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Demand Side Management (DSM) – A renewed tool for sustainable development in the 21st century.

A survey of the concept, its development and its applications.

HANS NILSSON
Chairman of the IEA DSM-Programme
Sweden

SUMMARY

Demand Side Management (DSM) was widely discussed in the 1980's as the alternative to supply side "overspending" in energy systems. In the US DSM was carefully regulated with detailed procedures for investigating cost-effectiveness, rate-impact, programme deliveries, availability for different groups of customers etc. Public Utility Commissions had hearings with advocates from both sides.

Outside the US the application was in most countries less formal but the basic idea was the same; that the least-cost option for the energy system performance should be chosen when more supply or less demand were compared on equal terms. The "Negawatthour" (NWh) was made the conceptual alternative to the Megawatthour (MWh).

Market liberalisation has changed the conditions and DSM has since developed, subject to the circumstances of market and regulatory regime, differently in the countries of the world. The basic idea remains and its implementation is evolving due to new technological possibilities and to requirements regarding energy security and environmental sustainability of systems.

In the 21st century, with the imperative demand to create sustainable energy systems in order to prevent the climate change and at the same time allow for more welfare to more people, DSM has to be re-invented as a tool. In doing so, we will certainly also find that wide application of DSM fosters more efficient and more innovative energy technologies for global markets.

KEYWORDS:
DSM; Demand Side Management; Energy Efficiency; Regulation; Technological Innovation, Technology Deployment

hans@fourfact.se

CONTENTS

1. DSM is a means to increased welfare

The fundamental DSM concept was based on that the user did not want energy (kWh, m3 oil, BTU gas) per se, but "energy services" (light, heat, motive power), which is the output from the equipment that used energy as an input. The total use of resources should be efficient and when the service needed could be provided cheaper by using a different type of equipment (that used less energy) it should be done. The saved resources could be used to create greater total welfare. Decisions on such actions could be made by a "least-cost calculation" in which both supply side (energy) and demand side (equipment) were considered together. "Integrated Resource Planning" (IRP) was the tool to do so. For many, the least-cost has however been limited to consider least-cost supply resources because dealing with the demand resources was both conceptually complicated.

It is well-known in welfare-theory that there could be situations where all actors will be able to find improved welfare, or at least one will, whereas the others would either be indifferent or could be compensated for their loss. Trying to obtain such a situation would be "Pareto-sanctioned". Getting at least equal energy service with a lower total use of resources would therefore, from a societal point of view, be preferred. This way of thinking is straightforward and appeals easily to common sense.

1.1 One system - different actors.

The basic problem was that this opportunity to raise the total welfare was foregone since investments in supply and demand (efficiency) are made by different actors with totally different perspectives and knowledge. The utilities on the ***supply side*** invested with a low discount rate because they had more knowledge of technology, they had a low risk profile, especially as they acted within monopolies and knew that their supply would be bought (sooner or later), and they were acting within their core business.

For the individuals on the ***demand side*** it was just the opposite. They did not know much about technologies or how to calculate their possible profit. They bought refrigerators and lamp-bulbs and did not perceive them as energy-using equipment but rather as a good providing a service. They did not have access to capital for investments in the superior, but (sometimes) more expensive, solutions. As they were seeking comfort, energy efficiency was seldom on their radar-screen. They were acting as if they had a high (implicit) discount rate, as illustrated in Figure 1.

The result was overspending on the supply-side and underspending in efficiency on the demand-side. The case to increase Demand Side investments was obvious. But how? The DSM-approach used was to reward customers to do the objectively (if however not obviously) correct thing by acquiring and installing energy efficient equipment. Those who have invested in supply, and done so in the good faith that customers were rational, lost the revenue they had anticipated. The case could be argued and defended, but controversy was also built into the system.

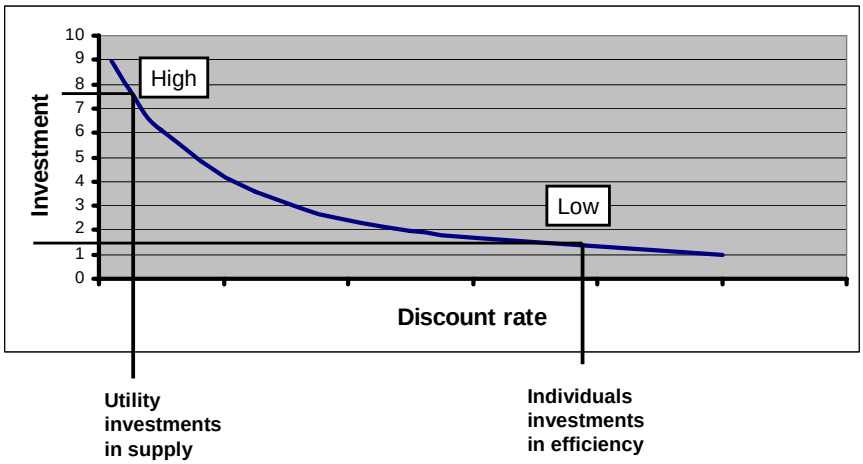


Figure 1: Supply and demand side investments as function of the discount rate shows "overspending" on the supply side for equal "energy service".

This DSM-approach is all-right for analytical purposes and as a touchstone to create guidelines. The reason that it does not work as well to design market actions is that energy efficiency is not a tradable good in itself. Energy efficiency is invisible. It is a characteristic embedded in products that are designed to provide the energy service. Therefore very few) end-users will make the calculations that rational economy assumes.

1.2 Efficiency is the basis for welfare

There is however a case for improved energy efficiency that goes beyond the simple discussion about the nature of DSM. The IEA has shown that energy efficiency is a bigger component in welfare development than normally recognised. If the countries in the IEA study had kept energy intensity on the same level today as 30 years ago they would have had to use almost 50% more energy today than they actually do. [5]

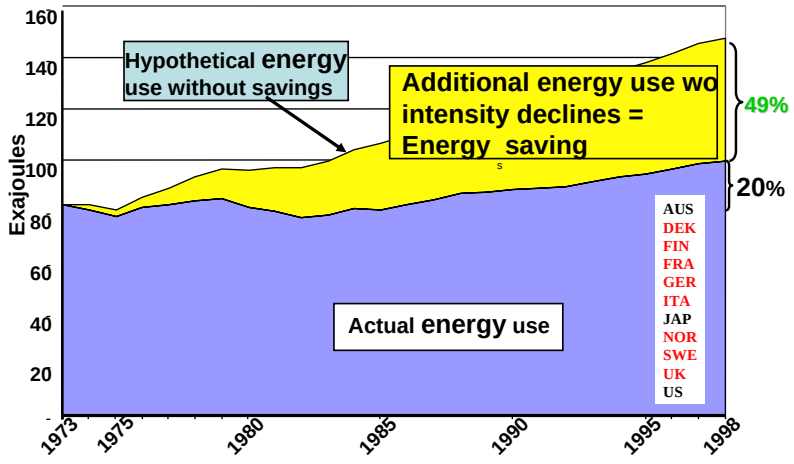


Figure 2: Actual energy use and hypothetical energy use in absence of energy intensity improvements

The conclusion is that ***the level of consumption we enjoy today depends more on the improvements in energy efficiency than in the growth in energy use***. It would, at least

theoretically, have been possible to reduce the energy use without loosing in total welfare in the countries concerned.

2. The market – products, principles and peoples perception.

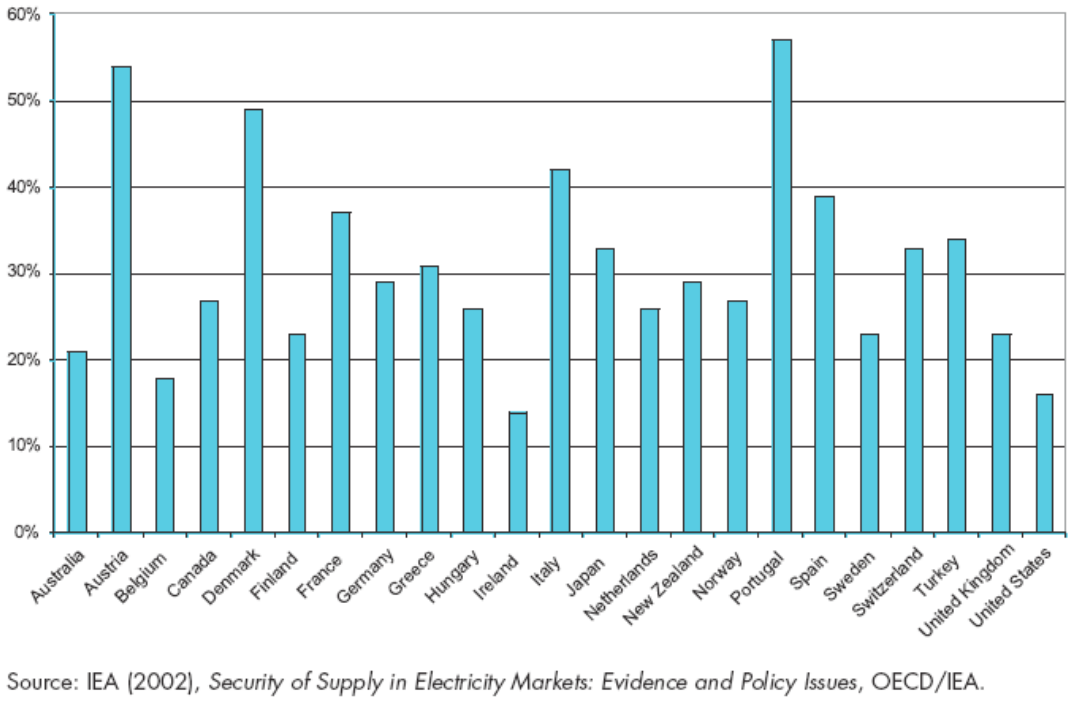
There was not much opposition to the thinking behind DSM except when it came to its implementation. Some argued that the market was in equilibrium and that seeking another state would incur (too high) transaction costs. People had made their choices on rational grounds knowing that it would be too cumbersome to find alternatives. Some opposition was also found in the utilities among staff that was very familiar with energy supply, but felt uncomfortable dealing with demand side and petty small-scale technologies. Some were even offended by the idea that their honest work, doing good for the society in bringing energy that enabled development, could be challenged [1].

In the U.S., the DSM-process was institutionalised in “rate base cases” before Public Utility Commissions. In Europe the processes were less formal. Many utilities owned by municipalities, however, had a long tradition in customer relations on a detailed and personal level as civil servants. In countries with fast growing economies (especially in Asia) the concept of DSM became quite natural and attractive. The resources needed to “fuel” the expansion had to be economized and the consequences of wasteful use, in terms of environmental and social impact, are so visible.

In the era of liberalisation, DSM was shunned as a regulatory measure in a society that primarily wanted less (or no) regulation. Prices should carry the necessary information to customers for all products and they would then naturally make the correct choices between more supply and more energy efficiency. Planning was not necessary and in the competitive market the competition should also expand to embrace energy services and be presented to customers, by the utilities, as “product differentiation”. [2] Such differentiation has however not occurred except for some bigger customers or as promotion for some possible energy shifts (electricity to substitute fossil fuels) with smaller customers.

The liberalisation seems to have made some utilities even more reluctant than they once were to deliver energy efficiency. If their market share is satisfactory and costs can be reduced by trimming the system, the utilities may be comfortable with things as they are. Society, however, may not find it as comforting to see that reserve capacities are reduced and the risk for huge disturbances is mounting. The International Energy Agency (IEA) has noted that reserve margins, difference between peak power demand and available capacity, in several of the member countries is shrinking, figure 3 [3].

So here is a dilemma. In the old system utilities could be, at least mildly, ordered to do DSM but not any more. And liberalisation has, at least not yet, delivered such services in their product differentiation.



Source: IEA (2002), *Security of Supply in Electricity Markets: Evidence and Policy Issues*, OECD/IEA.

Figure 3: Reserve Margins in IEA Countries 1999 (%). [3]

3. DSM today – Coming back strong

In many cases the attributes of DSM receive attention and appreciation. Balancing via the demand has positive impacts on both the reliability and the security of systems, but also on price volatility, environment and climate, system cost and industrial development. All these issues are of interest, not the least to the energy industry, either for arguing their business-case or their credibility.

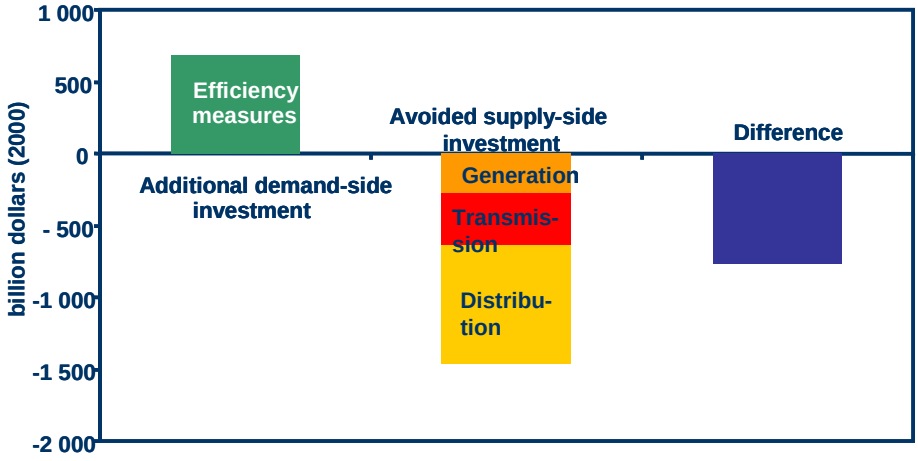


Figure 4: DSM-measures save 1 Trillion USD out of 10 in investments

And the savings are there to be made. The IEA calculated in their World Energy Outlook 2004 a conservative measure of savings in investments for power generation, transmission and distribution during 2003-2030, was found to be approximately 10%, or1 trillion USD out of a total investment of 10 trillion USD, as shown in Figure 4. [4]

With the new order for markets the instruments to achieve a change in demand have also developed and will develop further with new technologies for communication, end-use technologies (LED, Heat-pumps etc.), miniaturisation (to build intelligence into appliances), small-scale renewable supply technologies, etc. Business adaptation, to handle the climate change, will probably also motivate new business models to deliver the invisible resource that energy efficiency is.

The measures to manage demand can be of many sorts as seen in the table 1. There are basically two main approaches, either to mandate (order) that something should be done or to make use of the market and the economic instruments. In reality most measures combine the two approaches.

APPROACH	TYPE		EXAMPLE
Mandated	Standards		• Minimum performance (MEPS) • Top-runner standard
	"Agreed Actions"		• Voluntary Agreements • Technology Procurements
	Delegated Actions	By actor	• Regional bodies • Municipalities
		By Means	• Commitments • Certificates
Market Acceptance	Price-responsive customers		• Taxes; Tax reduction • Price elasticity (Demand Response)
	Non-price responsive customers	"Commoditising" energy efficiency	• Energy Services (ESCO) • Labels

Table 1: Measures, types and examples of Demand Side Management to improve energy efficiency. Some that may apply more to utilities are shadowed grey in table.

It would be ideal if all customers where price-responsive, but since they are not, several instruments have been developed to make energy-efficiency more like a commodity (commoditising) and enable more rational choices. Mandating is typically used to give explicit information or explicit tasks about certain technologies and certain actors that should be activated, whereas the market acceptance is used when the object can not be easily identified but the performance characteristic can be well defined.

Also for mandated actions there are developments to enable the customers/user to make a better rational choice. Certificates and commitments can be used for finding the least-cost delivery of certain measures. For standards there are measures that target not only the minimum standard (MEPS), but identify and promote the best performing products. For municipalities the measures could also be supporting market improvements by giving advice about products, calculation methods, installation etc. Technology Procurements are developed and used to identify innovative features and to challenge manufacturers to deliver new products.

This process of "commodisation" and tradifying of energy efficiency is creative and has seen the development of Energy Service Companies (ESCOs) with many different modes of application; development of "White Certificates" and "Energy Efficiency Commitments" to

engage the energy industry; development of incentives and metering to enable Demand Response activities. And this process has only just begun.

3.1 The technical problem and challenge remains the same

While liberalisation has certainly changed the landscape for DSM-advocacy and implementation, the need for DSM remains and is even greater now due to climate and environmental issues. And from a technical and an objective point of view, it is still the same old story. There is a need to change the load shape (peaks and valleys) and to change the load level (conservation and growth).

Whereas in the old days the objectives were formulated from the utilities need (and wish) to get a more flat and predictable load curve, the task today is more to serve societal needs and customers. The task is to keep the energy system working and to prevent black-outs and to shift from carbon-fat to carbon-lean systems, as illustrated in Figures 5 and 6.

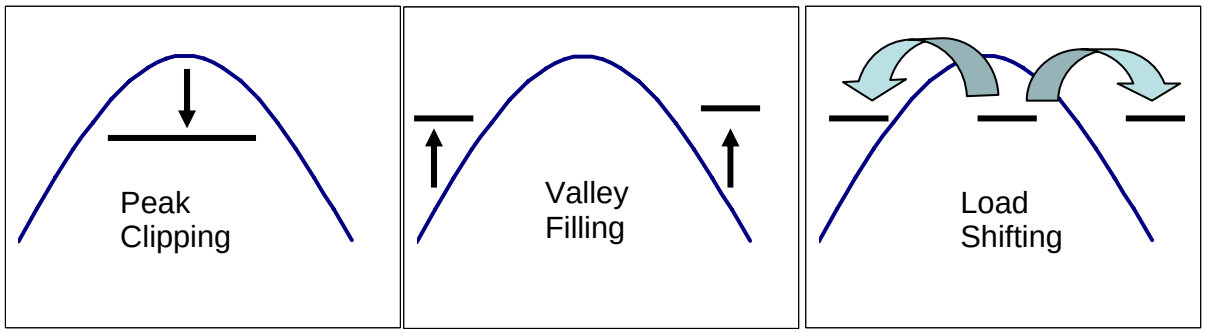


Figure 5: Load Shape changes. (Adapted from Clark Gelling, speech made 1982)

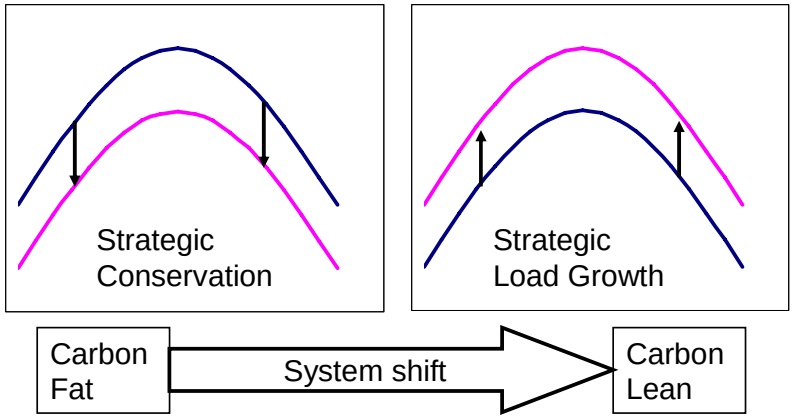


Figure 6. Load Level changes (Adapted from Clark Gelling, speech made 1982)

Utilities have discovered the benefits for their business of load-shape changes and to develop new market products for demand response, DR, but are gradually also more interested in the load level changes as a way to communicate customer benefit and thereby develop customer relations.

3.2 The ultra-profitable carbon-driven economy

The new element on the energy-scene is the need to reduce greenhouse-gases (GHG) and to find ways to do it fast. In a market survey made by Vattenfall and presented to the world economic forum in Davos it has been shown that many measures to reduce carbon-emissions have “negative costs”, i.e. they will save money and not cost money for its owner [6], see figure 7 and Appendix. Many of these measures are well suited to be treated with DSM by utilities and/or other actors.

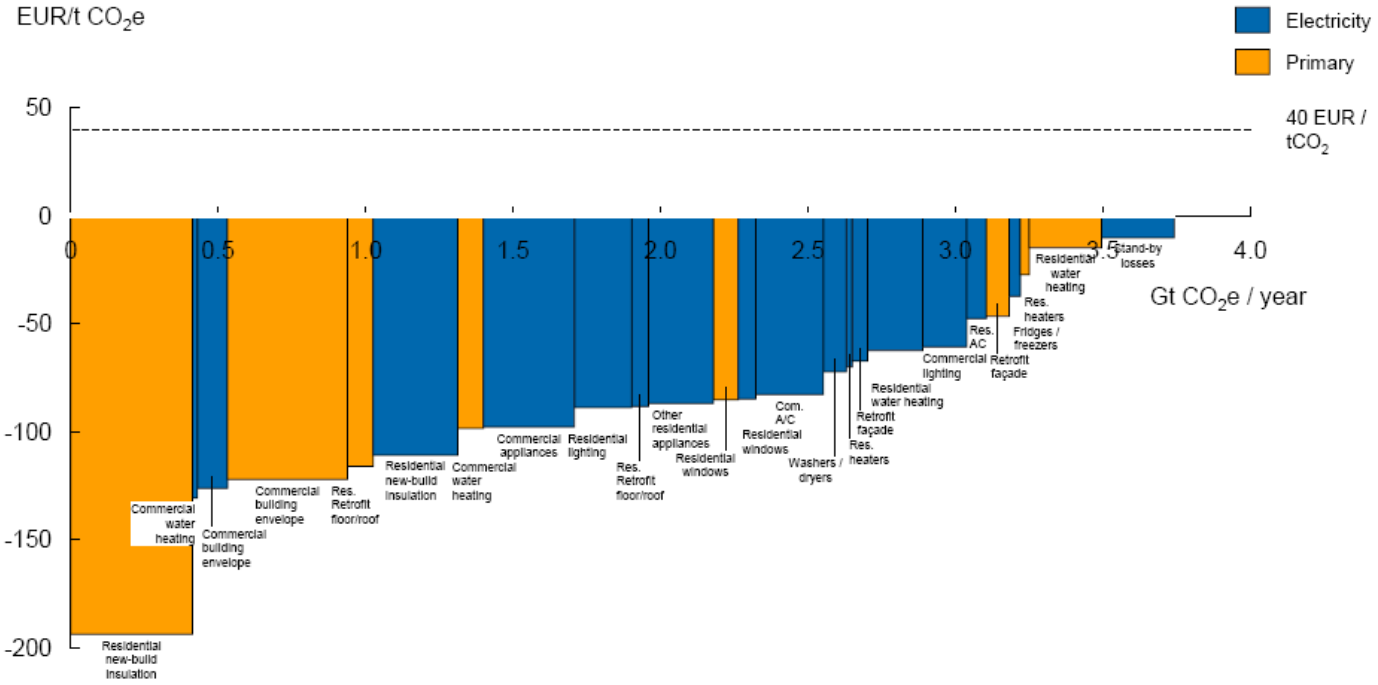


Figure 7: Marginal Abatement Cost Curve for Buildings 2030 (Global)

As can be seen from this graphic presentation we are returning to the classic DSM-dilemma. There are so many profitable things to be done, but they will not happen by themselves. We need either some sort of regulation or someone that can change this situation into a business-opportunity.

If carbon-dioxide is priced and the utilities will have to pay for emissions either by tax or by buying “emission permits” it could be more rational for them to pay for energy efficiency improvements. Assuming that 1 kWh from a coal-fired condensing power plant emits 1 kg of carbon-dioxide a price of 10 USD per tonne of carbon-dioxide has the value of 1 USC.

Finding a way to:

1. Release the un-realised potential for profitable efficiency (see figure 7 and appendix)
2. Divert paying for in-productive emissions into productive investments for efficiency

would be possible to transform into business where both utilities and other facilitators would have a role.

3.3 Regulations has changed into directives and recommendations

In the absence of a clear guidance for energy efficiency there have been developed more indicative means to “illustrate” the benefits and trigger activity. Under the pressure both to economise shrinking supply of fuels and to find ways to combat climate

change, both Europe and the United States have launched “directives” and “recommendations” to encourage DSM-actions on state-level.

Europe
The European Union has issued a directive on energy efficiency and end-use energy services [7] in which the EU-member states are requested to issue new legislation. In this it will be required that:
* The public sector will be exemplary to improve energy efficiency in all their activities
* Utilities participate by financing and by developing services to customers

Metering and billing should be more informative and energy audits should be offered to customers. One possible means could be development of “White Certificates” as an instrument [8] and [9].

USA
The U.S. Department of energy made several recommendations to the U.S. Congress in a report March 2007 [10] and that contains 10 recommendations on how utilities can better encourage and promote energy efficiency with their customers. A national energy efficiency action plan has also been issued by the U.S. Environmental Protection Agency and in which the utility role on the market is outlined [11].

In these cases it is obvious that the federal level and the union level in both the U.S. and in Europe expresses a strong wish that energy efficiency should be more systematically organised, but since the final decisions have to be made on a state and a company level they address themselves to them with their requests for action.

4. Actors and Products for new preferences

In the traditional DSM-business the utilities had the main role to play to develop a “level playing field” for supply and demand. Today when the issue also is more urgent we can identify several other actors that will have to be operative such municipalities and traditional buildings-, installation- and service-industry.

4.1.1 The liberalised utilities

In the liberalised energy market structure the vertical integration of the power sector is split up and in each link subject to competition. Some parts are natural monopolies because of their technical structure and needs to be regulated more in detail. The consumer can chose freely between supplying companies.

The generation companies in the power sector may be less interested in making energy efficiency part of their core business, but it would make sense if the owners of these companies hedged their investments by putting some interest in the energy service business.

The transmission and distribution companies may have a more profound interest in using DSM-measures actively as they could save and postpone investments as shown by the IEA World Energy Outlook, see Figure 4, but also as new business activities for them within the area of Demand Response. There is a need for balancing services to be developed.

	Business interest in DSM		
Actor	**Peak Load**	**Load Level**	**Remark**
Generation company	**No** (prices are set on the margin)	**No** (loss of sales)	Windfall profit may be regarded to be too high by authorities
Systems responsible (regulator)	**Yes** (to avoid systems break-down)	**Possibly regional and in special situations** (to avoid bottlenecks and to maintain systems to develop as planned)	Very different organisation between countries.
Transmission and Distribution	**Yes** (to maintain systems and avoid bottlenecks)	See above	Where "white certificates" and commitments are introduced they concern the load level operations from these actors.
Energy supplier	**Yes** (as a business opportunity to shift loads and operate in pools)	**Yes** (primarily as a marketing instrument)	
IEA DSM-Programme tasks pertaining to utilities	**Task II, VIII, XI, XIII, XV and XVII**	**Task I, VI, VII, XIV and XVI**	-

Table 2: Different utility functions and their interest in DSM as a business opportunity on a liberalised market

If we look on the driving forces in directives and recommendations from the central levels in Europe and the U.S. there are a few functions named where the utility business are supposed to act.

- **Funding** in both traditional ways (by taxation; Public Benefit Charges; Levies) but also with more developed mechanisms as in the case of certificates where an obligation put on the utility can be procured and/or traded.
- **Facilitating services** by more advanced metering, billing services and pricing that allows a greater flexibility
- **Services development** with a more or less active involvement in dissemination of products.

4.1.2 Municipalities and industry

Municipalities have great opportunities to act for DSM in their many roles as planners, regulators, building owners, service providers and through their information to the citizens. This has been in focus for the IEA DSM-Programme task IX that has explored the subject and gathered information on practices in several countries.

Energy Service Companies should still develop service concepts and tailor them to more variations of customer needs as well as for customer understanding of the service concept itself. There could be a need for standardised service concepts and more distinct verification of energy savings as well as for more specialised service companies. This is presently investigated in IEA DSM-Task XVI (and earlier in Task X).

Traditional business working with installations could develop towards energy services but also towards more "aggressive" marketing of the energy efficiency characteristic. The manufacturing industry already has created new concepts. Intelligent equipment that responds

to communication with the supply side and with its “caretakers” is not science fiction any more.

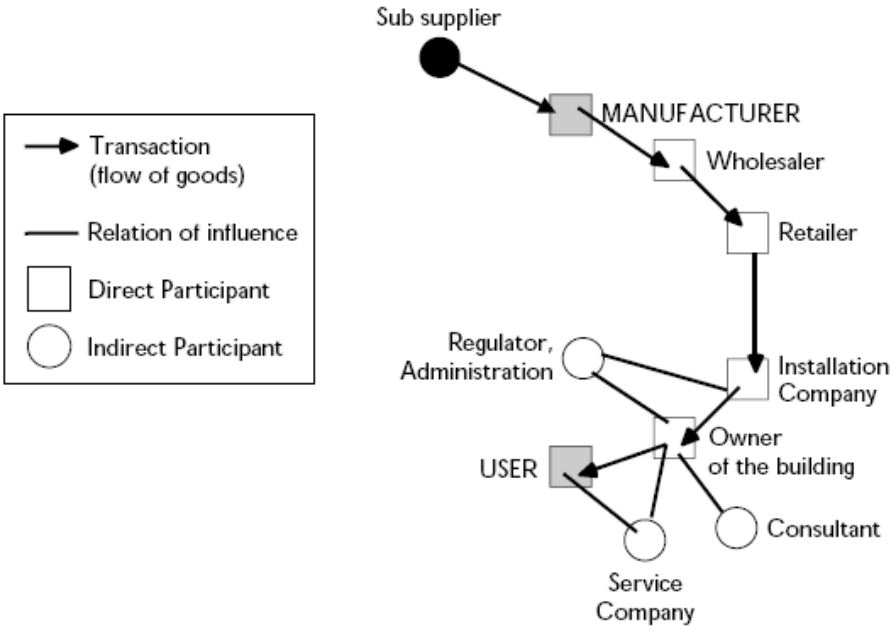


Figure 8: Product dissemination from Manufacturer to the User involves many different businesses. [12]

The delivery of energy efficient applications is still in many cases not mature in the meaning that the energy-performance characteristic is invisible and how it should be correctly regarded in a calculation is un-known. A development in the market organisation is badly needed to create the “level playing field”.

4.2 New technologies (and new business models).

This development of services goes hand-in-hand with development of new technologies that enables customers and enables services. In particular the trend of improves information technologies and the trend for smaller supply side technologies to make use of renewable supply such as PV, wind and (micro-)CHP opens up for completely new system configuration. IEA DSM-Programme Task III has developed a method for technology procurements that could be used to further boost the technology development.

Some traditional DSM-problems may be solved with small-scale supply measures that manufacturing business can now provide. Distributed generation down to single-family housing is possible. New renewable supply sometimes suffers from intermittency which can be solved with development of DSM as a balancing action (or as virtual storage) for their full integration into the systems.

Communication between customer and supplier as well as improved computerisation will enable both smart-grid services and smart-appliances that are able to adapt to local circumstances and to present situation in load, pricing, congestion etc.

It should however be remembered that new technology may also require institutional changes to be successful. New automated intelligent metering requires at least the following elements to be put in place to work:

- Meters
- Communications
- Software for calculation, billing, verification, settlement
- Pricing structure that rewards load management
- Institutional models (including regulation)
- End use capacity to accommodate (e.g. Storages)

5. Policies, Measures and their Impact

Still, to many on both the supply side and the demand side of business, the entire thinking is a "paradigm-shift" which will require support from governments. Policies should be more explicit both as regards the carrots and the sticks for load-shape and load-level actions.

Load Shape: Countries should develop a regulatory regime that appoints responsibility for resource adequacy in the electric systems and, when the regime so allows, makes demand side balancing service the prioritised option. The impacts of adopting such a policy include:

- **Less price volatility** by improving short term price elasticity
- Improved **system reliability** by reducing peaks and adding to safety margins
- Enhanced **system security** by reducing dependency on vulnerable supply resources
- Improved **restoration capacity** by dispatching in/after emergency situations
- **Less costly network reinforcements** since energy efficiency measures will be active alternatives
- **Distributed generation** as alternative to transmission lines.
- Improved **operation and use of flowing renewable** sources
- **Elastic response** as complement to competition (lack in number of companies and excess in market concentration)

Load Level: Countries should have a system for assessment of the least-cost delivery of energy services, which includes both the demand and supply side, and allows a judgement on divergence from possible sustainable paths Based on this it should be decided how market actors could be engaged and supported in delivery of the services. The impacts of adopting such a policy include:

- Development of **markets for energy service companies** and performance contracting
- **Allocation of commitments and obligations** that mobilises actors for large scale energy efficiency actions, e.g. use of "White Certificates, Public sector procurement, municipality initiatives, etc
- **Organisation and targeting of support programmes** for energy efficient products
- Improved allocation of **obligations for reduction of GHG-emissions** between sectors and countries
- Improved use of **market communication mechanisms**, e.g. standards and labels
- Input to how further **research and support** mechanisms should be distributed among actors.

6. The IEA DSM-Programme support

The IEA DSM Programme has been active, and has followed the pace of development in the DSM-area, for the past 15 years. The programme seeks to deliver the tools needed, regardless of regulatory regime and market organisation, and to do so on a global basis. The IEA DSM-agreement has as its vision that:

Demand side activities should be active elements and the first choice in all energy policy decisions designed to create more reliable and more sustainable energy systems[1].

		Cluster		
Annex		**Load Shape**	**Load Level**	**Crosscutting General aspect**
I	Database and Evaluation		■	■
II	Communication Technologies	■		
III	Technology Procurement		■	■
IV	Integrated Resource Planning			■
V	Marketing		■	■
VI	DSM on Liberalised Markets		■	■
VII	Market Transformation		■	■
VIII	Demand Side Bidding			
IX	Municipalities Role		■	■
X	Performance Contracting		■	■
XI	Metering and Pricing	■		
XII	Energy Standards		■	
XIII	Demand Response	■		
XIV	White Certificates		■	
XV	Network-Driven DSM	■		
XVI	Competitive Energy Services	■		
XVII	Integration of DSM, EE, DG and RES	■		
In Preparation				
Advanced Lighting Programmes				
DSM and Climate Change				
DSM Participation in System Operations				

[1] Explanatory note: *Demand side options have to be expressed in terms, and made available, as equal to supply side options in order to facilitate a comparison. An energy system with a low demand requires less energy and hence allows for expanded use of renewable energy. The way to arrive at a sustainable supply is to, at the same time, reduce demand and raise the use of renewable supply.*

Table 3: Work in the IEA DSM-Programme (www.ieadsm.org)

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APPENDIX : Abatement cost as calculated by Vattenfall [6]

General defninition

$$\text{Abatement cost} = \frac{[\text{Amortization* of initial capex}] - [\text{Annual savings}]}{[\text{Annual tons of } CO_2\text{e abated}]}$$

Example

Refrigerators

Typical cost of poor refrigerator		630	EUR
Typical cost of good refrigerator	-	550	EUR
Cost difference	=	80	EUR
Life-time of equipment		15	Years
Annualized difference*		8.5	EUR / yr
Consumption of poor refr.		395	kWh / yr
Consumption of good refr	-	225	kWh / yr
Energy savings	=	170	kWh / yr
Technical cost		49.5	EUR / MWh saved
Electricity price	-	72.5	EUR / MWh
Net cost of improvement	=	-23	EUR / MWh
CO2 intensity of electricity		0.49	tCO2 / MWh
Abatement cost		**-47**	**EUR / tCO2**

Divided by

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