Value Creation and Value Capture of Advanced Electricity Meter Information

By

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ABSTRACT

Advanced or smart metering has been a hot topic in the electricity community for several years. Despite the excitement about the technology, few business cases are actually able to justify the investment cost. One reason for the gap between costs and benefits is that major benefits such as avoided investments have long payback times and are difficult to monetize. However, another aspect which is largely overlooked is the value creation through non-electricity market related business models. These business models range from advertising over customer profiling up to insurance or juridical usage of data gathered from advanced meters.

This paper summarizes the finding of a number of studies on the value of smart meter information on electricity market related benefit and gives an overview of non-electricity market related business models. The paper gives quantitative estimates of the value for electricity related activities such as energy efficiency, avoided investment and dynamic pricing. In additional it provides a qualitative analysis of the value and barriers of non-electricity market business activities.

In addition to this the study also gives a short outlook on how this value might be captured and which players are best positioned to capture significant shares of the total created value.

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1. Value creation of smart meter information

The value of smart meter information is the sum of the value of many purposes it can be used for. Firstly, the advanced metering of electricity consumption can be used for energy efficiency purposes. This includes optimizing devices such as heating, ventilation and air-conditioning (HVAC) or by behavioral change induced by dynamic pricing mechanisms. Energy efficiency is a major argument from a macro-economic perspective. The benefit of reduced requirements for building new power plant from peak shaving is difficult to monetize, but can nevertheless become a significant advantage for society as a whole.

Secondly, electricity information can be used to optimize the operational procedures for utilities. For example, remote meter reading saves significant costs, reduces outage times through faster outage detection and customer information can be used to reduce churn as well as give utilities better information on customer profiles. The information on consumer profiles can be used to better understand the effect of dynamic pricing schemes. Load profiles can also be useful for non-electricity related businesses. For example, the load profile gives information about the appliances (residential) or equipment (commercial and industrial) and thus offers opportunities for direct marketing, insurance usage, consumer profiling and other purposes.

1.1. Value analysis

The value analysis estimates the value of information from different activities. In this part of the thesis the value analysis does not distinguish which player actually captures the value, but only the total amount of value created. This means that value transfers from one player to another are not included, as they would cancel out. Nevertheless they are sometimes mentioned if their magnitude is extremely high to illustrate that transfers have not been forgotten.

1.2. Energy Efficiency value

The analysis of energy efficiency value is divided into two sections. The first section introduces the terminology and gives a qualitative overview. The second section describes the quantitative assessment and estimation of benefits of each separate issue.

1.2.1. Qualitative analysis

The value of energy efficiency can be split into two categories – short-term (or mostly price) benefits and long-term avoided investments. {{49 Faruqui, Ahmad 2008}} The information from smart metering can for example be used to introduce dynamic pricing. As dynamic pricing enables customers to shift of consumption from peak times to base time it creates value for the whole system. If load is shifted peak times with higher variable production costs times are substituted by base times with lower variable costs. (Faruqui and Wood 2008, 1-57)

The challenge for measuring the total value of demand shifting is the reduction in consumer value of using electricity at a less convenient time. The consumer value for using electricity at a less convenient time of use is less, but estimating by how much is almost impossible. Therefore I introduce two extreme positions to make the lower and upper bounds of the value clear. In the later analysis I will assume that the real position is somewhere between these extreme assumptions. Firstly, the value changes exactly as much as the price, meaning that shifting demand does not create any value for the customer. The price of the consumer is reduced by the exact same amount as the reduced consumer value. This would mean that consumer shifting does not create any benefit for themselves but only monetizes consumer surplus. However, the consumption shift decreases prices at peak times (and slightly increases prices at base times) and thus changes prices for all customers even if they do not react to peak prices. Therefore the value for the customer group as a whole is created as all customers benefit from a lower price of electricity at peak times. The slightly higher base electricity price reduces this benefit slightly.

The second extreme to estimate the customer benefit is to assume that the value for usage of electricity does not change at all. This means that consumers are completely indifferent when they consume electricity. Although this seems irrational at first, this position does apply to some electricity usages. For example, a residential consumer is indifferent if the dryer starts at 11pm or 3am as long as it is finished in the morning. Similar an industrial complex does not care whether the automatic cleaning of a machine starts at 7pm or 11pm. Of course for other appliances such as a TV-set or a cooking stove in the residential area or manually controlled machines in the industrial segment this does not apply. Both extreme positions make the upper and lower bound of the value become clear.

The benefit for the producer also depends on assumptions on market circumstances. As the peak demand is reduced, the wholesale price drops and the economic rent on all power plants scheduled at that time is reduced by the amount of the price drop. On top of that the number of hours peak power plants (PPP) run is reduced. There are three unique cases to analyze the value which depends on why the investment into PPP took place.

Firstly, the regulator made the electricity generators invest in these plants as they had to provide quality of service and capacity for even the highest hours of demand. This is the case in basically every regulated market and even in most de-regulated markets the investment in PPPs was performed before competition was introduced. In a regulated market with a fixed compensation this is no problem for the electricity generator, as the compensation is fixed (based on criteria amongst others fixed assets or cost plus margin varying from region to region). In a competitive market this assumption would imply that the PPPs actually are a loss making investment, as they can never recover their capital costs. The only reason why they exist is the regulatory setup and the fact that electricity generators make enough profits to cross-subsidize these investments.

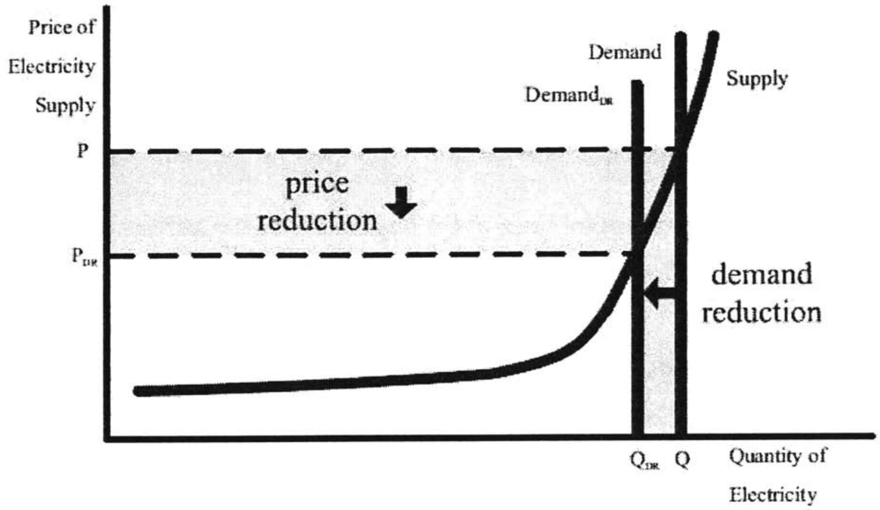

Figure 1 – Illustration of reduced peak demand and according price reduction
Source: US Department of Energy, "Benefits of Demand Response in electricity markets and recommendation for achieving them - A Report to the US Congress Pursuant to Section 1252 of the Energy Policy Act 2005", 2006

The above case shows that PPPs could never finance themselves in a stand-alone fashion. In order to make stand-alone PPPs an economically reasonable investment they would need to retrieve their capital costs. Therefore the operator of the power plants would need to price capital costs into the bid to receive an interest on the investment. Normally power plants e.g. base power plants receive an economic rent, as the wholesale price for electricity is higher than their marginal cost of operations. The marginal cost of operation in this example includes both, fuel costs, start-up costs and all other cost of operation such as maintenance. The economic rent can be used to recover their high capital investment (e.g. for nuclear and coal power plants). PPPs are likely to never receive an economic rent as no other power plant has higher marginal costs. Peter Cramton, Peter Stoft and later Paul Joskow call this the missing money problem, as the lack of compensation for investments affects the investment in new PPP power plants and can thus create shortages such as in California. (Cramton and Stoft 2005, 2011, March 16){{50 Cramton, Peter 2005}}(Joskow 2006, 2011, March 14) If the market works effectively meaning that each power plant always issues bids for power at the marginal cost PPPs cannot recover their capital costs, unless the provider is able to price this in from the beginning on. This second scenario thus implies that markets are not operating 100% efficiently as competition for PPP bid is low enough to allow higher bids than marginal cost and that the regulator does not force utilities to bid at their marginal cost. This scenario is highly unlikely as market regulators would do not allow bids that include capital costs. At maximum bids could include small shares of the capital costs which cannot be detected by the regulators.

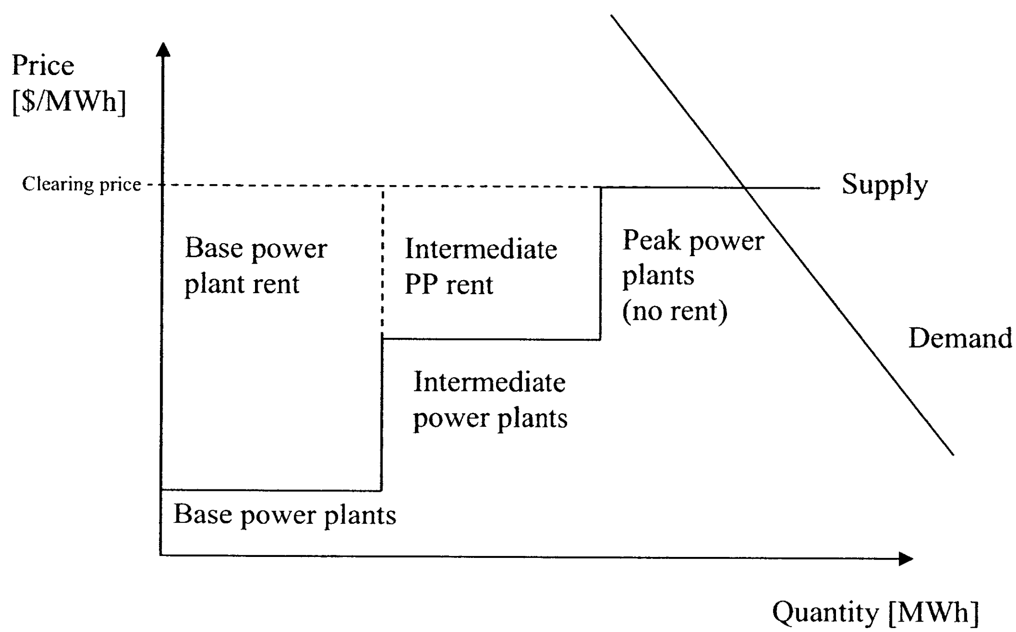

Figure 2 – Illustration of missing money problem (clearing price equal to PPP marginal costs)

The third scenario explains an economic sense behind investing in peak power plants for electricity generators as part of their portfolio. As electricity generators often operate a whole fleet of power plants for base, intermediate and peak demand the discussion should include the effect on the whole portfolio and not focus on stand-alone PPP analysis. Even if peak power plants cannot receive an economic rent, the high price during PPP hours increases the rent for all other power plants of the portfolio. This would also be the case in both scenarios above. The unique feature of the third scenario is that the utility can decide on the characteristics of the peak power plant. If the regulator allows the electricity generator to choose the kind of power plant they invest in, it would increase its margin by investing in very efficient, low marginal cost base and mid-range power plants, but investment in very cheap and extremely high variable cost peak power plants. This way the utility would not break any market rules, as it always prices at marginal cost. The utility would never be able to directly recover its investment on the PPP from their bids, but the utility would most likely get more than enough to cover the investment costs from the increased rents on the rest of the portfolio.

If the first scenario was true shifting demand would reduce the number of hours a PPP runs. The utility only receives the exact marginal costs for the hours and thus does not care how many hours the plant runs. However, the price is reduced and the rent for all other power plants with it. This affects the revenue of the electricity generators and reduces its benefits. On top of that electricity generators would have no incentive to invest in new PPP as they would have difficulties to recover their investment cost. In the second scenario of demand response the utility loses due to both, lost contribution margin on the hours of operation of the PPP and lower rent on all other power plants. As stated before, this scenario is unlikely as recovering significant portions of the capital costs is restricted by regulators. The third scenario is basically the same as the first scenario, only that the implication is that the electricity generators artificially held the price even higher during PPP hours and thus loses more rent than in the normal environment with efficient PPP. In any of these scenarios the electricity generator loses from demand response capacity being introduced to the system.

The only scenario for a utility to gain benefits in the short-run is under the assumption that the wholesale price was capped and the electricity generators had to sell its electricity at peak hours under the marginal costs to satisfy regulatory restrictions. The price would then not change making the rent on all other power plants stay equal and the loss of PPP running would be reduced. Therefore the exact impact of demand response on the benefit of utilities depends on the market environment and regulatory setting.

In the long-run the case for benefits from demand response looks quite different as avoided investment costs create significant benefits for electricity generators. Demand response reduces the peak demand and therefore reduces the long-term demand for new capacity investments. Consequently the generators have lower capital investment but can offer a similar service to its customers. This massively increases the return on invested capital or assets for the electricity generators as the total investment and total assets are reduced significantly.

It is difficult to evaluate whether bids are priced at marginal costs. This exact problem is the debate of many law suits and regulatory hearings around the world. For this paper I assume that PPP owners have other electricity generating assets and thus face effects on their portfolio if the price changes due to demand response mechanisms. The quantitative analysis illustrates the result for all three scenarios.

Similar short-term and long-term benefits also apply to the transmission and distribution system. Firstly, a reduction of peak demand reduces congestion of transmission lines. A system without congestion will be able to support the cheapest power sources better and thus reduce costs of electricity. Secondly, the fraction of line losses to total power throughput is reduced. The fraction of line losses is a quotient of P_{loss}/P (P being the power demand at a specific point in the network). The total loss is equal to the power squared (P^2) times the resistance (R) divided by the voltage squared (V^2) ($P_{loss}=P^2R/V^2$). Thus P_{loss} is equal to the current squared (I^2) times the resistance ($P_{loss}=I^2R$). If the demand at a specific point increases, the current has to increase (since $P=V*I$) as the voltage is fixed. The resistance depends on several factors, but the most important one being the thickness of the copper wire (which can be made hollow to increase the diameter further at relatively low weight). P_{loss} however increases quadratically with P as the voltage remains stable and resistance also is fixed. Therefore the fractional loss will increase with a higher power demand at peak times. Demand response which decreases the hours of extremely high demand thus reduces the transmission losses in average throughout the year. (Hokin)

On top of the operational advantages of transmission and distribution system demand response also reduces the investment into new transmission and distribution lines for the same reason as for generation capacity. As the peak demand is reduced, the necessity of new transmission and distribution lines is reduced and the transmission and distribution charge could be reduced in the long-run against a baseline scenario with no demand response. This will again decrease electricity prices.

1.2.2. Quantitative analysis

The total benefit from energy efficiency and demand shifting consists of the operational and investment benefits on both the energy supply as well as transmission & distribution system.

The first section is the operational benefit of the electricity generation and consumption sector. Although the mechanism for the reduction of the wholesale price is clear, estimating the exact number is complex. Smart meters enable dynamic pricing in the market. This leads to a more responsive consumption pattern, reducing demand at peak times with high prices. The wholesale price is defined by the bids of the electricity generators which should equal marginal cost of production of the most expensive unit generating electricity. As demand drops the wholesale price drops as well. The steeper the cost curve is, the higher the price reduction. For example the most expensive hour in North-Eastern Massachusetts/Boston (NEMA/BOSTON) of operation in 2010 cost almost $550/MWh whereas the one-hundred and first most expensive hour only cost around $150/MWh.{{33 Independent System Operator New England 2010}} For then onwards the price stayed fairly stable and only dropped slowly with each hour being marginally cheaper. The average price in 2010 was around $50/MWh. A similar picture can be seen throughout the years before. In 2008 and 2007 the numbers are almost identical. In 2009 the drop in price was only from around $260/MWh to $120/MWh for the first 100 hours. In 2005 and 2006 the price drop was even from more than $1000/WMh for the most expensive hour to less than $200/MWh to the one-hundred and first most expensive hour of wholesale electricity. (Independent System Operator New England) This shows the potential of demand response to reduce the price even if it is only used for a few of hours every year. The Independent System Operator New England performed a study estimating that for 2005 a 1% reduction in demand at the highest priced hours would have resulted in a 15% drop in price. (Independent System Operator New England 2005b)

The demand response capacity in 2009 in Massachusetts was 5.34% (or roughly 650MW) of the total installed capacity. (Independent System Operator New England 2010b) In 2004 the demand response capacity across the USA was about 3% and the actual delivered peak reduction was around 1.3%.(U.S. Department of Energy 2006, 1-122) Assuming a similar ratio of capacity to actual reduction, Massachusetts could already deliver more than 2% peak reduction through demand response. The FERC estimates that more than 20% of demand response capacity is possible if full participation (including a complete smart meter and dynamic pricing role-out) is achieved within the ISO-NE.(The Federal Energy Regulatory Commission Staff 2010, 1-118) Again using the same ratio, this would translate into a peak reduction potential of around 8.6%. In another study The Federal Energy Regulatory Commission (FERC) even estimated that the potential for peak reduction in Massachusetts alone from residential price mechanisms is 6.2% for a 4 to 1 price and 9.83% for an 8 to 1 price ratio.(The Federal Energy Regulatory Commission Staff 2010, 1-118) Of course, the benefit of every additional percentage point peak shifting diminishes extremely quickly.

The complex issue is to derive the demand reduction at peak times, increase at base times and price impact. Chua-Liang Su and Daniel Kirschen modeled this impact with an algorithm describing supply and demand bids for a hypothetical market similar in size to the NEMA/BOSTON nodal point. They found a slight increase in price during base times and a decrease in price during peak times. (Su and Kirschen 2009, 2011, March 14)

Credit Suisse's estimate of the price effect of changes in this base/intermediate capacity is linear, with energy price declining about $0.0045/MWh for each MW of capacity added and rising the same amount for each MW removed. (Synapse Energy Economics Inc. 2009, 1-277)

This would give an estimate for the increased price during base times if loads are shifted. However, the report does not give an estimate for the reduction of the wholesale peak price due to added demand response capacity.

An illustrative example of the total price effect is to take these figures and assume a 1% reduction in the 100 most expensive hours and an increase of the same energy consumption in any base/intermediate one-hundred hours. Taking the estimate of the ISO-NE report from 2005 the peak price would be reduced by 15%.(Independent System Operator New England 2005b) As demand response capacity in Massachusetts can reduce the extreme peaks by around 2% this is a rather conservative estimate. The average price for the 100 most expensive hours in 2010 in NEMA/BOSTON was $192.21/MWh. A 15% reduction would reduce the price by $28.83/MWh. The average consumption in the 100 most expensive peak hours in NEMA in 2010 was roughly 4,195MWh leading to a total consumer saving of almost $12.1 million. The base load increase caused by the 1% load shift would increase the load by 42MW for 100 hours. Assuming that an increased load has the same effect as a decrease in capacity for base/intermediate load the price would increase by $0.0045/MWh or a total of $0.19/MWh for 100 hours. As the load for these hours is only around 3000MWh the total consumer price would increase by around $60,000. This results in cumulative consumer savings over $12 million per year. The total wholesale cost of electricity in 2010 at this node is roughly $1.294 billion meaning a price reduction of the yearly average price of electricity by 0.93%.(Independent System Operator New England)

Depending on the assumption on consumer's indifference to the time of their electricity consumption two extreme cases were discussed in the last section already. If consumers are not indifferent they will have less benefit from the electricity consumption. The first extreme assumption is that they have the exact consumer surplus as before and the whole reduction in price is compensated by the loss of consumer value. In this case the total value for the consumer is the $12 million through a reduction in the wholesale price. The opposite position is that consumers are completely indifferent and thus also receive the complete benefit of lower prices for the 4,200 MWh shifted. As the price at new at peak is about $114/MWh higher the total price advantage would be an additional $478,800. However, firstly this assumes the extreme position that no consumer value is lost and secondly even if accurate can be neglected due to its comparatively small size.

This illustrative example shows that by enabling demand response through dynamic pricing smart meters can transfer significant benefits from the electricity generators to the consumers.

The exact negative impact on the producer side depends on the assumptions taken. If the PPP were bidding at their marginal cost, no benefit is lost to the producer if they run lower hours. Assuming that the marginal cost increased linearly for the last 42MW of the load stack the producers lost roughly $239,400 (half of $478,800) in benefits from dispatching the PPP – the amount of economic rent on the last 42MW. In additional they also lost the exact amount consumers gained from wholesale price influence on the rest of the generation portfolio (also due to reduced rent). If the PPP even had their capital costs priced into their bids the lost benefit was even higher. If the PPP power plants held the price artificially high, the only the loss would still be the same as in the first scenario. The last option is that the PPP power plants were actually bidding below their marginal costs due to regulatory constraints such as a price ceiling. Not having to run these PPP in that case would actually benefit the producers, if the wholesale price stayed stable.

Summing up, under all assumptions the lion share of the consumer benefit is not a net benefit for society, but merely a transfer from wholesale market bidders to buyers or electricity producers to consumers.

In contrast to this, the benefits of avoided investments in electricity generating assets are mostly a net benefit. If a similar service can be provided at less cost then net value is created. FERC estimated that peak demand can be reduced by 20% and also assumed half of this would come from the residential sector. As residential demand only makes up around one third of total demand this means that residential consumers would need to reduce their individual demand by around one third. (Newell and U.S. Energy Information Administration 2010)

Another estimate is implied in the quantification of benefits in PJM by Faruqui and Wood. The study estimates that the benefit for capacity is equal between $294 and $594 per customer depending on the pricing scheme over a period of 15 years. Using the same input factors as in the study this translates into a capacity offering of 0.36kW to 0.74kW per residential customer at any hour of the year.(Faruqui and Wood 2008, 1-57) Assuming that peak demand per residential customer should be somewhere between 2 and 4 kW this results in a reduction potential between 9% and 37%, which is somewhat similar to the FERC estimation for the residential sector. (Rosin et al. 2010)

Instead of calculating the avoided investment costs of power plants I will calculate the value of demand response capacity using the forward capacity price for the nodal point NEMA/BOSTON. In the nodal point NEMA/BOSTON capacity was issued in the forward capacity market with a value of roughly $160/MW/day on average in 2010. (Independent System Operator New England) If we assume the same total reduction potentials of 0.36kW to 0.74kW per residential customer as calculated for the PJM market then this would translate into an annual value of capacity savings between $21.02 and $43.22 per customer.{{62 PJM Interconnection 2010}} This does not take into account that the value of capacity would decrease as more and more people bid into the capacity market. However, the total electricity consumption is also assumed to increase and limits this pitfall in the analysis. On top of that demand side capacity will influence the long-term planning and a trend for more demand side capacity will thus decrease the number of new plants that would have otherwise been built, further stabilizing the capacity price. This calculation is extremely simplifying the issue and should therefore only be seen as a rough estimate or directional guidance.

In additional to the benefits from operational and investment energy supply source come the benefits from transmission and distribution. An in depth analysis for the operational benefits would require to identify the exact lines that are used at their maximum capacity and calculate the constraints that derive from congestions. For the investment benefits, a similar analysis for planned and avoided investments would need to be taken. In order to limit the scope of this discussion I combine both categories and assume that each kWh saved reduces the operational and investment costs for transmission and distribution costs by the amount that is charged for these services to the consumer. As demand is shifted this simplification implies that all benefits are either investment benefits or reduced congestions and that the whole cost of transmission is investment and congestion cost. This simplification also does not take into account that the cost of transmission mostly depends on the capital invested and not solely on new investments. Even with no new investments, the price of transmission would stay stable until all lines are fully depreciated. The here taken assumptions therefore only hold in a very long time horizon.

Transmission at base times is basically free as no congestion is created and no new investments become necessary. This quantification excludes the qualitatively explained higher line losses from the calculation. The increased line efficiency should however be comparatively small to the other here mentioned benefits and can therefore be neglected.

In the ISO New England transmission costs were equal to $3.60/MWh in 2006 and estimated to increase over the next ten year. (Independent System Operator New England 2010a) Faruqui and Wood estimated that the total benefit from reducing the peak consumption for transmission was $15kW/year for PJM. As PJM is in many respects similar to the ISO New England (transmission cost of $3.94/MWh in 2009, expected to rise as well) I will use the estimate from Faruqui and Wood for this benefit analysis.(PJM Interconnection 2010) As discussed before residential demand response could reduce the peak demand of up to 10% at full potential. In order to calculate the benefit per meter it makes sense to only take the residential sector, as most industrial complexes have different requirements for meters anyway. In the NEMA-BOSTON node the peak demand in 2010 was 5436MW at 3pm on July 6. A reduction of 10% would reduce the cost of transmission by $8.154 million. As the total transmission costs for this node were close to $95 million this is equal to a reduction of

8.62% or a reduction of $0.31/MWh in the price of transmission. As the consumption of a typical New England household is around 7,500kWh/year this would reduce the electricity bill per household or meter by around $2.33 per year. (U.S. Energy Information Administration 2005) This does not mean that transmission costs actually sink, but only that smart meters have a benefit of $2.33 per year under the here given assumption against a baseline scenario with no smart meters and no demand response.

The operational and investment benefits from distributional savings will not be quantified. Distributional savings will be extremely difficult to obtain. An individual or small number of individuals will most likely not be willing to reduce their individual peaks which would save investments into distributional infrastructure. Reducing the individual peak of a household would mean not watching two TVs, cooking and letting the washing machine run at the same time. Nobody would take such drastic measures to save a small amount of money. On top of that the operational losses from distributional load being more smoothly distributed will not be comparatively small. Therefore I will only quantify transmission benefits and present a conservative assumption by leaving distributional benefits out of the analysis.

Summing up all estimates from this analysis smart metering can create a net benefit between $23.35 and $45.55 per meter per year from energy efficiency measures. These net benefits result from the investment advantages from electricity generation and transmission assets. Dynamic pricing and demand response does have a significant effect on the distribution of benefits between electricity generating entities and electricity consuming entities, but does not create net benefits itself. The effect is merely that benefits are transferred from producers to consumers. It does however enable avoided investments due to peak shaving and thus is the basis for the here mentioned benefits.

1.3. Operational optimization value

The operational benefits mainly consist of avoided meter reading costs, faster outage detection, improved customer service and better management of connects and disconnects. According to a study by Ahmad Faruqui, Ph.D. and Lisa Wood, Ph.D. in January 2008 the operational benefits should cover 50-90% of the smart meter investment.(Faruqui and Wood 2008, 1-57) Their estimation is based on the assumption that the benefits are discounted over a period of 15 years and that the total investment costs are $100-$200 for a smart meter. Taking all these assumptions together, the operational benefit could vary from $50-$180 at a discount rate of 8.5%.(Faruqui and Wood 2008, 1-57) Assuming these benefits are linearly distributed this would roughly translate into annual benefits of $5.30 and $19. Dr. Erik Shepard from Waterbridge Consulting was quoted in an interview to estimate the operational savings at 60-85% of total investment and thus at a similar range.(Shepard and Cornish) In order to understand in more detail where the exact operational benefits from smart metering is generated I will analyze each section separately.

1.3.1. Avoided meter reading costs

A study performed by Ahmad Faruqui, Ph.D. and Lisa Wood, Ph.D. in 2011 goes into detail about the distribution of the operational benefits of different categories. The study is based on a model that estimates the benefits for four "model markets" in the South, Central, East and West of the USA. The avoided meter reading costs per meter and year are equal to $24 for the South, $12 for Central, $7 for the East and $6 for the West.(Faruqui and Wood 2011) The large difference between the costs is based on the fact that the East and West are estimated to have Advanced Meter Reading (AMR) technology whereas the Central and the South do not. AMR here describes technologies that allow reading the meter without actually entering the premises but by driving by the meter.(U.S. Department of Energy 2006, 1-122) AMR does not refer to remote metering management. At the moment no detailed information on the report is publically available, but most likely distance, number of rural customers and other factors influence the cost per meter reading further. The study assumes a 20 year time period and a discount rate of 7.78%.(Faruqui and Wood 2011)

Other studies show lower savings for avoided meter reading cost. A study by the Ascent Group believes that by installing Advanced Meter Reading technology the cost for meter reading are reduced from $0.73 as an industry average to $0.24. If we assume monthly meter readings this would translate into roughly $6 savings per year by installed AMR meters instead of traditional meters. However, even if remotely read sophisticated meters would have no cost at all, they would only save an additional $3 per year.(The Ascent Group Inc. 2010) This means that Ascent Group estimates roughly half of the savings Faruqui and Wood estimate.

Another study by Accenture for Germany estimates savings from installing remotely read meters at €3.50 per year. This estimate is roughly in line with the Ascent Group estimate. However, it is difficult to compare Germany with the USA. For example in Germany meter reading are only performed once a year, whereas in the US usually once a month. Nevertheless the bandwidth of results from different sources and for different markets shows the controversy in the amount of benefits from avoided meter reading. (AT Kearney 2008)

All in all I estimate a benefit of $6-10 benefit per year for replacing a traditional meter with a remotely read meter and a $3-5 benefit per year for replacing an AMR meter with a remotely read meter. For Massachusetts these benefits are most likely rather at the lower end, as most of the population lives in or near urban areas. Assuming a mix of traditional and AMR meters and by rule of thumb I estimate the benefit at $4 for the NEMA/BOSTON node being fully aware that this estimate incorporates significant uncertainty.

1.3.2. Faster outage detection and improved customer service

Quantifying the benefits of faster outage detection is far more difficult than estimating the cost benefits from avoided meter readings. On the one hand this benefit is a cost benefit, as the retailing utility needs less resource to detect the exact outage point. On the other hand it is a revenue benefit. Firstly, the time of outage is reduced and the utility can resume quicker selling power again to its customers. Secondly, the quality of service is increased and the utility will have satisfied customers leading to a higher willingness to pay, increased customer attractiveness and lower customer churn. This calculation does not take the reduced outages due to lower peak demand into account, which would also increase the quality of service.

Faruqui and Wood estimate the benefit at between roughly $20 and $50 per meter over a period of 20 years. If the benefits are linear this would translate into a value of $2 to $5 per year at the discount rate of 7.78% assumed by Faruqui and Wood. For Massachusetts I estimate that the value is slightly lower than the average. Massachusetts is comparatively densely populated. The model utility East of Faruqui and Wood also shows benefits of around $2.50 per meter and year which seems a reasonable estimate for Massachusetts.

1.3.3. Better management of connects and disconnects

Remotely controlled meters allow fast and easy connect and disconnects of electricity services. In countries were electricity theft and unpaid electricity bills plays a major role this can bring significant benefits. In the USA and especially Massachusetts this is rather a positive side effect. Faruqui and Wood estimate that the benefit of this section is between $1.30 and $4 per meter for twenty year discounted or between $0.13 and $0.40 cents per meter per year without discounting. For Massachusetts I will take again the estimate for the model utility by Faruqui and Wood which had a benefit of $0.14 per meter and year.

1.3.4. Summery of quantification of operational benefits

The analysis showed the individual benefits of all sections sum up to between $5.00 and $15.50. My best estimate for Massachusetts which incorporates significant uncertainty is equal to about $6.60. Again, these numbers are purely illustrative as calculated using rough estimations and various assumptions. Also these numbers only take the lower and high estimates, but do not include uncertainty. Therefore the graphic below does not show uncertainty or any confidence intervals, but only displays the range of estimates.

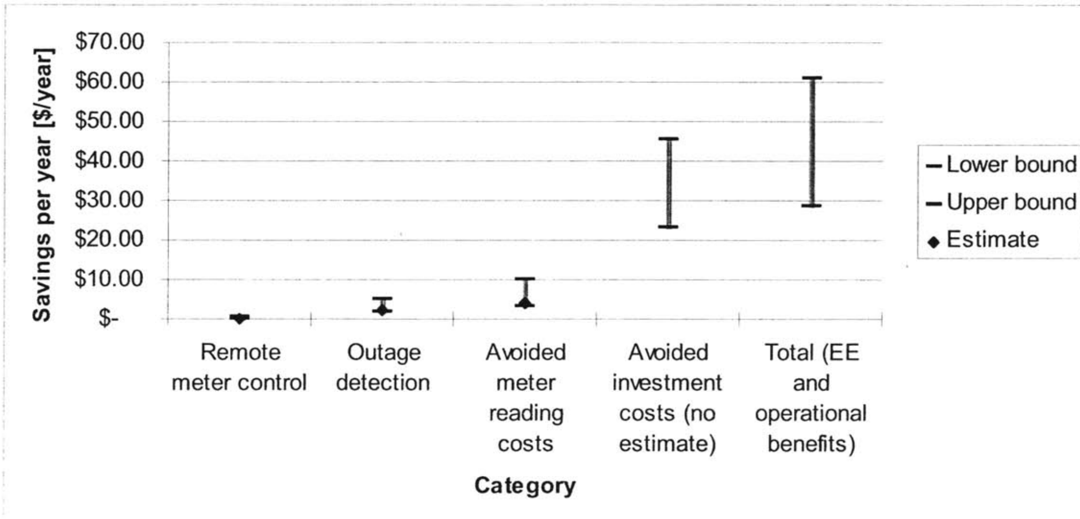

Figure 3 – Summery of Energy Efficiency and Operational Benefits

1.4. Value from non-electricity market related activities

The value and business models described in this section are quite different from the other two sections as it is largely detached from the energy purpose for electricity metering. The value from energy efficiency and the operational benefits improve functions that were available before as well. However the business of passing on information to third parties taps into new business fields. Although the activities are different from each other all include using or passing on information collected by smart meters. Many parties that use such information were traditionally not connected to the electricity market prior. A good example of such a business model is gathering consumer information and selling this information to marketing companies. As these business models are operating in a new environment this section will assess the boundaries and challenges for such models first and then go into detail about the value creating activities.

1.4.1. Boundaries for non-electricity related activities

There are three major boundaries to extracting value from information generated by smart meter for non-electricity market related activities. Firstly, a smart meter has technical boundaries. If the business model for example tries to identify which exact source is consuming how much electricity to give recommendations to the consumer such an identification process needs to be technically possible. Different technical boundaries apply to different business models.

Secondly, legal boundaries about who owns the information and by whom it can be used apply. In the USA it is not 100% clear which exact legal restrictions apply as the technology is still very young. However, even if no restrictions exist at the moment legal risk in this dynamic environment applies.

Thirdly, the business model has to operate within the socially accepted norms. Privacy and security issues pose a significant challenge to selling the information to third parties. A similar example is the internet. As the technology evolved social norms are formed that define which business models are acceptable or are not acceptable. These three boundaries define the solution space for the non-electricity market based business models.

1.4.1.1. Technical boundaries

The foundation to sell information to third parties is that information needs to be collected by smart meters in the first place. This requires two-way communication as information exchange needs to take place. Smart meters are generally able to handle two-way communication and therefore enable such communication. However, the exact technical boundaries depend on the information that needs to be collected. Basically two dimensions are important for the technical boundaries – which information needs to be collected and in which time intervals.

For example, for a business model identifying information on the specifics of the appliances real time information is irrelevant. Monthly information on which appliances are in the household is sufficient. However, the meter needs to be able to identify consumption patterns. In comparison for a business model analyzing the usage behavior not only appliances, but also detailed timing information is necessary. This information then could be used in lagging form or in real-time.

For almost all activities the smart meter needs to be able to identify more than the total amount of electricity consumed. This poses a totally new and different technical challenge. If the appliances (or the commercial or industrial equipment) are equipped with communication devices to directly interact with the smart meter the problem is solved. As long as the communication protocol is able to handle such signals, the smart meter can then detect which appliance is in a household and also when it is switched on. However, until such “smart appliances” have gained market penetration many years will pass. Therefore in order to make such a business model viable within the next years other technical solutions need to be found.

One possibility is to install a database that contains the information of all appliances and compares the pattern of consumption to these patterns. This way the database could narrow down the number of possible appliances and make educated guesses on what is most probable. The first thoughts about using such techniques came up long before smart metering became popular. In 1989 by George W. Hart, Edward C. Kern, Jr. and Fred C. Schweppe from MIT issued a patent for a device able to perform “non-intrusive load monitoring”.(Hart, Kern Jr., and Schweppe 1989) The method identified appliances by recording the real and reactive power and compared it to information that was collected from the household. The system already identifies the problem of a meter that is only able to record total consumption. If only total consumption data is available too many appliances will have the same profile. It will be possible to identify certain categories, e.g. a cooking stove and ventilation system might needs around 0.5-1kW for two hours in the evening.(Rosin et al. 2010) If however the smart meter is able to record more than just total consumption more variables become available. Recent smart meters can record positive and reserve active power as well as leading and lagging reactive energy, maximum demand, RMS voltage & current, power factor and frequency.(Nation Power Switzerland 2010) Comparing these data points to a database that contains the exact information sets on each variable for each unique appliance, detecting appliances becomes much more viable. Of course, it is not possible to get to 100% certainty. Nevertheless, by excluding improbable combinations of appliances (e.g. three cooking stoves of different models) the smart meter will give fairly exact information on which appliance is in the household.

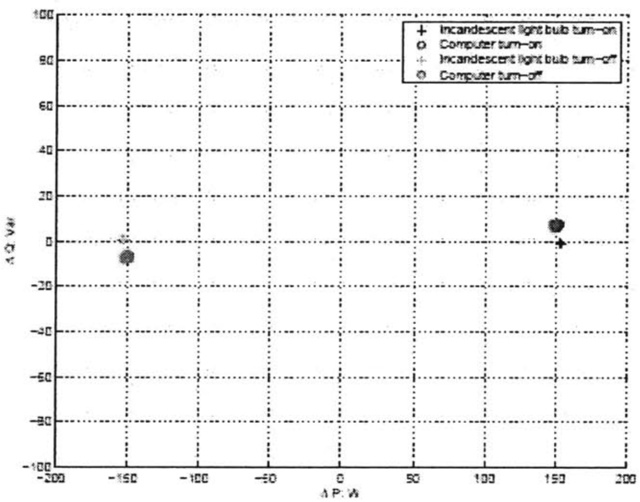

Figure 4 – Sketch of different devices along real and reactive power
Source: Christopher Laughman, Douglas Lee, Robert Cox, Steven Shaw, Steven Leeb, Les Norford, Peter Armstrong, "Advanced Intrusive Monitoring of Intrusive Loads", IEEE Power and Energy Magazine, March/April, 2003. 56-63.

A second important issue is the granularity of the meter. Granularity describes the time interval in which information about consumption and other variable is collected. The granularity of measurement gives insight into the characteristics of an appliances as it starts and stops. Many smart meters which have been deployed in residential areas only consolidate date in five minute or even longer intervals. Utilities were interested in reducing their operational costs as described above. Therefore a higher granularity would not have given them any additional benefit. However, this is much too long to detect start-up and shut down patterns. More sophisticated smart meters have granularities of down to 5 second intervals or even shorter. However, even with these shorter intervals detection of unique models is difficult. The smart meters which are developed right now will be able to offer granularities of around 1 second intervals and might reach prices which are affordable even for the residential sector. Increasing the granularity will reduce the number of wrongly identified appliances through non-intrusive load monitoring. On top of that granularity can become important for business models which try to analyze behavior in detail.

Some technical challenges can also be overcome by getting the customer to interact with the business. The number of misidentifications of appliances can be reduced if the customer adds additional information about the appliances. By offering the customer value through energy efficiency measures, e.g. via a smart phone application that records consumption information on each appliance, the customer could be induced to switch on and switch off the appliance and provide basic information (e.g. product category) to the website. This decreases the risk of the database detecting a wrong appliance. On a more sophisticated level, the website could even detect the usage patterns and product categories provided by the customer as well as make the customer choose his or her appliance from a list. If the appliance is not in the list, the customer might give information such as "none of these" or search the database for the exact model. This customer interaction would have two advantages. Firstly, the information is almost 100% certain. Secondly, the database is improved and updated without relying solely on information provided by appliance manufacturers.

This short introduction into the technical possibilities of identifying specific appliance models shows that it is not easy to deploy such solutions on a significant scale, but that solutions are technically feasible in general. On top of that technical limitation will gradually be reduced as more advanced technologies are deployed and new technical solutions are developed. Technical boundaries can and will be overcome by new business models.

1.4.1.2. Legal boundaries

The legal framework for the smart grid and smart metering so far is largely unclear. The National Institute of Standards and Technology (NIST) has the responsibility of ensuring an interoperable smart grid, including the legal standards. In its last comprehensive document, the NISTIR 7628, it states that "it is important to understand the current legal frameworks..., which may be amended to explicitly apply to the smart grid".(National Institute of Standards and Technology, U.S. Department of Commerce, The Smart Grid Interoperability Panel – Cyber Security Working Group 2010) This shows that many frameworks which normally apply to other industries have not been adopted for the smart metering market yet. Future changes in the legal system are probable.

1.4.1.3. Legal boundaries towards privacy and security

"The question we confront today is what limits there are upon this power of technology to shrink the realm of guaranteed privacy"

The statement by Supreme Court judge Antonin Scalia describes the challenge of setting legal boundaries for the use of information collected by the smart grid. (Supreme Court of the United States 2001) The answer to this question remains unclear so far. Even the term privacy is not universally defined. Many, as well as the NISTIR 7628 define it as having four dimensions: Privacy of personal information, privacy of the person, privacy of personal behavior and privacy of personal communications. Privacy of personal information is the right to control information that can be used to identify a person based on specific criteria (physical, economic, location, and social). Privacy of the person describes the right to control one's body and all medical, physiological and psychological aspects connected to it. The privacy of personal behavior is the right to keep information about personal activities from being shared with others without authorization and the right for privacy of personal communication applies to being able to communicate without surveillance, monitoring or censorship.(National Institute of Standards and Technology, U.S. Department of Commerce, The Smart Grid Interoperability Panel – Cyber Security Working Group 2010)

Smart meters collect a significant amount of information that could be used to identify a person. In order to uphold the first dimension of privacy, the privacy of personal information legal standards needs to be set.

The first sub-issue of this challenge is the ownership of data collected by smart meters. It is unclear from a legal point of view who owns the data.(National Institute of Standards and Technology, U.S. Department of Commerce, The Smart Grid Interoperability Panel – Cyber Security Working Group 2010) Several arguments have been made for the information being owned by the consumer. Firstly, meters are paid through the distribution rate charge which is an obligatory charge for the consumer. This implies that as the consumer pays for the deployment of the technology which collects the information, the consumer also should have the right to claim the information collected from it. Secondly, the ownership of information is associated to the privacy of activities of the consumer. Therefore the consumer should have the ownership of such information as the consumer is impacted by its release to third parties. Thirdly, the ownership of information is the gateway to innovative business models which can be derived from such information. If the ownership is with a specific retailer (e.g. the former vertically integrated utility), it can gain an unfair competitive advantage over other competitors. The consumer, who naturally only picks winners based on performance, should have the ownership of the information to ensure fair competitive markets.(Burstein, Mulligan, and Urban 2010) The idea that the information belongs to the consumer implies that the consumer gives certain rights to other entities. For example, the right to access such information for the purpose of billing and network planning needs to be accessible to the retailers. The consumer however holds the right to refuse passing the information on to other parties or using the information to non-utility operation related purposes.

Opponents argue that the information should reside with the parties putting the infrastructure in place, which means in most cases the utilities. The utility, meaning the retailer which once belonged to the vertically integrated electricity provider, owns the electricity meter. Therefore the information that is derived from a smart meter should belong to the utility. The same applies to the information on your shopping behavior in a super market which also belongs to the supermarket. Although this seems logic, the problem is that customer cannot choose who provides their electricity meter. Under a framework giving the ownership to the utility they would be obligated to offer their private information to the utility, whereas nobody is obligated to get a frequent shopping card or shop at places accessing shopping information. Although the issue is not resolved I assume that consumers will be granted some sort of right over the data on their electricity consumption. This means that all business models need to interact with the end-consumer to attain some sort of permission to access, store, use and pass on the information collected.

The second issue is whether ownership of data is the right framework or whether additional rules and regulations are needed for a comprehensive privacy framework. Even if the consumer owns the information, the retailer needs to be the custodian of some of this information for billing purposes. In order to guarantee privacy either the customer would need to restrict what information is made available to the utility or the activities that a utility is entitled to do.

The challenge of setting a legal framework to ensure the first dimension of privacy is not put in place. The same applies to the other three dimensions. The privacy of the person could be breached if an insurance company started to interpret data to identify physical conditions or fitness. A smart meter reading could be used to derive personal information by identifying how much TV a person is watching, how long a personal fitness trainer is used (health impact) or how often a person washing clothes or showering (to derive recreational sports routine, personal lifestyle, etc...).

The concept of privacy of personal behavior or guarding the knowledge of personal activities has partly been covered already in the paragraphs on personal information. Additionally, if electric vehicles were available and distributed charging station recorded information a personal movement pattern could be constructed, which would further breach the privacy of personal behavior.

Last but not least the privacy of communications or right to communicate without surveillance could be breached if third parties or the government is able to monitor the information flow without legal reasons. With no comprehensive legal requirement on security issues, smart meter providers do not face standards to protect the access to their information, but can decide themselves how important this issue is. The only cases available on this dimension of privacy are the cases about police requirements and rights to identify marihuana growers. The police used high electricity usage pattern in line with marihuana growth and started to investigate against these individuals. In 2001, in The United States of America vs. Kyllo the Supreme Court stated that they "think that obtaining by sense-enhancing technology any information regarding the interior of the home that could not otherwise have been obtained without physical intrusion into a constitutionally protected area, constitutes a search" and is "presumptively unreasonable without a warrant".(Supreme Court of the United States 2001) However, in other cases such as the State of New Jersey, vs. Keith R. Domicz, it was argued that the police was allowed to receive some data, such as the total electricity consumption as this did not negatively affect privacy of individuals.(Supreme Court of New Jersey 2006) These incidents show once more the lack of a comprehensive framework which defines the legal standard.

Currently no framework for any of the four dimensions of privacy exists to apply to such breaches of privacy. Nevertheless, it is reasonable to estimate that such frameworks will become effective once breaches become obvious and affect a higher number of people. Therefore the lack of a legal framework does not only hurt consumers, but also utility and other businesses which are threatened by the uncertain future legal settings.

1.4.1.4. Social boundaries

Social boundaries describe the limitations set by social norms and standards which businesses should respect in order to gain social acceptance. This includes ethical standards and well as norms of operations. Although a business is operating within the legal boundaries it can quickly become unattractive to stakeholders if it is presumed unethical. Especially in new technologies or business models this issue is important, as social and ethical norms can develop dynamically over time and are therefore difficult to respect. In some cases, the first wave of business models can define a standard business conduct which if accepted by the public shapes the landscape for following business models.

1.4.1.5. Social boundaries towards privacy and security

Social perception about new technologies and business models can play a powerful role in how such business models can or cannot operate. Especially if these new technologies have to be adopted on a large scale or affect a large number of people public perception becomes very important. Google Street View for example faced similar legal frameworks in the USA and in Germany. However, German citizens were much more concerned about privacy issues which ultimately led to public and political debates about the service. Google still has to be extremely careful offering this service in Germany as it faces public and political actions if the social perception worsens. In the case of Google Street View blog posts of some concerned German citizens show the misunderstanding as they thought that they were recorded 24/7.(Niggemaier and BildBlog 2010) From a system dynamics point of view, strong reinforcing feedbacks can make the perception tip towards on or the other extreme. Once such a social perception has sunk in, the process is difficult to reverse. Smart metering is similar to Google Street View as it affects basically every household and because it is a technology issue. Smart metering is even more complex than Google's service and therefore misperception and poor understanding are almost inevitable.

A survey by Ponemon Institute assessed the perception of almost 2,000 adults about smart metering. Firstly, the survey showed that many people have poor knowledge about smart metering. One third of the participants did not even know whether a smart meter was installed in their home and only 15% of all participants said that they were informed adequately about the functionalities by their retailer. The survey also assessed the privacy impact of smart metering. Almost 40% of the participants believed that smart metering would diminish their privacy and only 8% believed in privacy improvements. In the group claiming to have smart grid knowledge even half of all participants had privacy concerns and only 4% believed in privacy improvements. This poses a major problem for smart metering, as the privacy concerns seem to increase with better knowledge of the technology. About 80% of all participants were concerned about negative impacts on privacy through occupancy and specific appliances usage patterns as well as consumption records in general. Two-thirds were concerned about data that solely identified appliances without measuring real-time usage.

Nevertheless, the study also showed the boundaries of the concerns and gave reason for hope that people would accept the usage of their data under certain circumstances. Whereas 58% of all participants have concerns about sharing their data with third parties for non-electricity related usages, only 32% would still be concerned if the personal information was anonymized or masked. (Ponemon Institute LLC 2010) A major reason people have less concerns about de-identified data is the concern of organized crime usage real-time usage data to find out when a house is empty and where they can find high priced items. 85% of all participants voiced that they have high concern about targeted home invasions based on malicious use of smart metering data.

The challenge is to convince customers that their data are really anonymized. Only 43% believe that customer research and only 19% believe that marketing and advertisement businesses will actually hold their promise of de-identifying such data. Participants had the highest confidence in net planning purposes, but even then only 75% believed that data could be really de-identified. This shows the challenge for a business to profit from this area where consumers seem to have less privacy concerns. Unfortunately no statistic exists on how real-time versus lagging information would influence the acceptance. As major fears such as targeted burglary or surveillance would be impossible from lagging information it can be deducted that the privacy concerns would be much lower than for real-time information.

Summing up, this research study has given significant insight into consumer's perception of smart metering. Firstly, consumers and non-consumers are poorly educated about smart meters. Secondly, almost half of all participants have privacy concerns and the bigger the knowledge about the technology, the bigger the concerns. Thirdly, identifying specific appliances is one of the many significant concerns. Lastly, the concerns could be severely diminished if personal information was anonymized or lagging, but only few consumers have confidence into customer research or marketing and advertisement businesses to do so.

The findings of this study impact the prospects of business models based on selling information to third parties severely. In order to persuade customers to release personal information providers of such business models will have to overcome significant confidence obstacles and most likely offer some kind of payback to the customer. (Polestar Communications & Strategic Analysis 2006, 1-49) This payback could take different forms such as offering value through the offered service (e.g. energy efficiency improvement through better knowledge about consumption), vouchers for new investments (appliances or energy efficiency investments) or even monetary compensation.

1.4.1.6. Other social boundaries

Privacy and security concerns are the most prominent social boundaries, but other boundaries exist as well. Some advocacy groups concentrate on health, fairness or national security concerns. However, most of these claims have no scientific backing so far and are only voiced out by small groups of society.

Some smart meter opponents, such as Elisa Boxer-Cook in Maine or the Sebastopol-based group EMF Safety Network studies the health impacts of electromagnetic fields and radio frequency radiation.(EMF Safety Network) They claim that smart meters can cause health issues such as dizziness, nausea, migraines, muscle spasms and insomnia.(77 SmartMeters.com 2010) However, no medical studies have found any link between the radiation of smart meters and such diseases. Even the Food and Drug Administration and the World Health Organization say there is no convincing scientific evidence that weak frequency radiation signals from wireless signals cause health dangers.(Vergano and USA Today 2011) On top of that smart meters produce weaker signals and are further away from the body than mobile phones and should therefore be less dangerous. Without the backing of serious medical studies, these opponents will remain to be a small subgroup of the opponents of smart metering. Nevertheless, locally these groups can gain momentum and block or delay smart meter initiatives. On top of that, they can argue that people should be allowed to choose whether smart meters are installed on their house. If smart metering becomes an opt-out technology many benefits could be lost, especially the operational benefits for retailers. The prospects of information based business models should however remain large untouched.

Another concern that was voiced out by smart meter opponents was that smart meters are less accurate than mechanic meters. In both California and Texas, role-outs of smart meters had to be halted as claims about large bill increases, such as in the case of Peter Flores whose bill rose from $200 to $500 after a smart meter was installed, circulated.(Vergano and USA Today 2011) Independent studies confirmed afterwards that smart meters are extremely accurate and actually increase the accuracy. For example a study in Texas confirmed that the accuracy of metering increased from 96% to 99.96% in average.(Whitley 2010) The study however did show that two out of more than 5,000 meter measured the electricity inaccurately. Claims of inaccuracy can increase the cost and time needed to role out smart meters, but should not significantly impact the prospects of data based business models.

Last but not least, national security is a major issue that may affect the different business model in an unforeseeable fashion. So far, it is not clear how far regulators might go to make the communication structure of the smart grid safe. However, it is clear that the issue is taken seriously by Congress, other government authorities and focus groups. The lack of interoperability is the first challenge that is tackled by the NIST. It is unclear what security issue arise from their assessment and how this will affect the regulatory framework for smart metering. Therefore this issue might change the prospects of different business models, including business models relying on passing on information to third parties.

1.4.2. Value creation through passing on information

This section describes the value creating activities that can be derived from passing information to third parties. Business models may overlap and include multiple value creating activities. Each section should therefore be understood as either a stand-alone solution or as part of a business model.

1.4.2.1. Identification of appliances (consumer information)

Smart meters collect real-time information on the real and reactive power flow. This information can be used to identify specific appliances using non-intrusive load monitoring. The first pre-requisite is that the smart meter collects complex information and that this information is granular enough to derive detailed, accurate profiles of appliances. Secondly, a database is necessary to compare these profiles to stored profiles of specific appliances identification. In the perfect case the user even interacts with the platform and verifies that the right appliance model is identified or corrects the platform.

The value of such information depends on the detail of information. An important distinction is whether the information is in aggregated (anonymized) or personal form. In aggregated form no single households could be identified, however clusters (e.g. based on postal code) or model profiles could be identified. Obviously, the smaller the cluster the more detailed the information, but also the higher the risk of identification through data mining techniques.

On top of that different response times are possible to avoid identification of specific persons. For example, appliances companies could use only monthly updates to avoid that individual purchases can be used to identify specific households. Even more importantly the time specifics of identification have other impacts on privacy concerns. Firstly, it makes a large difference if time specific usage patterns throughout the day are analyzed or whether the exact time of usage is masked. In one case behavior is identifiable, whereas in the other case all that is known is that appliance A was used at some point during the day. Secondly, depending on when the information is made available some privacy concerns can be reduced. For example, even if the information shows specific times of usage, but is only made available one month after the actual event happened concerns like targeted burglaries are almost completely ruled out. Again, the smaller the time scale (up to real time information) and the shorter the information release lag, the higher the value of the data, but also the higher the impact on privacy concerns. In this case however the value of the information only decreases marginally. A marketing research company does not require daily updates on consumer behavior – monthly or even quarterly updates are almost as valuable.

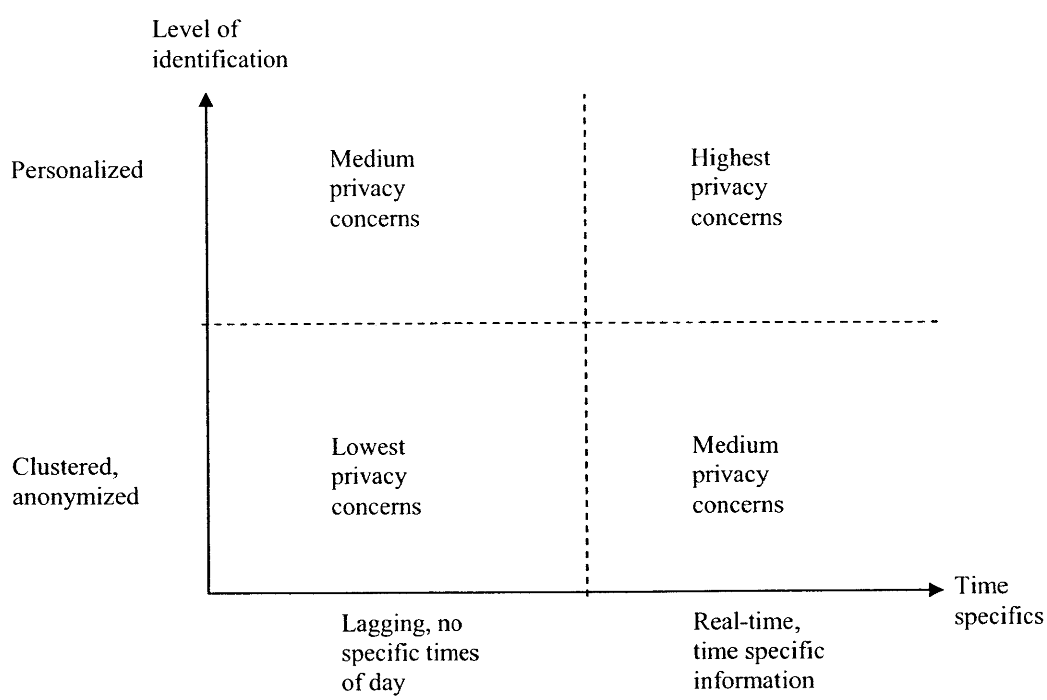

Figure 5 – Illustrative two-dimensional matrix on magnitude of privacy concerns depending on time specifics and level of identification

Independent of the time scale and the granularity of subjects, appliances companies would get detailed information on where their appliances are bought and how much market share they have in detailed regions. This information would enable to monitor and react to trend on an unprecedented scale of detail. The companies could for example monitor the success of specific appliance models in specific neighborhoods and possibly even link this to promotions or offerings in specific retailers. This would support their retail strategy significantly. On top of that accurate and detailed information about repurchases, cross-purchases and switching patterns would become available.

This could enable appliance companies to evaluate brand loyalty and react to trend in changes quickly. For example, an appliance company manufacturing all household appliances might discover that customers purchasing their model of washing machine have a higher likelihood of all purchasing their dryer (or not). Additionally, companies could adapt their product development strategies to consumer preferences as they have more detailed information on their buyers. Perhaps a fridge aimed at low income households is increasing popular with high income households using it as a secondary fridge in the garage. The history is full of success stories for appliances which were used for different purposes than intended. Smart metering could give quicker feedback on actual driver of success or failure of specific models in specific regions.

1.4.2.2. Identification of appliances (advertisement)

The same information about appliances could be used to send targeted advertisement. Depending on the detail of available information advertisement could either be targeted at regions or if personal information is available even at individuals. If only aggregated information is available the advertisement could target regions with a high brand penetration to enable cross-purchasing behavior of other appliances. If a high proportion of the people in a region hold a specific appliance close to the end of its lifetime targeted advertisement could become valuable. Assuming that information is available on household level the advertisement can even react to more granular information or behavior patterns.

The compensation for such information usually depends on the quality of the "sales leads". If information and advertisement leads to a significant chance of a purchase then this information is increasing in value. It is difficult to quantify the value of these sales leads, but a good lead is highly valuable. As the smart meter data could potentially create leads for every household and for every appliance, this information has immense value.

Most of the value for this activity is concentrated on the residential sector. Firstly non-intrusive load monitoring could potentially only be used to identify specific machinery in commercial and industrial complexes if the database includes this machinery. In industries with specialized or even customized machinery this will be difficult. Secondly, the purchasing criteria will include much more dimensions than the one of residential consumers. An industrial complex producing steel is unlikely to buy a molding machine every x years as the purchase affects the whole production line and depends on other circumstance (e.g.

schedule pressure, expectation of customer orders, etc...). Therefore this activity will be concentrated on the residential sector.

1.4.3. Identification of appliances (insurance)

Information on specific appliances on an aggregated or personalized level is also valuable to insurance companies. Information on an aggregated level could grant insurance companies a more precise assessment of the value at risk from burglary in specific neighborhoods or regions. Although similar information and relatively good estimates are already available for such purposes from other sources this could increases the accuracy of such estimates.

If the information however is available on a personalized scale many new values for insurance purposes become unlocked. Firstly, the information can be used to analyze the specific appliance value in a household. This could lead to variable insurance rates, which especially for households with lower value appliances could lead to a win-win situation between customers and insurance companies. A good comparison is the variable rate insurance for cars, which requires a system that records the exact hours of driving and is valuable for customers with few driving hours. The insurance company could for example develop products targeted at low-income households. Another possible product would be an insurance rate that changes with every newly purchased item and therefore always charges a fair amount.

Secondly, the insurance company would be able to verify exactly which appliances were in the household in case of a burglary to avoid insurance fraud. The customer on the other hand could bargain for lower prices as fraud becomes impossible. At the moment insurance companies have to price fraud into all insurances and therefore have to charge more from honest customers. Again, this could lead to a win-win situation for honest customers and insurance companies.

Note that for any of the here stated purposes no real-time or close to real-time information is necessary. A monthly summary of appliances in enough to satisfy the here stated purposes. This means that this value creating usage is not as critical in terms of privacy concerns as other possible usages. Nevertheless, for insurance purposes the value of the information increases significantly if the information is personalized. A major barrier to these business models is therefore the trustworthiness of the insurance company to store and use the data responsibly.

1.4.3.1. Identification of behavior to induce energy efficiency

Energy efficiency measures hold significant potential to address not only global climate and energy consumption issues, but also to provide significant benefits to the engaged parties. Although energy efficiency measures often have positive net present value using reasonable discount rates and lifecycle period assumptions, they face major barriers which make enabling energy efficiency a major challenge. Among others these barriers include market barriers, price-elasticity barriers and access to capital.(The Federal Energy Regulatory Commission Staff 2009) An example of a market barrier is the principle-agent conflict of a house owner renting out his property. The occupant could profit from energy efficiency investments through a lower electricity bill, but only for a limited time. If this time period is shorter than the payback period of the investment energy efficiency measures do not make sense for the occupant. The home owner profits in the long-run as the property increases in value, but does not profit from energy savings directly. He could only retrieve this benefit by showing the benefit for the occupant and increasing the rent by amount of the savings to justify such investments. Therefore major energy efficiency investments into rented property are difficult, even if the net present value of the investment is positive. A typical price-elasticity barrier is a very high implied discount rate for energy efficiency savings. Homeowners often apply mid range two-digit discount rates for those investments.(Dubin) Last but not least the high capital costs of many energy efficiency measures make them difficult to realize.

These barriers cannot be disabled by smart meter information, but smart meter information can enable behavior based energy efficiency which is not subject to the same barriers. Smart metering data can enable value creation through both: lagging or real-time recommendation. Firstly, by identification of specific appliances and benchmarking their energy efficiency against peers consumers can identify the efficiency potential of replacing specific appliances. They can also benchmark their usage pattern (e.g. for HVAC systems) against peer households in the neighborhood.

OPower is already delivering a similar business model in which consumers get information on their usage and get benchmarked against comparable peers.(Opower) Obviously recommendations on some issues purely from electricity consumption data are problematic. For example, if the HVAC system is new and above average efficient, but the monthly consumption is higher than average than there could be several reasons. It could be due to bad isolation, windows/door opening behavior, house usage pattern or number of people in the household just to name a few possible sources of the problem. Therefore the recommendation tool will not have perfect accuracy. Nevertheless, showing a number of recommendations to the consumer and letting the consumer decide which is most reasonable also offers value. Comparable business models such as OPower or Efficiency 2.0 also cannot offer 100% accuracy with their recommendations.

With real-time data, an energy efficiency recommendation model could even be brought to a new stage. Real-time data could for example show consumers that their HVAC system is performing above average in the evening, but due to bad programming is using too much electricity during the day. Consumer can react to such information by adjusting their programmable thermostat.

All in all, there are many different possibilities how data from smart metering can be used to drive energy efficiency. The assessment of the exact incremental value of such measures is difficult, as a significant part of the value from such information could also be driven by other measures such as home-audits, data mining driven business models such as OPower or Efficiency 2.0 or building codes.(Opower; Efficiency 2.0) Nevertheless energy efficiency measures are a possible value driver of smart meter information. The incremental value might be limited, but the energy efficiency recommendation activities can be important to persuade consumers to interact. Therefore this activity can become a very important leg of a multisided platform business model which combines this with other activities such as consumer information, advertisement or insurance based value creation.

1.4.3.2. Parental monitoring tool

Energy Efficiency analysis requires to present the consumer of electricity with information on his or her own usage. This data can also be used by the consumer for different purposes. For example, the user can identify specific appliances at specific times to monitor other people living in the house. For example, parents would have access to information on usages while they are away and if such information is available through a web portal or similar technology even remotely and in real-time. Parents could identify "suspicious behavior" (full pool pump/heating, stereo system and full lighting throughout the night) and maybe even curtail specific appliances at specific times to restrict others (e.g. minors) from using these. This usage of information is an additional value driver for smart metering information – at least for those in charge of it. Due to the security concerns of being able to remotely monitor the electricity usage in real-time this information could also be accessible from inside the house and only on a lagging basis. Parents could then still monitor their children's usage, but security concerns would be lower as the information does not leave the house.

1.4.3.3. Monitoring of lessees for compliance

Landlords often include restriction into their contracts to guarantee that the value of their properties does not deteriorate. In many apartment landlord-lessee contracts a maximum of people is included (especially for smaller apartments) or a restriction to sub-rent the apartment to third parties applies. If smart meter information was made available to the landlords they could easily and remotely control for compliance of such restrictions. This would however only be possible if time specific information was made available. Although this opportunity would provide significant value to landlords, it would also infringe on the privacy of the lessee. Nevertheless, in certain circumstances e.g. student dorms, assisted living or other community living centers this might be a feasible option. On top of that high privacy concerns simply mean that landlords would have to offer significant value to the lessee to gain access. The value creation itself is therefore still possible, but the value capture for the landlord might be difficult.

1.4.3.4. Plug-in electronic vehicle behavior

Plug-in electric vehicles (PEV) could impact the transportation sector and even the way of life significantly. Combining information from PEV with smart meter information can play a significant role in enabling value drivers for both technologies.

Firstly, utilities or other parties could aggregate the bill for remote charging if the car can be identified (e.g. through identification protocols). The entity would not only be able to show the consumer an overview of total recharging cost, but also learn about the driving behavior of the consumer and give recommendations accordingly. On a macro scale, this could enable grid operators to further optimize their load forecasts and operate the grid more stably and efficiently. On top of that if PEV were allowed to sell electricity back to the grid in times of high demand, retailer (or third parties in co-operating with the retailers) could automatically credit the consumer for such sales and net the difference on the monthly charge. Selling electricity back into the grid from PEVs is a significant value driver to make PEVs affordable and is only possible with smart meter information. Therefore smart meters are likely to become a complimentary technology for large scale PEV roll-outs.

Secondly, insurance companies would be interested in PEV charging information to adjust the risk profile of a driver. The information would refine the risk assessment as the insurance company becomes aware of the exact times and charging locations of the driver. This could further improve variable rate insurance offerings. Obviously, this information could also be made available to insurance companies via GPS tracking or other technologies and is therefore not unique to smart metering.

Thirdly, marketers could use recharging locations to analyze consumer profiles or even send targeted advertisement to PEV drivers. For this usage it is important to analyze how detailed the information (aggregated vs. personalized) and how granular the time horizon of such information is. If personalized data is available on specific times then this data can be used to track specific movement patterns. Although this creates a lot of marketing value, it also impacts the privacy significantly, even if such information is only made available on a lagging basis. To restrict privacy impact models specific times could be anonymized or masked. In any case using PEV driving data to create consumer profiles or for other marketing and advertisement purposes is a major value driver if used within the social boundaries. The privacy impact of locational or behavioural data however is a significant limiting factor.

Last but not least smart metering information from PEV recharging can be used to verify compliance of PEV lessees. In the case of apartment surveillance, information significantly infringes on the privacy as the information gives insight to the way to life and private activities of the apartment lessee. In the case of PEV lessees this seems less important and recharging locations only give limited insight. Furthermore no in-depth analysis is necessary to detect compliance breaches. For example, if a PEV is only leased out for use within city boundaries and is recharged outside the city, the lessor could receive an alarm. This way the lessor would not have access to any information unless the contract is actually breached.

The same system could also be used to protect cars from theft as any recharging of a stolen vehicle is registered in real-time. As for the insurance usage of PEV recharging information, this information could also be made available through other sources such as GPS tracking devices and is not unique to smart metering.

1.4.3.5. Law enforcement and civil litigation purposes

Smart metering information (or even traditional metering information) can be used for law enforcement and civil litigation purposes. Firstly, it is possible to a limited degree to verify the whereabouts of persons of interest. By using real-time electricity usage data some conclusion can be drawn. For example if a person claims to be home during a specific time watching TV, such claims can be verified. Obviously a running TV and a burning light do not prove that anybody was actually there. However, activities such as cooking, which include frequent changes in electricity consumption by manually operated device prove that somebody was present. On top of that PEV could be placed at specific locations if they are recharged.

Secondly, electricity usage pattern can be used to identify criminal activities such as marihuana growth. Again, as of now this information is not 100% certain. A report from a police officer stated that a suspect of marijuana growth which was purely identified based on electricity consumption turned out to be an internet business man with a lot of servers in his basement. The legal requirements on the usage of electricity data, whether real-time or monthly aggregate information, remain unclear. However, the current legal trend seems to show that the usage of such information without prior suspicion will not be allowed in most states. Nevertheless, after arrest information of electricity usage might give insight on magnitude of operations. For example, an arrested marijuana grower could defend himself by showing that he only stored the equipment for an accomplice by showing his electricity records had on increased consumption. Vice versa the prosecution could disprove such allegations by proving the opposite. The value from smart metering information for litigation and legal enforcement purposes is a better functioning system of law and order, which is difficult to quantify. Another value can come from private for profit businesses specializing in offering such data for litigation processes for a fee similar to expert testimonies.

1.5. Summary of value creation

The analysis of the total valued created through smart meter information shows a couple of important facts. Firstly, the uncertainty for any for the here mentioned estimates is huge. Every single number depends on several estimates and assumptions, which are often all but clear and straight forward. Therefore all here mentioned numbers should be regarded as directional guidance instead of precise facts. Furthermore for many value creating activities, especially the ones in the non-electricity related market no numbers are estimated as the uncertainty is currently too high.

Secondly, following the here taken estimates and assumptions energy efficiency measures create a value between $23.35 and $45.55 per meter per year, whereas operational savings only create benefits between $5 and $16 per meter per year. The lion share of energy efficiency benefit consists of from long-term advantages due to avoided electricity generation and transmission investments. The benefits from avoided investment alone are higher than the total operational benefits. The high contributing factor of operational benefits is avoided meter reading costs, especially in rural or sparsely populated regions.

The benefits from non-electricity market related activities are extremely difficult to quantify, as each activity is a separate business case. The total potential value of these activities can be extremely high, if the technical, legal and social barriers are overcome. Even without quantifying these benefits the qualitative analysis shows that the total benefit of all these value creating activities can be significant and possibly even lie in the range of the benefits from energy efficiency measures. The exact business models, and value capture dynamics to receive these benefits is described more closely in the next section.

2. Value capture of smart meter information

The previous section has shown that smart meter information can create significant value. This second segment of this paper analyzes the market dynamics and attempts to identify which player is best situated to capture this value. It describes the market environment by analyzing the history and environment for incumbents as well as new players and finally gives an estimation of how much value can be captured by each player under these market dynamics.

2.1. History of the electricity market and regulatory framework in Massachusetts

Around the world, just as in the USA and in Massachusetts, the electricity industry has been heavily regulated since its birth. With the Public Utilities Holding Company Act (PUHCA) in 1935 the US government set a comprehensive framework for utilities to engage in business activities. It specifically aimed at regulating the holding structure and limiting the activity of a vertically integrated utility to one state.(Energy Information Administration 1993, 9) This included remuneration based on an asset-plus payment profile, licenses for investments as well as regional monopoly rights to the vertically integrated electricity suppliers.(Energy Information Administration 1993, 10) Under this setup one company was responsible for the entire value chain from generation over transmission and distribution down to retailing, marketing and other customer service aspects for a specific area of service, most often the area of a state. The Securities and Exchange Commission (SEC) was responsible to regulating the holding companies in the electricity industry.(Energy Information Administration 1993, 10) Although this structure did not allow for competition it provided consumers with stable prices and high reliability and stayed in place for several decades.

The general opinion changed in the last quarter of the 20^{th} century. The oil crisis of 1973 encouraged the federal and regional groups to increase the non-fossil electricity generation in order to decrease the oil price impact on electricity prices. As a reaction, the National Energy Act which included the Public Utility Regulatory Policies Act (PURPA) was introduced in 1978. This Act enabled non-fossil generation sources to compete in the market. The monopolistic structures in transmission, distribution and retailing were however left untouched and even the generation segment was only opened to specific non-fossil technologies. The Act was mainly aimed at increasing energy independence and not at creating open markets.

A major provision of the act was that utilities in many states were obligated to buy electricity from independent power producer (IPPs) at their own avoided cost. This helped to create many IPPs across the country, but did not lead to a real liberal market, rather to a differently regulated one. However, an exception allowed utility companies to operate without registration. Using this technique they could engage in non-regulated activities to increase their financial position. By 1981 only three gas and nine electricity companies were still registered.(Energy Information Administration 1993, 22) Summing up in the 1980's only minor changes were made to the PUHCA, but it led to diversifications and acquisitions throughout the country.(Energy Information Administration 1993, 30)

In 1992, the PUHCA was finally reformed and a major step towards deregulated wholesale markets was instituted with the Energy Policy Act (EPAct of 1992). The most important change allowed registered utilities to engage in non-regulated activities and loosened the tight grip of the SEC.(Warkentin-Glenn 2006, 118)(Warkentin-Glenn 2006; Warkentin-Glenn

2006) This act started the process of allowing non-utilities to access transmission capacity of the existing infrastructure. It also defined a new group of entities the exempt wholesale generators, which could compete with utilities in the generation market.(Warkentin-Glenn 2006, 118) Generally three different trading models were possible under this act: wheeling, decentralized markets and integrated markets. A major difference between these options was that under the wheeling model utilities provide access to transmission capacity under scheduled contracts. No spot market exists and the utility further provides imbalance, congestion and ancillary services. This means that the market is not fully competitive and that the system operator needs to own plants. Later the Federal Energy Regulatory Commission (FERC) further improved the system with the orders 888 and 889. These orders were primarily aimed at decreasing the privileged position of vertically integrated utilities under the wheeling model against new entrants.(Hunt 2002, Chapter 7)

In decentralized trading markets the operators only schedules the contracts and administers the balancing and congestion contracts. In a perfectly working decentralized market all functions are taken over by traders and market participants. Decentralized markets require four trading markets (for energy, balancing, congestion and ancillary services) and have high complexity. The cost of electricity on these four markets needs to converge, which it does not always do in reality. This can lead to inefficiency, increased bureaucracy or even reliability problems. Although decentralized markets can work better than the wheeling model and grant more freedom to market participants, they also increase complexity and risk.

The integrated market model has significant advantages over the decentralized model in this regard. The operator turns the wishes of the traders into a cost plan and makes the market work smoothly. As only one market exists, the problem of non-convergence is solved by the design.(Hunt 2002, Chapter 7) Although integrated markets can have many different aspects and facets, most reforming states try to implement integrated markets of some sort.

In the last years of the 20th century deregulation took off in some states. California tried to deregulate its market and failed miserably due to a number of reasons.(Lambert 2006, Chapter 6, p. 146) Nevertheless, all New England States but Vermont started the deregulation process in order to move towards competitive markets.(American Public Power Association 2008, 1-7) In Massachusetts the Electricity Utility Restructuring Act was passed on November 25th in 1997, which marked a milestone to deregulated, competitive energy markets for the state.(Massachusetts Government 1997) A major goal of this act was to increase consumer savings by introducing competition. (Polestar Communications & Strategic Analysis 2006, 1-49)The act started a seven year plan to restructure the industry and step-by-step move towards deregulated, integrated electricity markets. Major passages of the act allowed consumers to freely choose their utility provider and allowed new providers to enter into competition with the established utilities. This means that the monopolistic structure was abandoned in favor for an open market. The act also forced formerly vertically integrated utilities to split their distribution and generation into different, independent parts. This measure was supposed to decrease the market power of the former monopolies and further increase competition to the market.

Another goal of the act was to increase interregional transmission to increase the reliability of electricity services. The act concluded that more interregional connections and cooperation would result in higher reliability and better service. Other areas of the act were environmental protection and education. By educating electricity consumers more environmentally friendly technologies could compete with fossil generation assets in the new market structure. Although the act tried to introduce free markets the regulators were aware that this drastic change could not happen over night. In order to protect consumers from harsh price changes the regulators set a temporary price cap at $1000 per MWh on wholesale markets to protect the retailers and the consumers of extreme prices.(Massachusetts Government 1997) Obviously this cap was solely aimed to limit extreme peak prices as this price would translate into $1/kWh. If this cap was set to limit the retail price it would still mean an increase by around 1000% or by far the most expensive electricity price in the world.

The specific regulations of other New England States have different details, but aim in the same direction as the Electricity Utility Restructuring Act in Massachusetts. As electricity generators were no longer regulated a new entity had to be formed to supervise the industry. The New England States also cooperated by forming the Independent System Operator New England (ISO-NE), a non-profit organization that ensures "the day-to-day reliable operation of New England's bulk power generation and transmission system, by overseeing and ensuring the fair administration of the region's wholesale electricity markets, and by managing comprehensive, regional planning processes."(Independent System Operator New England 2005a) The ISO-NE operated interim markets to facilitate investments in new plants and give investors more stable predictions of future prices and regulatory circumstances. This helped to overcome one of the problems California faced when investors stopped increase generation capacity due to an unclear future.(Mc Namara 2002) The ISO-NE also tries to keep the interconnection lines between states run smoothly.

2.2. Wholesale market price components

In order to analyze the business opportunities of electricity retailing it is essential to understand how the wholesale price of electricity is calculated and which factors influence the wholesale price. Even though the market deregulation has created the opportunity for different players to compete in the retail space, all of these players need to purchase electricity in the wholesale market. Therefore the wholesale market is an important factor for the analysis of the retail concentrated business models.

The Independent System Operators (ISO) New England publishes detailed information on the different components of the wholesale electricity cost curve.(Independent System Operator New England 2010c) The wholesale electricity price consists of three categories, the cost of energy, the cost of capacity, the Net Commitment Period Compensation (NCPC) as well as some other cost categories.

The cost of energy or Real-Time Load Marginal Price made up around 80% of the wholesale price in 2009. It represents the hourly average cost of one MWh at a specific time and at a specific node. In order to have one consistent example all the following examples of specific prices will be limited to North-Eastern Massachusetts and Boston which are all located in the same node. The prices for other nodes are likely to be very similar throughout Massachusetts.

The cost of capacity is a cost wholesale customers need to pay to the entities guaranteeing electricity capacity. It made up for roughly 15% of the total wholesale price in 2009. The cost is determined by an auction and is adjusted every month.(Independent System Operator New England 2011, 1-29)

NCPC refers to payments that are made to generators that were dispatched by ISO to ensure resource adequacy or transmission security of specific location or of the entire system. The NCPC consists of the first contingency payment, which is made to generators that experienced a shortfall in revenues after being committed by the ISO. The second contingency payment is made to generators that experienced a shortfall in revenue after being committed by the ISO to provide zonal-level insurance.(Independent System Operator New England 2011, 1-29) The NCPC made up around 5% of the wholesale electricity price in 2009.

On top of these three main categories, many smaller parts such as regulatory cost, forward reserve costs, real time reserve costs, inadvertent energy, emergency energy, marginal revenue loss fund, auction revenue rights, the ISO Schedule 2 & 3 and the NEPOOL payment complement the wholesale price. However these categories normally only play a minor role and are comparatively small to the other three main categories.

The total wholesale price is the sum of all these components. Looking at the wholesale price throughout different years, different seasons or different hours it becomes obvious that a number of factors influence the exact price. These influencing factors will be analyzed more closely throughout the next section.

2.3. *Influencing factors on wholesale price*

2.3.1. Energy Mix and Commodity prices

80% of the wholesale price of electricity consists of the marginal cost of generating electricity.(Independent System Operator New England 2010c) This means that the energy mix of power plants and the commodity prices play a huge role in influencing the wholesale price curve. The mix of power plants is static and only changes over very long time periods. In Massachusetts about 50% of electric power is generated by gas fired power plants.(Oceana Organization 2009, 1-1) This suggests that there should be a strong correlation between the cost of energy (expressed by the Real-Time Load Marginal Pricing) and the price of gas used of electricity generation. Especially as gas power plants have high variable cost they often are the most expensive unit in the system, which defines the wholesale price. The correlation between these two prices from January 2005 to September 2010 is 0.93 – a very strongly positive correlation. Even the correlation between the actual wholesale price of electricity (including all other costs) and the gas price is 0.91. This shows that the gas price has a very strong influence on the movement of the wholesale price of electricity. The correlation is not equally strong in every single year. In 2005, 2008 and 2009 the correlation is over 0.9. However, it was around 0.6 in 2006, 2007 and the first nine months of 2010. This suggests that other factors also have a significant influence on the wholesale price of electricity in Massachusetts.(U.S. Energy Information Administration)

2.3.2. Other factors influencing wholesale price

The wholesale price of electricity is also influenced by many other factors. As this section is only meant to outline this topic I will not go too detail for these factors.

Firstly, the temperature plays a great role in influencing the wholesale price. In Massachusetts both heating and cooling play a role in influencing the wholesale price. As cooling has a higher aggregated electricity demand the summer with higher temperatures leads to a higher demand and thus a higher wholesale electricity price.

Another important component which is related to the temperature is cooling equipment, specifically the saturation of central air-conditioning (CAC). Larger CAC systems lead to higher peaks during hot hours of the day as the system will have higher total demand than several smaller distributed air-conditioning systems. However, if enabling technology like programmable thermostats is used wisely it can also lead to a lower total demand as air-conditioning units are only working while residents need them.

These are only two other examples of wholesale price influencing factors. Obviously many other factors such as cloud levels, specific events (such as sport events), regional holidays and other factors play a role in determining wholesale demand and prices. The goal of this section is only to illustrate that many factors determine the wholesale price and specifically the difference between the peak and base price for electricity. As the difference between peak and base prices as well as the average price of wholesale electricity is important to assess the prospects of different business models it is essential to keep the influencing factors in mind.

2.3.3. From wholesale price to retail price

As described earlier the wholesale price of electricity consists of many different components. The most important two factors however are the price of actual electricity of the Real-Time Load Marginal Pricing (RTLMP) and the capacity price. The RTLMP is influenced by the factors mentioned in the last section and varies between around $500/MWh and almost $0/MWh in 2010 at an average of $49.23. Theoretically the price could become negative as well if a power plant issues negative bids in order to stay online during a short period to avoid a shut-down and consequent start-up. The RTLMP changes every hour and therefore is the major factor for wholesale price volatility.

The capacity price is fixed for long periods of time (mostly monthly) and thus does not introduce the same amount of volatility. In 2010 it was $6.68/MWh for 2010 and thus contributes around 15% to the total wholesale price of electricity.

All the other price components usually make up less than $1/MWh. They mostly consist of the forward contingency payments but also of regulatory costs, forward reserve costs, real time reserve costs, inadvertent energy, emergency energy, the marginal revenue loss fund, auction revenue rights, the ISO Schedule 2 & 3 and the NEPOOL payment. Most of these costs are also fixed over longer periods of time.

Taking an example of an almost average hour of electricity pricing the RTLMP is $50/MWh, the capacity charge is $7/MWh and all other costs are another $1/MWh. This would aggregate to a price of 58$/MWh (or ct5.8/kWh). In order to derive a retail price the cost of transmission and distribution as well as operational costs of the retailer and the retail margin need to be added. The retail price will also include the cost of distribution losses. In 2005 the transmission costs and distribution costs were \$3.60/MWh and \$68.90/MWh respectively.(Independent System Operator New England 2010a) Adding these charges the price of retail electricity increases to \$130.50/MWh. On top of that the company responsible for marketing and retail operations will price in its costs and a small profit margin. Unfortunately no data for the operational costs and typical retail margins are available. A rough guess is to increases the price by another 5-7%. Margins in the retail electricity business are typically small and the operational costs of an electricity retailer are low.

2.4. *Description of market segments*

The electricity market consists of three segments: generation, transmission & distribution and retail. Originally all these steps in the value chain were conducted by a single vertically integrated utility. However, after the deregulation of the electricity industry their functions have become decoupled. Therefore it is important to define clearly which functions are covered by which segment for latter definition of business models.

2.4.1. Generation

Historically electricity generation was only conducted by centralized electric power stations which were mostly fuelled by coal, gas, nuclear or hydropower. However, in many countries decentralized electricity generation is slowly increasing in importance. The implementation of solar panels, wind turbines, smaller gas (or often biogas) power plants and small hydro stations are starting to change the picture. As a definition for this paper, electricity generators are businesses that generate electricity and sell this electricity to the wholesale market or via fixed contracts to retailers. A self-sufficient house which is consuming electricity it produces itself is thus excluded. Electricity generators also take over functions of balancing the grid and are in constant contact with the system operators to perform this function.

2.4.2. Transmission & Distribution

Transmission and distribution services include all services provided to transfer electricity from one point to another. In Massachusetts the ISO-NE oversees the transmission and operates the grid as a non-profit entity. The ISO-NE also ensures that non-discrimination to electricity generators is guaranteed as it dispatches power plants according to the power needs of each node.

2.4.3. Retail

The retail market includes all functions that interact with the customer. This includes marketing, branding, ensuring quality and reliability of electricity as well as billing. The retail market of Massachusetts is open to new entrants. A retailer does not need to produce any electricity, or own any assets. It could be a merchant that purchases electricity in the wholesale market, purchases transmission and distribution services and offers its customers electricity and other services it has bought. An electricity retailer can thus be very similar to retailers in other industries such as a supermarket or a drug store.

2.5. Retail Business models in Massachusetts:

The section gives an overview of the different business models in the retail market of Massachusetts. A detailed description on the utilities can be found in the appendix.

2.5.1. Utilities:

Utilities are the traditional form of organizing electricity markets. In regulated markets utilities are given regional monopolies and control the whole value chain from generation, over transmission and distribution down to retail operations. In deregulated markets utilities are not allowed to operate all parts anymore. Until 2005, utilities operated electricity customers under Standard Offer Service. From 2005 onwards all customers were moved to basic service, which means nothing else then to receive electricity from a utility instead of a Competitive Electricity Supplier. In Massachusetts most utilities are managing the distribution and retail side and only have a limited investment in generation. The following section describes the four major utility companies operating in Massachusetts.

2.5.2. Competitive Electricity Suppliers

Competitive Electricity Suppliers (CES), which are also called power resellers or electricity sellers are companies that were allowed to enter the Massachusetts electricity market after 2005. The goal of competitive electricity markets is to allow competition in the wholesale and retail sector of the market. By having a variety of players which offer different services at different prices the market is meant to become truly competitive. CES are one of the two major legal forms in Massachusetts to enable such a competitive retail market.

They are allowed to generate their own electricity or buy it in the wholesale market. CES compete with utilities for customers and can set any rate or contract type to engage in competition. From a theoretical perspective, CES are mostly similar to the retail operation of utilities. Historically however, they are different as they were only allowed to compete since 2005. Therefore most CES are still small and are operating in niche segments.

2.5.3. Electricity broker

An electricity broker is a business which facilitates the sale of electricity, but does not take title to the power and is therefore not an electricity seller. (massachusettselectricity.com) Apart from this difference the business model of an electricity broker is similar to that of a CES. Electricity broker too mostly target commercial and industrial segments.(Department of Energy, Department of Public Utilities)

2.5.4. Summary of new retail entrants in the electricity market

Currently a hand full of competitive electricity resellers is operating in Massachusetts. The total number of electricity brokers in Massachusetts in much higher than that of the competitive electricity resellers. This does not automatically mean that they have a higher market share then competitive electricity brokers as they can be assumed to be smaller in size. In total, they too do not own a significant market share of the total Massachusetts retail market.

Both mostly serve commercial and industrial segments and only few supply services to retail customers. (Department of Energy, Department of Public Utilities) The major reason is that the cost of reaching retail customers is significantly higher, especially if conducted on a small scale. With around 10% all competitive electricity reseller taken together served only a small share of the retail market in Massachusetts in 2007. In comparison in the industrial and commercial segment the market shares of competitive electricity resellers is between 30% and 90% for small and large consumer respectively.(Government of Massachusetts, Department of Energy Resources 2008)

2.5.5. Non-electricity related new entrants

Until now the electricity market was controlled by a few large utilities, which only faced some new pressure from CES and electricity brokers. The electricity sector was fairly independent from other sectors and worked in its own ecosystem. With the introduction of smart metering this might change. As telecommunication and information technology will become a core competency for the grid and customer management new players are expected to enter the industry and alter the industry dynamics. This section will give a brief overview of possible players or types of players that might play a role in the future of the electricity industry.

2.5.6. Smart meter manufacturers

Meter manufacturers are not really a new player to the industry. For centuries specialized entities have provided consumers and utilities with power meters without playing a big role in the industry dynamics. With the introduction of the smart meter this could change. As smart meter manufacturers have the best knowledge of the technical potential of their meters they could extend into the service space to increase their margins. Offering downstream services is a popular generic strategy if margin in manufacturing deteriorate as the market matures. Without going into detail differentiation in the smart meter market will be difficult as more and more players offer meters with similar technical capabilities. Offering value enhancing services such as a customer interface, energy efficiency and appliance identification tools to customers as well as outage identification or direct communication tools to utilities could become an important factor for smart meter manufacturers to differentiate as pressure in their core business builds up.

Smart meter manufacturers like Echelon, Elster, Landis+Gyr, GE or Itron all have access to capital and have been growing significantly in the past. Most of the players in this space are listed companies with employee numbers in the four digit range (except GE of course). On top of that the companies are running profitable, global businesses operations in their core manufacturing capacity. Some of the entities like GE and Itron have diversified business operations and are not purely dependent on smart metering as a short-term income source. This means that smart metering manufacturers over all can afford to invest in new business models even if these business models do not produce short-term earnings.(Leeds and GTM Research 2009, 1-145)

2.5.7. Telecommunication and infrastructure providers

The smart grid can be described as the marriage between information technology and the electricity grid. Whenever two industries collide, capabilities from both sides are needed. Which industry ultimately is able to capture most of the value can be viewed an opportunity as well as a threat. For telecommunications and infrastructure providers the smart grid and smart metering should be seen more as an opportunity. Their core business is not affected by this new market, however they could not only profit from increased demand of infrastructure investments, but also from building sustainable business models on top of this infrastructure. Big players such as Cisco Systems, Oracle and SAP have started to explore this space and its possibilities.(LaMonica 2009)(Echelon Public Relations Statement)(CleanThinking.de 2011) Just like smart metering manufacturers, telecommunication and infrastructure providers can wait for cash-flows. With deep pockets these companies are willing to invest significant amounts of money and can be expected to aim for long-term value creation rather than short-term cash flows.

2.5.8. Information aggregators

As the smart grid will increase the amount of information that can be used for electricity and non-electricity related purposes, entities that specialize on information aggregation will become interested in the smart grid and smart meter market. First signs of such interest are Google Philanthropy starting the Google power meter or Apple entering the home energy management space. (Google Power Meter) (48 Smart Grid News, News Analysis 2010) In additional, a number of start-up companies have entered the realm of aggregating smart metering information for different purposes. Especially businesses that function as platforms and offer services to different entities are likely to be successful. For example, business models that offer energy efficiency and energy monitoring services to end consumers and at the same time offer services to utilities could become powerful intermediaries.

While the mature players like Google and Apple have deep-pockets, access to capital and can afford going through years of negative cash-flows, small start-up companies might not be able to do so. Especially as the market gets increasingly crowded with prestigious competitors and start-ups, funding for new entrants from angel investors and venture capital firms will become difficult to obtain.

2.6. *Implication on value capture and best ownership*

The first section of this paper qualitatively and quantitatively analyzed the total sum of benefits created. The previous sub-sections further showed that a variety of players from different industries are interested in capturing a portion of this value. The major unsolved question however is, which players are most likely able to do so. For this analysis it is always important to keep two facts in mind. Firstly, the entity which creates the value initially captures the value. Secondly, depending on market pressures and market dynamics other entities force the value creating entity to pass value on to them. The entity creating value will therefore very unlikely be able to retain the whole value for itself.

2.6.1. Capture of energy market related activities

The first paragraphs of value capture focus on the value created from energy efficiency and operational improvement value. The value of energy efficiency is divided into short-term or price related benefits and long-term or avoided investment benefits. In the paragraphs on value creation two extreme positions of the price benefit for consumers, depending on the change in consumer value of electricity at changed hours of usage were introduced. Assuming that the actual consumer benefit is somewhere between the two extreme positions, at least for some consumers, additional value is created through changes in behavior.

The retail electricity provider creates the value through offering new pricing schemes. It could theoretically capture value from new pricing models, if it passed less then the total benefit on to the consumer. Given the competitive and unique environment of retail electricity companies this is however unlikely. Firstly, consumers (especially residential consumers) have been shown to have low price elasticity. This means that making consumer change their behavior in the can only be done by giving them significant price incentives. A tricky price scheme might be able to convince consumers that they receive price benefits, whereas in reality they do not. However, as electricity bills are compared on a long-term basis, this perceived but non-existent benefit is difficult to create.

An alternative to behavior changes is to specifically look for businesses (mostly industrial complexes) that have unrelated load pattern without changing their behavior. These "cherry picking" retail electricity business models would have to pass less benefit on to the consumer. However, as finding these businesses is easy and no competitive advantage can be created as a provider the competitive pressure in this segment is high and the benefits effectively have to get passed on to the consumer. Therefore pure cherry picking retail models cannot run on a large scale.

Secondly, retail electricity companies have difficulties differentiating their service from one another and therefore are subject to competitive pressure. With the deregulation of the Massachusetts retail market the boundaries to entry are relatively low. Differentiation as a retail electricity provider is also very difficult as product differentiation is impossible. Some retail provider try to differentiate based on the premise that they offer electricity from renewable energy source. However, firstly a specific customer will always get the same mix of energy, disregarding the retail provider. Electrons do not obey the command of a retail provider, but only the rules of physics. Ensuring that only electricity from renewable energy sources reaches a specific customer is therefore impossible. On a system level a provider can guarantee that the same about of renewable electricity is put into the grid as his consumers use. The generation of renewable energy is subsidized in any case, which means that consumers willing to pay more for renewable electricity are simply giving a voluntary donation to help the increased generation of renewable energy.

Last, but not least developing a new pricing scheme does not require complex capabilities and new pricing schemes can be copied easily. If a company can obtain a competitive advantage through a new pricing scheme, competitors will react quickly and offer similar schemes destroying the competitive advantage and passing the value on to the consumer. If a competitive advantage can be created from new pricing schemes it does not seem sustainable.

The result of these aspects of retail electricity markets are significant competition and extremely low margins. The lion share of this value from new pricing schemes and operating advantages (e.g. faster outage detection) should be captured by the consumers.

In addition to this consumers will capture significant value from the drop in wholesale prices. The here described drop does not mean that wholesale prices actually sink, it could also increase over time. However, against a reference or baseline scenario incorporating no dynamic pricing and demand shifts the wholesale price will be reduced. The value of this reduced price will be a significant transfer of value from producers to consumers. This means that consumers will capture a significant part of the shot term or pricing related value of smart meter information.

The issue of value created by the electricity generators such as long-term or avoided capacity value capture is more complicated. Firstly, it is questionable if and over which time horizon power generators are able to capture the value of avoided capacity. Value creation implies that they normally would have to build new capacity and due to the effect of demand side management can avoid doing so. However, as power plants have extremely long life-times this applies in the very long-term. In a market like Massachusetts where total electricity consumption is assumed to increase over the next century value creation is possible as new power plants will be required. Nevertheless, the time horizon for these benefits will be extremely long. Neglecting this challenge and assuming that the benefits from reduced capacity can be fully captured by generators, the question is how much of this value has to be passed down through the value chain and which player keeps how much.

Power generators are operating in an oligopolistic market and have significant market power. Under normal assumptions this would lead to a high value capture of the generators as they do not need to pass on high portions of the created value. Electricity markets however are not a typical market. Firstly, the price for wholesale electricity depends on the bids on the market participants, which should reflect the marginal cost of the unit with the highest variable cost. If the load profile of the market becomes flatter fewer power plants have to be built as the peak is lower, but also intermediary power plants can run a higher number of hours. All other being equal this means that the rent for these intermediary power plants should increase, assuming that the wholesale price is higher than their marginal cost for most hours of operation. This means that disregarding market power electricity generators should capture the value as the mechanism for passing on value - the wholesale price - is not governed by market power but by market design.

Secondly, a major aspect is the investment for the metering device. If the utility paid the investment cost for the meter, which it does in many instances, the utility will require compensation for its investment in the meter. The electricity generators have a lot of market power to retain this value and should be able to defend it. However, the regulator could hinder them from setting their return freely. If the utility paid for the device then a reasonable return rate on the meter investment can be justified in front of the regulators. Even in “deregulated” competitive market the regulator still plays a crucial role for many issues, such as the wholesale market bids, market power regulation and other charges.

Three principle mechanisms for granting electricity generators a return are feasible. Firstly, the generators pay and nothing else changes. The benefits from operative benefits and avoided investment will fully pay for the benefit and the generators are satisfied with not further changes. This is unlikely as many studies have estimated these benefits to cover only part of the investment cost using reasonable discounting assumptions.

Secondly, generators retrieve the investment cost by passing the cost of the meter on to the consumer via a service charge or distribution charge. For generators this is very attractive as all the risks are held by the consumers and generators should be able to retain a significant portion of the benefits. Depending on the charge set consumers and generators share the benefits. The tougher the regulator is setting the charge on the generators, the more value the consumer will be able to capture.

Thirdly, if the generators can bid over their marginal cost keeping the wholesale price high and still avoid generation investments, then they will be able to capture a significant share of the total value. In the light of market regulation this scenario however seems unrealistic.

Summing up, most of the value from avoided capacity should be captured by the electricity generators, leaving them with the biggest share of the total value. The difficulty for electricity generators however is the long payback time as this benefit is only realized in the long-term. The discount rate, or underlying financing and risk structure is therefore the major influencing factor for the attractiveness of smart metering information for electricity generators.

The long-term benefits from transmission and maybe distribution are created by the grid operator. In the case of Massachusetts the grid is operated by the ISO New England. If benefits reduce the price of transmission the ISO will reduce the system charge in the long-term which means that the consumer should capture this benefit. Retail electricity providers could raise their prices as transmission prices drop and retain some of the value, but with high competition and low differentiation in the retail electricity market this is unlikely.

2.6.2. Capture of non-electricity market related value

Making predictions about the value capture in non-existing markets is an extremely complex issue. Nevertheless I hope that the here shown framework helps the reader to make his or her own thoughts about how this market will play out and conduct additional research on this issue in the future when more information is available.

2.6.2.1. Framework

The framework analyzes the prospects of value capture along five dimensions. The dimensions are ordered by importance based on my personal intuition:

- Confidence of consumers in new business models and social acceptance
- Company culture, risk disposition and entrepreneurial spirit
- Synergy effects with existing business
- Capabilities
- Financial support

The first dimension is confidence of consumer and social acceptance with regard to privacy and information concerns. This dimension is most important as all business models which try to create value through the transfer of information need the explicit or implicit consent of the consumer. As shown before although the legal framework is not settled and undergoing a dynamic process an explicit consent will be needed at some point. If an entity starts with an advantage or is able to build confidence faster than others, because consumers trust this entity with their information, it will gain a significant sustainable advantage over its competitors. Building trust is extremely difficult and time consuming, whereas destroying confidence on the other hand can happen very quickly. Therefore confidence in the provider and operator of these new business models is not only one of the most important dimensions, but also one of the most dynamic.

Secondly, innovative markets require the right company culture, a certain amount of risk disposition and entrepreneurial thinking. Large hierarchical entities tend to think in the terms of their existing business model and neglect entrepreneurial activities. Start-ups on the other hand have the advantage of starting on the plain field and therefore being able to define their business model from scratch. As the business model design is crucial this category is very important. On top of that risk acceptance is part of this category. Risk acceptance is crucial for these business models as the dynamics of the market can change quickly. The legal standards as well as social acceptance are not fully explored and may change abruptly. With these dynamic market parameters even formerly successful business models can be driven into bankruptcy. Only entities willing to accept these risks will therefore be able and willing to compete in this market.

The third dimension consists of synergy effects between existing business operations and the new smart meter information based business model. Entities can potentially add additional value to smart meter information based business models on the cost and on the revenue side. On the cost side, information aggregation requires computational hardware and software. Entities that have invested in such infrastructure are likely to incur less incremental costs for additional operations than others. On the revenue side, if the information for smart meters can be combined bundled or differentiated with other information its value will increase. Estimating the synergy effects on a qualitative and quantitative level is difficult without knowing the exact business models and the exact use of their information. My intuition is that synergy effects will play significant role as the market grows, but will be less important in the first years of developing business models. Therefore I placed this dimension as medium in importance.

Fourthly, the capabilities needed for value creating activities are a necessity to drive these business models. Consumer interaction, information and data mining related capabilities as well as operational efficiency are important criteria to successfully operate these business models in a competitive environment. Although capabilities are always an important aspect for business operations, they are less important for defining the value capture for two reasons. Firstly, most of these capabilities are unique and have to be newly acquired by all players. Therefore obtaining a competitive advantage over others is difficult. Secondly, obtaining these capabilities is easy compared to gaining consumers' trust or compensating for synergy effects. Therefore this market will most likely not be capabilities driven.

The last dimension is financial support and access to capital. Many of the here described business models do not require excessive amounts of financial support. Consequently, small start-ups not able to match the financial backing of large utilities, smart meter or telecommunication firms can compete on par with in this capital extensive market. This does not apply to the smart meter investment itself, but only to the business models using smart meter information. The advantages of bundling smart meter investment and information based business models are included in the synergy section. The information based business models do not necessarily need to pay for the smart meter equipment, but can profit from existing infrastructure.

Potentially more dimensions could become important in the future. For example the legal status and regulatory framework might influence the flexibility of some entities. Especially utilities might not be able to operate as freely in this market, if regulators decide that utilities have an unfair advantage in the retail market. Although I believe that such restrictions are possible, no restrictions exist in Massachusetts. Therefore this dimension will not show up in the subsequent analysis.

2.6.2.2. Best ownership comparison

2.6.2.3. Utilities

The analysis for utilities shows significant disadvantages on the one side and high potential on the other. On the one hand utilities are not in a perfect position to capture the value from smart meter information related business model. My personal intuition is that utilities are thinking of smart meters as a technology delivering operational advantages and avoided investment. This intuition is derived from a number of industry interviews as well as informal meetings with representatives of different utilities. The service aspect and its potential is not the focus of utilities so far. Therefore I believe that utilities currently do not have the entrepreneurial thinking and company culture to start venture into this new, undefined space. It is however not founded on hard data and the reader should decide whether he or she thinks that utilities lack the right company culture and mindset. Like many mature businesses they think of smart meters in terms of their core business.

The synergies of utilities with their existing business model are medium. Data mining could help to provide value added features to their customers such as energy efficiency measures. They could also analyze consumer pattern and reduce consumer churn via better consumer understanding. However, these advantages are operational benefits with limited scope. Even worse, starting an information aggregation venture and failing could negatively impact the core business of utilities. Combining all these facts with the low risk disposition of utilities will reduce the likelihood of utilities entering this field at all. Utilities have some experience in data mining, web based business models or selling information to third parties. Utilities thus hold a medium position in terms of existing capabilities, but even on the capabilities dimension utilities cannot gain a significant advantage over others.

Nevertheless, utilities hold a huge advantage in terms of consumer trust. The survey by the Ponemon Institute in December 2010 shows that 59% of all consumer trust utilities with their information – ranking them first among all businesses. The only other group scoring over 50% was telecommunication and wireless companies with 57%.{{75 Ponemon Institute LLC 2010}} This dimension alone could turn the potential of utilities around. The additional fact that utilities have access to financial support is only of secondary nature.

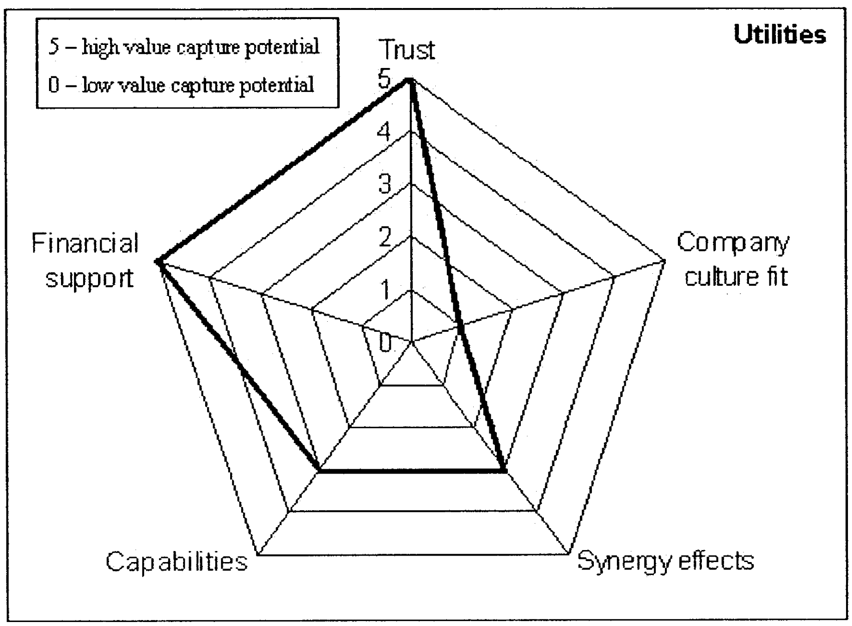

Figure 6 – Potential for value capture of utilities

Summing up, utilities are unlikely to rush into these new business models as their core business can be adversely affected by confidence issues, their company culture does not fit the requirements and they only hold some capabilities. Capturing the value from information based business models therefore is difficult for utilities. Nevertheless, if utilities do not engage directly in driving the business model they could be a valuable partner for other entities. With the high consumer trust utilities could grab a share of the created value through partnerships and alliances. This would limit the risk for utilities and still allow them to participate and retain some value. Therefore utilities will play a role in the market – but most likely only as a partner granting and supporting consumer access to another entity.

2.6.2.4. Smart meter manufacturers

For Smart meter manufacturers the disadvantages seem to prevail to capture significant value in this market. The confidence of consumers to handle their information appropriately into smart grid companies is in the medium range with 46%. {{75 Ponemon Institute LLC 2010}} On top of that smart meter manufacturers are first and foremost manufacturing companies. The company culture of manufacturing companies is typically product focused, risk averse and centered around their core market and manufacturing capabilities. With highly limited experience in information aggregation, end-consumer contact and retail based business models smart meter manufacturers do not hold key capabilities. Therefore smart metering companies score low on company culture and capabilities and only medium on consumer trust.

The biggest advantages that smart meter manufacturers have are the understanding of the technicalities of the meter and the consumer access through the meter. This grants them positive synergy effects as they could bundle service related business models with the existing hardware sales. Another minor advantage is the access to capital that the large smart meter manufacturers hold.

At this point in time I believe that smart metering companies are mostly engaged in technical capabilities of their meters instead of driving service related business models. Company culture, capabilities and trust are not perfect fits for meter manufacturers. However they could partner with other entities to bundle products and capture a small share of the value. All in all I believe smart meter manufacturer will only play a minor role in the value capture of information based business models.

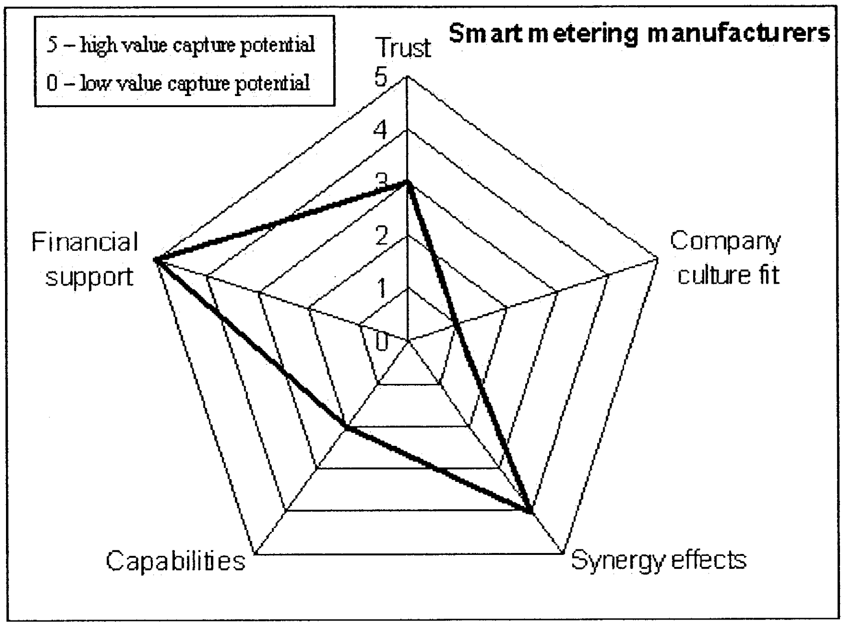

Figure 7 – Potential for value capture of Smart meter manufacturers

2.6.2.5. Telecommunication companies

Telecommunications companies come from a different industry, but the position for value capture is similar to that of utilities. Although consumers trust them well with their information, their company culture is centered on their core business. Their core business is not related to these business models and they are unlikely to diversify into these new business models due to their company culture. With limited synergy effects from gaining access to consumer electricity information, but high potential negative impacts on their core business if consumer trust is lost telecommunication companies could see these new ventures rather as a risk than an opportunity. Telecommunication providers hold capabilities in information aggregation and consumer data storage, but only limited know-how to monetize this information. In my opinion telecommunication providers are unlikely to play a major role in the value capture of information based business models. This leads to the conclusion that telecommunication provider will capture only a minimal share of the value through communication based partnerships or providing capabilities for information transmission and aggregation.

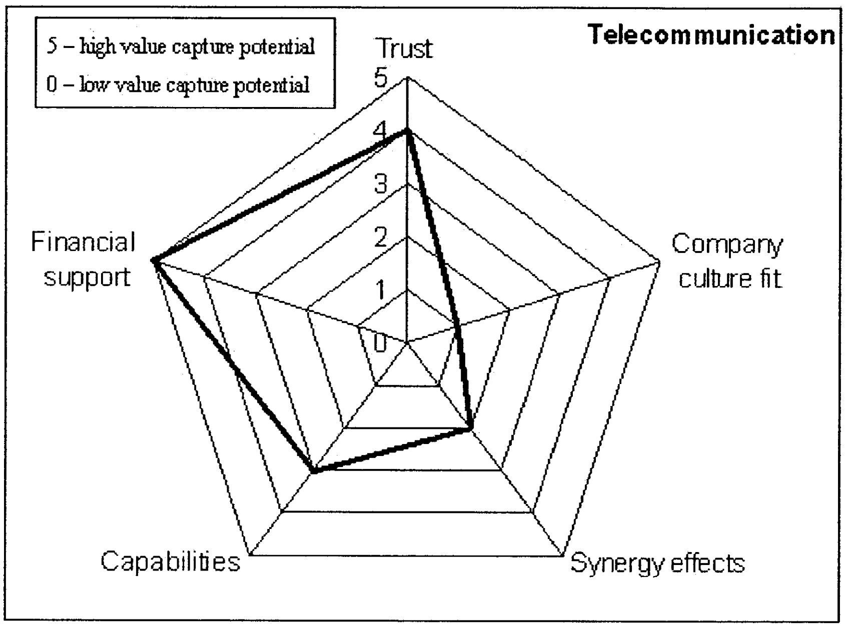

Figure 8 – Potential for value capture of Telecommuncation companies

2.6.2.6. Information aggregators

Information aggregators, such as Google are in a very interesting spot to enter the market for smart meter information based business models. They enjoy multiple advantages over other entities. Firstly, they are experts in gathering information, sorting it and monetizing information by selling it to third parties. Secondly, they could gain revenue based synergies from their existing business. For example they could combine the information from smart meters with other information and add value by combining different data sources. Although this would add value such a usage of information would raise even higher privacy concerns. On the company culture dimension information aggregators score well. Companies like Google or Apple are open to new business models in dynamics environments and explicitly support venturesome activities. Google for example has entered a variety of different spaces successfully and supports intra-preneurship activities fiercely. All these reasons make information aggregators appear perfect candidates to capture a significant share of the total value created.

However, they face one significant barrier – trust and social acceptance. In my opinion privacy is the single most important dimension determining success in this market. The Ponemon study does not give an estimate about information aggregators, but shows that internet service companies share the lowest rank with the federal government. Only 29% of all consumers believe that internet service companies handle their information adequately and information aggregators would score in a similar range. On top of that, whereas only 33% of all consumers view the confidentiality of internet searches as important, 69% rate the confidentiality of their electricity information as important. The fact that consumer accept an internet search engine to gather information on the behavior is therefore not transferable to smart meter information. Although information aggregators face significant challenges from privacy concerns I believe that they are in a good position to capture at least part of the value created from smart meter information based business models.

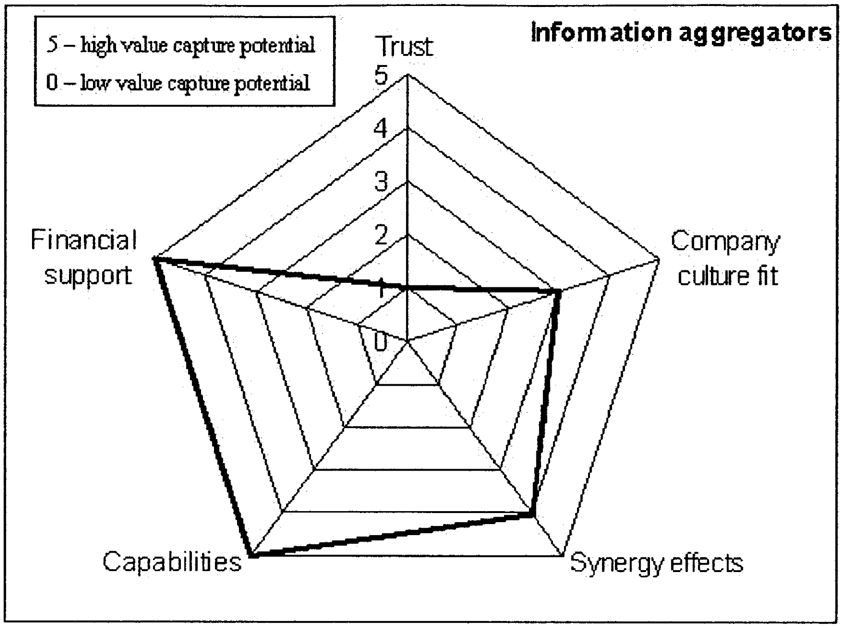

Figure 9 – Potential for value capture of information aggregators

2.6.2.7. Start-up companies

Start-up companies can accept the significant risk which is involved in this field. New ventures always accept the risk of failure and just as in many other markets, new companies have the advantage of defining their business models without having to fit it to any existing structure. With capabilities and financial support only being of limited importance start-up companies should be able to overcome these two challenges which often pose significant challenges for new entrants. The major obstacle for new entrants, as for all entities in this market is to gain the trust of consumers that their information is handled adequately. Start-up companies do not start with any track record, which can be viewed as a disadvantage or advantage depending on the point of view. All in all I believe that this field is attractive to new entrants and that the probability that new entrants will be able to capture a significant part of the value is high.

How the best business model for start-up looks like is difficult to estimate. However, it needs to incorporate the following facts. Firstly, consumer access and trust needs to be facilitated by utilities or other retailers with significant consumer confidence. Therefore new entrants need to build a platform based business model offering value to retailers and consumers. A good way would be to offer the energy efficiency services to the customers of the retailer for free. The new entrant could for example provide smart phone application making measuring and monitoring electricity usage easier. Persuading the retailer by offering value to it and its customers on a continuous basis is a major challenge, but helps to scale the model, increase adoption rates through consumer access and reduce privacy concerns.

Secondly, the business needs to provide value to end consumer without ignoring their privacy concerns. The start-up will not be able to persuade many consumers that their information will be sold to third parties without masking or anonymizing it. Furthermore the company will most likely only be able to commercialize information on a lagging basis e.g. a month after the information is collected. The concerns for real-time information are significantly higher and therefore using lagging information will increase social acceptance. Based on Figure 5 (page.38) this means that the start-up will operate in the quadrant with the lowest privacy concerns. Many of the value driving activities such as the identification of appliances or consumer profiling require real-time information and time specific information. The value is reduced through masking personal data, but still significant value remains in such business models. Concentrating on these activities, especially at the beginning would help to gain consumer acceptance and build trust. On top of that the business needs to communicate clearly that it will only use clustered, lagging and non-time specific information to openly communicate this to the consumers. Consumer find out sooner or later what their information is used for. As confidence can be lost extremely quickly only open and well executed communication to the consumer can create a sustainable business.

Last, but not least the business needs to provide value to the consumer on a continuous basis. Firstly, this can be done by offering energy efficiency analysis tools. If the business is able to persuade consumer to verify their appliances to load the data into the energy efficiency tool then it has already overcome a significant acceptance barrier. Secondly, giving consumers additional value via energy efficiency rebates for appliances or other monetary advantages is a good way of rewarding consumers for their continued support and information access.

I believe that these two stakeholders, utilities and end-consumer are the most important factors for a successful entry of a platform based start-up model. This analysis obviously applies to a limited degree to all new entrants, whether it is utilities, information aggregators or start-up companies.

2.6.2.8. Summary of value capture from non-electricity market based business models

Many different entities are interested in capturing a share of the value created by smart meter information related business models. Although utilities, smart meter manufacturers and telecommunication providers hold a significant advantage due higher consumer trust, they also face significant obstacles. The two most important obstacles are their traditional company culture and limited risk acceptance as well as negative synergy effects for their existing business models. Therefore information aggregators and start-up companies have the best prospects of capturing a significant share of this value.

3. Epilogue and personal thoughts

This paper gives an overview of the different value drivers of smart meter information as well as a short outlook on value capture prospects. The value created from energy efficiency measures as well as operational advantages is a significant portion of the whole value. However, the potential value from passing information on for non-electricity related purposes can also play a significant role in the future of using smart meters. The major obstacle for the usage of such information in this way is the privacy concerns of consumers. Therefore any business model, independent of the owner will need to deal with this challenge and persuade the consumer either by granting intangible benefits or via monetary compensation.

In this paper the value for these measures is not quantified. I hope that further research will try to quantify this value and contrast it to the value created by energy efficiency and operations advantages to make a fair comparison. As none of these business models exists at this point in time, writing a full business plan for each activity would be necessary. I see this paper rather as a starting point for further research which I hope it can help to inspire.

4. Appendix

4.1. *National Grid – Massachusetts:*

National Grid is an international utilities company which is headquartered in London and which operates electricity and gas transmission and distribution networks in the UK and the USA. The company was founded 1980 in the UK and expanded to the USA through a merger with Narragansett Utility (NEES) in 1998. In 2002 it more than doubled its US operations by acquiring a New York electricity gas and electricity company called Niagara Mohawk.(Hoover Inc. 2011, 1-3) Later it further expanded its US operations with the acquisition of US gas distributor KeySpan Corporation (KeySpan) in 2006 as well as the acquisition of the Rhode Island generation assets of New England Gas from Southern Union. In 2008 National Grid sold its 2.5 megawatt Ravenswood Generating Station in New York City to TransCanada Corporation for approximately $2.9 billion.(National Grid plc 2010, 1-191)

National Grid is providing electricity to 3.3 million customers and gas to 3.5 million customers in the USA.(National Grid plc 2010, 1-191) Although this seems rather small compared to 19 million customers worldwide, National grid is generating almost two thirds of its revenues in the USA. This share is also reflected in the number of employees, as 63% of its over 28,000 employees work in the USA.(National Grid plc 2010, 1-191) In the USA it operates three business divisions: electricity distribution and generation US, gas distribution US and transmission US. About one third of its revenues are in the US electricity business (generation, distribution and transmission), another third in the US gas business. Its distribution business is delivering its services to customers throughout the North-eastern States of the USA, including New York, Massachusetts, Rhode Island, and New Hampshire. It also operates the distribution system of Long Island which is owned by the Long Island

Power Authority (LIPA). Its US generation division operates 57 electricity generation plants on Long Island comprising oil and gas fired steam turbines, gas turbines and diesel driven generating units, providing 4.1 gigawatts (GW) of power under contract to LIPA.(Datamonitor 2010, 1-29)

In the financial year 2010 (ending March 2010) the company has collected revenues of 13,998 million GBP and a pre-tax profit of 2,193 million GBP. In comparison to 2009 its revenues has decreased by 10.5%, but its pre-tax profits have increased by 57.3%. This is reverse of the developments last year where National Grid was able to increase its revenues considerably by 36.8%, but lost 36.1% of its pre-tax profits. Compared to 2008, National Grid has increased its revenues by 22.4% at stable pre-tax profits (+0.5%) in 2010. However, its earnings per share from continued operations in 2010 are 5.7% lower than in 2008 (Basic shares, non-diluted). Earnings per share from total operations cannot be taken as a good performance indicator as 2008's profits were boosted by the sale of the Ravenswood Generation Station.(National Grid plc 2010, 1-191)

National Grid is a financial healthy company with a strong standing in the USA with a focus on the North-eastern region.(Datamonitor 2010, 1-29) It is the second largest electricity and gas company in the USA by number of customers. If needed, National Grid can also use revenues from electricity and gas business in the UK to invest in the US operations. Its economies of scale as well as its strong brand image create a good competitive position for future investments. A strong point, as well as a potential challenge is its internationally diversified position. National is less vulnerable to US based shocks than purely US based utilities, but faces additional risks from its UK operations. For example, National Grid had problems with Ofgem, the UK based administrative body for non-competitive behaviour in

February 2008.(Datamonitor 2010, 1-29) Such problems could also affect its US position. Furthermore National Grid also faces risks in its US based operations. Its agreement with LIPA can be terminated in case of default or poor performance. A horror scenario for National Grid is to lose this valuable part of its US operations if it was unable to uphold its performance. However, so far no indicators for such a failure have been made public. For its US operations, another major threat could be a future focus on UK based projects. National Grid has announced to invest heavily in carbon transportation networks in the UK as well as in BritNet; a 50:50 joint venture with a Dutch transmission company which is to invest in a subsea link between Britain and the Netherlands. On top of that National Grid faces the general business threats such as commodity prices, extreme weather conditions and stricter environmental regulation. To decrease the potential impact of stricter regulation National grid has announced to decrease its carbon emission by 80% by 2050 and by 45% by 2020.(National Grid plc 2010, 1-191)

Although Massachusetts is only a small part of its global operations, it is a promising one. National Grid is the largest provider of electricity in Massachusetts and has a very strong competitive position for the future. It is part of all measure programs such as MassSave and will continue to play a big role in the future of the electricity business in Massachusetts.

4.2. NSTAR:

NSTAR is the second largest utility in Massachusetts by number of customers. With roughly 1.1 million electricity customers and 300,000 gas customers in Massachusetts it is only playing in the same league as National Grid.(NSTAR 2010, 1-111) NSTAR was formed in 1999 out of the merger of Commonwealth Energy System and BEC Energy. Until 2003 NSTAR divested all its regulated generation assets. Since then NSTAR has focused on two sides of the electricity business: transmission and retail operations. Firstly NSTAR has undertaken transmission projects such as the high voltage direct current (HDVC) transmission lines to a hydro power plant Quebec in congestion with Northeast Utilities in 2008 or the proposed transmission structure with the region of Quebec as a whole in 2009. Secondly, NSTAR has undertaken various retail projects, such as NSTAR Green as well as participated in customer projects such as MassSave. In 2010 NSTAR has been approved to build a pilot smart grid project to monitor and reduce electricity consumption of its customers. NSTAR also initiated other energy efficiency projects such as the efficiency forward project in cooperation with the Massachusetts Institute of Technology (MIT).(Datamonitor 2010, 1-23)

NSTAR generates all its revenues in the USA from electricity and gas electric and natural gas sales, distribution, and transmission services. Its business is divided in three business divisions: electric utility operations, gas utility operations and unregulated operations.(Datamonitor 2010, 1-23)

With almost 84% of the revenue the electricity division is by far the most important for NSTAR. With 152,000 business electricity customers generating 57% of the revenue and almost one million residential customers generating 43% of the revenue NSTAR can be described as well diversified in terms of customer base.(NSTAR 2010, 1-111)

The gas division generates approximately 16% of the revenue. The lion of this revenue (62%) is generated by the 270,000 residential customers. The 30,000 business customers account of 28%. Other customers account for 5% and the remaining 5% are generated by off-system and contract sales.(NSTAR 2010, 1-111)

The unregulated services account for only 0.5% of the revenue and include operations in telecommunications and liquefied natural gas. The telecommunication services are limited to the city of Boston and the liquefied natural gas service is provided by Hopkinton LNG which consists of liquefied natural gas (LNG) liquefaction and vaporization plant and three above-ground cryogenic storage tanks. NSTAR also used to operate the Medical Area Total Energy Plant, which was discontinued in December 2009.(NSTAR 2010, 1-111)

NSTAR's recent performance is ambiguous. On the one hand NSTAR has not grown in terms of revenue in the last years. Its revenue of slightly over $3 billions in 2009 is only 4.8% higher than in 2004 and almost 5% lower than in 2008. However NSTAR has performed well in terms of profitability. Its pre tax income from continued operations has increased to almost $400 million. This means an increase of almost 50% since 2004 (10.7% CAGR) and an increase of almost 8% from 2008.(NSTAR 2010, 1-111) As the share structure has not been altered the increase in earnings per share is very similar.

The margin of NSTAR is similar, but slightly lower than that of National Grid. In 2008 NSTAR's operating margin before tax was 11.5% and thus much lower than National Grid's margin of 19.1%. However in 2009, NSTAR outperformed National Grid. While NSTAR could increase its margin to 12.9%, National Grid's margin crashed to only 8.9%. Nevertheless in 2010 National Grid recovered to 15.7%, while NSTARs could only increase its margin to 14.1% in the first three quarters of 2010 and last quarter of 2009. In January 2011 the stock price of NSTAR hit an all time high.(American Banking & Market News by ABMN staff 2011, 1-1) Although this fact also reflects the increased profitability of the company it was also highly influenced by the ongoing merger talks with Northeast Utilities.

In late 2010 NSTAR and Northeast Utilities announced their plans to merge the two companies to become New England's largest utility company servings around 3 million electricity customers and 500,000 gas customers in the region.(Northeast Utility and NSTAR 2011) The merger would give NSTAR shareholder 1.312 Northeast shares to form the new company. This means that around 43.7% of the new company would be owned by NSTAR shareholders. However, a two-third majority is needed to complete the merger and a number of groups have raised concerns. The Braintree union which includes almost 2000 employees of NSTAR has voiced out concerns about lost jobs, especially if the company headquarters would shift from Massachusetts to Connecticut.(Chesto 2011, 1-2) The State Department of Energy contacted the Department of Public Utilities to employ harsher standards on mergers. Rachel Graham Evans of the State department said that "mergers should require a standard of review that optimizes benefits for captive customers and citizens of the Commonwealth".(Pepose 2011) In other words, the merger could be tied to conditions on rate increases and service levels. Last but not least the current Massachusetts governor Deval Patrick tied the decision of the merger to a decision on Cape Wind, a large offshore wind project. He said that the merger would only go through, if the newly formed company agreed to buy energy from the Cape Wind project – a commitment NSTAR was so far unwilling to give.(Fitzgerald 2010) Although the merger is still quite likely, it is not certain yet. More importantly it is not certain what NSTAR or the newly formed company will have to give in return to agree on a compromise with the many interest groups in Massachusetts.(Kane 2011)

4.3. Unitil Corporation:

Unitil Corporation (Unitil) is a publically held utility company operating in electricity and natural gas distribution in New Hampshire, Massachusetts and Maine. The company is headquartered in Hampton, New Hampshire and employs around 450 people.(Datamonitor 2010, 1-21)

Unitil is operating in three business segments: Gas Operation, Electricity Distribution Utility Operations, and Non-regulated Operations. The revenue of the gas operations of Unitil grew significantly in 2009 to $152.8 million or 43% of total revenue due to the acquisition of two companies, Northern Utilities and Granite State in December 2008. Northern Utilities was bought to strengthen the gas distribution business of Unitil, formerly only operated under the subsidiary Fitchburg. With the acquisition Unitil more than quadrupled its customer number to 70,000. The gas distribution business generated almost all revenue in the gas operation with Northern Utilities generating $113.9 million and Fitchburg generating $34.8 million. Almost 60% of the combined revenue is generated from Commercial and Industrial (C&I) customers.(Unitil Corporation 2010, 1-92) Granite State is offering pipeline services in Maine and New Hampshire. It has generating $4.1 million, mainly by offering services to Northern Utilities and only to a lesser degree to third parties.(Unitil Corporation 2010, 1-92)

Electricity Distribution Utility Operations is supplying electricity to around 100,000 customers under the entities Unitil Energy and Fitchburg. Unitil Energy operates in New Hampshire and has generated $146.4 million in 2009 by serving approximately 72,000 customers. Fitchburg operates in north-central Massachusetts and has generated $63.5

million in 2009 by serving roughly 28,000. Both subsidiaries are roughly generating half their revenue from residential and half from C&I sales.(Unitil Corporation 2010, 1-92)
The non-regulated business unit consist of Usource, an energy broker and speciality consultant to large commercial and industrial users. It has generated $4.1 million in 2009.(Unitil Corporation 2010, 1-92) Other activities in Unitil Services and Unitil Realty which earn revenue primarily from short-term interests and real estate investment, but which do not play a greater role for Unitil as a whole.

In summary, Unitil is of much lesser importance in Massachusetts than National Grid or NSTAR. It only serves 28,000 customers with electricity and around 15,000 customers with gas through its subsidiary Fitchburg. Also its pre-tax margin was at only 7% and thus much lower than the margins of National Grid or NSTAR. However it has been able to grow its total revenues at 12% CAGR and its operating profits at 14% CAGR since 2005. Although this growth was mainly caused through acquisitions, Unitil is a part of the competitive landscape of Massachusetts electricity business which should not be left aside.

4.4. Northeast Utilities & Western Massachusetts Electric Company

Northeast Utilities (NU), the biggest New England utility company, is a holding company that operates several wholly owned subsidiaries in the electricity generation, distribution & transmission and the natural gas distribution industry.(Hoover Inc. 2011, 1-7) Its subsidiary Public Service Company of New Hampshire (PSNH) is operating in electricity generation, transmission and distribution, its subsidiaries Connecticut Light and Power (CL&P) and Western Massachusetts Electric Company (WMECO) are operating in electricity transmission and distribution and Yankee Gas Services Company (Yankee Gas) is in the natural gas distribution business. On top of that NU owns a few unregulated businesses, but NU has stopped most of its unregulated business activities recently. In total Northeast Utilities is serving more than two million customers, 200,000 gas customers and 1.9 million electricity customers of which 200,000 are located in Massachusetts.(Datamonitor 2010, 1-34) Northeast Utilities was formed out of a merger of three utility companies – Connecticut Light and Power, Western Massachusetts Electric Company and the Hartford Electric Light Company (HELCO) in 1966. Throughout the last two decades it integrated a number of companies including Public Service Company of New Hampshire (PSNH) in 1991, Select Energy in 1998, ES Boulos Company, Yankee Energy System in 2000 a high-voltage electrical contractor based in Maine and Niagara Mohawk Energy Marketing in 2001 as well as Woods Electrical Company and Woods Network Services in 2002. However it also sold a number of assets and entities such as its 17% stake in the Vermont Yankee Nuclear power plant in 2002, Northeast sold Select Energy Services and the sale of its competitive generation assets in Connecticut and Massachusetts in 2006. Summing up, NU has been business restructuring its business in the last twenty years. It started out as the first interstate vertically integrated utility as designed under the 1935 Public Utility Holding Company Act and is now a downstream focused electricity and gas distributor. Its Northeast Generation Services has become less and less important to the company.(Hoover Inc. 2011, 1-7) Nevertheless, WMECO has become the first utility in Massachusetts to gain approval for a 6MW solar energy plant.(Northeast Utility 2010, 1-71) Most recently it has announced to merge with NSTAR to become the biggest utility in New England. The success of this plan mostly depends on the disputes with interest groups in Massachusetts as discussed earlier.

The total revenue of NU has declined in 2009 by 6.2% to approximately $5.4 billion. Its profits however rose by 38.6%, mainly due to lower fuel prices and reduced amortization.(Northeast Utility 2010, 1-71) The recent increase in profits thus does not necessarily result from a sustainable competitive advantage.

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