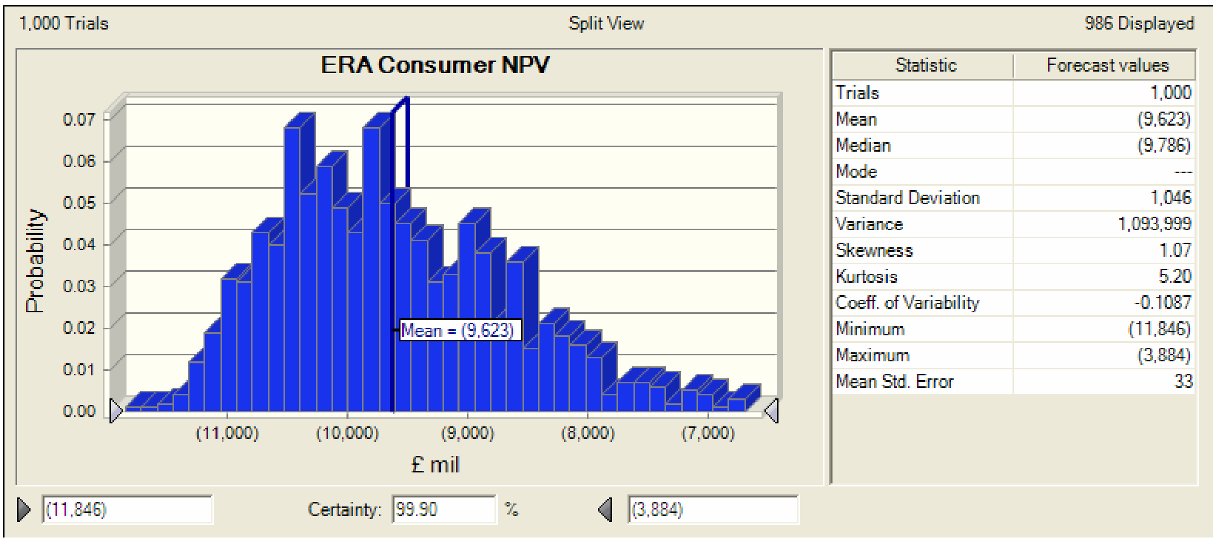
B.ii ERA - New, Replacement and Voluntary and Broadband



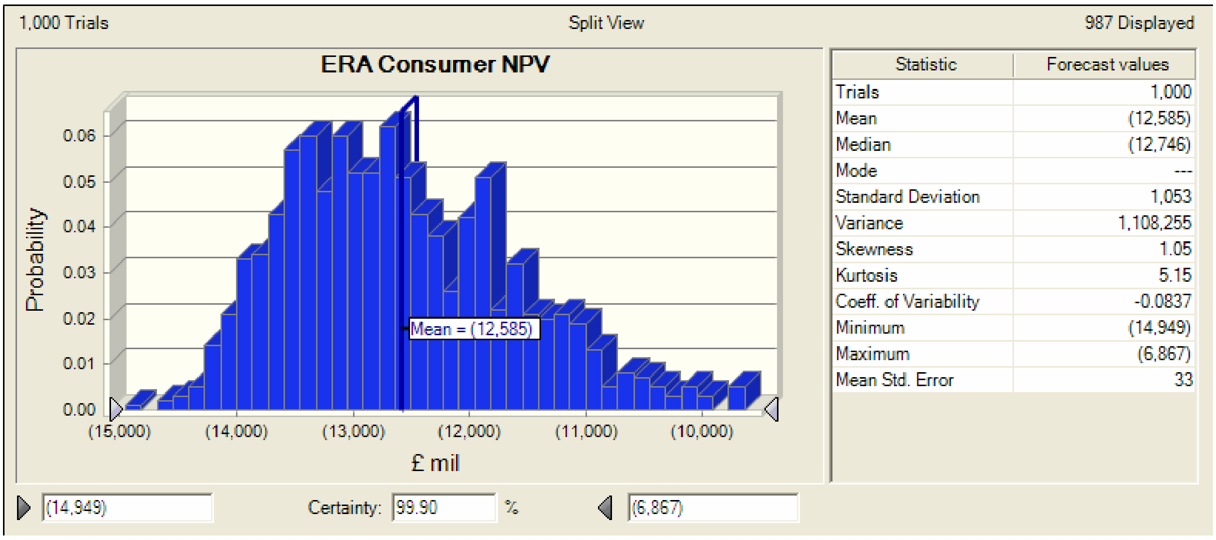
B.iii ERA - New, Replacement and Voluntary and WiMax



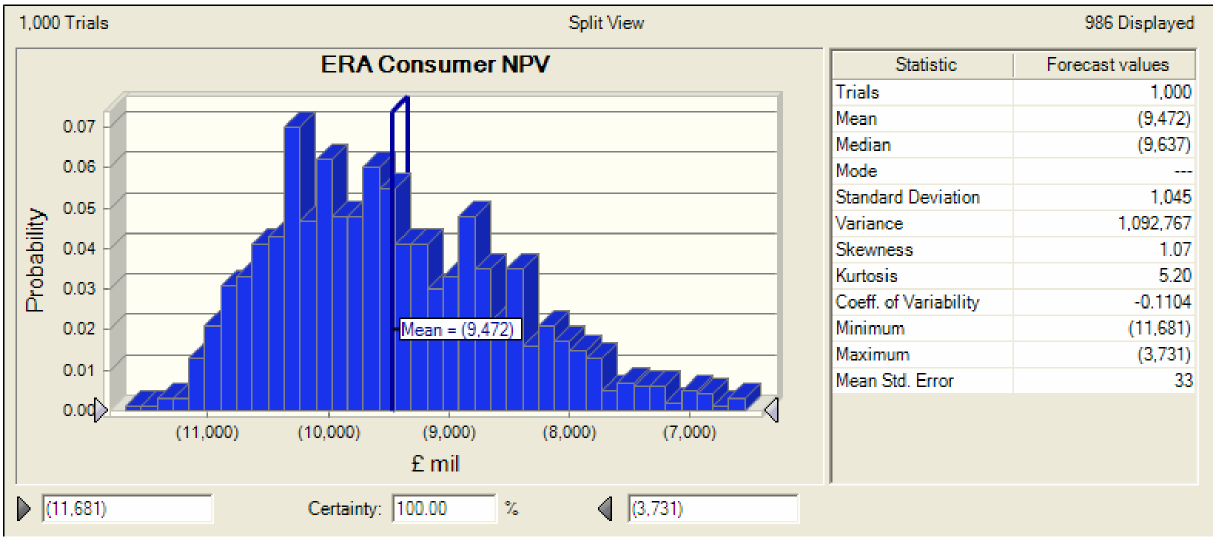
B.iv ERA - New, Replacement and Voluntary and 3G



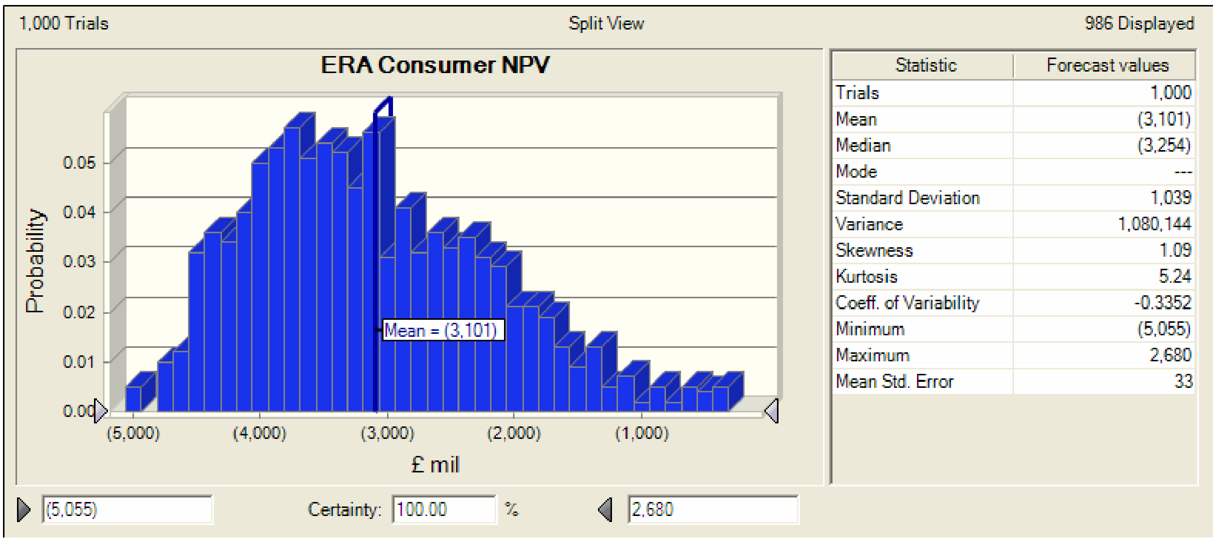
B.v ERA - New, Replacement and Voluntary and Hybrid 1



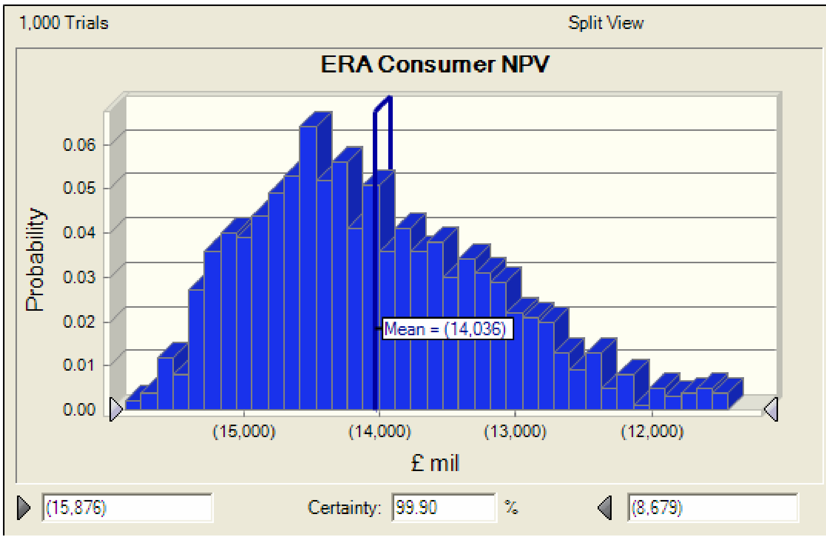
B.vi ERA - New, Replacement and Voluntary and Hybrid 2



B.vii ERA - New, Replacement and Voluntary without comms

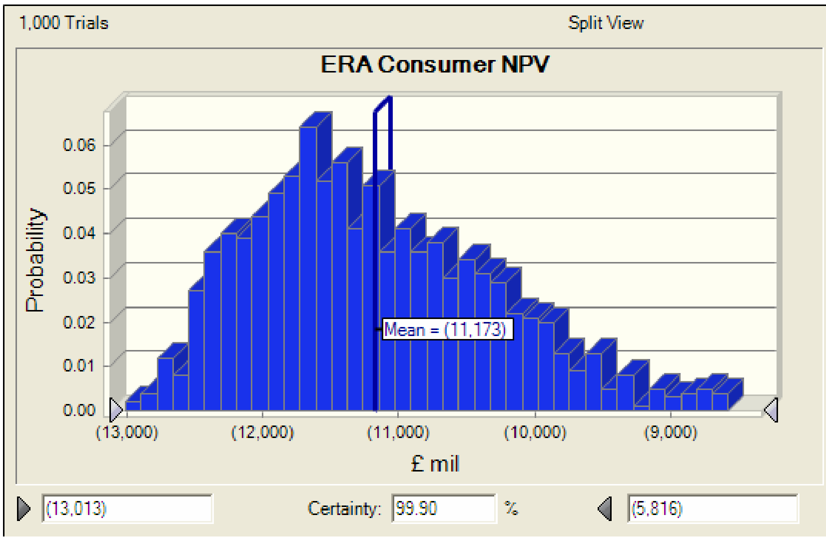


B.viii ERA – Regional Franchise and PLC



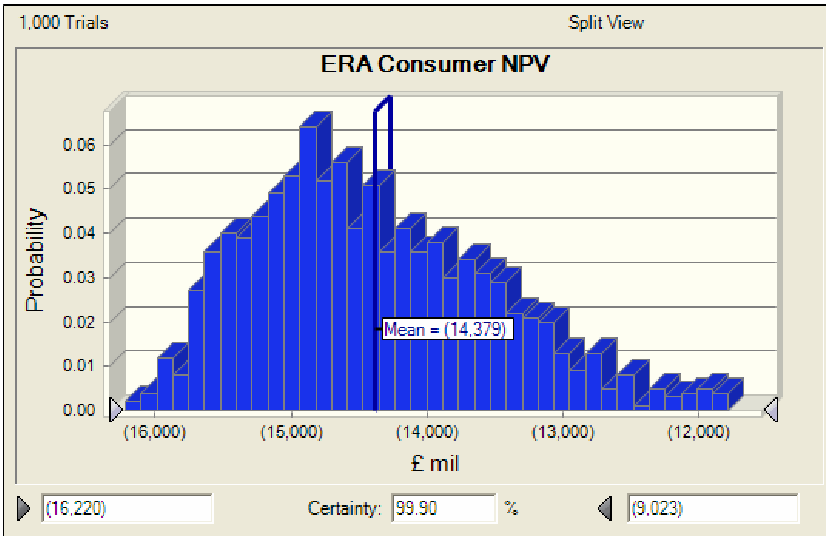
Statistic	Forecast values
Trials	1,000
Mean	(14,036)
Median	(14,208)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0692
Minimum	(15,876)
Maximum	(8,679)
Mean Std. Error	31

B.ix ERA - Regional Franchise and Broadband



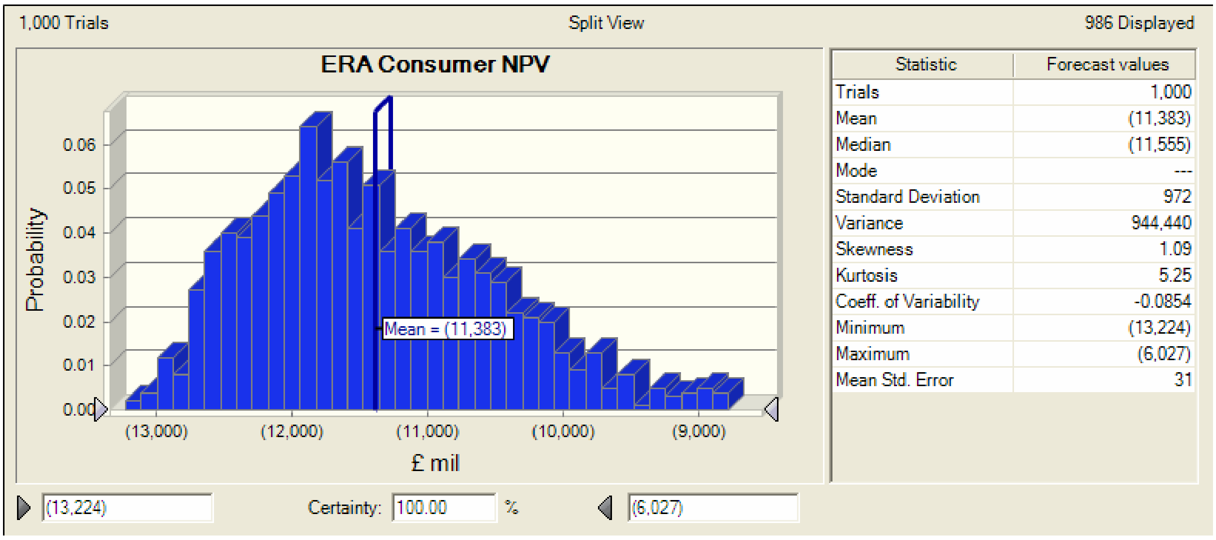
Statistic	Forecast values
Trials	1,000
Mean	(11,173)
Median	(11,345)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0870
Minimum	(13,013)
Maximum	(5,816)
Mean Std. Error	31

B.x ERA - Regional Franchise and WiMax

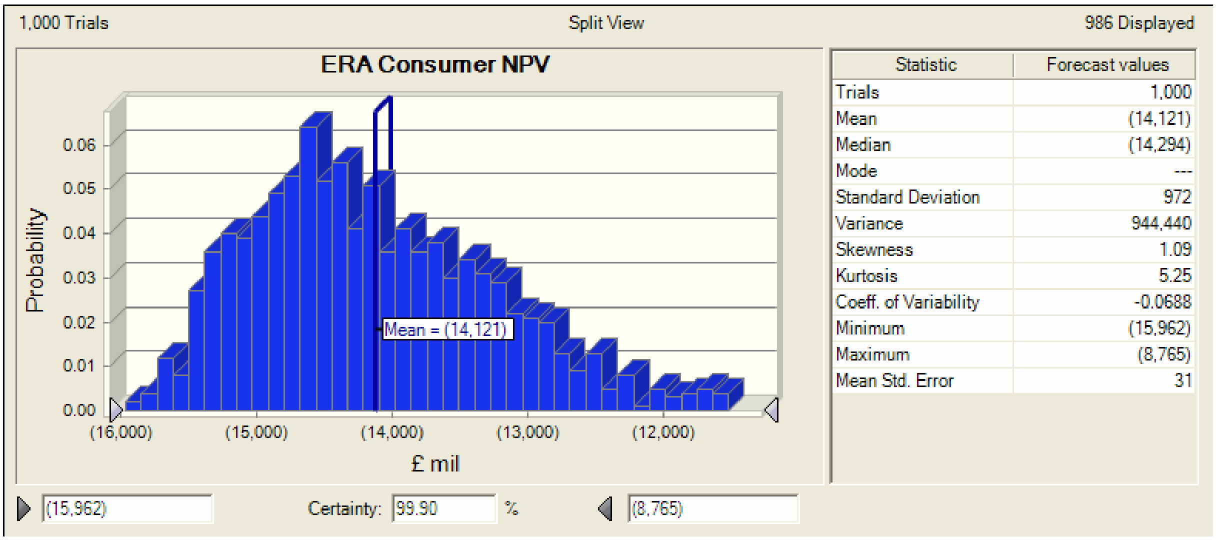


Statistic	Forecast values
Trials	1,000
Mean	(14,379)
Median	(14,551)
Mode	---
Standard Deviation	972
Variance	944,440
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0676
Minimum	(16,220)
Maximum	(9,023)
Mean Std. Error	31

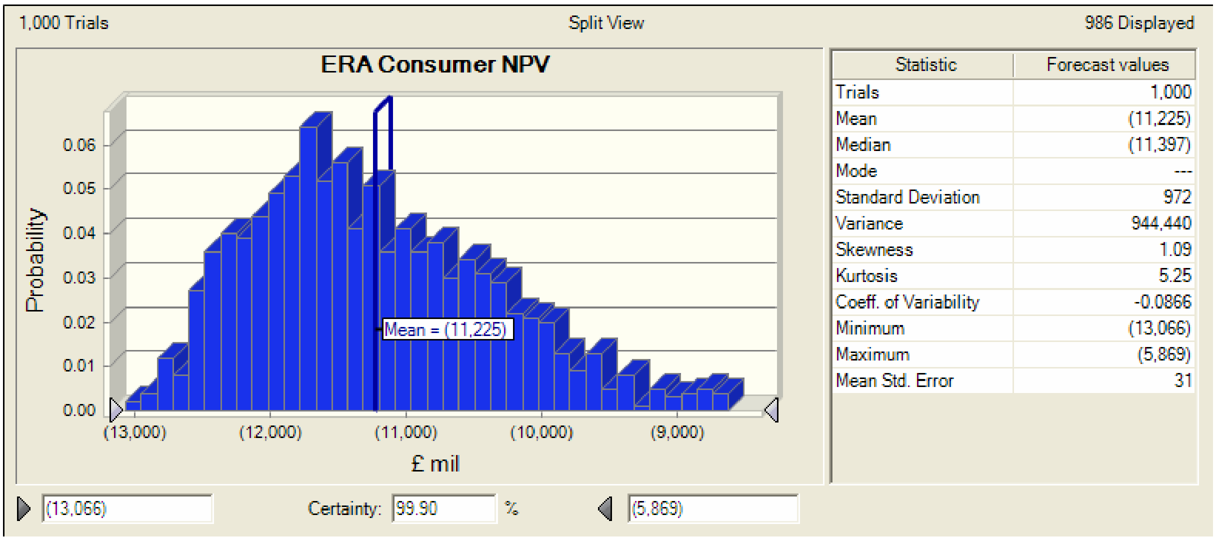
B.xi ERA - Regional Franchise and 3G



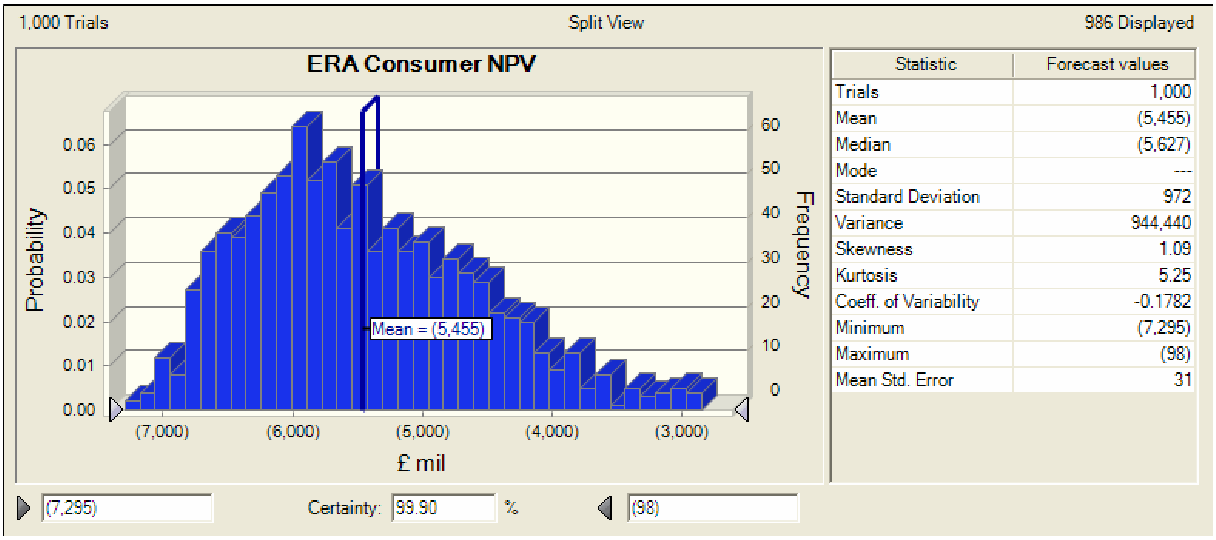
B.xii ERA - Regional Franchise and Hybrid 1



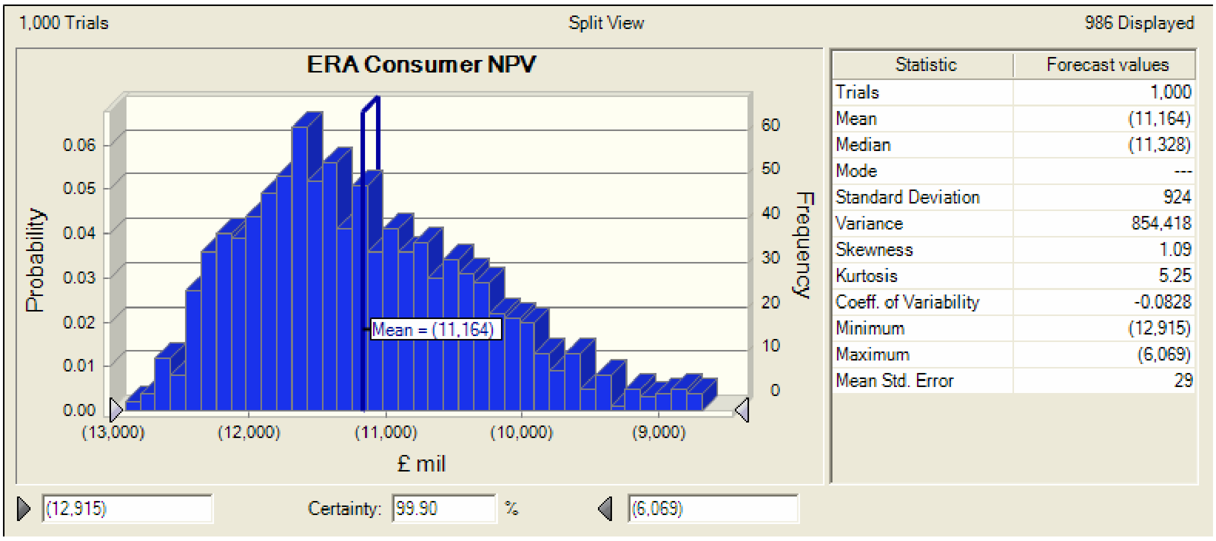
B.xiii ERA - Regional Franchise and Hybrid 2



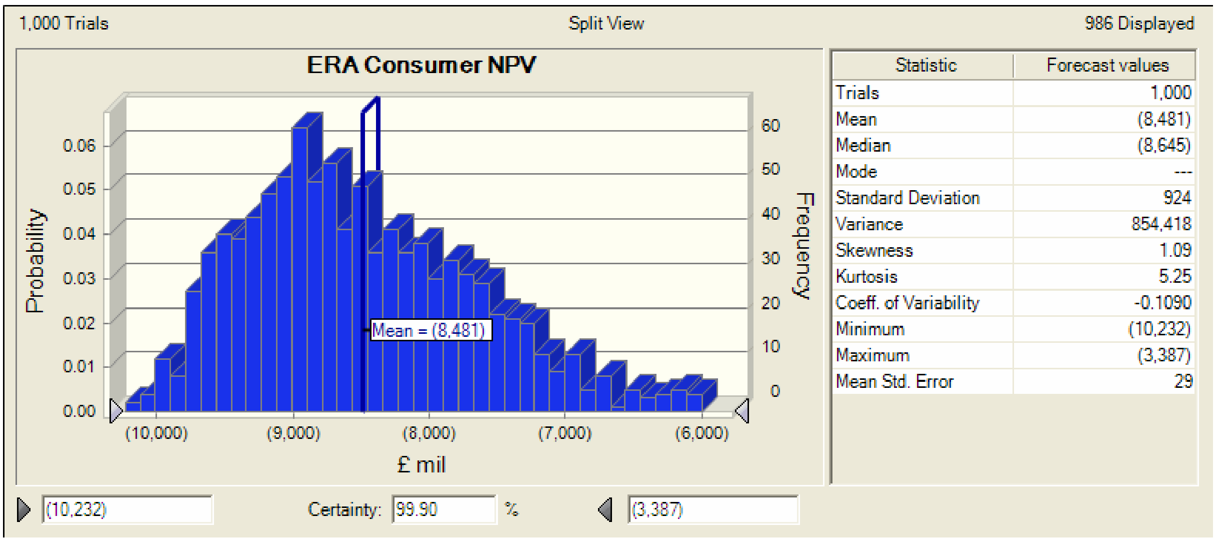
B.xiv ERA - Regional Franchise without comms



B.xv ERA – Market and PLC

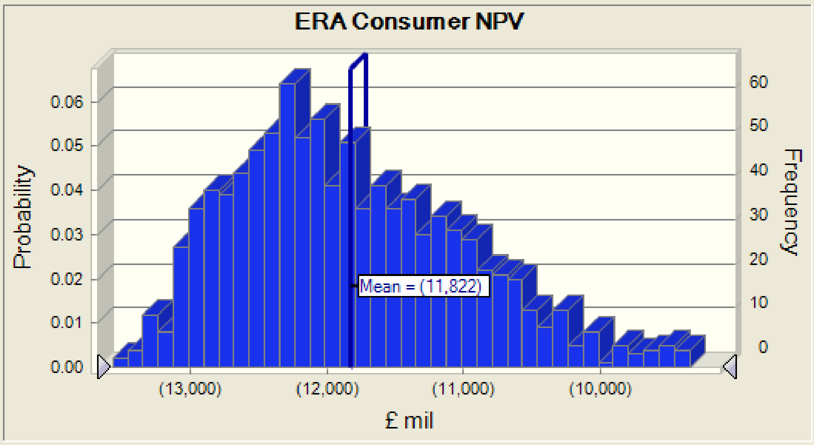


B.xvi ERA - Market and Broadband



B.xvii ERA - Market and WiMax

1,000 Trials Split View 986 Displayed

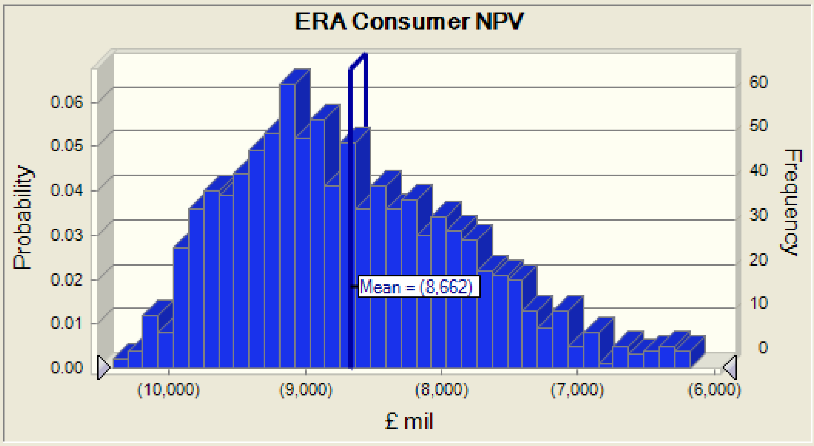


Statistic	Forecast values
Trials	1,000
Mean	(11,822)
Median	(11,986)
Mode	---
Standard Deviation	924
Variance	854,418
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0782
Minimum	(13,573)
Maximum	(6,727)
Mean Std. Error	29

(13,573) Certainty: 99.90 % (6,727)

B.xviii ERA - Market and 3G

1,000 Trials Split View 986 Displayed

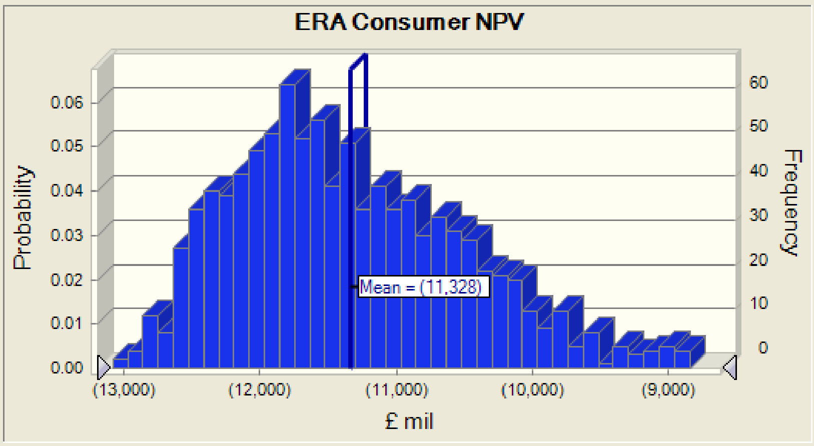


Statistic	Forecast values
Trials	1,000
Mean	(8,662)
Median	(8,825)
Mode	---
Standard Deviation	924
Variance	854,418
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1067
Minimum	(10,412)
Maximum	(3,567)
Mean Std. Error	29

(10,412) Certainty: 99.90 % (3,567)

B.xix ERA - Market and Hybrid 1

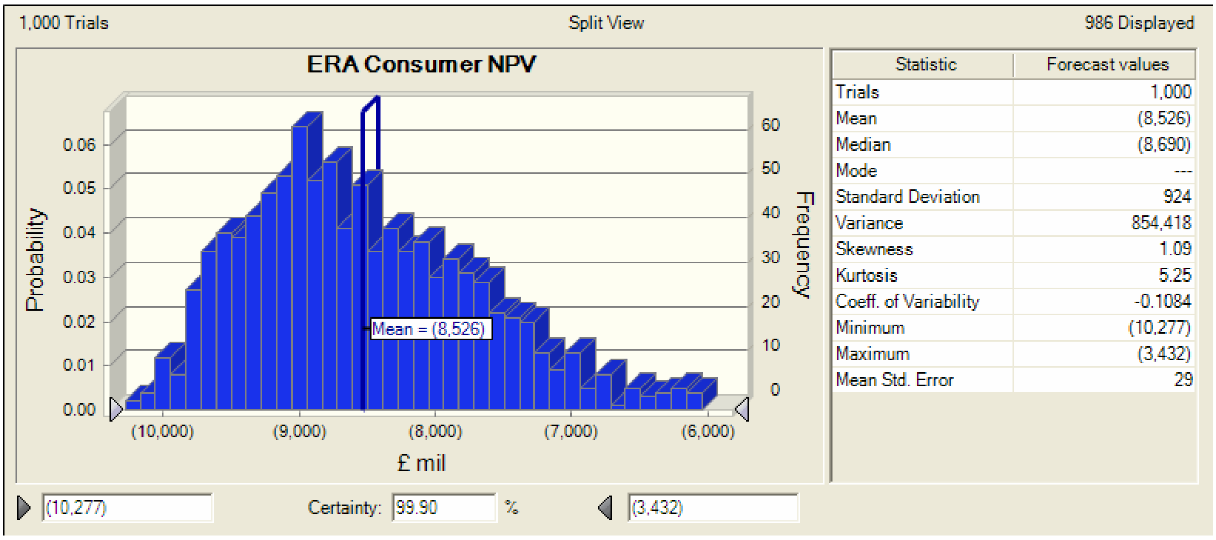
1,000 Trials Split View 986 Displayed



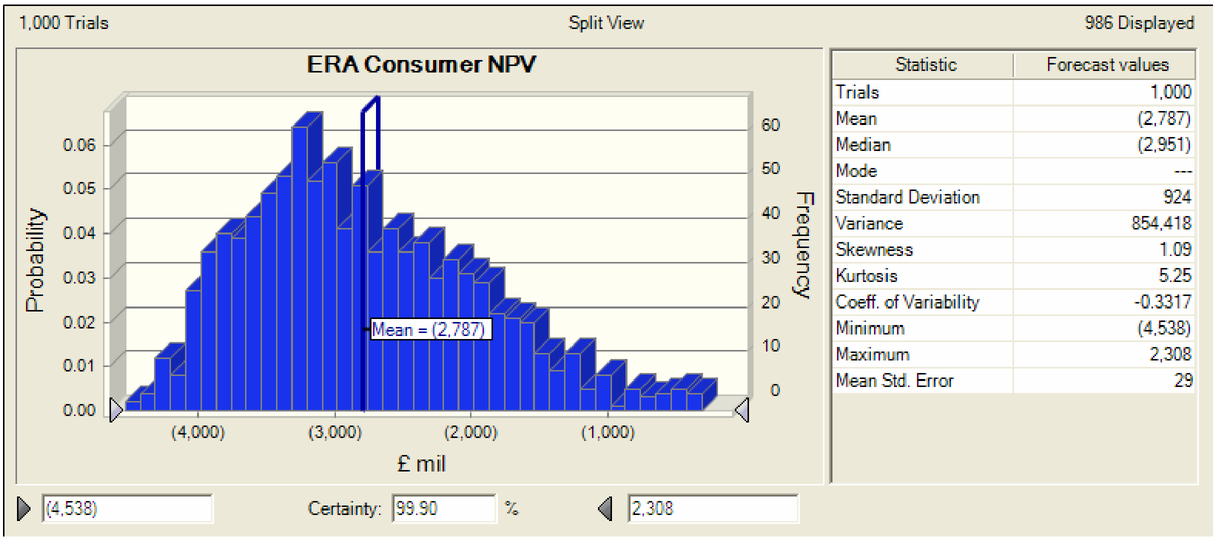
Statistic	Forecast values
Trials	1,000
Mean	(11,328)
Median	(11,492)
Mode	---
Standard Deviation	924
Variance	854,418
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0816
Minimum	(13,079)
Maximum	(6,234)
Mean Std. Error	29

(13,079) Certainty: 99.90 % (6,234)

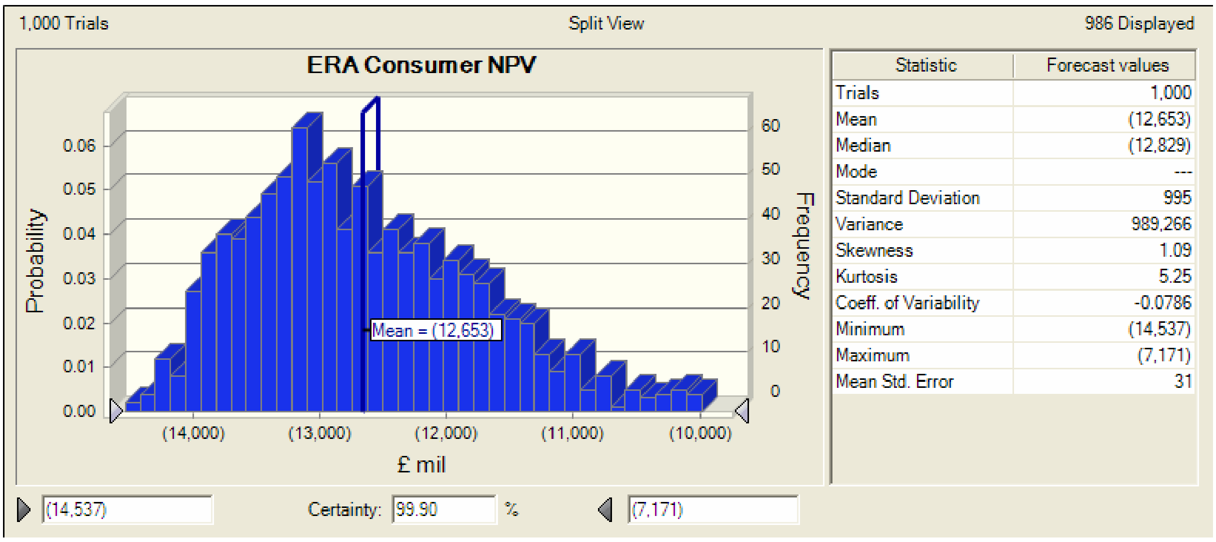
B.xx ERA - Market and Hybrid 2



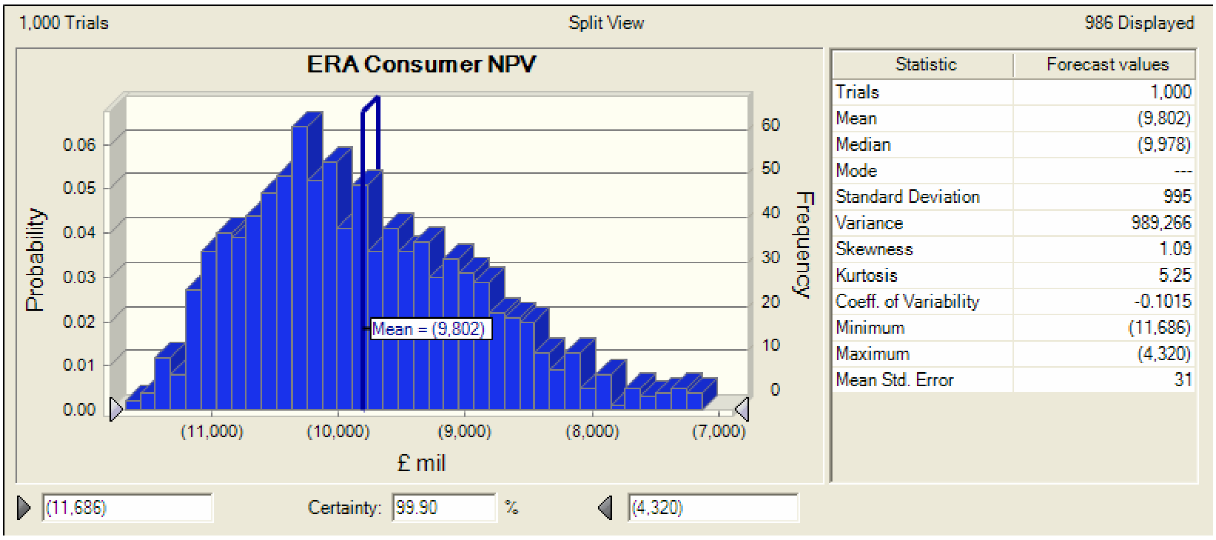
B.xxi ERA - Market without comms



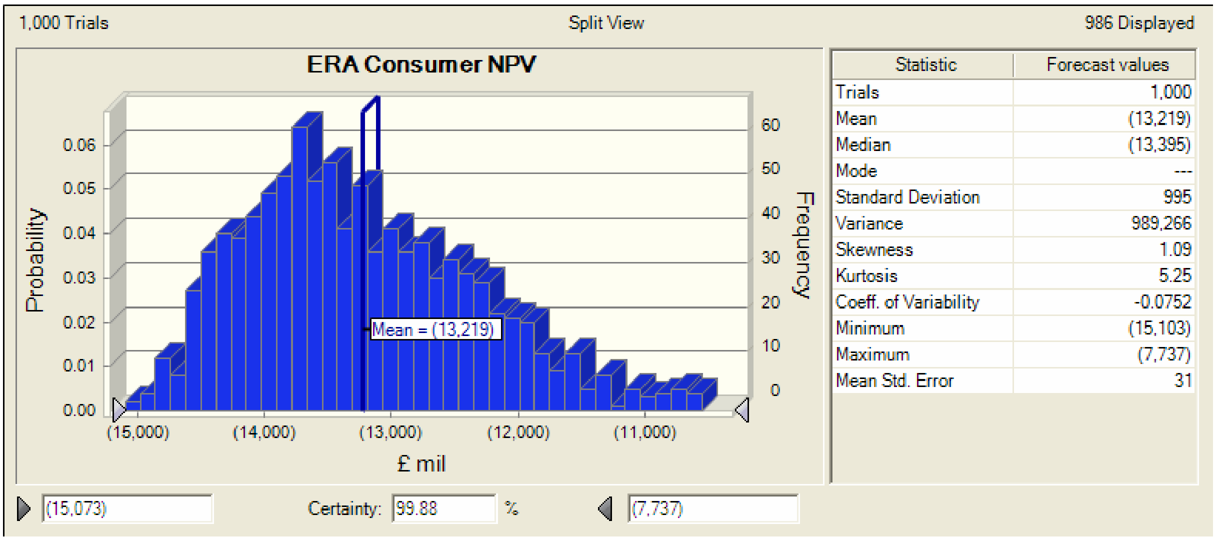
B.xxii ERA – Market Tip and PLC



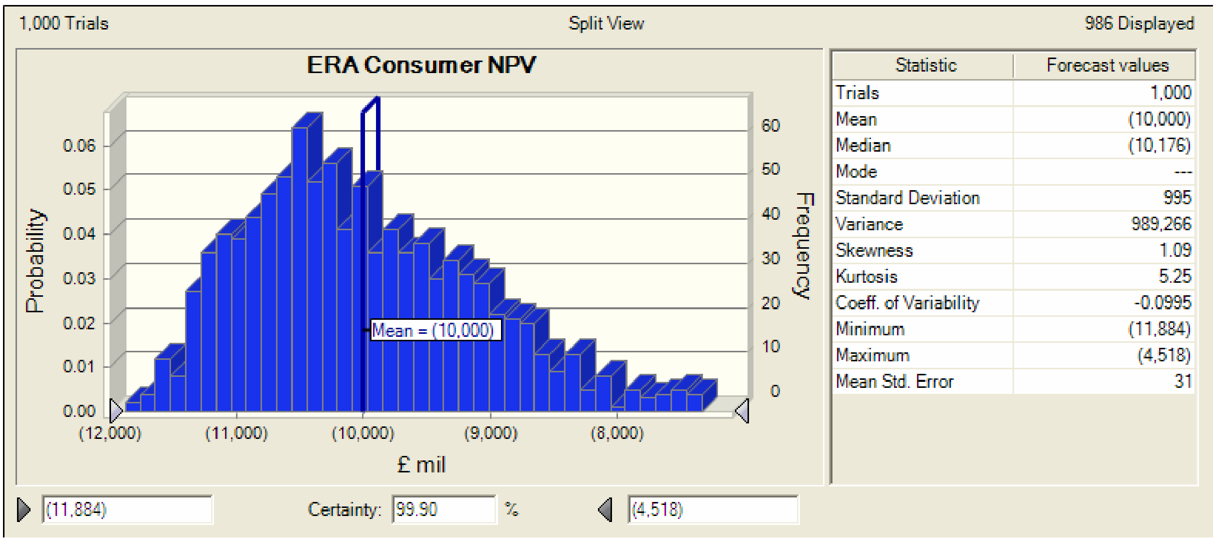
B.xxiii ERA – Market Tip and Broadband



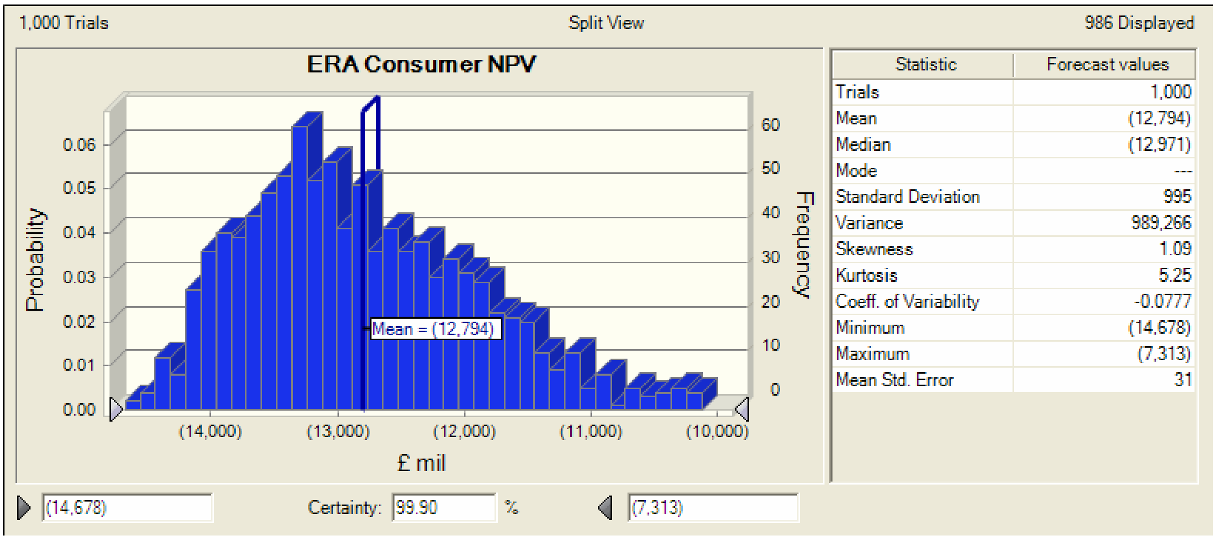
B.xxiv ERA - Market Tip and WiMax



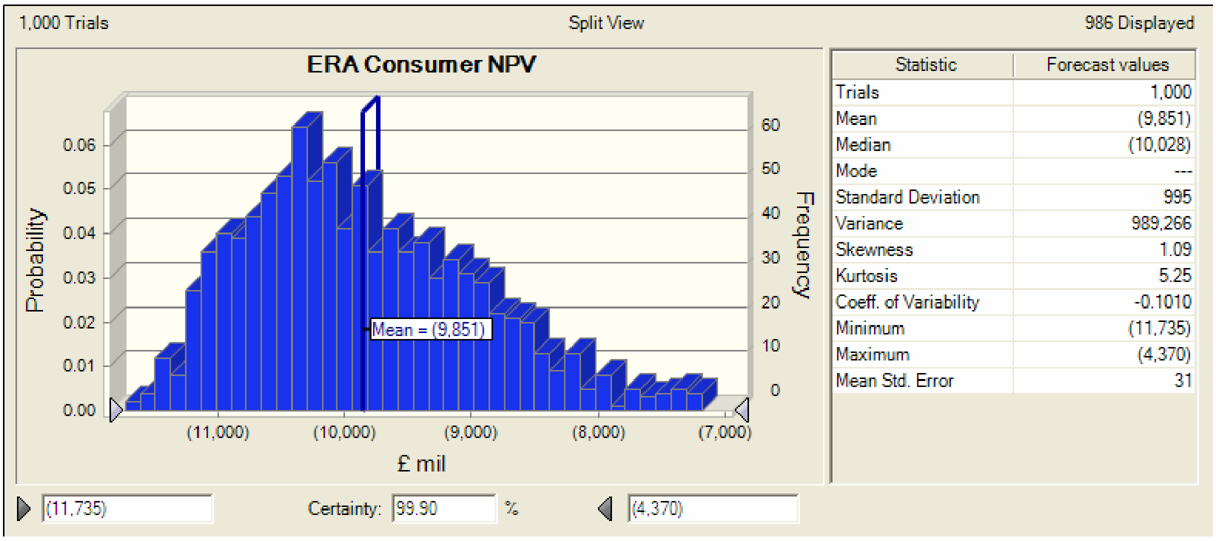
B.xxv ERA - Market Tip and 3G



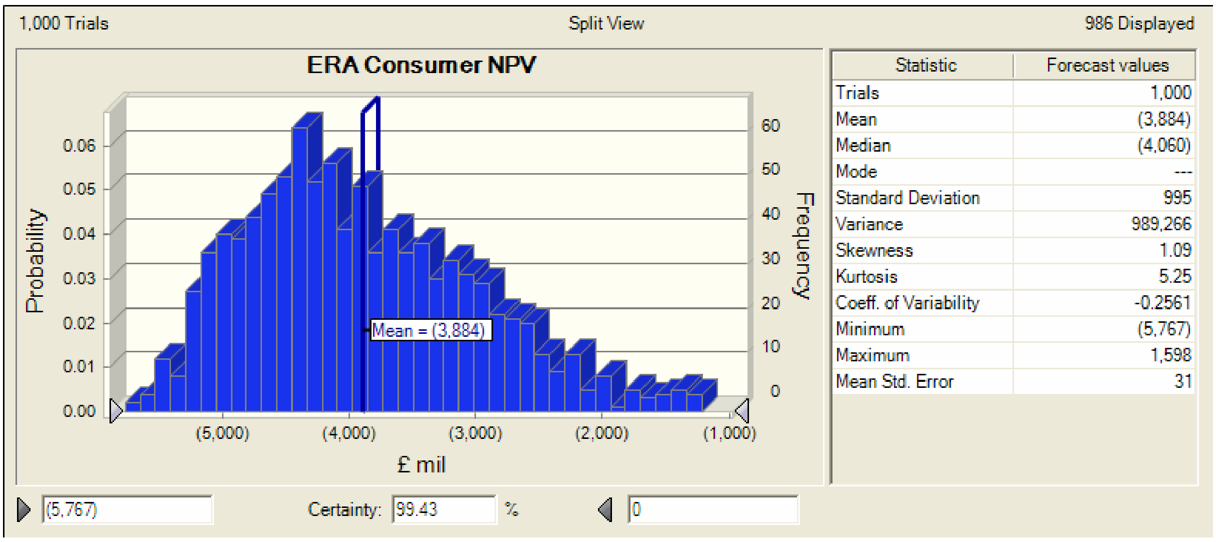
B.xxvi ERA - Market Tip and Hybrid 1



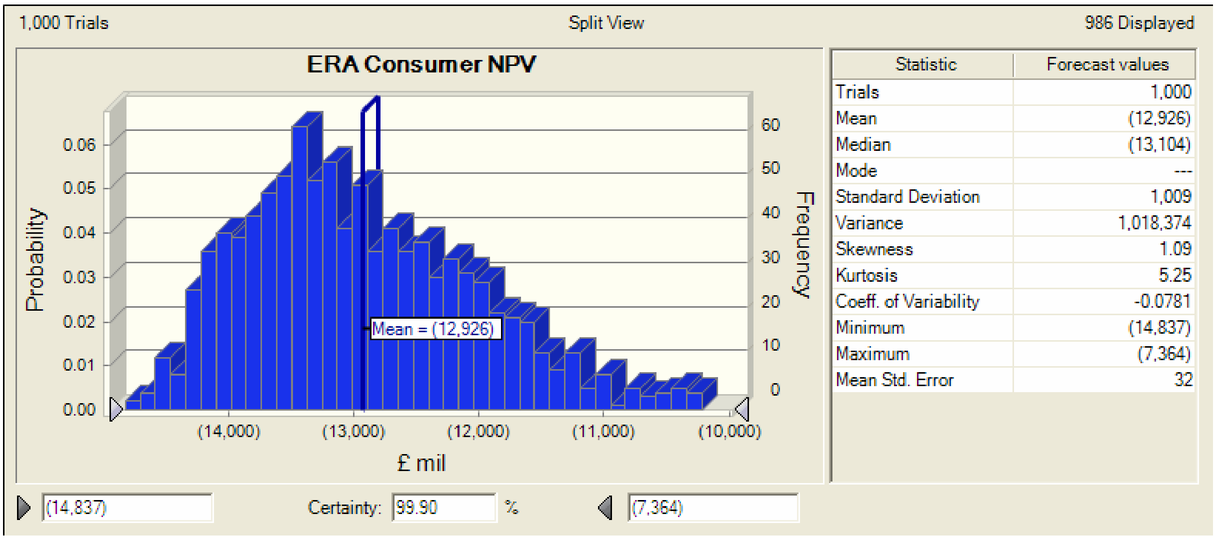
B.xxvii ERA - Market Tip and Hybrid 2



B.xxviii ERA - Market Tip without comms

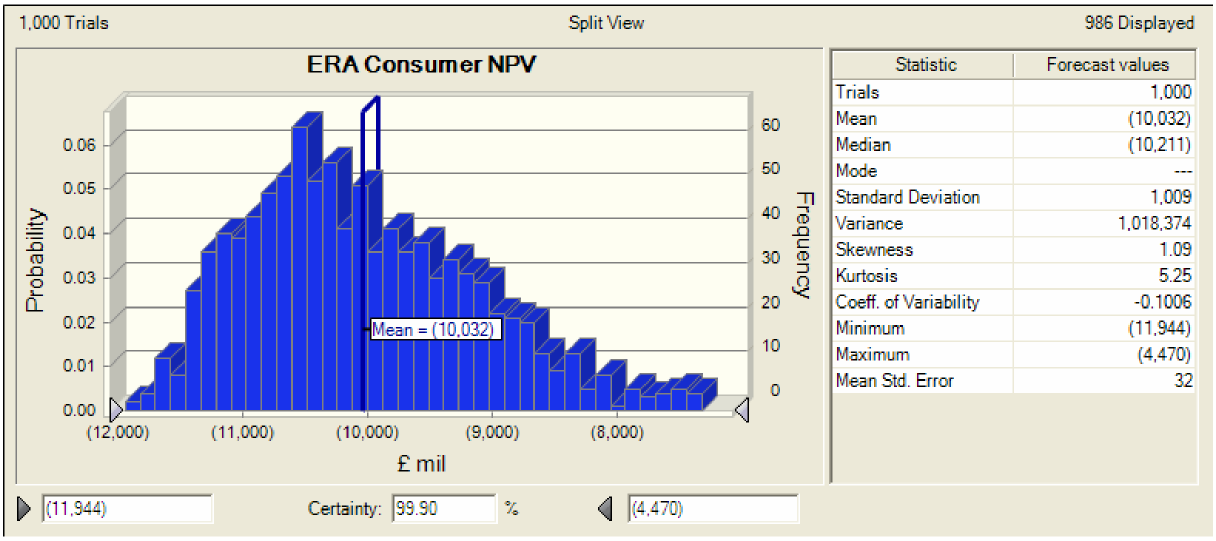


B.xxix ERA – Market Tip Fast and PLC



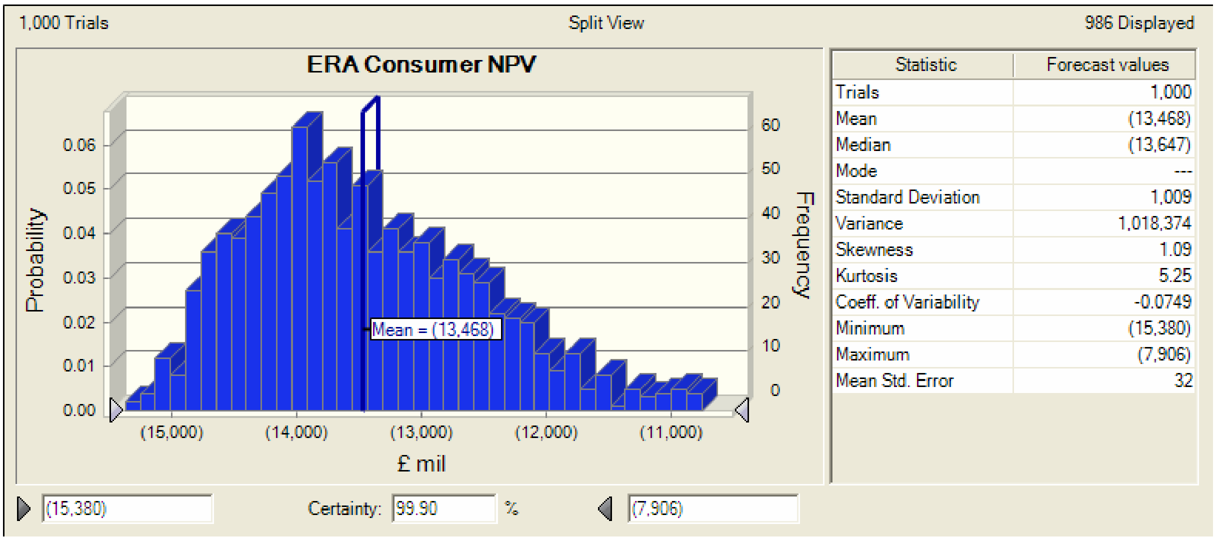
Statistic	Forecast values
Trials	1,000
Mean	(12,926)
Median	(13,104)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0781
Minimum	(14,837)
Maximum	(7,364)
Mean Std. Error	32

B.xxx ERA – Market Tip Fast and Broadband



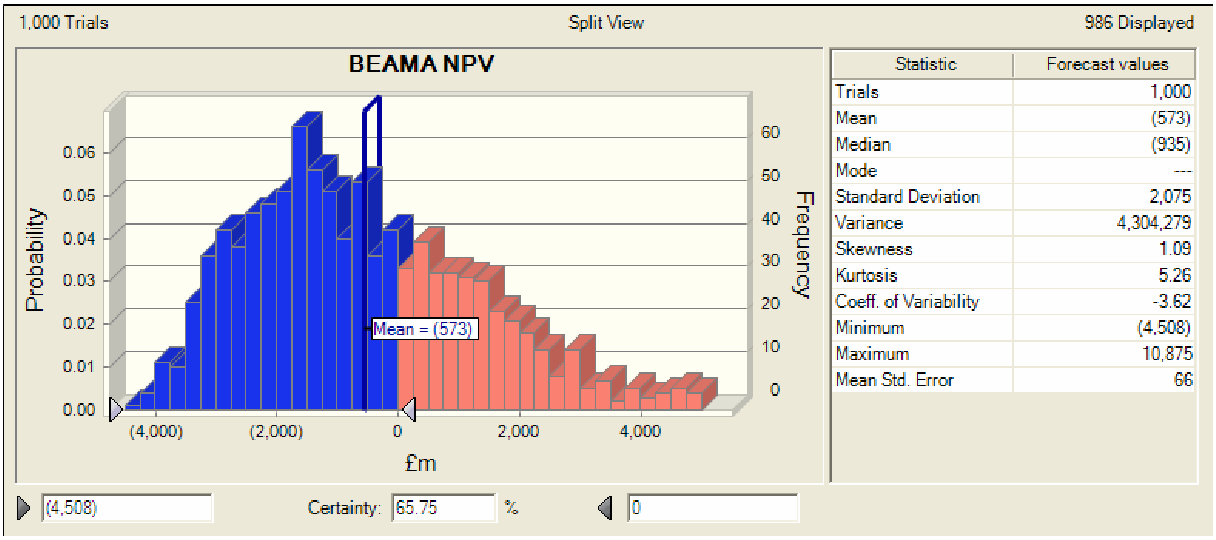
Statistic	Forecast values
Trials	1,000
Mean	(10,032)
Median	(10,211)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.1006
Minimum	(11,944)
Maximum	(4,470)
Mean Std. Error	32

B.xxxi ERA - Market Tip Fast and WiMax

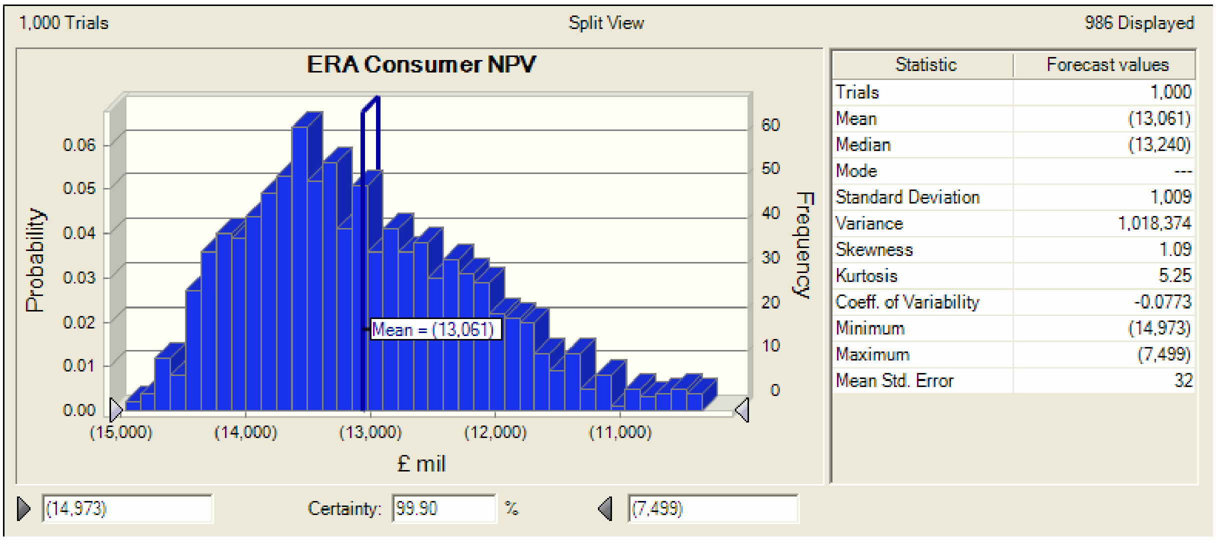


Statistic	Forecast values
Trials	1,000
Mean	(13,468)
Median	(13,647)
Mode	---
Standard Deviation	1,009
Variance	1,018,374
Skewness	1.09
Kurtosis	5.25
Coeff. of Variability	-0.0749
Minimum	(15,380)
Maximum	(7,906)
Mean Std. Error	32

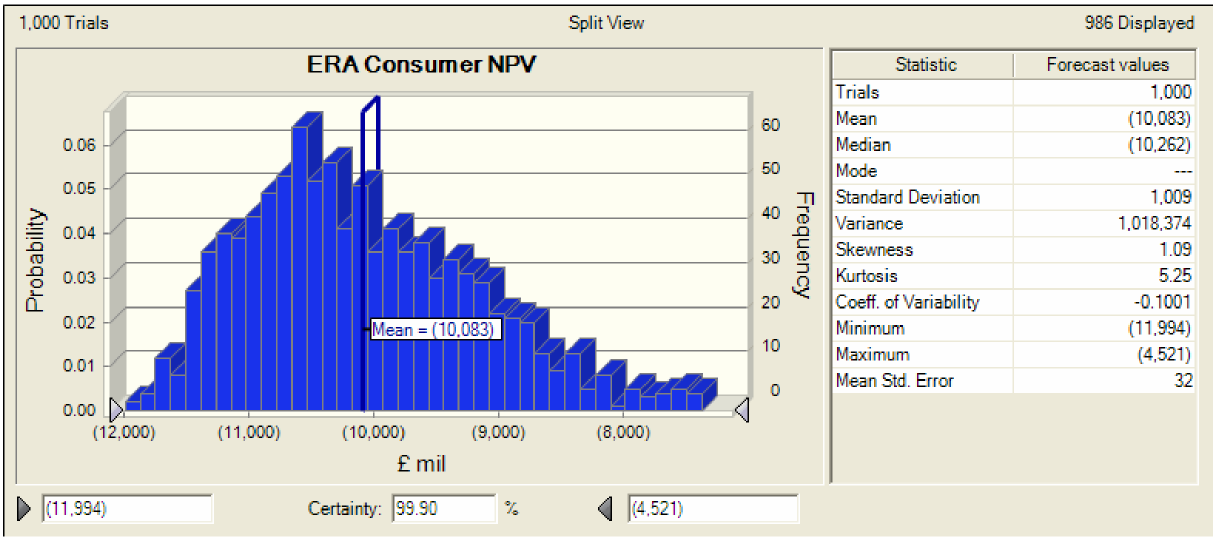
B.xxxii ERA - Market Tip Fast and 3G



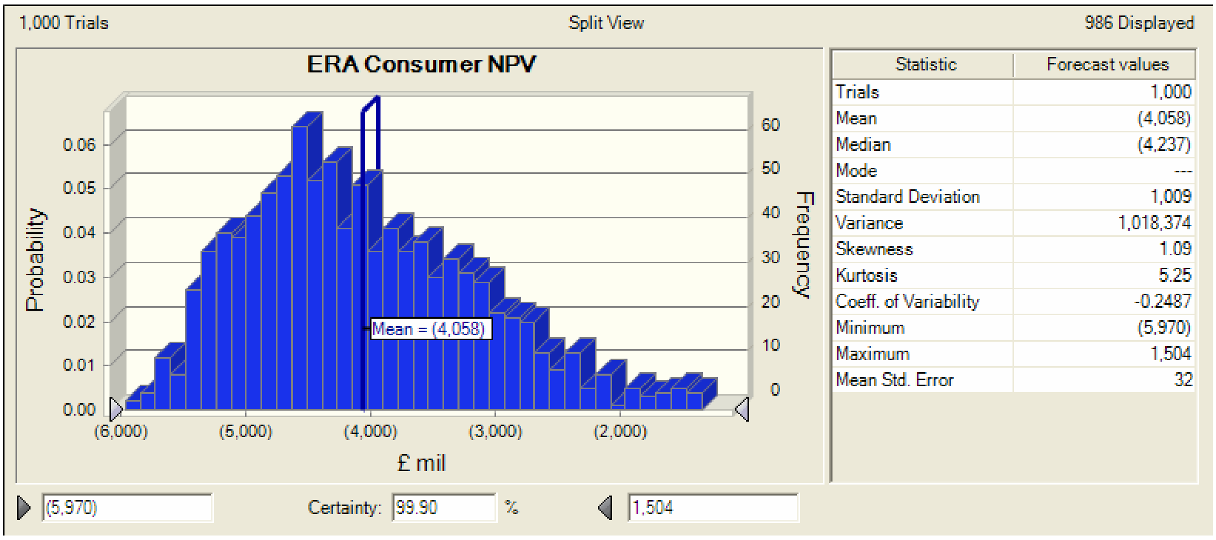
B.xxxiii ERA - Market Tip Fast and Hybrid 1



B.xxxiv ERA - Market Tip Fast and Hybrid 2

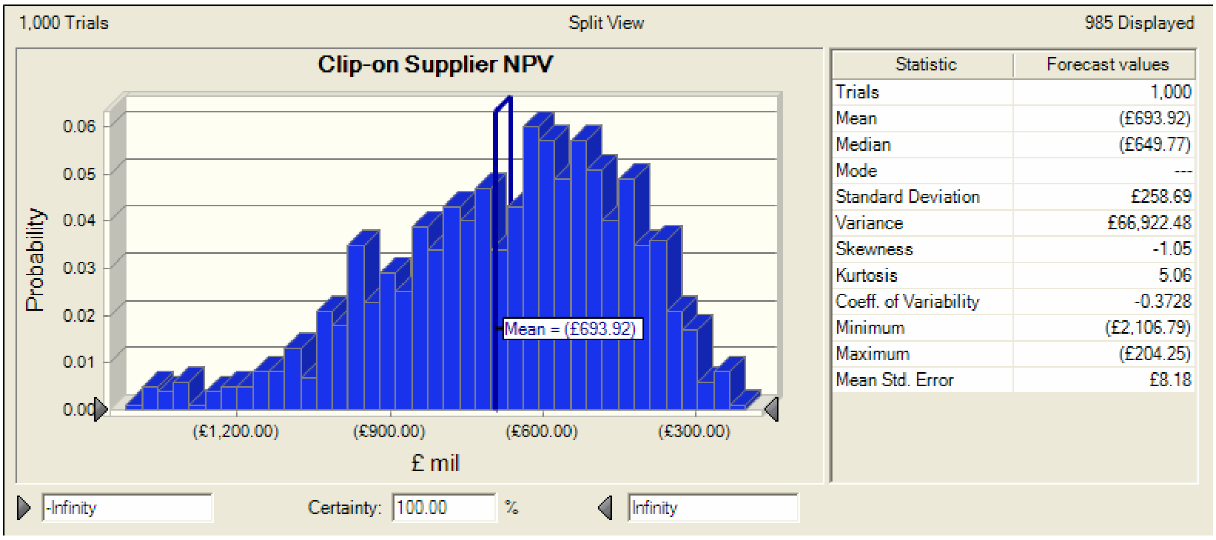


B.xxxv ERA - Market Tip Fast without comms



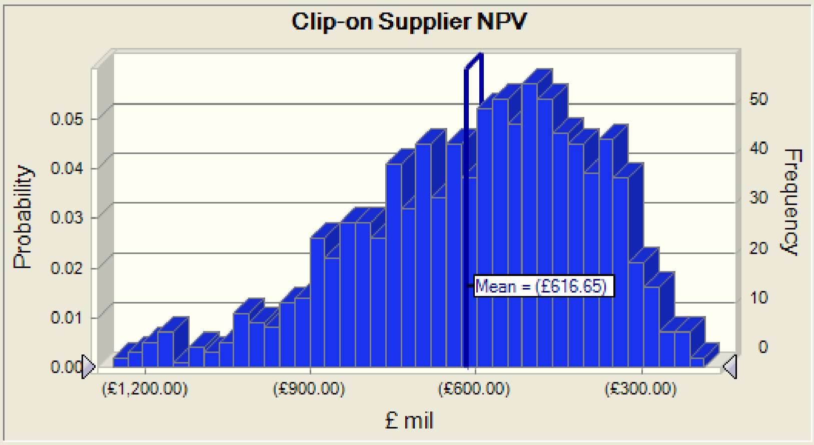
B.3 Suppliers

B.i Clip-Ons – New, Replacement and Voluntary



B.ii Clip-Ons – Market

1,000 Trials | Split View | 986 Displayed

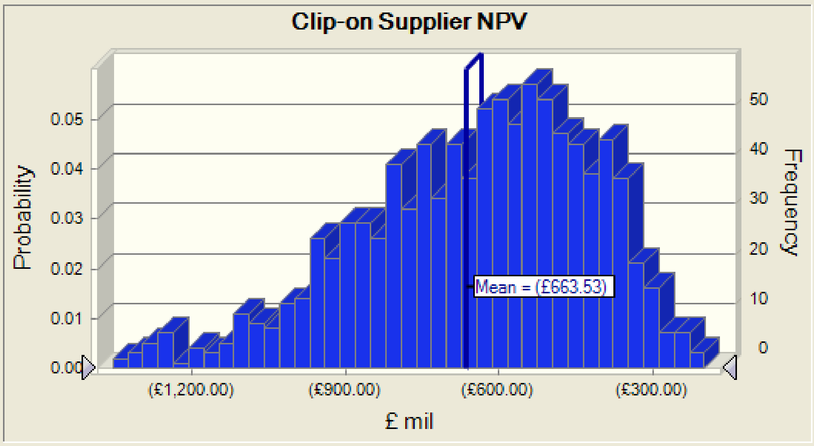


Statistic	Forecast values
Trials	1,000
Mean	(£616.65)
Median	(£577.38)
Mode	---
Standard Deviation	£229.37
Variance	£52,612.47
Skewness	-1.07
Kurtosis	5.14
Coeff. of Variability	-0.3720
Minimum	(£1,849.39)
Maximum	(£185.91)
Mean Std. Error	£7.25

(£1,849.00) Certainty: 99.90 % (£185.00)

B.iii Clip-Ons – Market Tip

1,000 Trials | Split View | 987 Displayed

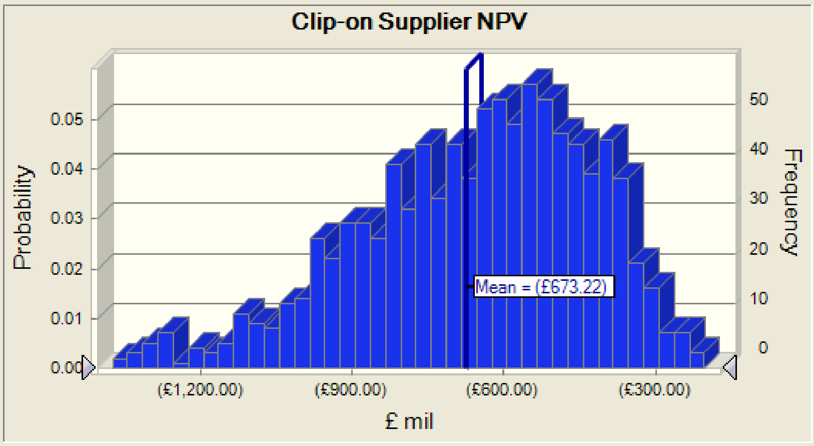


Statistic	Forecast values
Trials	1,000
Mean	(£663.53)
Median	(£621.28)
Mode	---
Standard Deviation	£246.81
Variance	£60,915.99
Skewness	-1.07
Kurtosis	5.14
Coeff. of Variability	-0.3720
Minimum	(£1,989.98)
Maximum	(£200.05)
Mean Std. Error	£7.80

(£1,989.60) Certainty: 99.90 % (£200.00)

B.iv Clip-Ons – Market Tip Fast

1,000 Trials | Split View | 987 Displayed

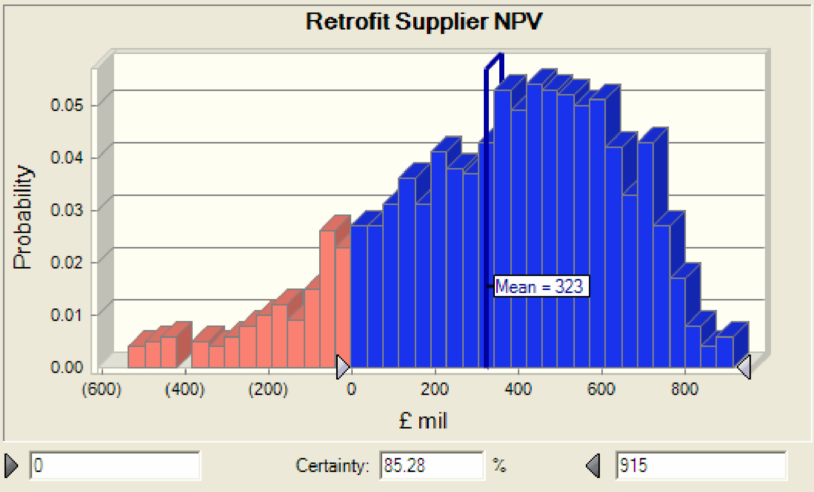


Statistic	Forecast values
Trials	1,000
Mean	(£673.22)
Median	(£630.35)
Mode	---
Standard Deviation	£250.42
Variance	£62,708.39
Skewness	-1.07
Kurtosis	5.14
Coeff. of Variability	-0.3720
Minimum	(£2,019.05)
Maximum	(£202.97)
Mean Std. Error	£7.92

(£1,989.60) Certainty: 99.88 % (£200.00)

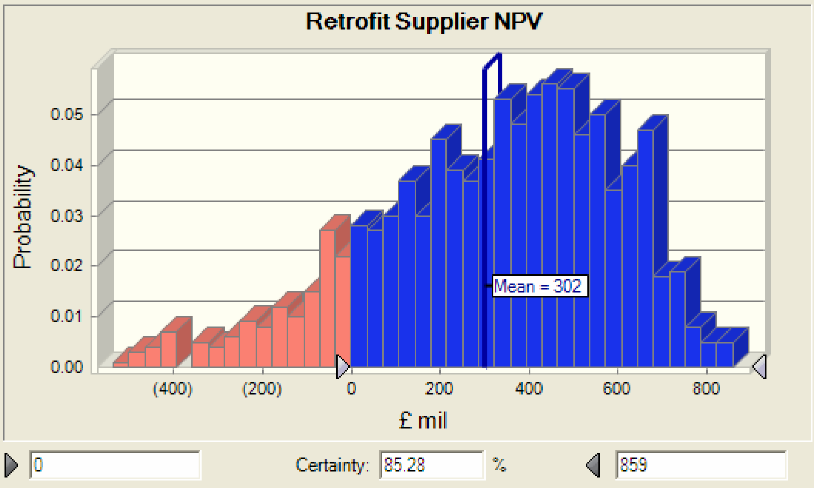
B.3.2 Meter Retrofit

B.i Meter Retrofit – New, Replacement and Voluntary



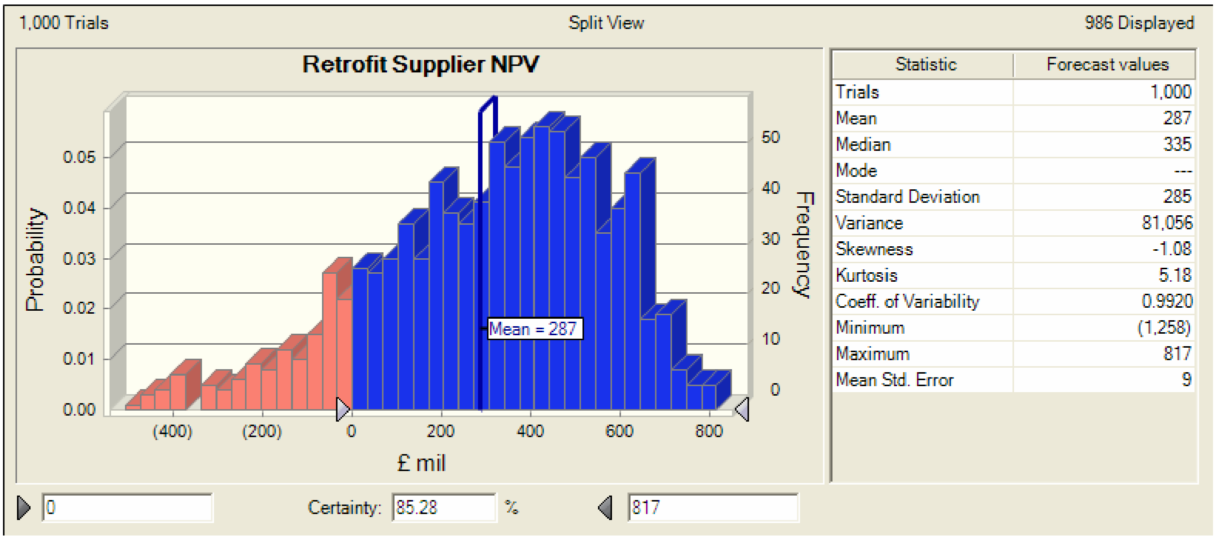
Statistic	Forecast values
Trials	1,000
Mean	323
Median	372
Mode	---
Standard Deviation	320
Variance	102,372
Skewness	-1.08
Kurtosis	5.16
Coeff. of Variability	0.9912
Minimum	(1,433)
Maximum	915
Mean Std. Error	10

B.ii Meter Retrofit – Regional Franchise



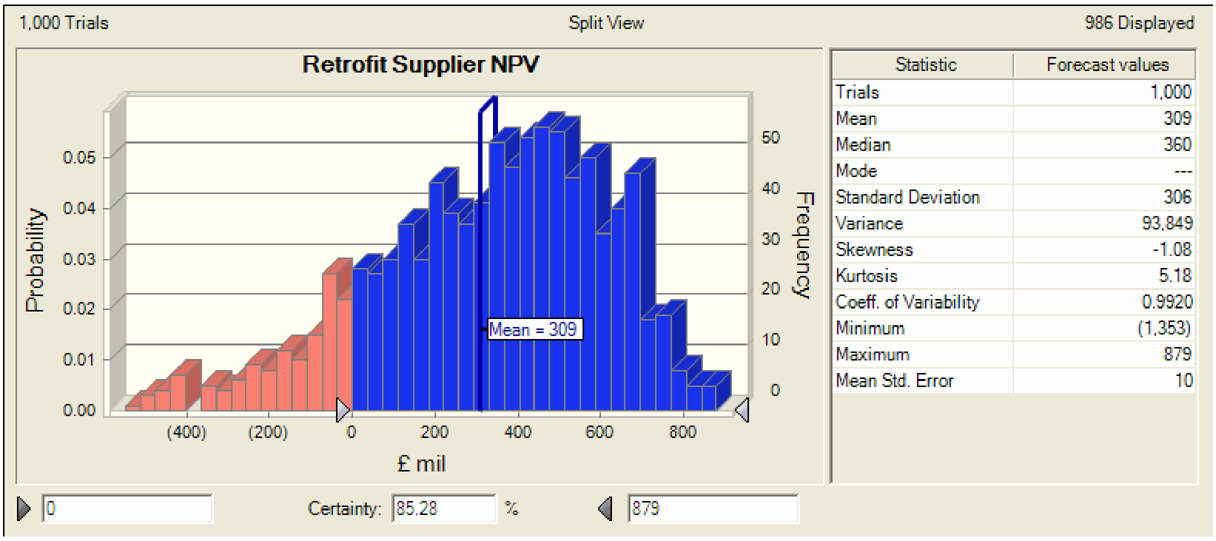
Statistic	Forecast values
Trials	1,000
Mean	302
Median	352
Mode	---
Standard Deviation	299
Variance	89,596
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.9920
Minimum	(1,322)
Maximum	859
Mean Std. Error	9

B.iii Meter Retrofit – Market



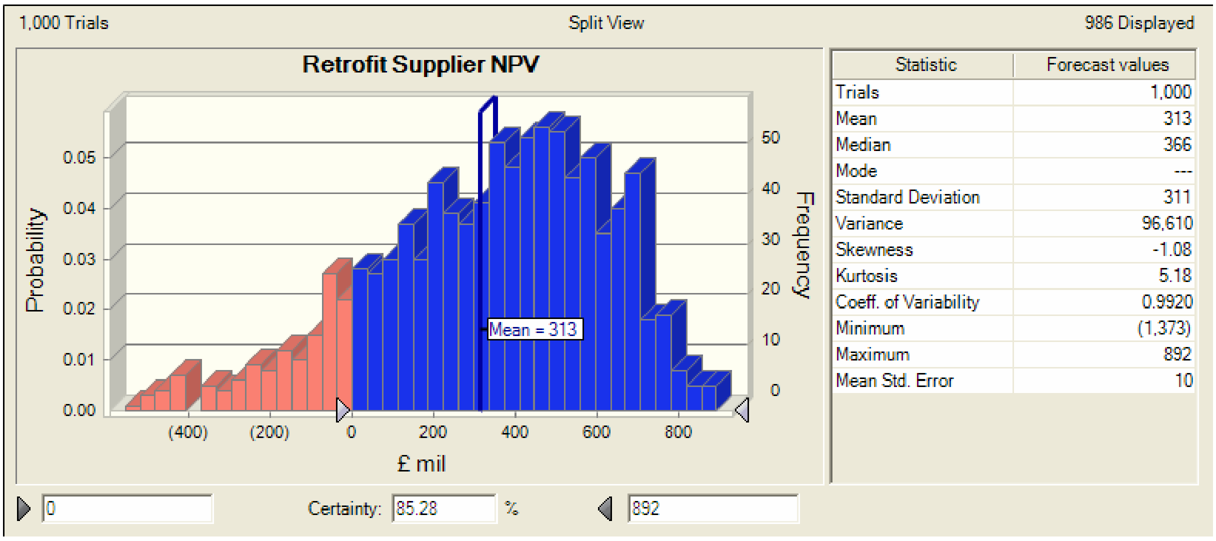
Statistic	Forecast values
Trials	1,000
Mean	287
Median	335
Mode	---
Standard Deviation	285
Variance	81,056
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.9920
Minimum	(1,258)
Maximum	817
Mean Std. Error	9

B.iv Meter Retrofit – Market Tip



Statistic	Forecast values
Trials	1,000
Mean	309
Median	360
Mode	---
Standard Deviation	306
Variance	93,849
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.9920
Minimum	(1,353)
Maximum	879
Mean Std. Error	10

B.v Meter Retrofit – Market Tip Fast

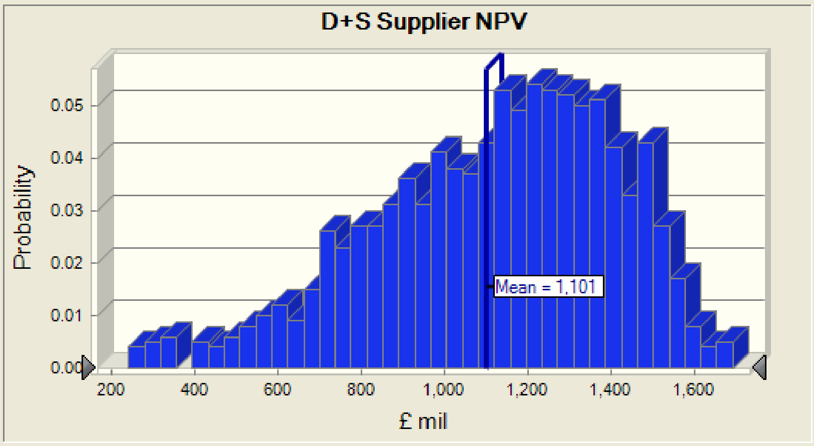


Statistic	Forecast values
Trials	1,000
Mean	313
Median	366
Mode	---
Standard Deviation	311
Variance	96,610
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.9920
Minimum	(1,373)
Maximum	892
Mean Std. Error	10

B.3.3 Dumb Meter and Smart Box

B.i D+S - New, Replacement and Voluntary

1,000 Trials Split View 985 Displayed

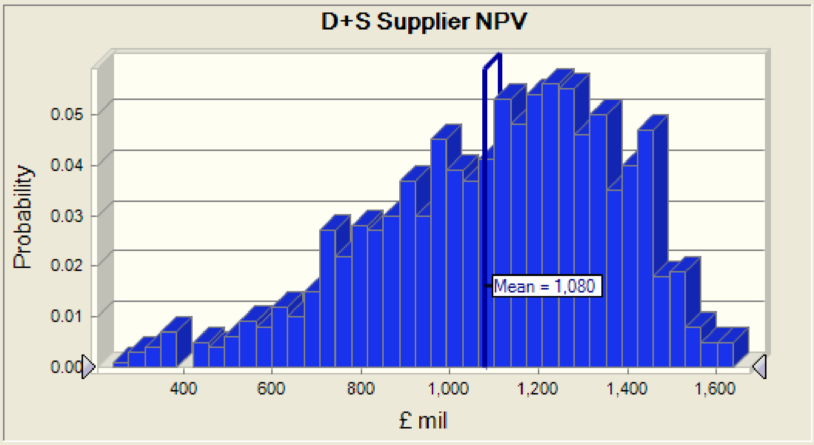


Statistic	Forecast values
Trials	1,000
Mean	1,101
Median	1,150
Mode	---
Standard Deviation	320
Variance	102,372
Skewness	-1.08
Kurtosis	5.16
Coeff. of Variability	0.2906
Minimum	-654
Maximum	1,693
Mean Std. Error	10

-Infinity Certainty: 100.00 % Infinity

B.ii D+S – Regional Franchise

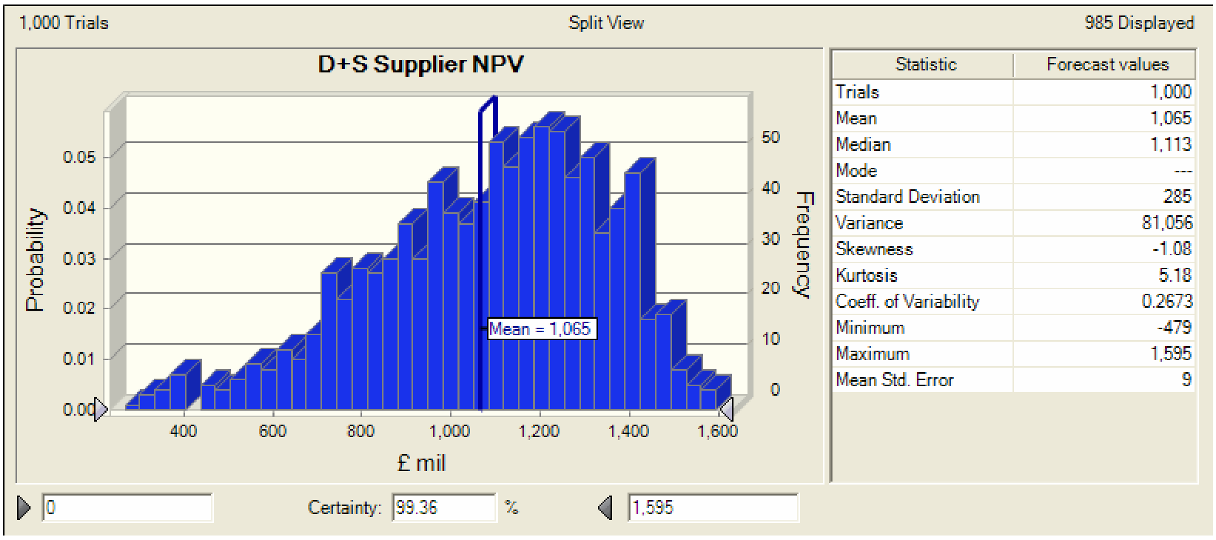
1,000 Trials Split View 986 Displayed



Statistic	Forecast values
Trials	1,000
Mean	1,080
Median	1,130
Mode	---
Standard Deviation	299
Variance	89,596
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2772
Minimum	-544
Maximum	1,637
Mean Std. Error	9

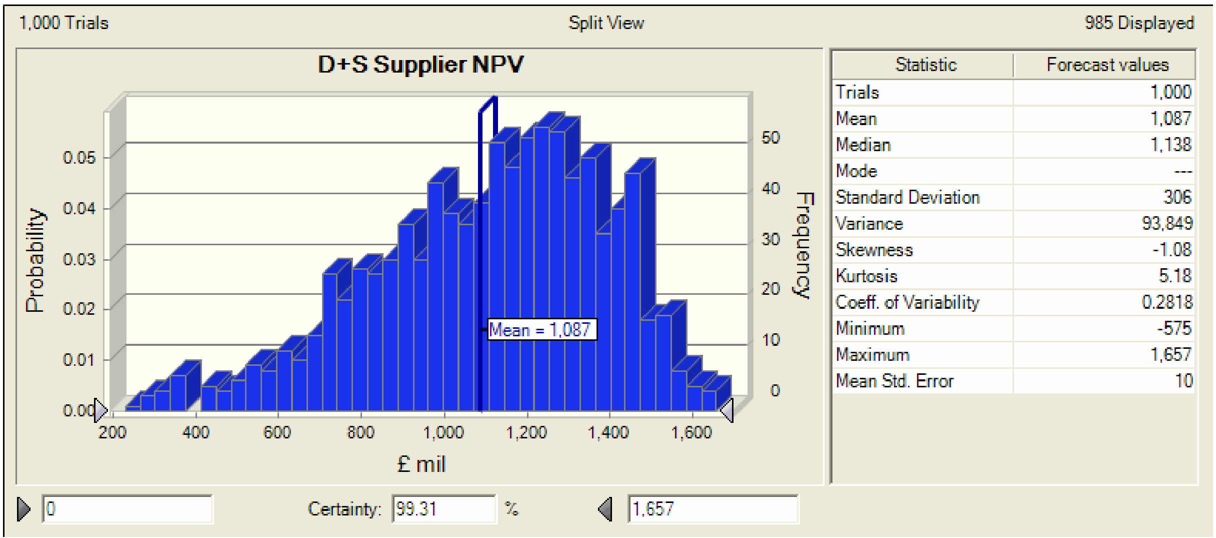
0 Certainty: 99.33 % 1,693

B.iii D+S – Market



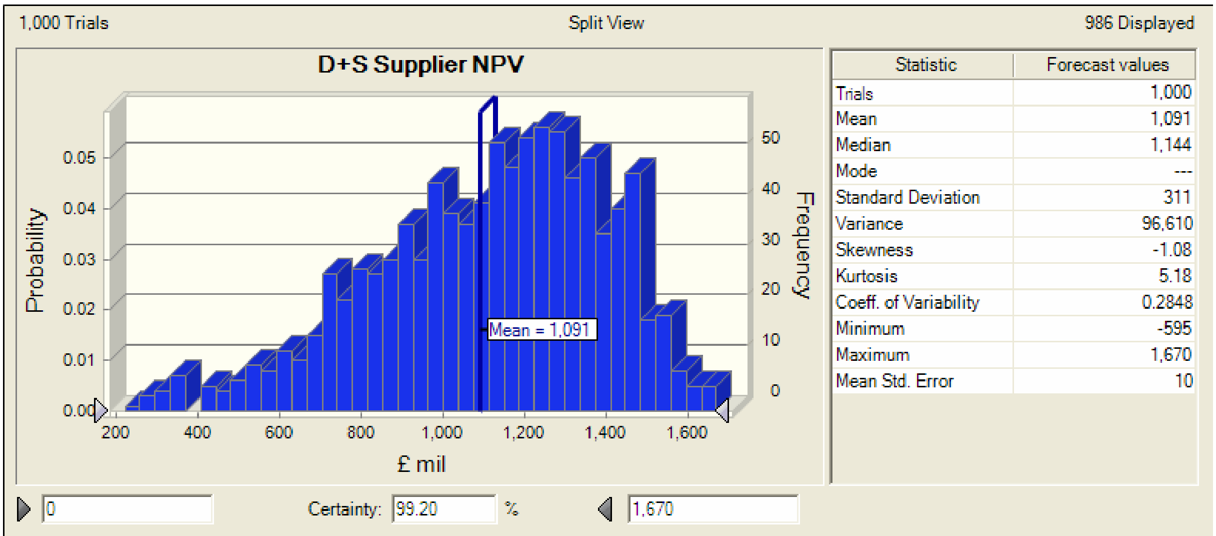
Statistic	Forecast values
Trials	1,000
Mean	1,065
Median	1,113
Mode	---
Standard Deviation	285
Variance	81,056
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2673
Minimum	-479
Maximum	1,595
Mean Std. Error	9

B.iv D+S – Market Tip



Statistic	Forecast values
Trials	1,000
Mean	1,087
Median	1,138
Mode	---
Standard Deviation	306
Variance	93,849
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2818
Minimum	-575
Maximum	1,657
Mean Std. Error	10

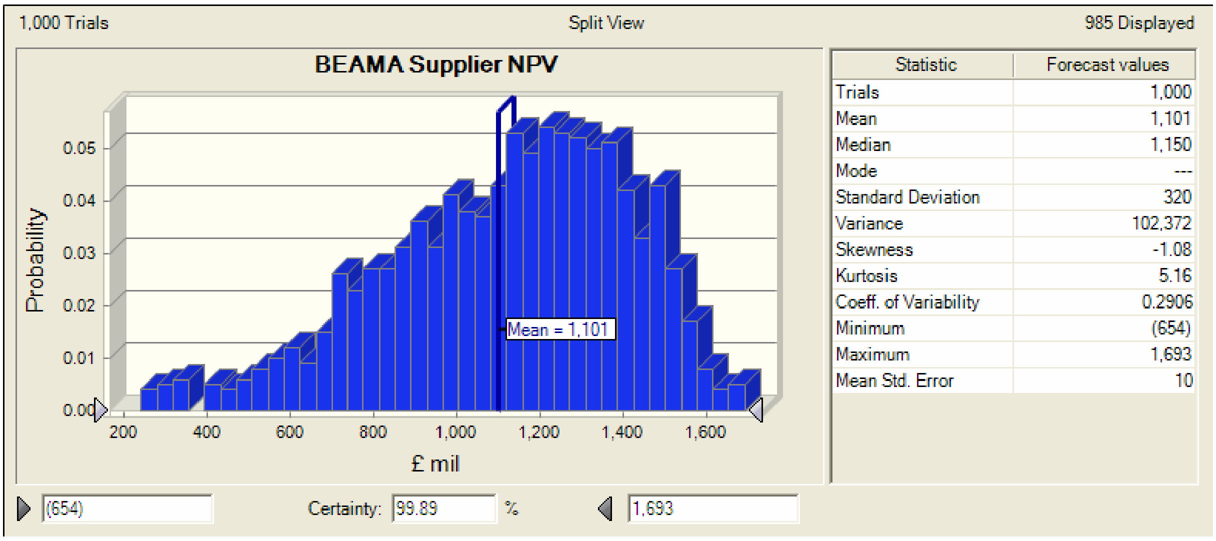
B.v D+S – Market Tip Fast



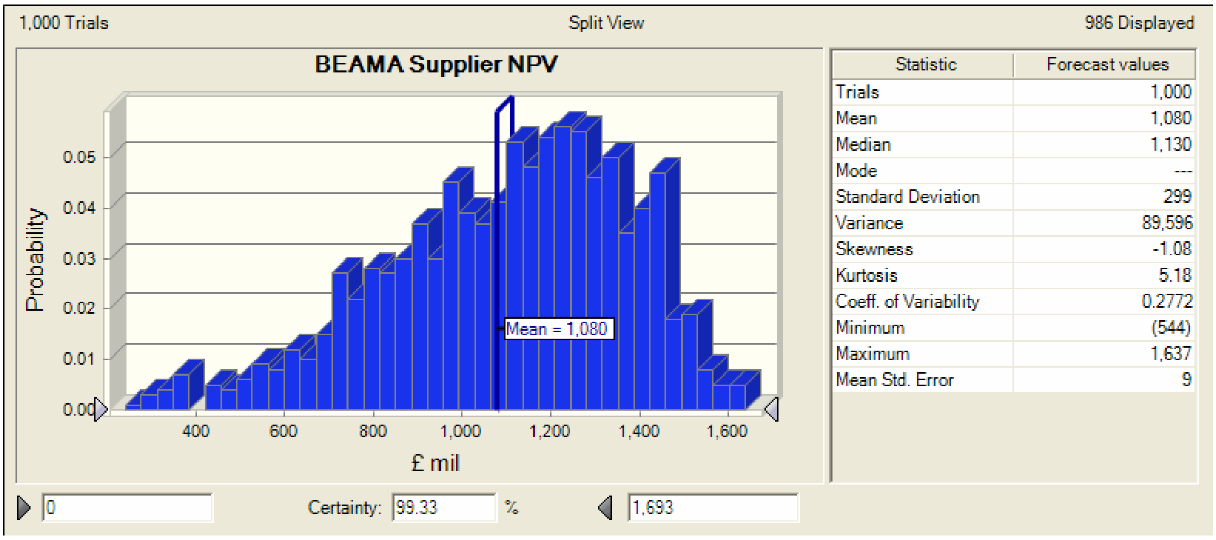
Statistic	Forecast values
Trials	1,000
Mean	1,091
Median	1,144
Mode	---
Standard Deviation	311
Variance	96,610
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2848
Minimum	-595
Maximum	1,670
Mean Std. Error	10

B.3.4 BEAMA Specification

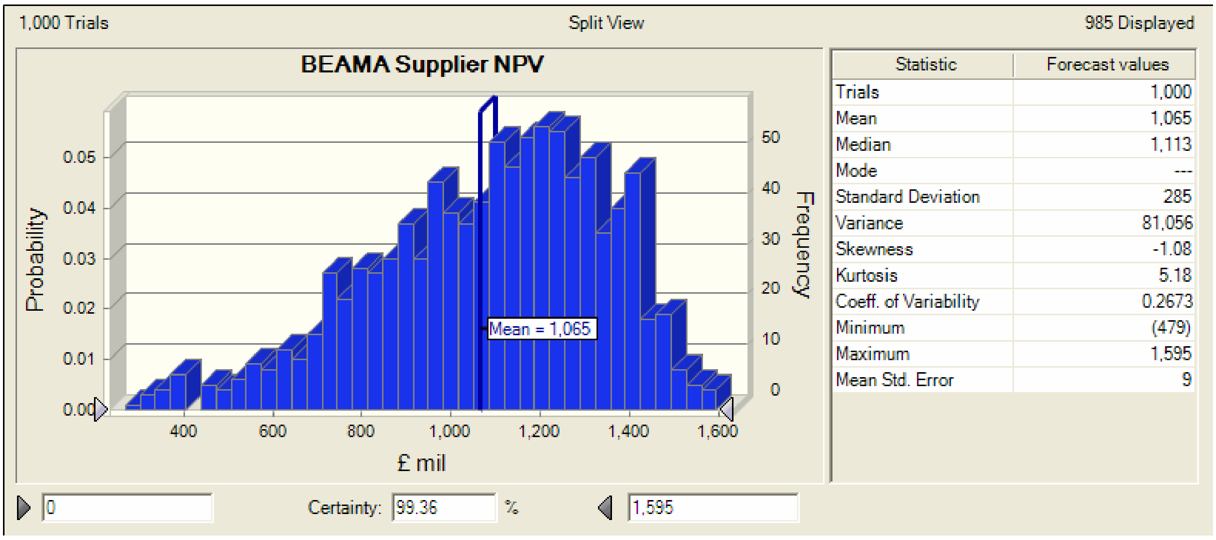
B.i BEAMA - New, Replacement and Voluntary



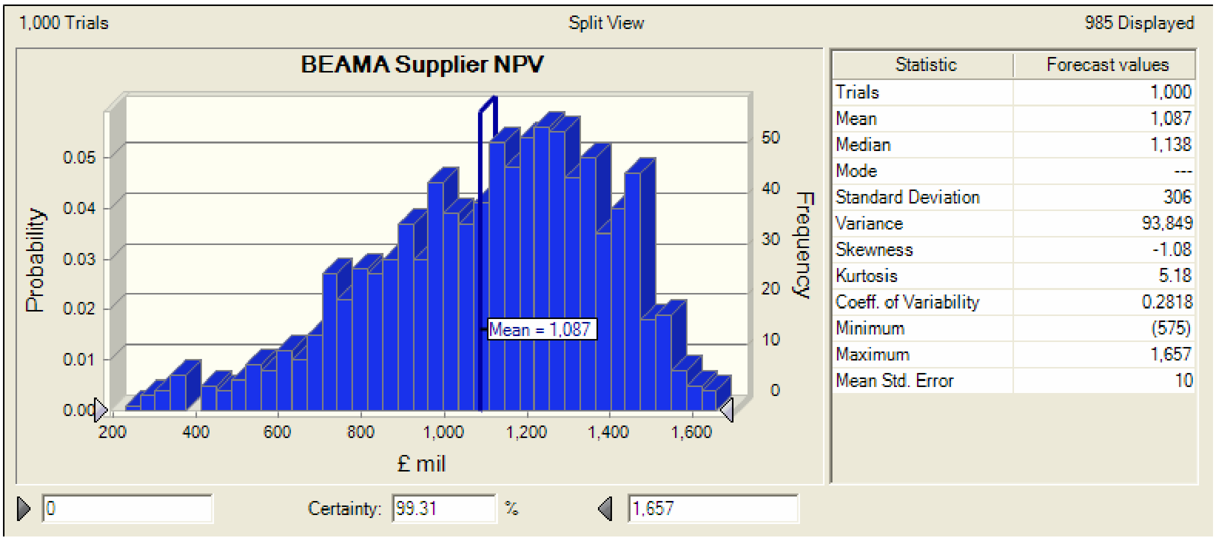
B.ii BEAMA – Regional Franchise



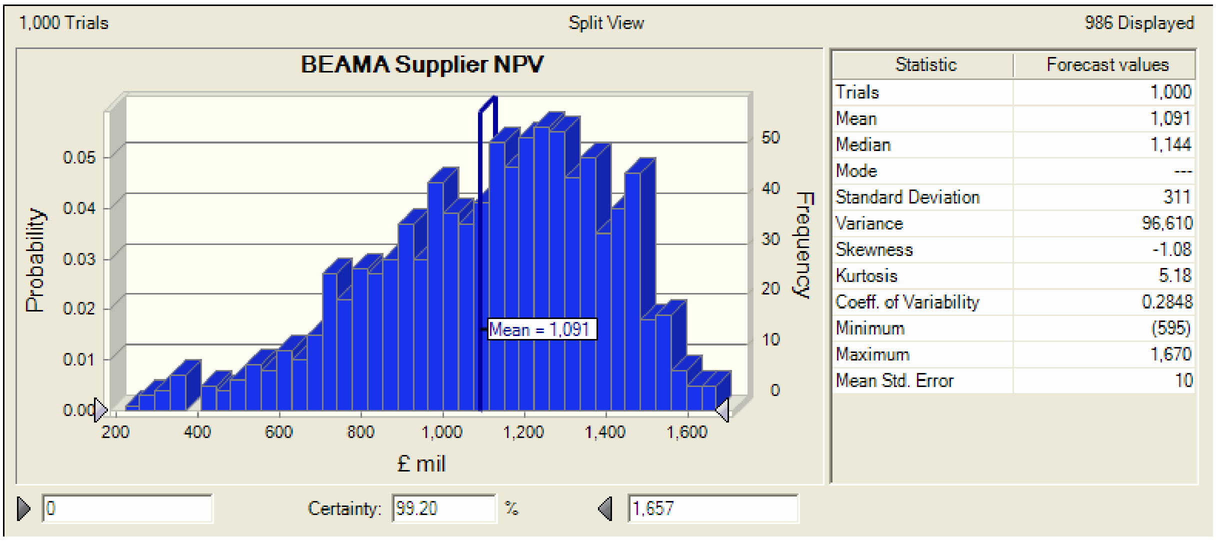
B.iii BEAMA – Market



B.iv BEAMA – Market Tip

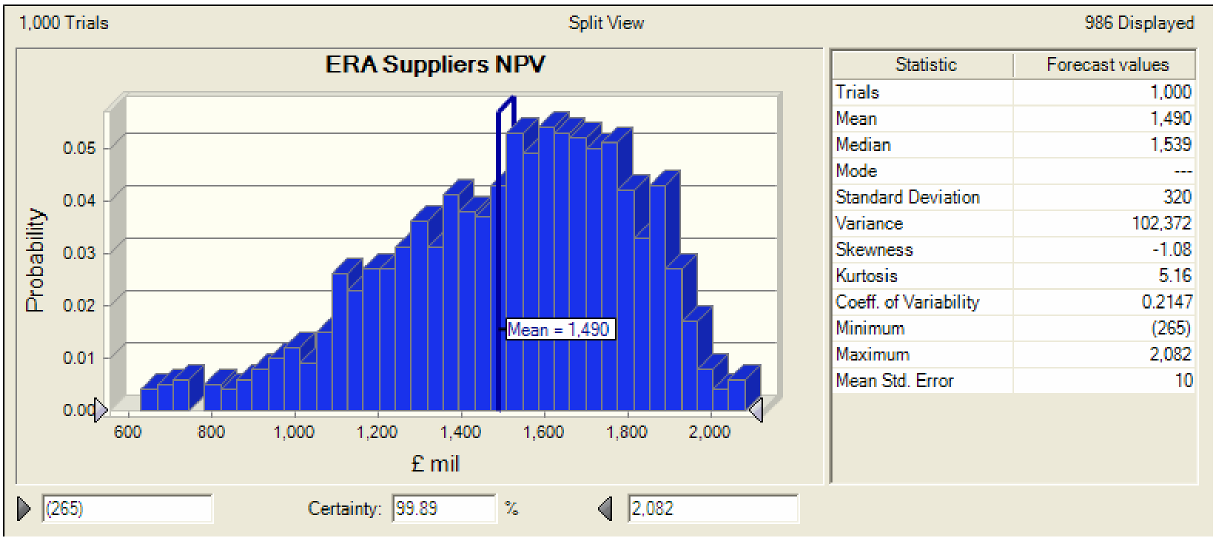


B.v BEAMA – Market Tip Fast



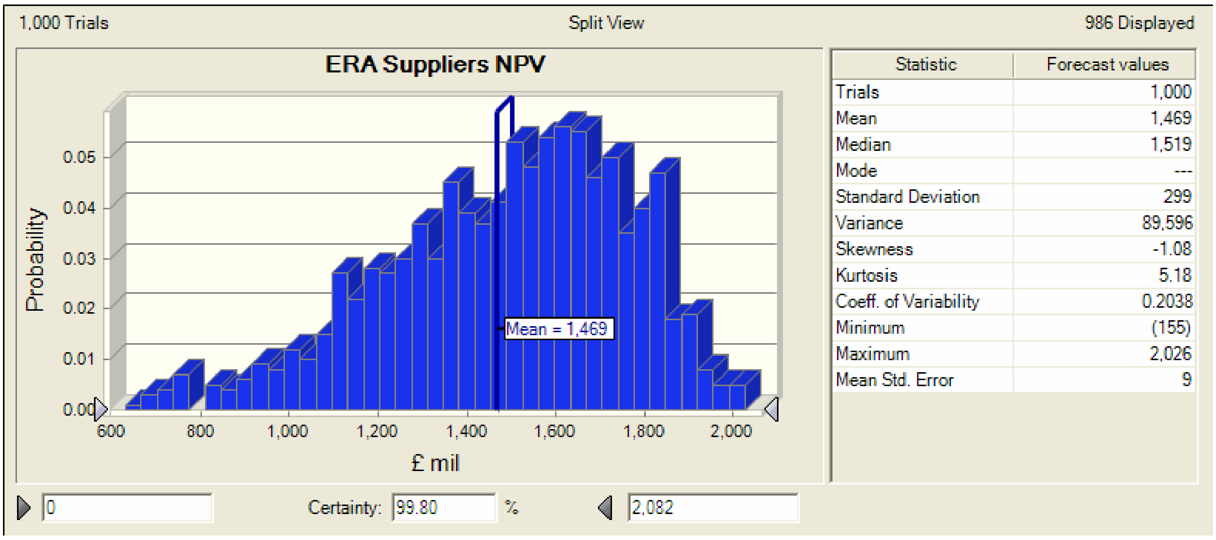
B.3.5 ERA Specification

B.i ERA - New, Replacement and Voluntary



Statistic	Forecast values
Trials	1,000
Mean	1,490
Median	1,539
Mode	---
Standard Deviation	320
Variance	102,372
Skewness	-1.08
Kurtosis	5.16
Coeff. of Variability	0.2147
Minimum	(265)
Maximum	2,082
Mean Std. Error	10

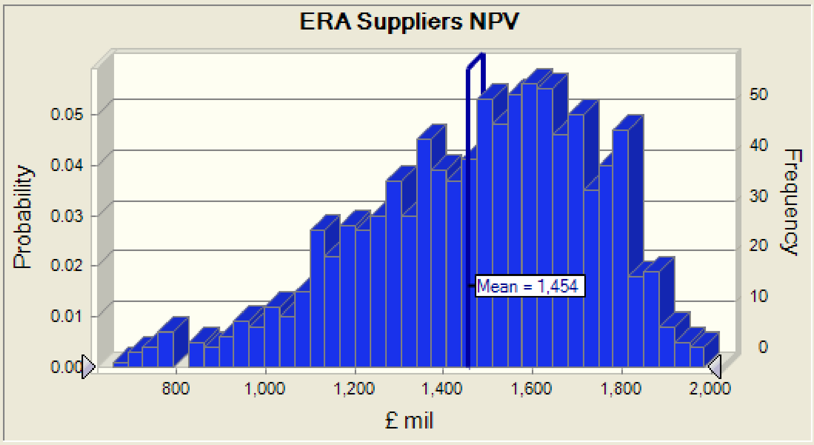
B.ii ERA – Regional Franchise



Statistic	Forecast values
Trials	1,000
Mean	1,469
Median	1,519
Mode	---
Standard Deviation	299
Variance	89,596
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2038
Minimum	(155)
Maximum	2,026
Mean Std. Error	9

B.iii ERA – Market

1,000 Trials   Split View   985 Displayed

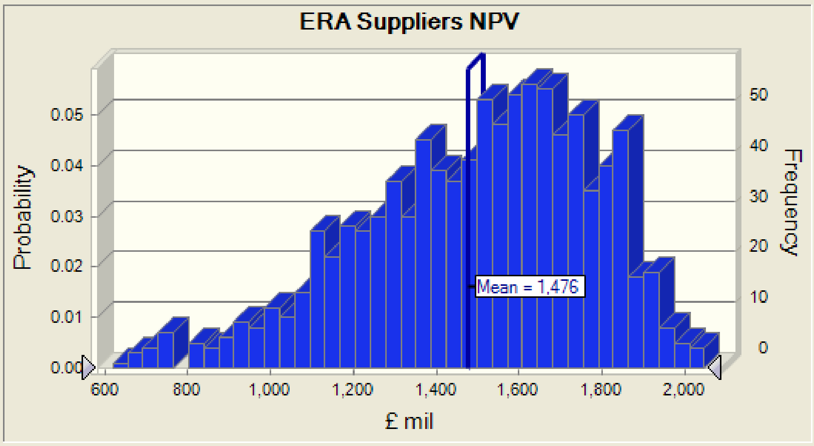


Statistic	Forecast values
Trials	1,000
Mean	1,454
Median	1,502
Mode	---
Standard Deviation	285
Variance	81,056
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.1958
Minimum	(90)
Maximum	1,984
Mean Std. Error	9

0   Certainty: 99.84 %   1,984

B.iv ERA – Market Tip

1,000 Trials   Split View   985 Displayed

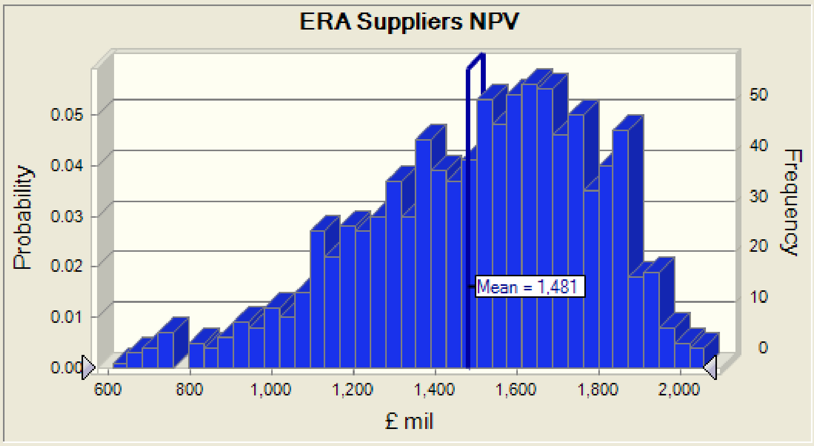


Statistic	Forecast values
Trials	1,000
Mean	1,476
Median	1,528
Mode	---
Standard Deviation	306
Variance	93,849
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2075
Minimum	(186)
Maximum	2,046
Mean Std. Error	10

0   Certainty: 99.78 %   2,046

B.v ERA – Market Tip Fast

1,000 Trials   Split View   986 Displayed

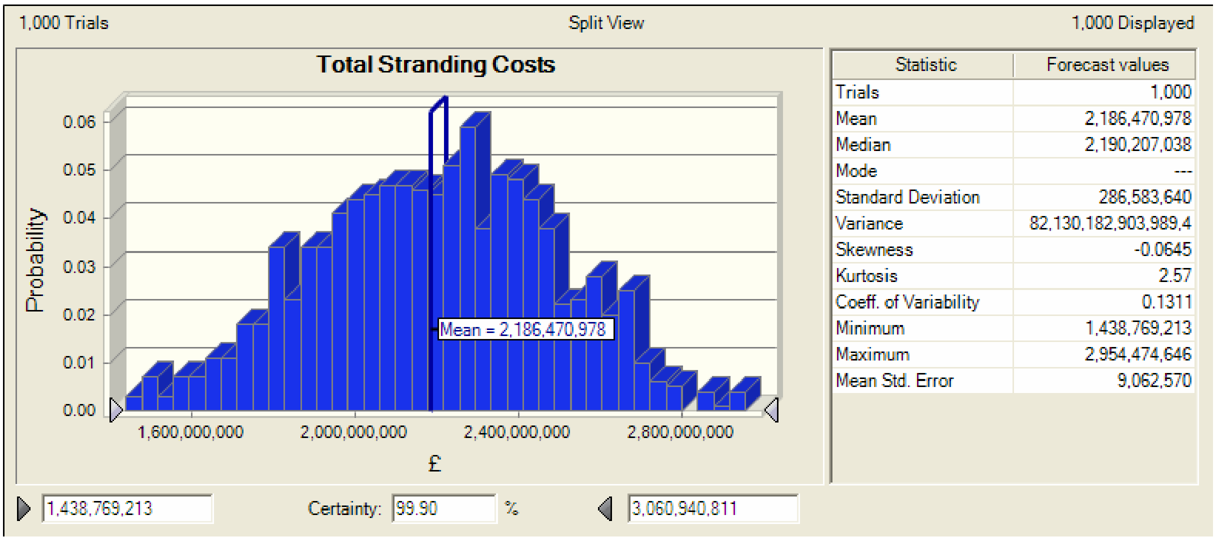


Statistic	Forecast values
Trials	1,000
Mean	1,481
Median	1,533
Mode	---
Standard Deviation	311
Variance	96,610
Skewness	-1.08
Kurtosis	5.18
Coeff. of Variability	0.2099
Minimum	(206)
Maximum	2,059
Mean Std. Error	10

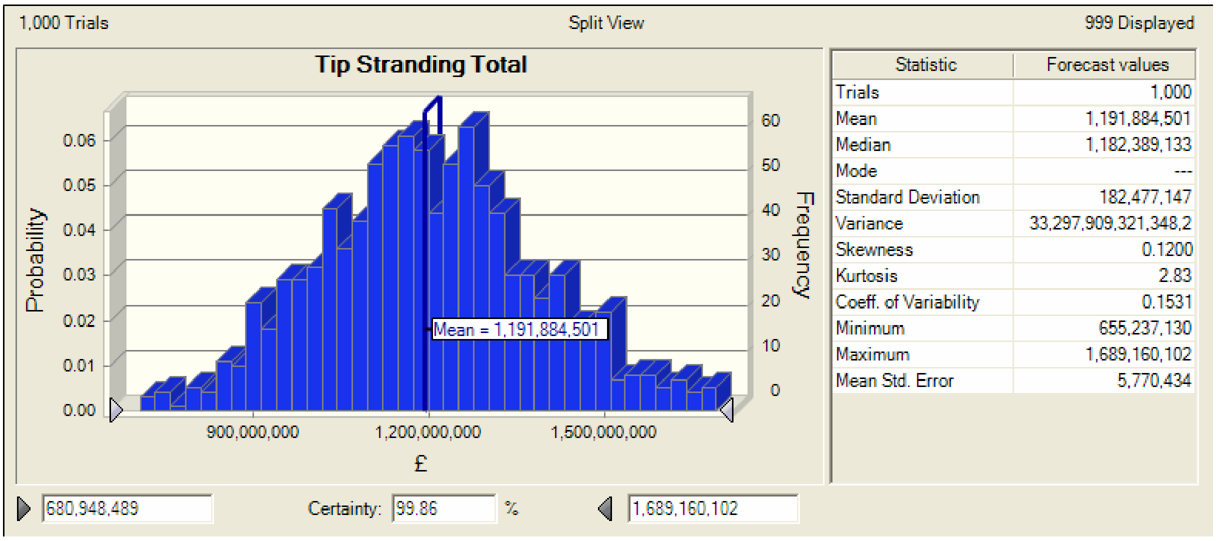
0   Certainty: 99.67 %   2,046

B.4 Stranding Costs

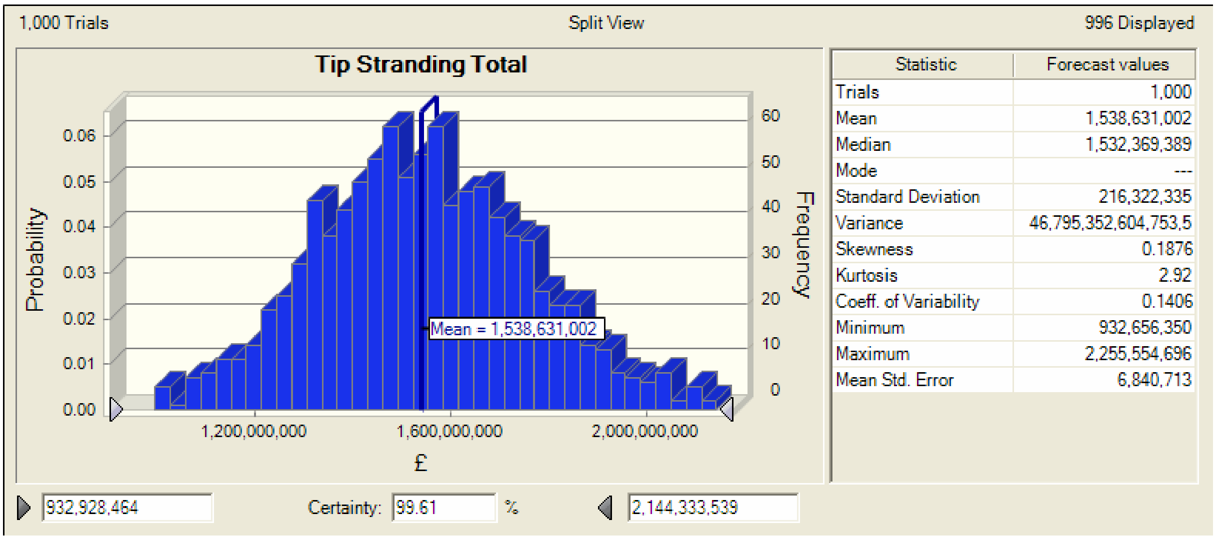
B.4.1 Regional Franchise



B.4.2 Market Tip

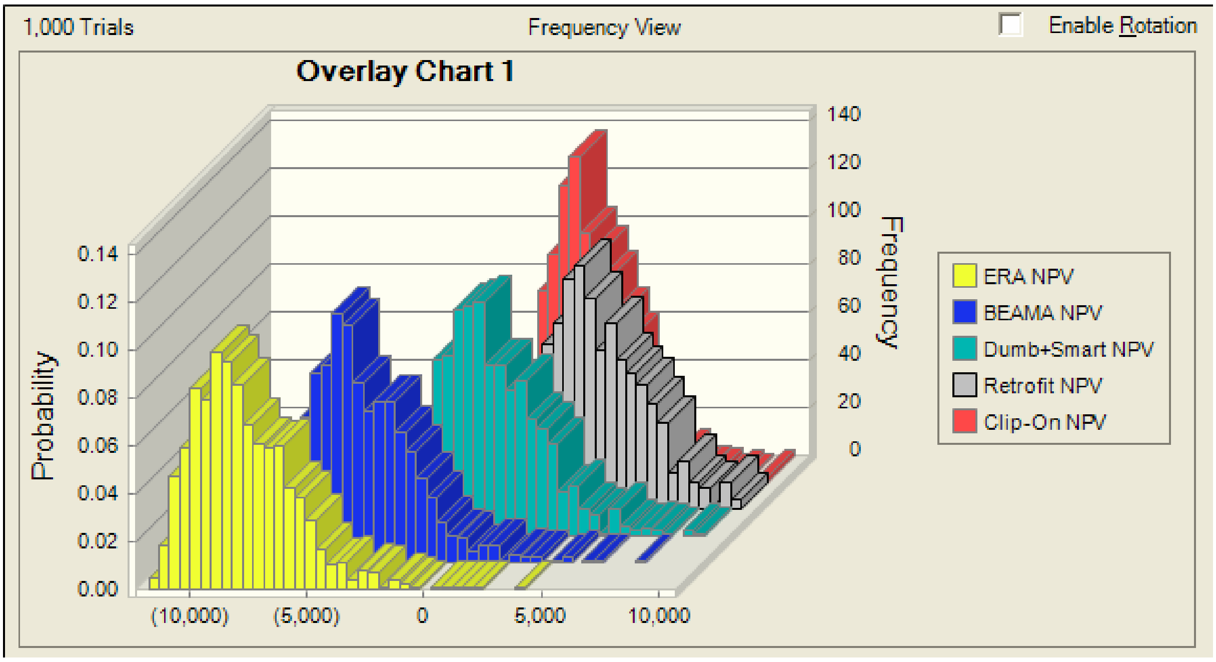


B.4.3 Market Tip Fast

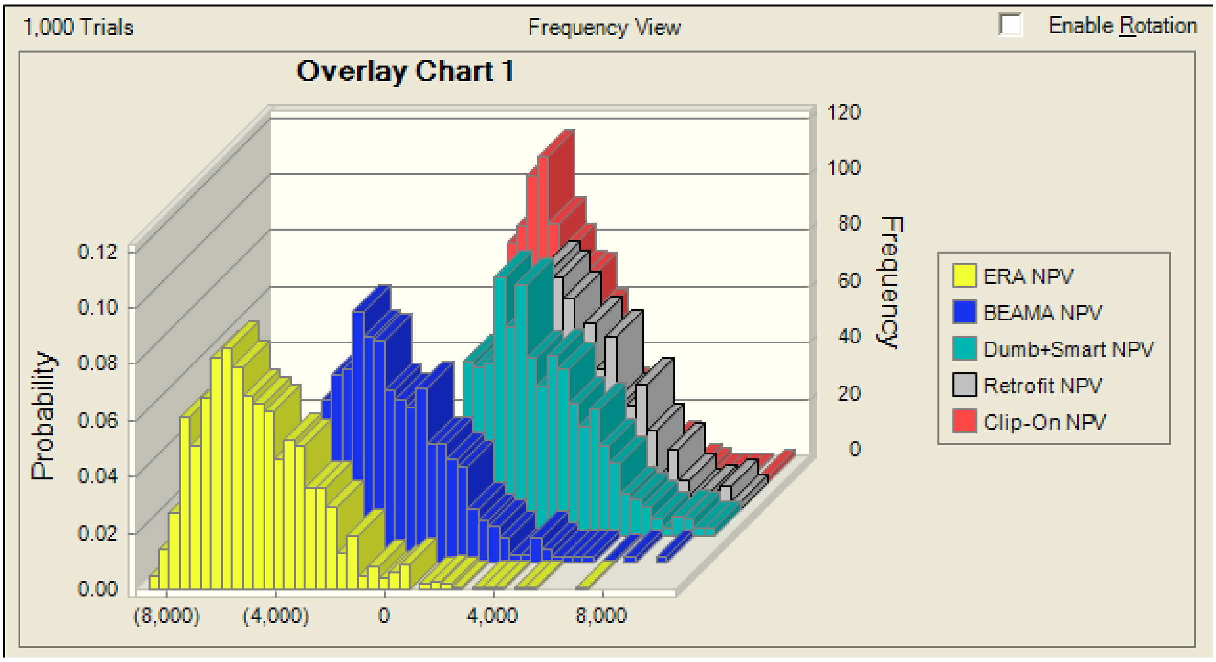


Appendix C Distribution Overlay Charts

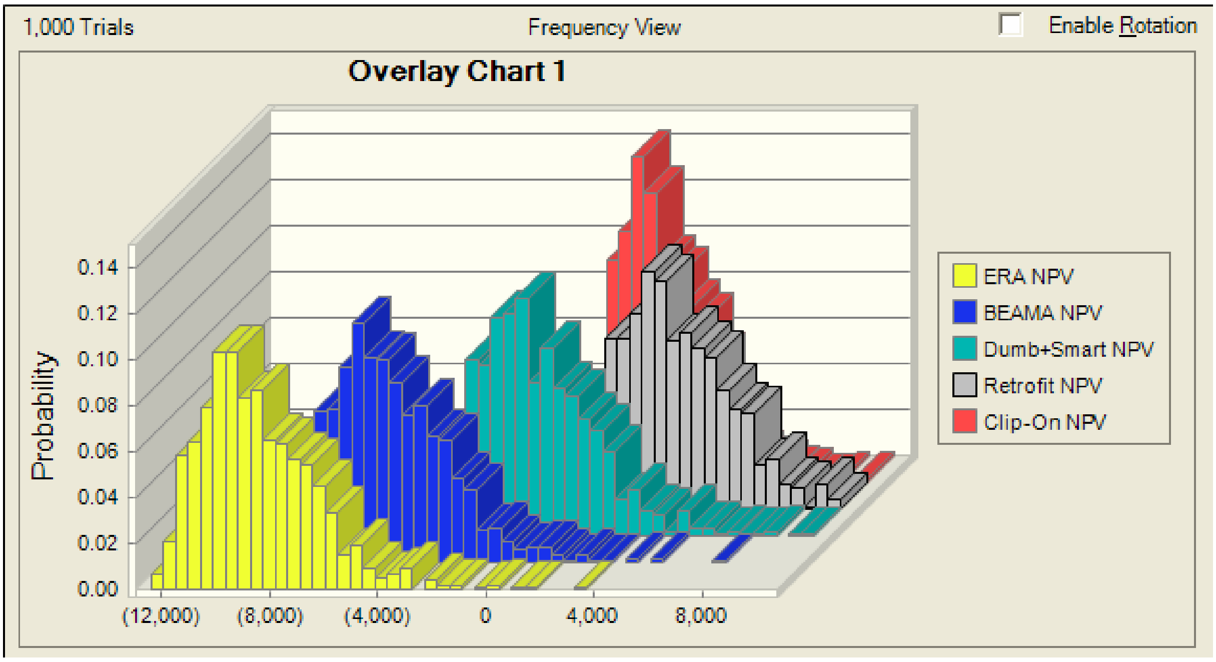
C.1 New, Replacement and Voluntary with PLC



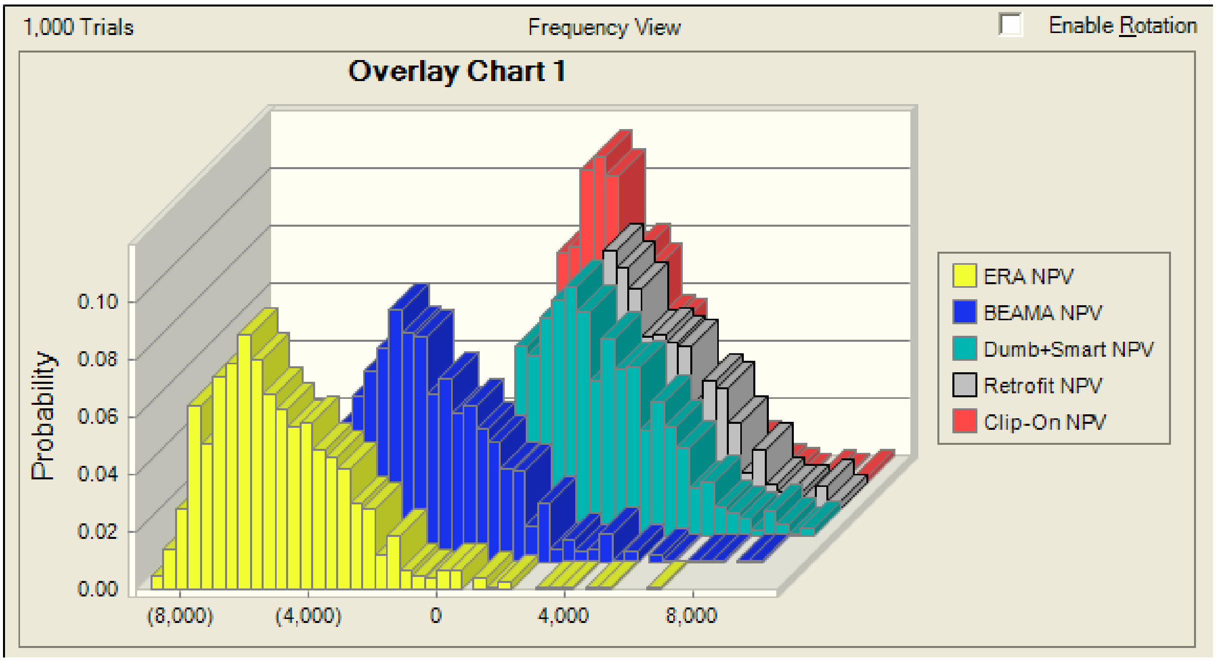
C.2 New, Replacement and Voluntary with P. Broadband



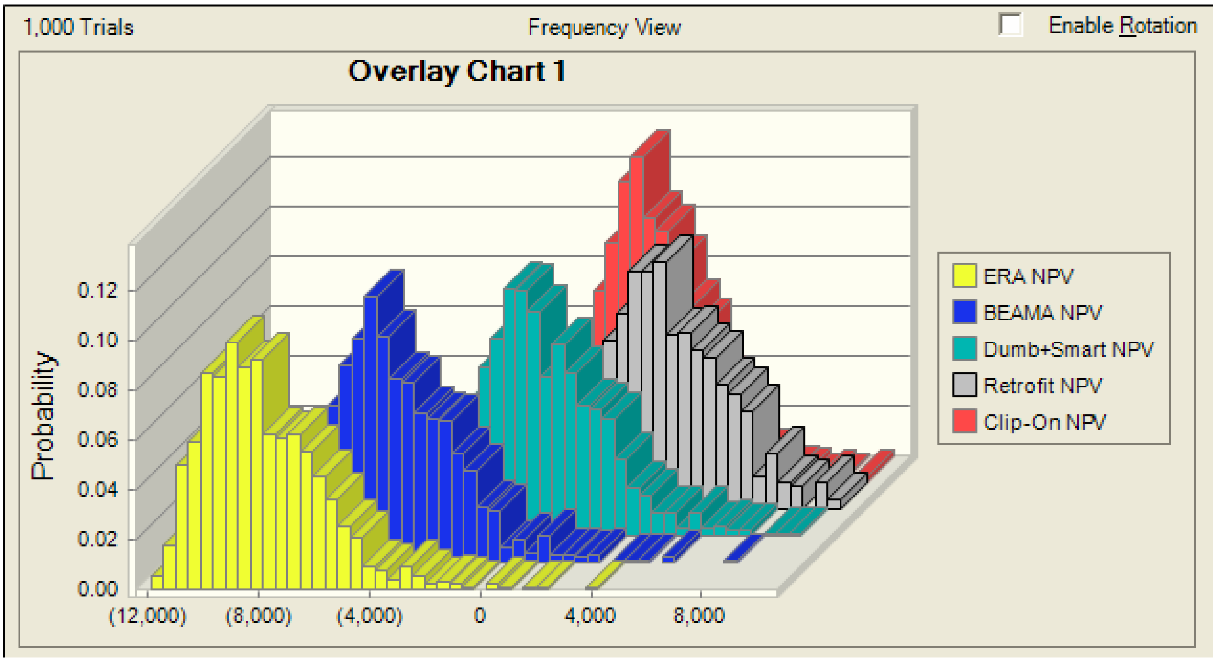
C.3 New, Replacement and Voluntary with WiMax



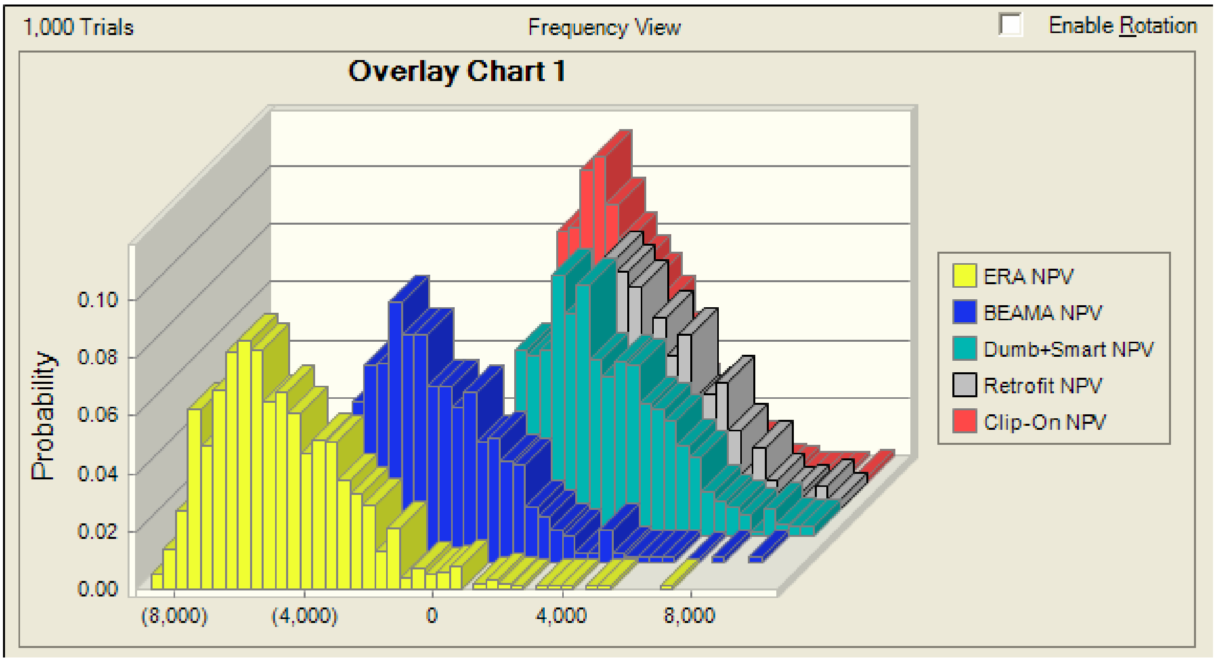
C.4 New, Replacement and Voluntary with 3G



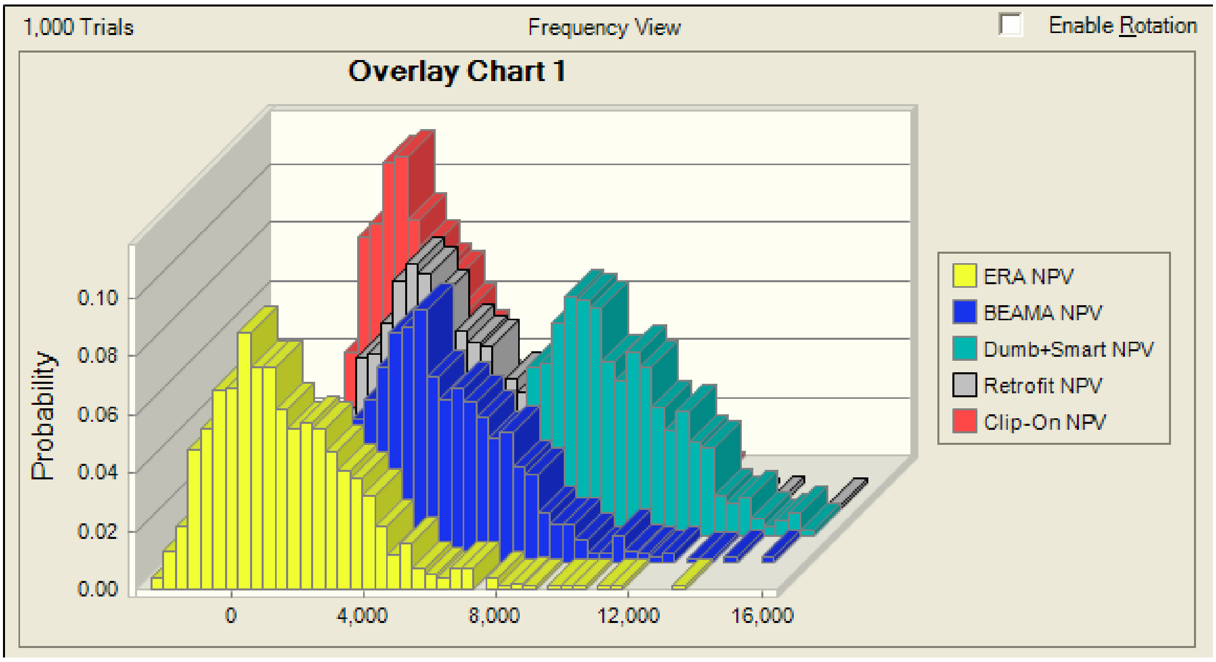
C.5 New, Replacement and Voluntary with Hybrid 1



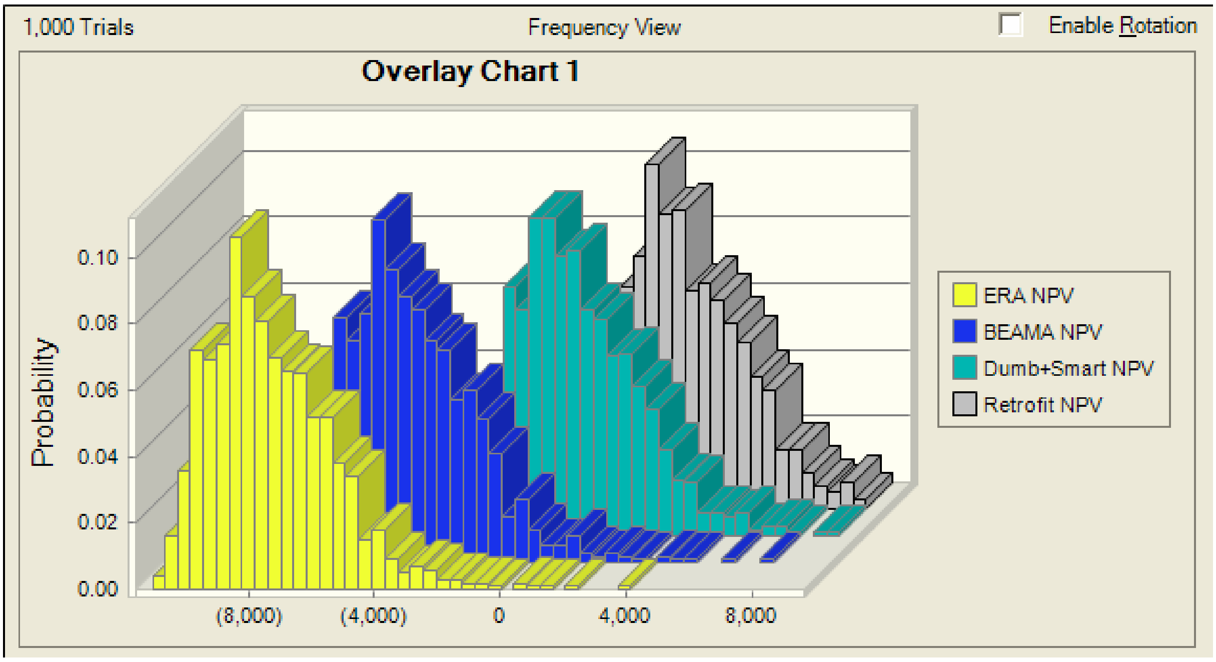
C.6 New, Replacement and Voluntary with Hybrid 2



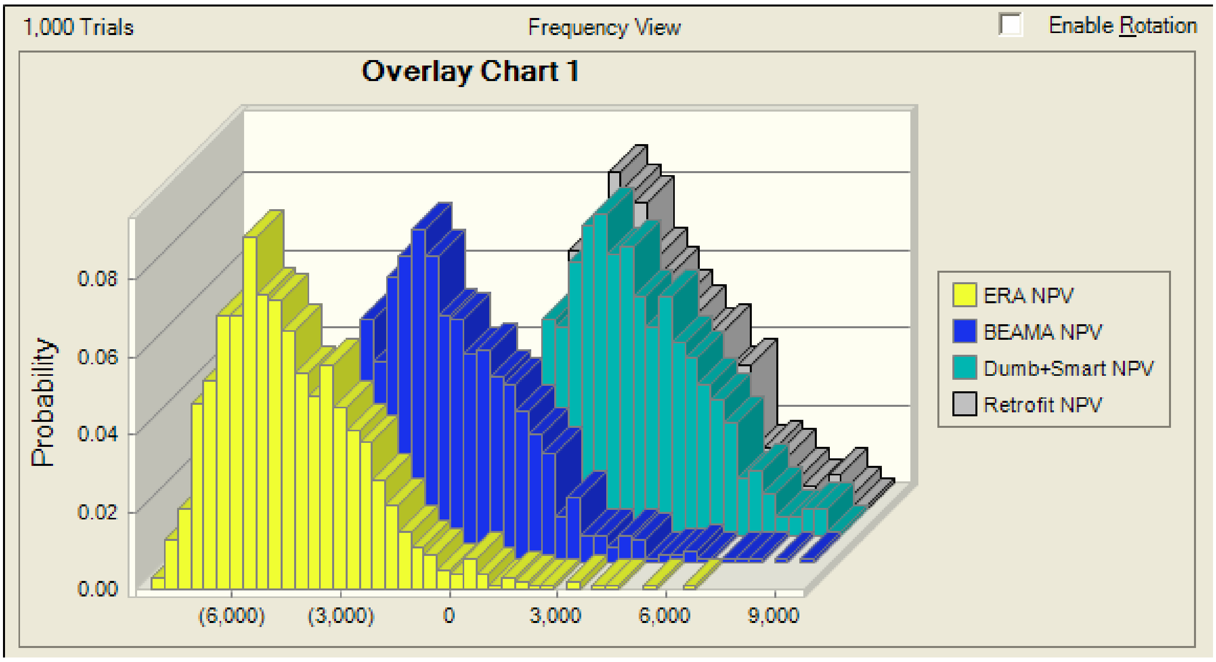
C.7 New, Replacement and Voluntary without comms



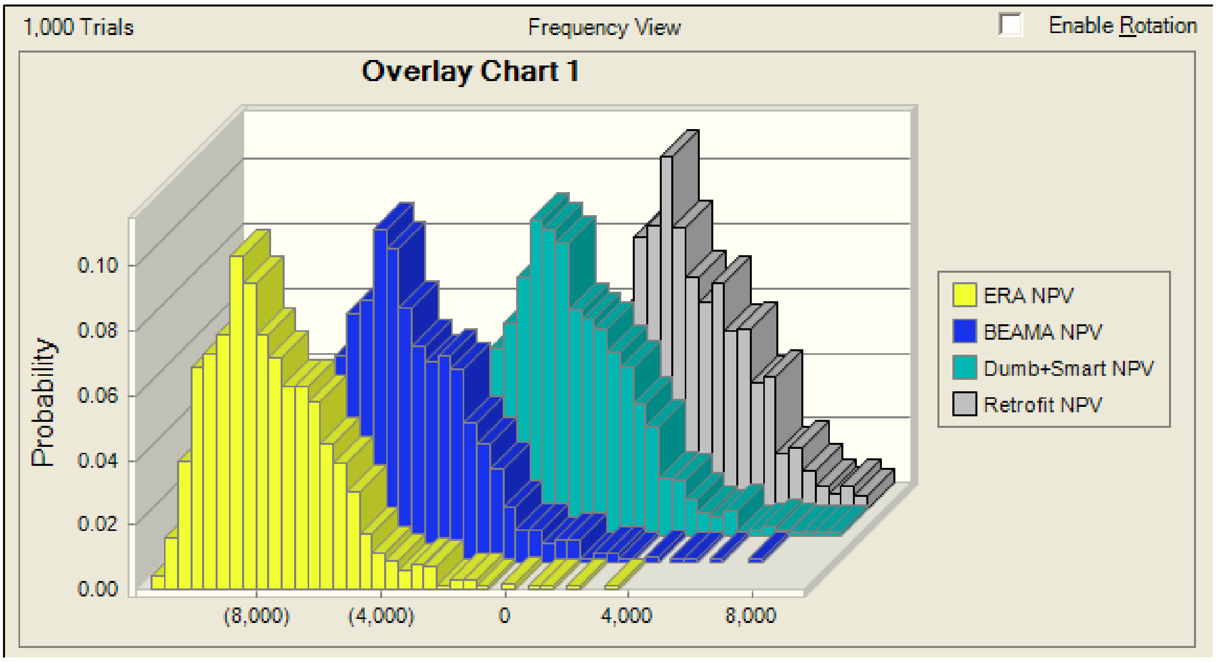
C.8 Regional Franchise with PLC



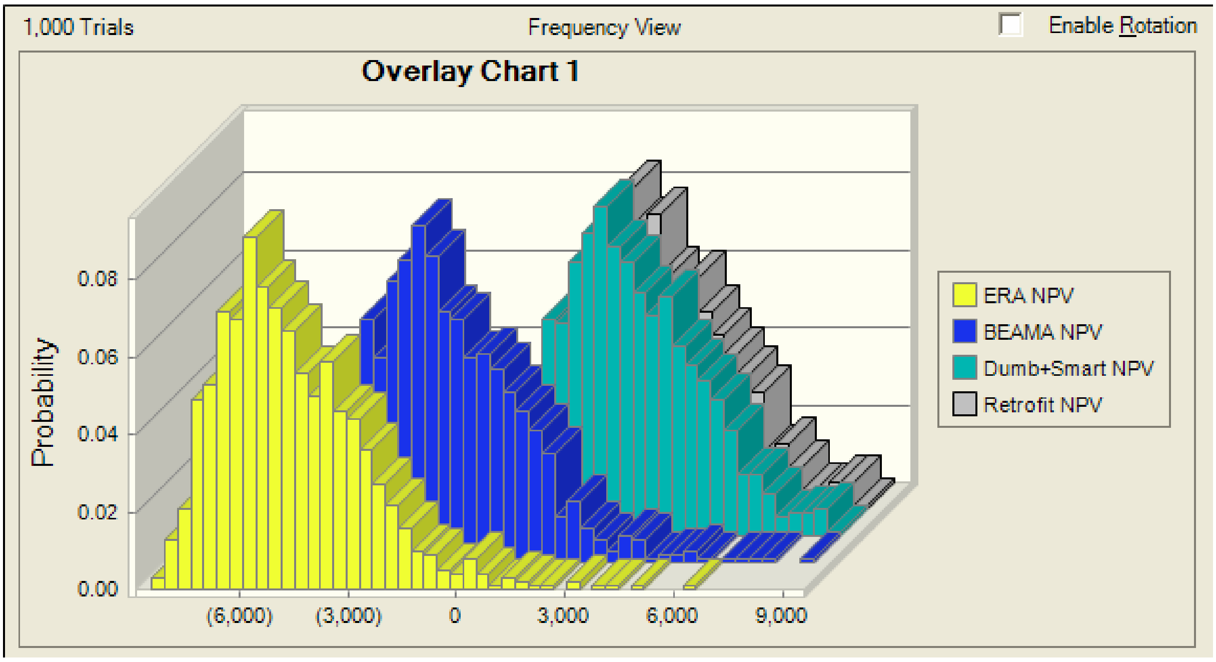
C.9 Regional Franchise with P.Broadband



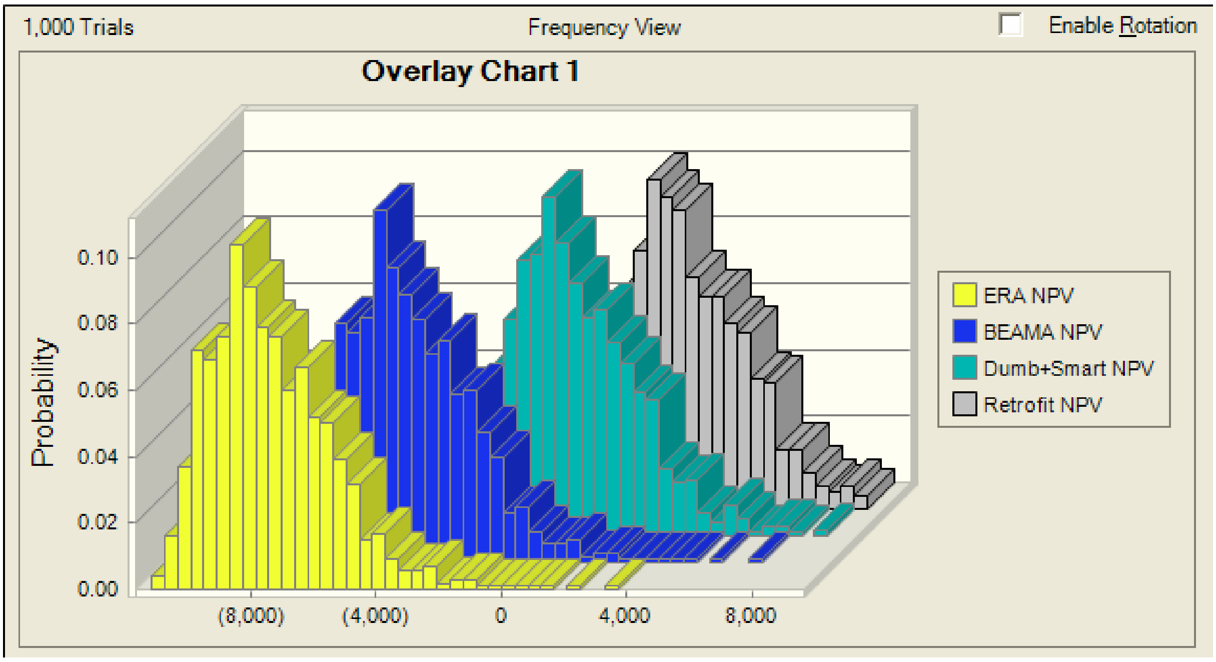
C.10 Regional Franchise with WiMax



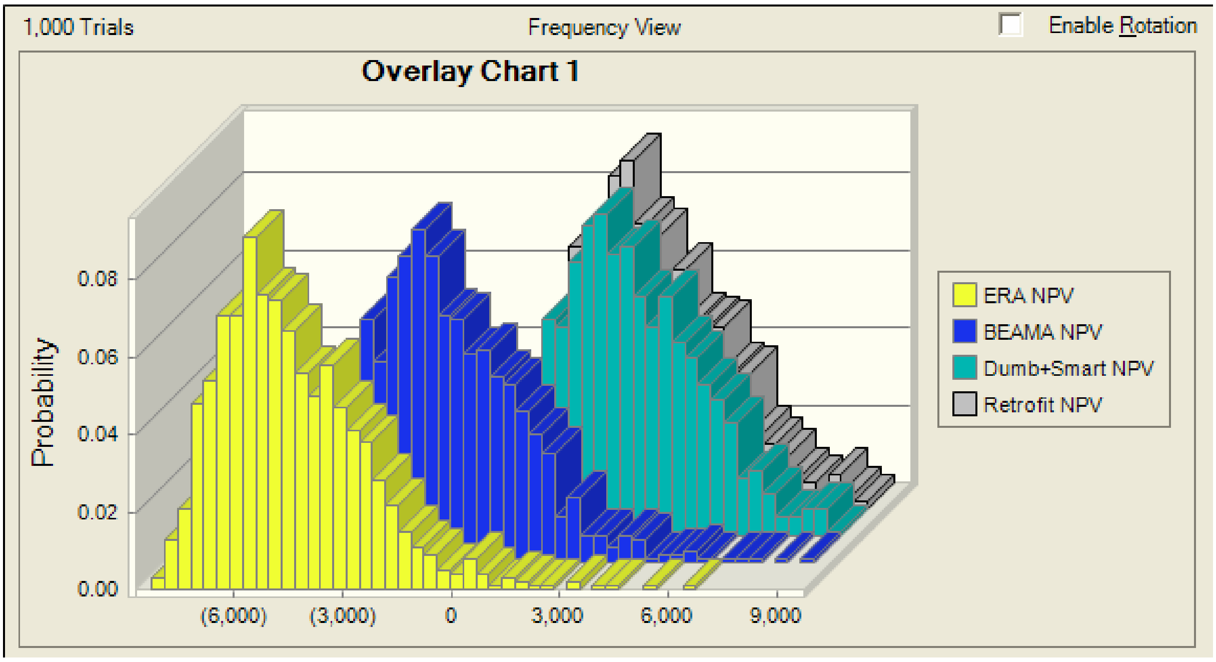
C.11 Regional Franchise with 3G



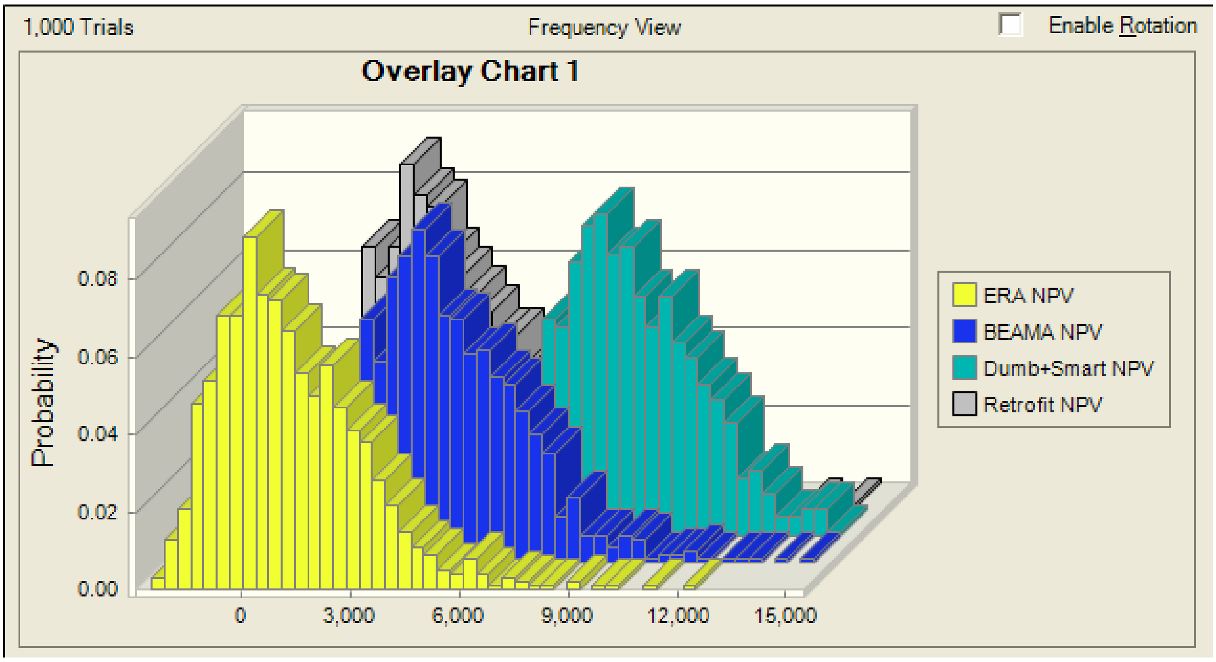
C.12 Regional Franchise with Hybrid 1



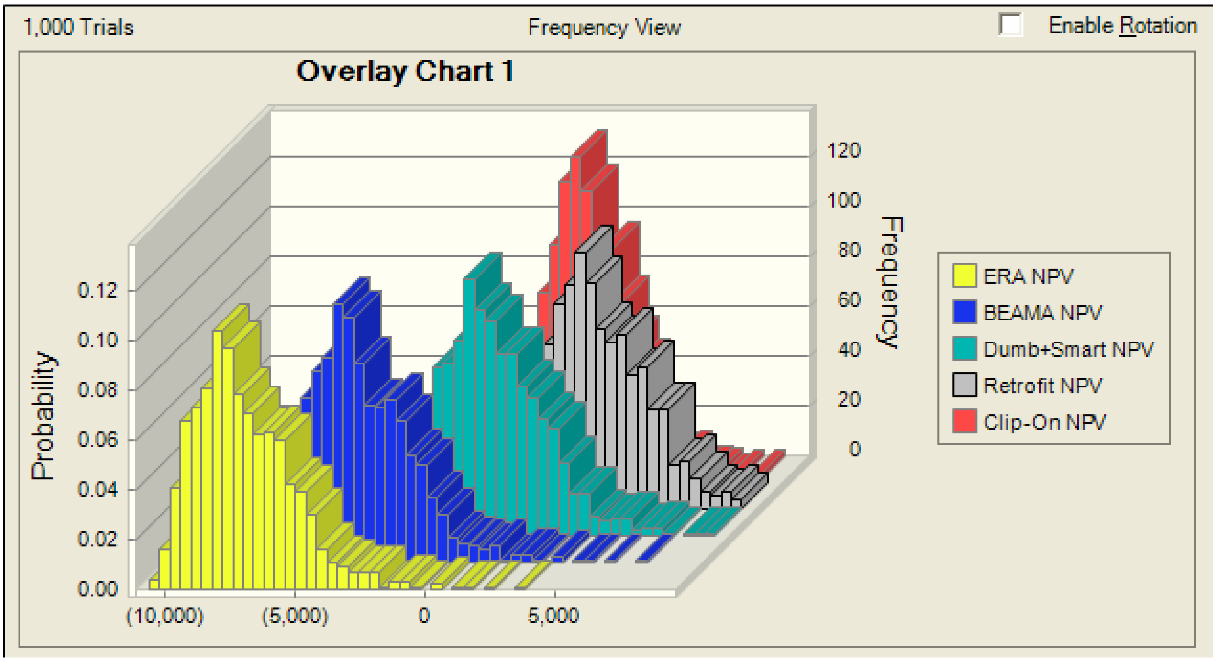
C.13 Regional Franchise with Hybrid 2



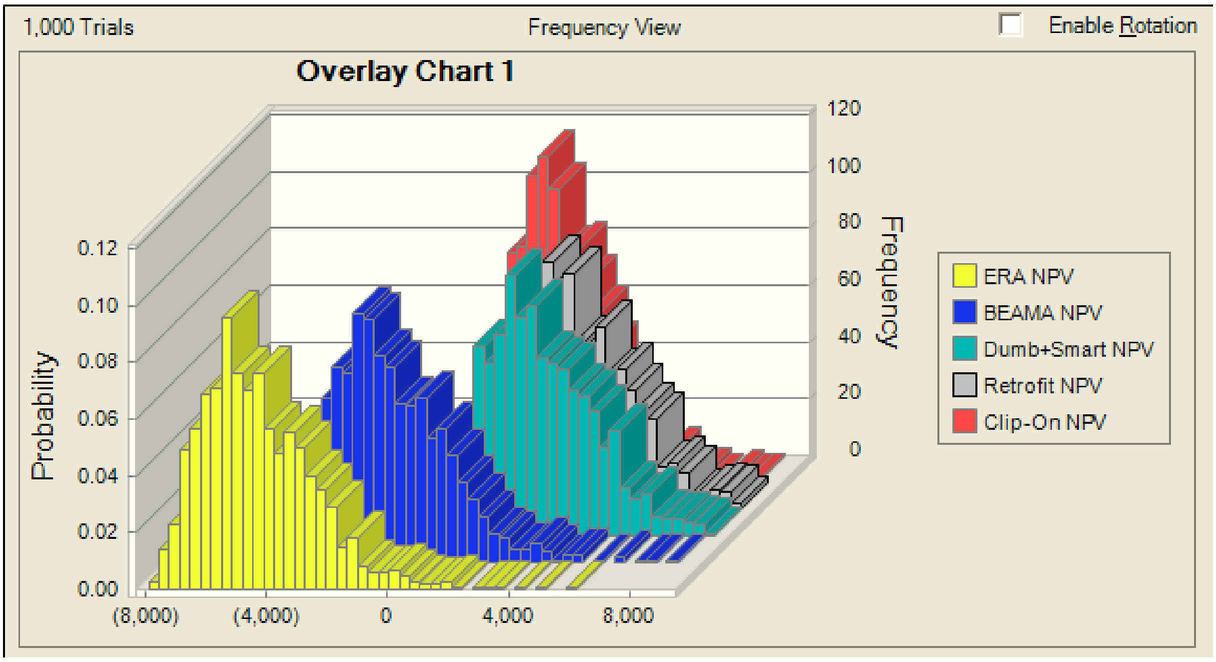
C.14 Regional Franchise without comms



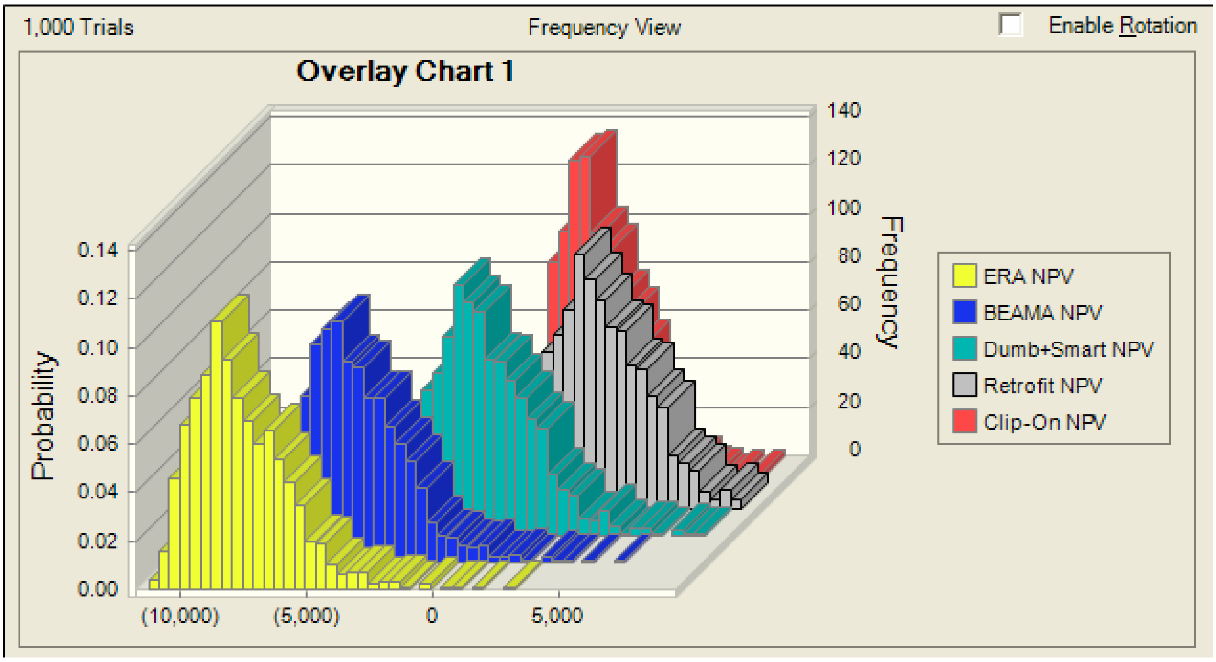
C.15 Market with PLC



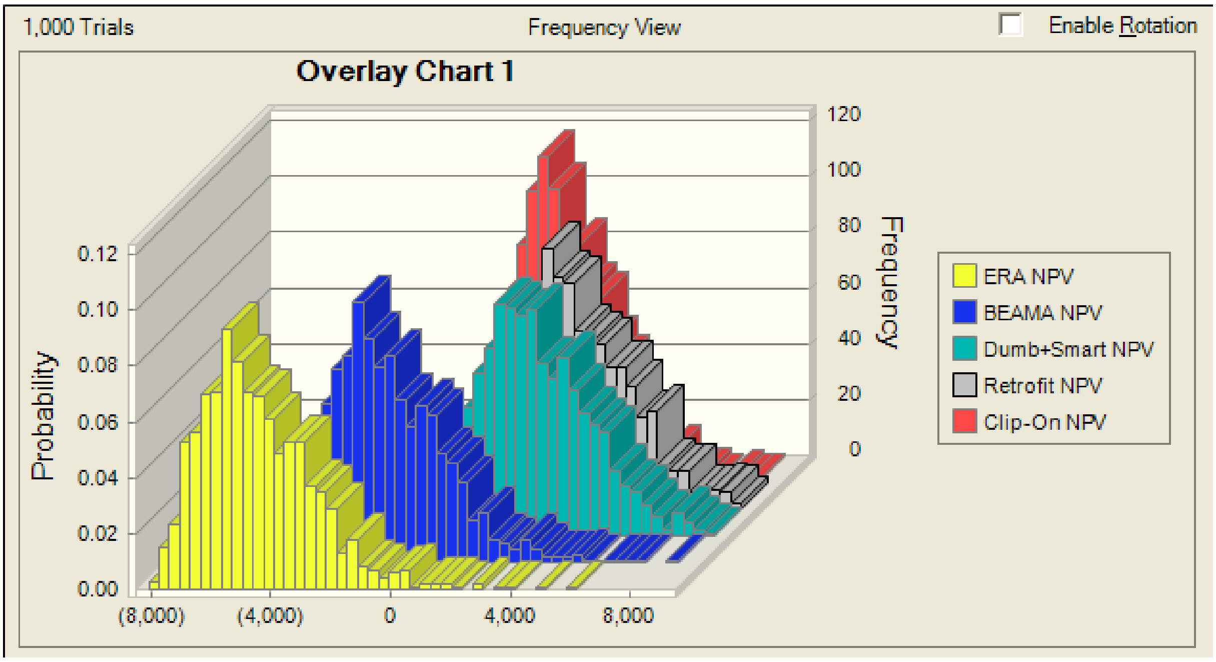
C.16 Market with P. Broadband



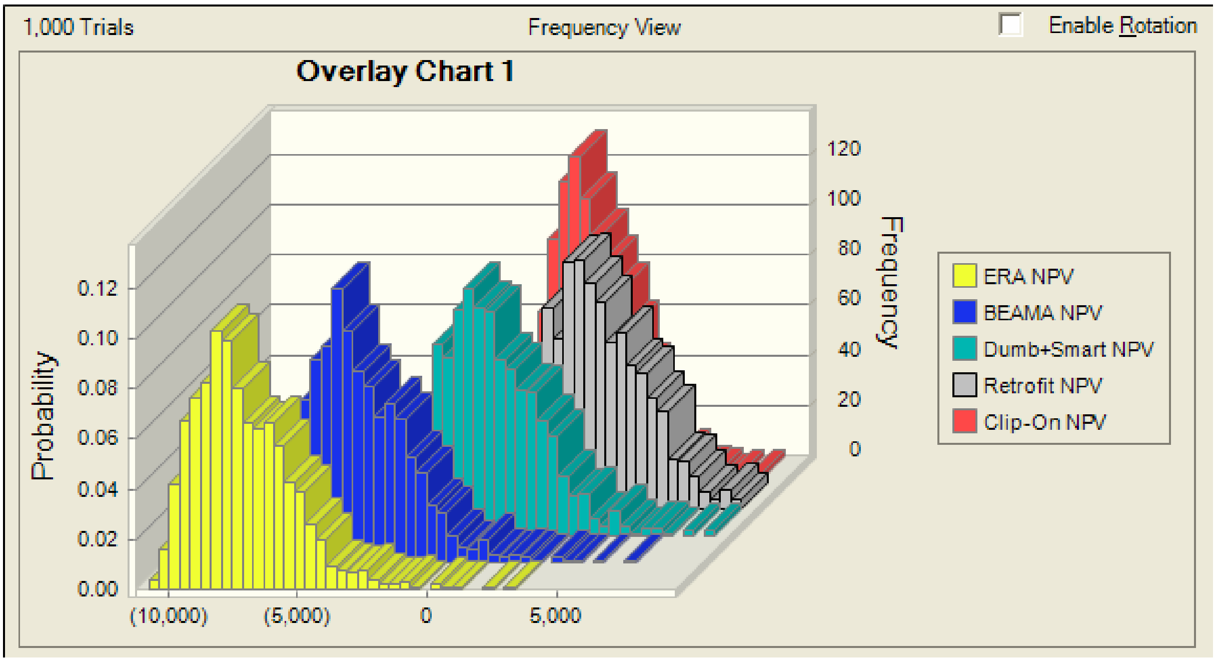
C.17 Market with WiMax



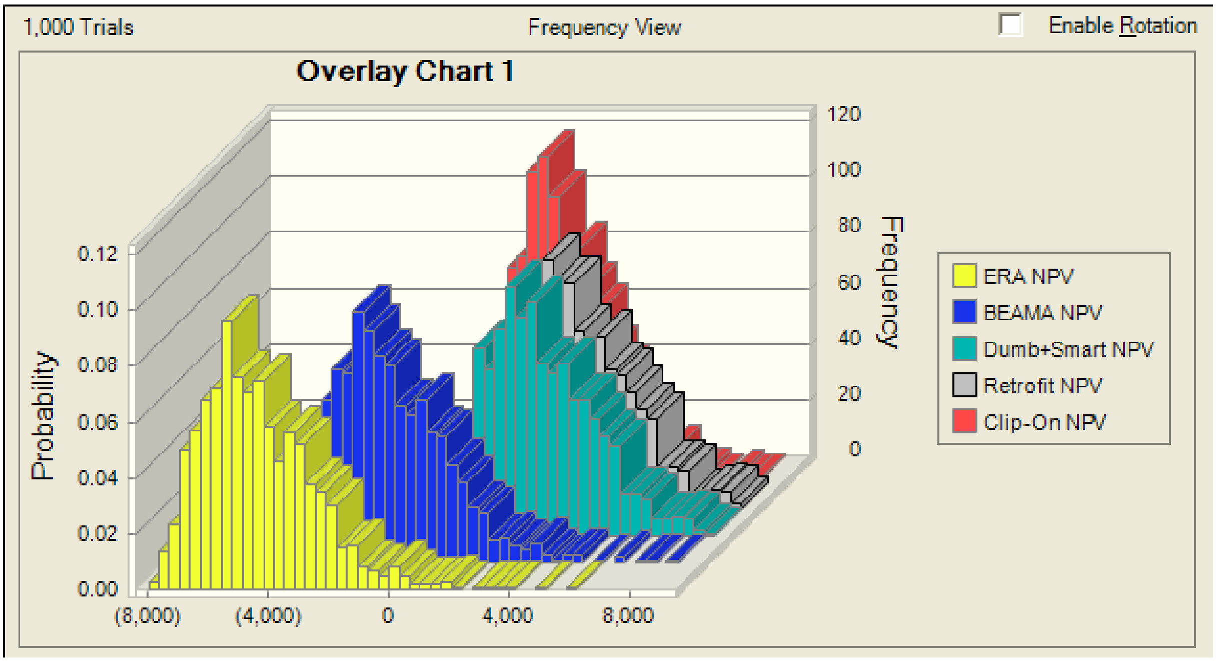
C.18 Market with 3G



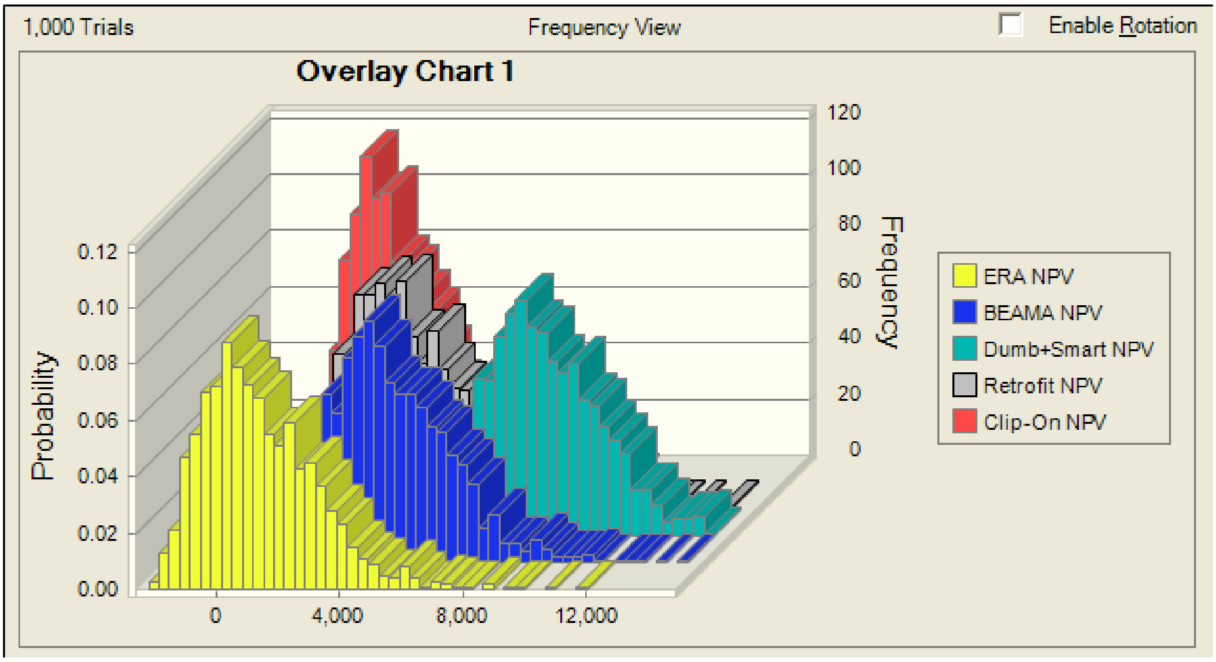
C.19 Market with Hybrid 1



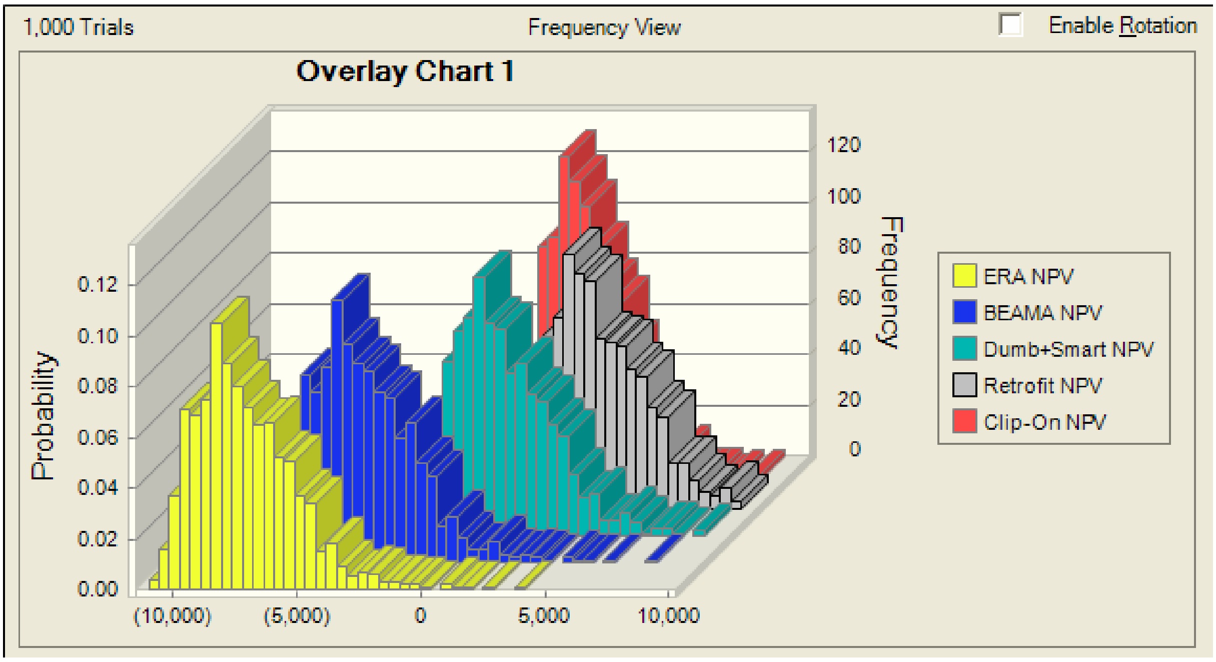
C.20 Market with Hybrid 2



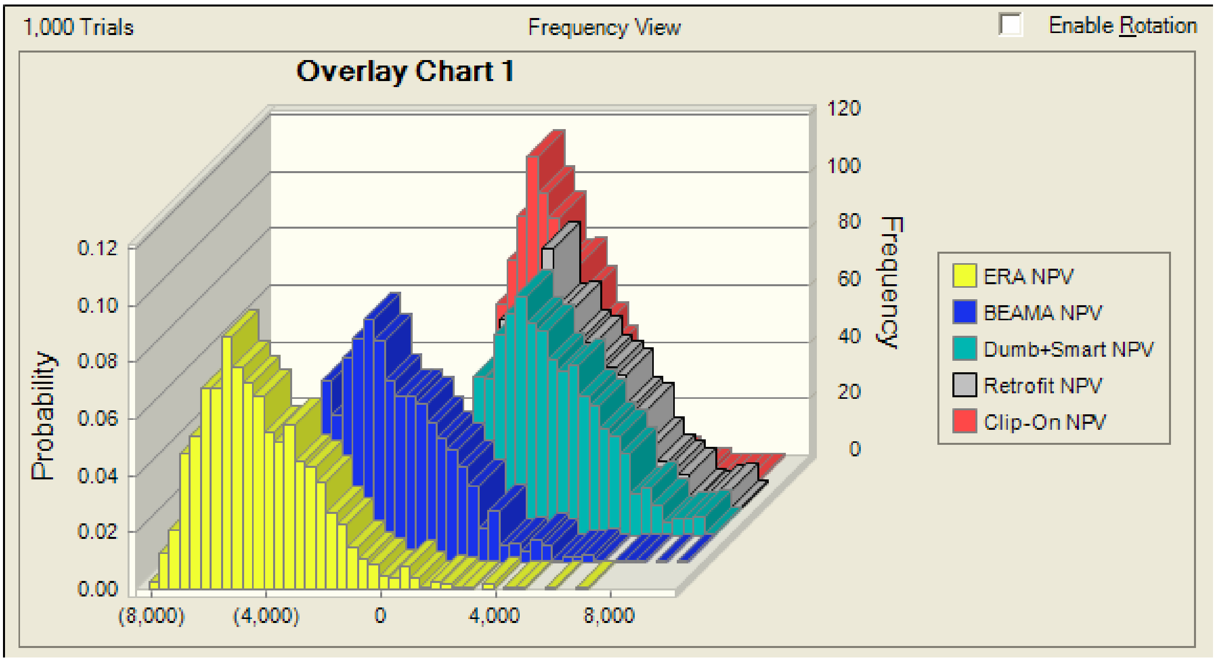
C.21 Market without comms



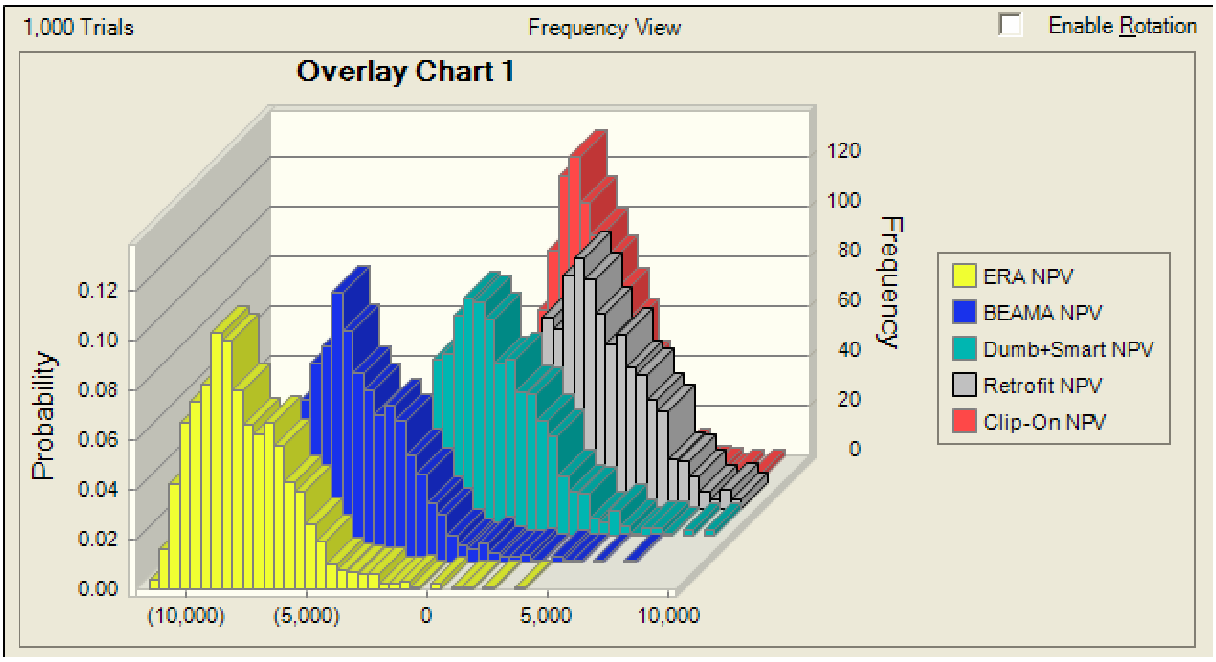
C.22 Market Tip with PLC



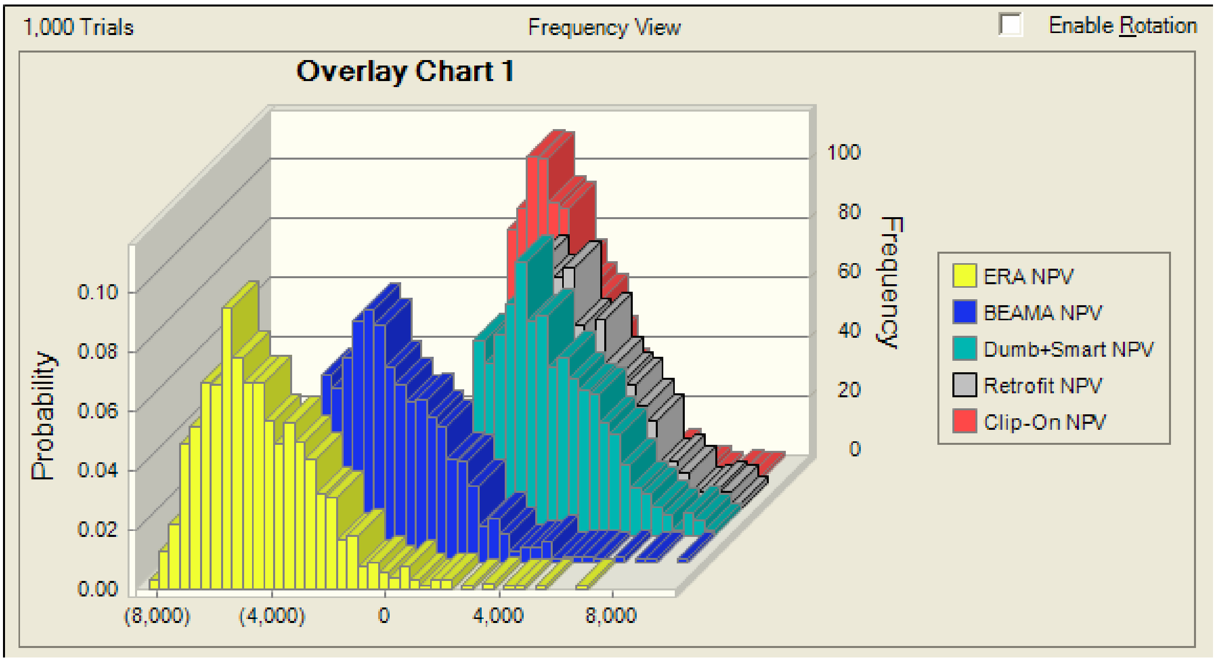
C.23 Market Tip with P. Broadband



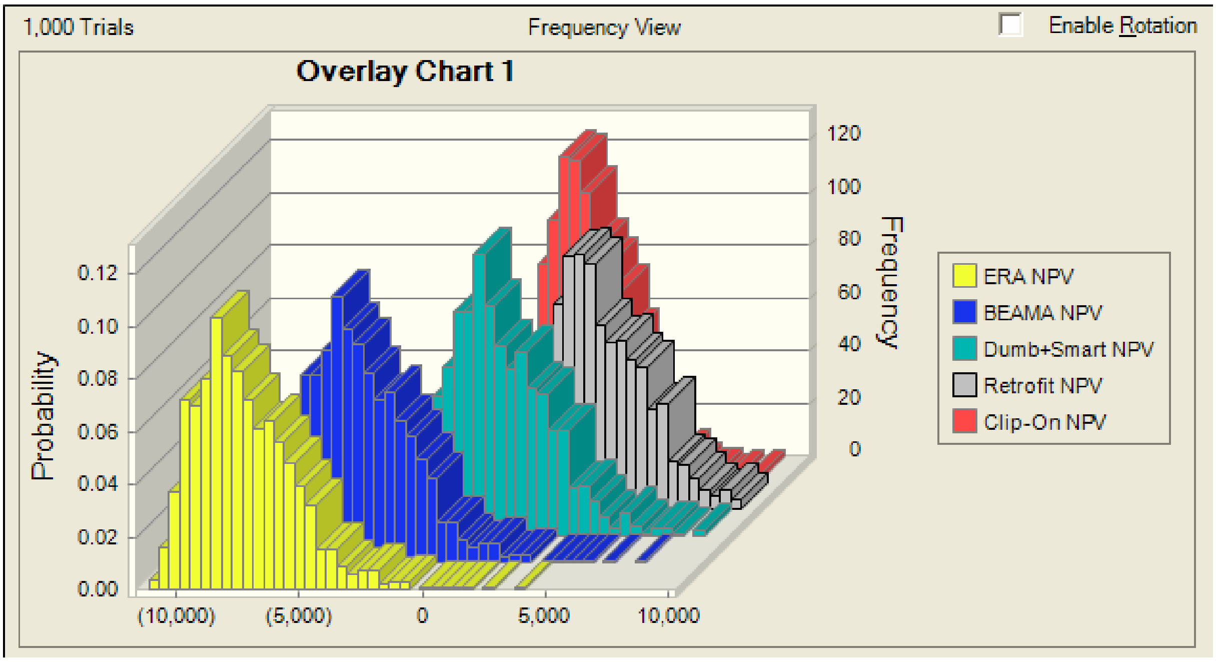
C.24 Market Tip with WiMax



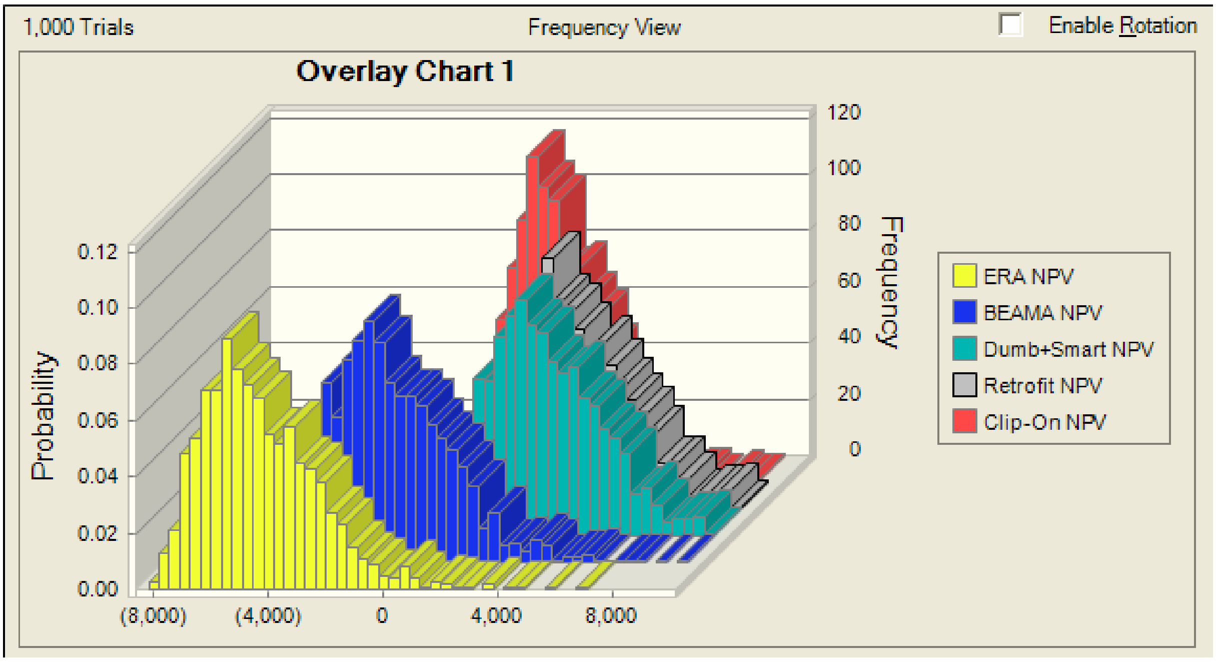
C.25 Market Tip with 3G



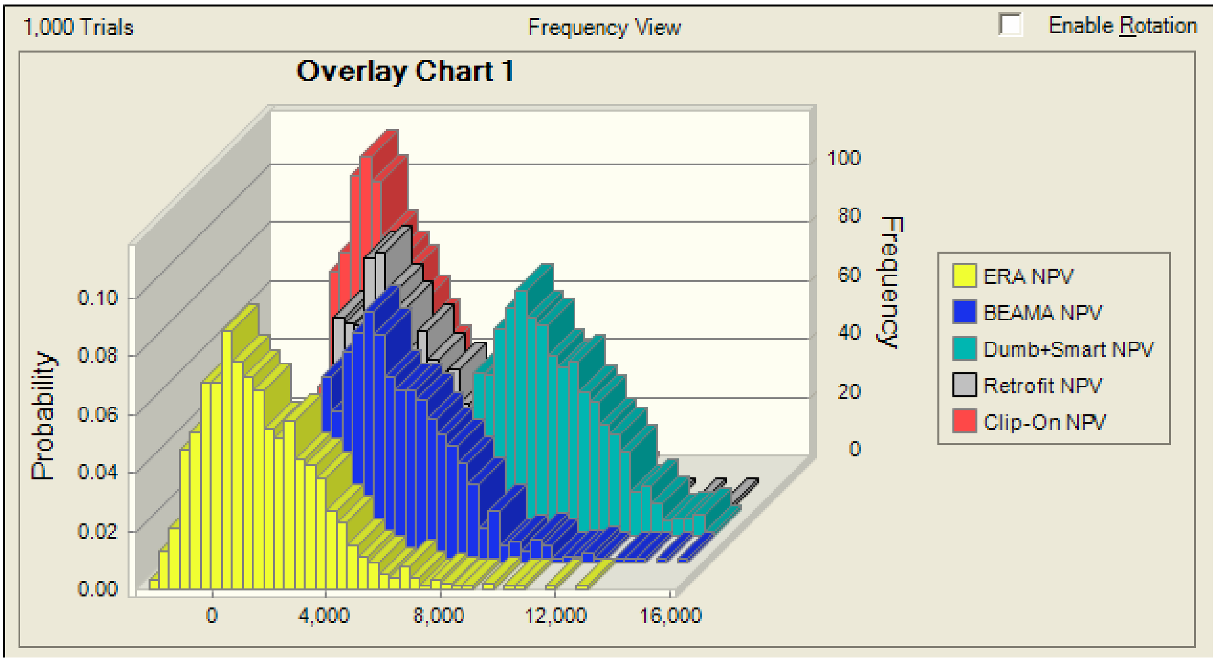
C.26 Market Tip with Hybrid 1



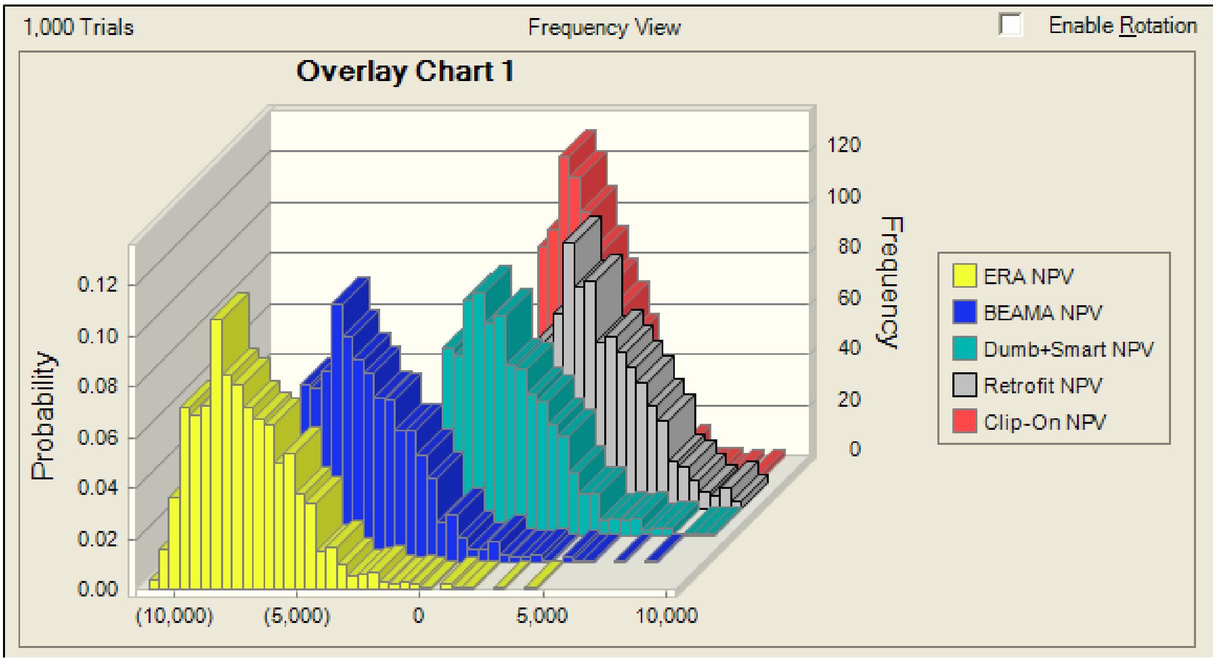
C.27 Market Tip with Hybrid 2



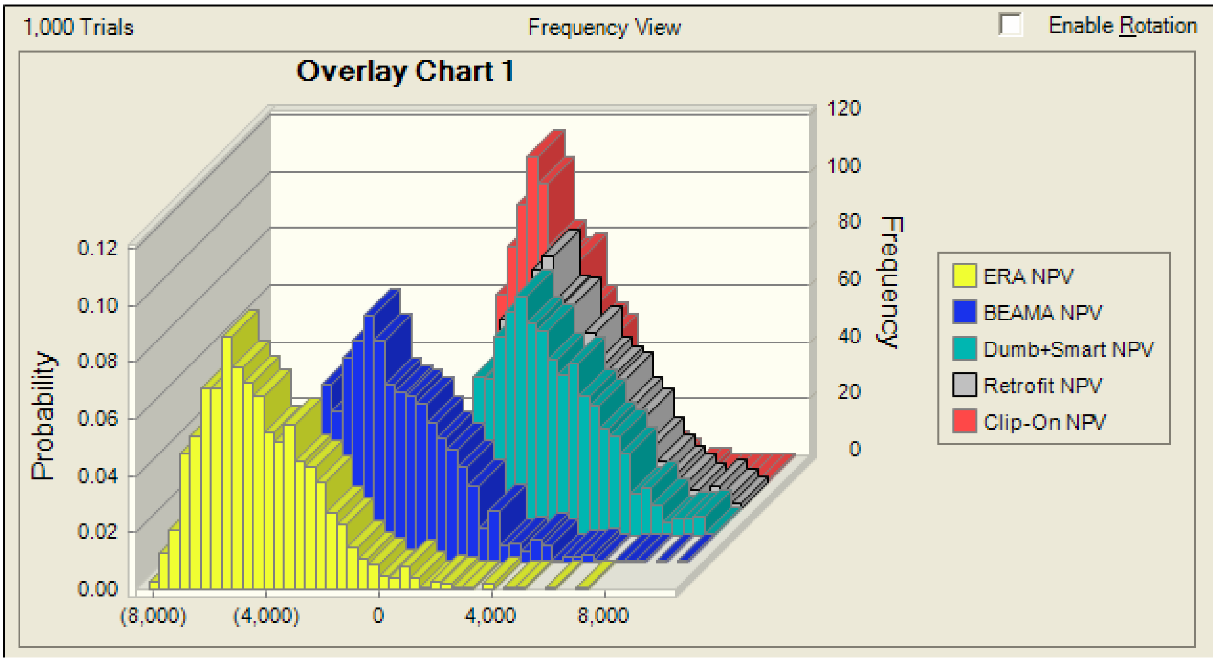
C.28 Market Tip without comms



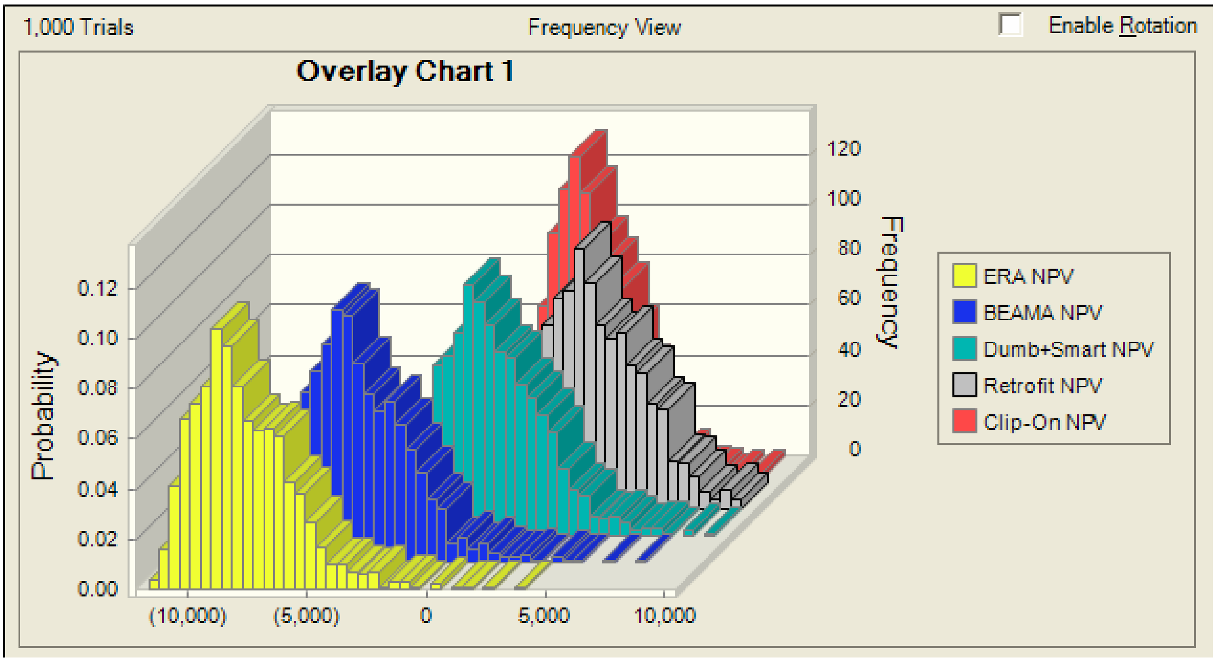
C.29 Market Tip Fast with PLC



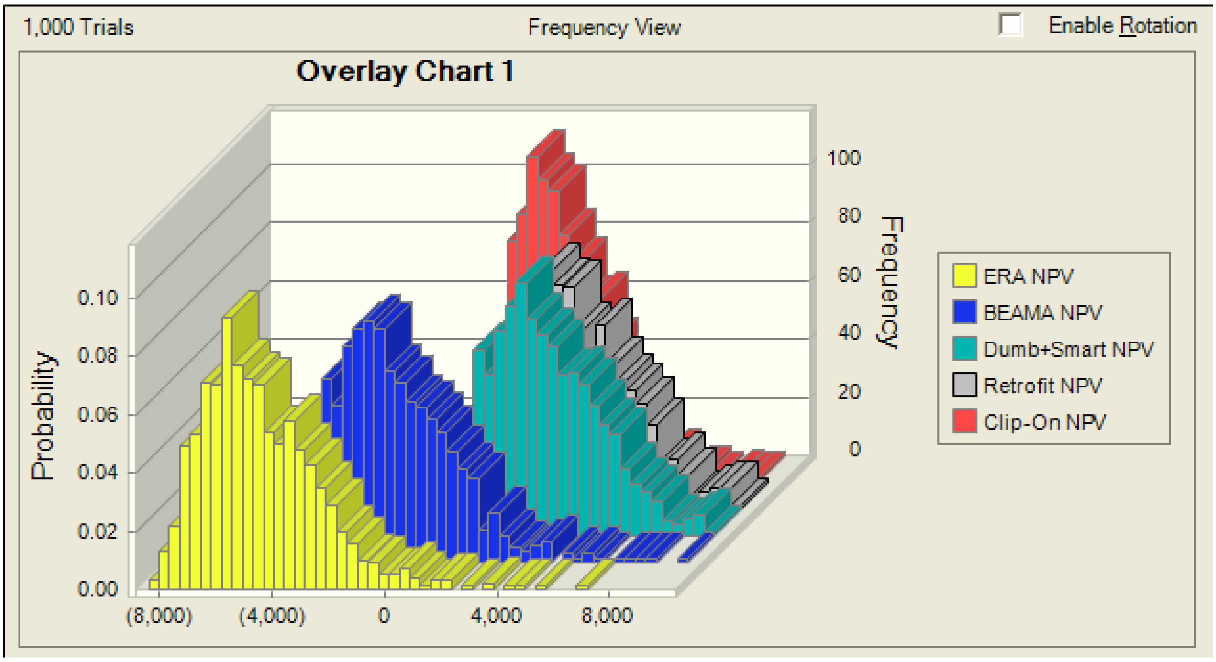
C.30 Market Tip Fast with P. Broadband



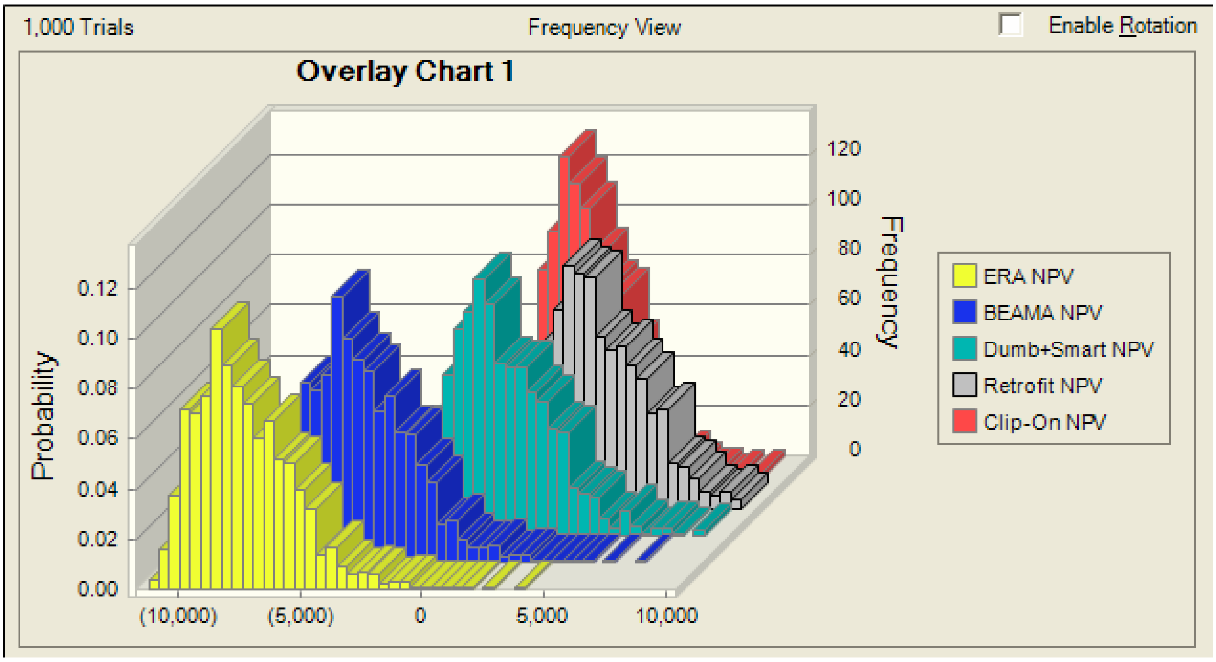
C.31 Market Tip Fast with WiMax



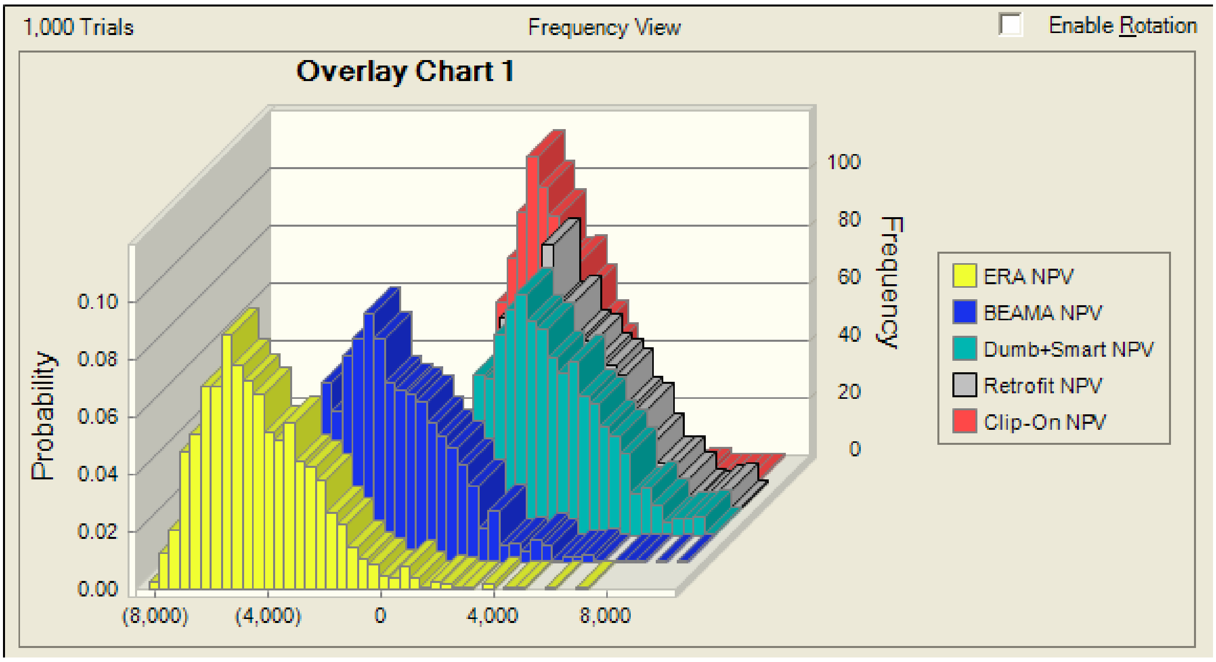
C.32 Market Tip Fast with 3G



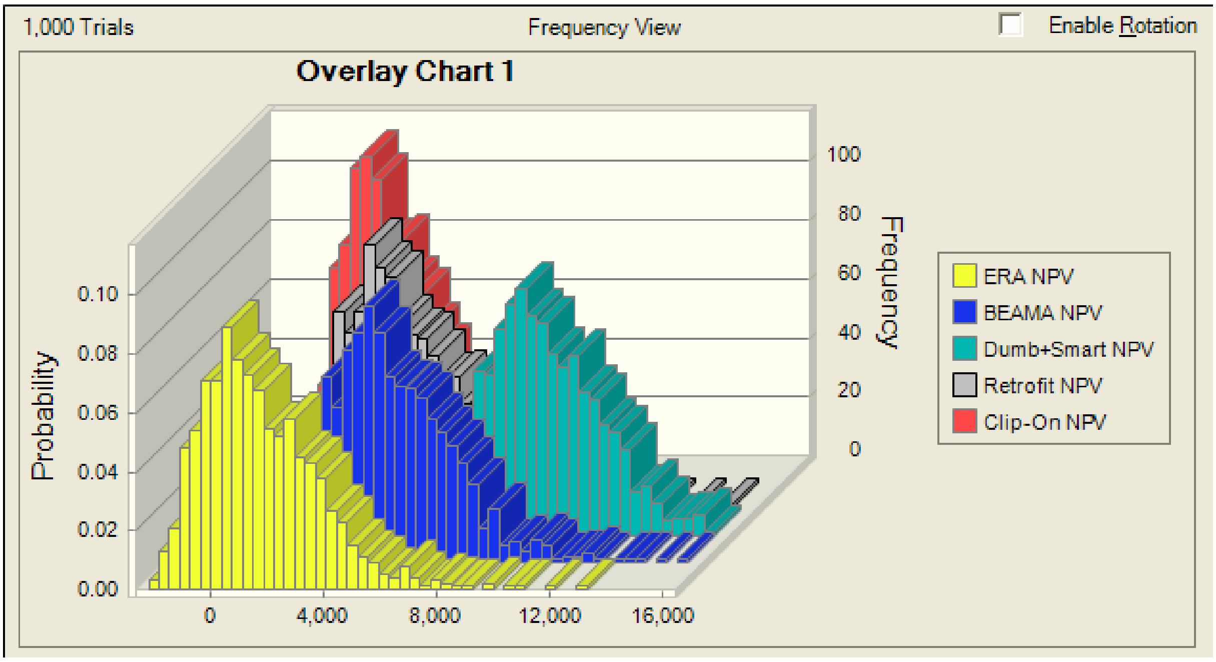
C.33 Market Tip Fast with Hybrid 1



C.34 Market Tip Fast with Hybrid 2



C.35 Market Tip Fast without comms



References

[1] NTA requirements v110.doc 08.08.2007 Kema Consulting.

[2] Companion standard interface P1 revision A 10 July 2007 EnergieNed I&C P1 version 1

[3 Companion standard interface P2 draft revision A 22 August 2007 EnergieNed I&C P1 version final

[4] http://en.wikipedia.org/wiki/OSI_model An explanation of the OSI reference model

[5]http://www.digitalhomemag.com/features/default.asp?pagetypeid=2&articleid=37984&subsectionid=1300&subsubsectionid=1597

[6] Smart Metering Operational Framework Proposals and options version 0.3 ERA

[7]6.1% of UK households have WiFi, - Strategy Analytics May 2006

[8] BWCS predicts 27% of broadband homes will have WiFi by 2007

[9] Characterisation of an unintentional WiFi interference device- The residential microwave oven Tanim Taher et al http://www.ece.iit.edu/~albanna/MWO_Tanim.PDF

[10] Watch your Watts : Communications engineer August/September 2007

[11] OFCOM Broadband Migrations Review Audit of OCC data on broadband migrations 10th July 006

[12] http://www.tmcnet.com/wifirevolution/articles/3163-d-link-unveils-its-first-wimax-router.htm

[13] Easyline+ project reference sources: "Sixth EU Framework Programme for Research and Technological Development (Cordis FP6)
http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&DOC=11&CAT=PROJ&QUERY=1191839686560&RCN=80533
"IST Ambient Assisted Living (AAL) in the Ageing Society Specific Targeted Research Project"
http://www.ist-world.org/ProjectDetails.aspx?ProjectId=ca0b9ff6bab04a69897afe30089dce62
"Arenque Knowledge Solutions, Easyline+"
http://www.arenque-ks.com/easynet/projectobjetives.html
"Assistive Human-Machine Interfaces for Smart Homes"
http://www.newi.ac.uk/groutv/papers/nrg2007/royrobinetmcginngroutpicking.pdf

[14] OECD (2006) "Accelerated Internationalisation by Emerging Multinationals: The Case of White Goods," http://www.oecd.org/dataoecd/59/8/36317032.pdf

[15] ESTIA Consortium (2006) "ESTIA Applications, Requirements and Architecture," http://www.ist-estia.org/deliverables/estia_alcatel_wp2_d21_final.pdf

[16] http://www.research.philips.com/technologies/syst_softw/phenom/index.html

[17] BS EN 62056-53:2007 – Electricity metering. Data exchange for meter reading, tariff and load control. COSEM application layer.

[18] BS EN 13757-2:2004 – Communication systems for remote reading of meters. Physical and link layer.

[19] 03/308772 DC – EN 13757-4. Communication systems for meters and remote reading of meters. Part 4. Wireless meter readout (radio meter reading for operation in the 868-870 MHz SRD band).

[20] PD ISO/TR 21730:2007 – Health informatics. Use of mobile wireless communication and computing technology in healthcare facilities. Recommendations for electromagnetic compatibility (management of unintentional electromagnetic interference) with medical devices.

[21]http://www.ukerc.ac.uk/ResearchProgrammes/TechnologyandPolicyAssessment/TPAReboundEffect.aspx

[22] http://www.hm-treasury.gov.uk/media/A/E/greenbook_mott.pdf

[23] Oxford Dictionary of Economics

[24] Khatib, H., (1996) Financial and economic evaluation of projects with special reference to the electrical power industry, Power Engineering Journal, February, p.49

[25] Smart Metering: A report prepared for Centrica, Frontier Economics, October 2007