BEST PRACTICES IN TECHNOLOGY DEPLOYMENT POLICIES

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Abstract*: The project was initiated in order to find out if there are some success-factors for projects aiming at development of markets for a more efficient use of energy or for introduction of renewable fuels. It thus deals with the shaping and execution of so called "Deployment Policies" and not the selection of such a policy before others. The project is still working and the results are so far tentative. Though one of the findings is that the programmes are highly contextual and not easily copied between countries and/or sectors, there are nevertheless success factors that can be identified and be repeated in their own context. Ii is easier to do so if one applies a "split vision" and use the approach from several policy models. The real successful programmes have been developed over a long time, they combine several policy issue/areas (coherency), they reflect over their own results (feedback) and they use the force of the users (demand-driven).*

Objective

The purpose of this IEA project is to review successful programmes to deploy advanced energy technologies and to identify the elements that contributed to their success. This project is of interest because there is a need to employ technologies to reduce climate destabilising emissions, to better transfer information from government research to the private sector, to promote economic development through advanced technologies and to make technologies available to developing countries to promote sustainable development. A number of questions are addressed including:

- What processes are used to define technology deployment goals and develop technology development programmes?
- How is technology deployment policy linked to R&D policy?
- Are strategic goals (such as energy security, global climate change, pollution abatement, economic productivity, etc.) used to define technology deployment goals and programmes?
- How is success in technology deployment defined and what types of deployment policies or programmes appear most successful?
- Are there common factors among successful programmes?
- Are there circumstances under which a particular type of policy tends to work best?
- What "best practices" can be identified regarding industry involvement in developing and executing deployment programmes?
- What "best practices" can be identified regarding how and when programmes are evaluated?
- How should programme evaluation be designed into deployment efforts?

Material and Methodology

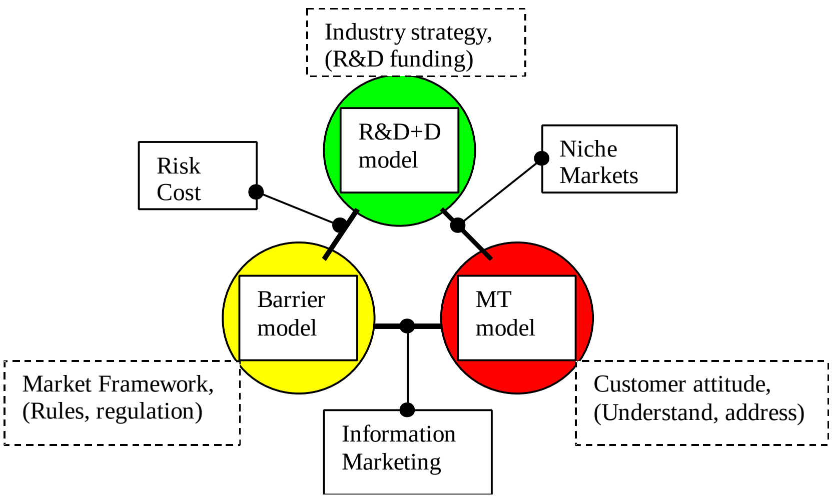
Out of a group of 55 cases that were suggested from member countries and delegates working within the IEA structure, a selection was made, and finally 22 submitted as cases to be analysed. They are covering sufficiently well demand and supply as well as different types of fuels, from 10 of the 26 IEA countries. Further to that there is one case that deals with an EU-project and one with an application from an IEA "Implementing Agreement".

In the first analysis the variety of the cases was investigated and showed that the cases had a very different background and ättitudes". Some where:

- Developed and promoted as a response to perceptions that the general framework for markets was inadequate. There was a some sort of barrier for introduction or spreading of new technologies
- Focusing on Industry skill and the opportunities if products could be improved and manufactured in larger scale. There was a need to make better use of R&D resources.
- Aiming at a broad coverage on the market and to find the strategic partner that could lead the trend. There was a need for an orchestration in the Market uptake.

These three different attitudes in shaping of a programme and projects are sometimes very dominant in choice of measures and in choice of success criteria, but it is even more striking that there are elements of the different attitudes in almost all of the cases. It was then obvious that in the attempt to make an analysis that could distinguish success-factors it is necessary to use several different models. In the ongoing analysis of the cases this combined framework has been further elaborated with the view that the models are not substitutes for each other or that anyone of them is better, but that they are complementary and that successive applications give further insights.

Figure: Model complex (See also APPENDIX for details)



- The Barrier Model focuses on the framework within individuals make decisions based on economic rationality but could be hindered because of the barriers.

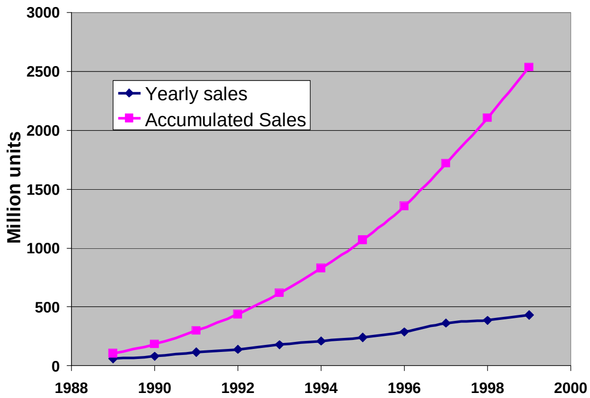
- The R&D+D Model focuses on Industry strategies and how they are affected by R&D funding as well as by deployment activities. The industry use the available knowledge base and they read the signals from the market to decide to take up more or less (and different) production.
- The Market Transformation Model (MT) focuses on Customer/User attitudes and how they guide decisions as well as how they can be addressed by marketing activities. The model takes into account the positions that the actors have on the market and how these positions could promote or hinder a change.

Generally case studies have the strength that they represent the reality as opposed to a laboratory or a field test material. They however also have the weakness that the generalising conclusions are hard to make. Specific situation as regards tradition, culture, politics etc that prevails where the case is situated has to be taken into account. This raises severe methodological problems. In the analytical process the cases are taken apart piece by piece according to the triangulation structure mentioned above in search for the elements that creates success.

Criteria for success

The aim of deployment programmes is naturally to get a lasting impact on the market. Such impact could be measured in Volume, Penetration to market, Performance improvement and lowering of Price/Cost or even in combinations thereof. Some such market changes have been seen and recorded for energy related equipment and in some cases they have been related to deployment activities of some sort. It is however worth to keep in mind that several of these impacts take time to get and to register.

a) Volume growth
Establishment of a market for "new" products takes considerable time. Compact Fluorescent Lamps (CFL) has been one of the target products for many activities throughout the last decade. The accumulated output has between 1988 and 1999 doubled almost 6 times. The yearly sales are 1999 in the order of 500 million units world-wide, which represents a tenfold increase in sales since 1988. It is assumed that the total amount installed is some 1300 Million units.[1]



[1] *Soaring CFL sales*, IAEEL Newsletter 1-2/2000, International Association of Energy Efficient Lighting.

b) Volume and Market Penetration

In spite of the impressive volume growth for CFLs as shown above the market penetration is generally low. The total volume for light bulbs is estimated to be 10 –15 Billion units per year, which means that the sales of CFL is a share between 0.5% and 3%.

Across the European Union the average number of light bulbs in households is 24. The amount of households that has a CFL and the average amount of CFL per household are recorded as follows (mostly 1995 data).[2] The penetration to the market is on the average less than 5% and in the households that owned CFL a bit above 10%.

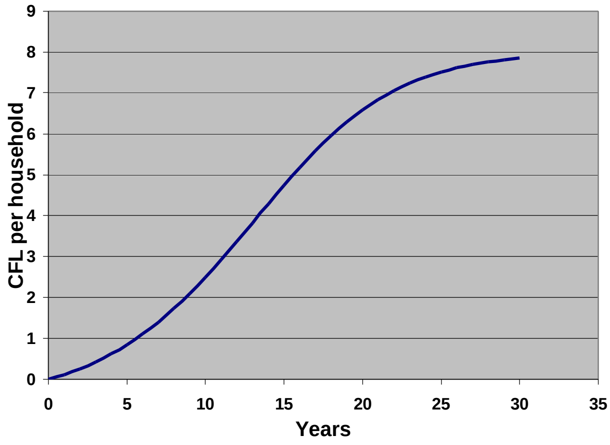
Country	**Households with CFL (%)**	**Average CFL per household**	**CFL per owning household**
Belgium	29	0.9	3.7
Denmark	46	2.0	4.4
Finland	-	1.0	-
France	-	0.5	-
Germany	51	2.1	4.3
Greece	11.5	0.1	1.0
Ireland	22	0.9	4.0
Italy	55	1.1	2.0
Netherlands	62	2.7	4.5
Spain	11.5	0.2	1.7
Sweden	10	0.4	4.0
UK	23	0.7	3.0
EU average	**32**	**0.9**	**2.8**

Tests of CFL applicability for household purposes with the present configuration of fixtures and lighting show that an average of 8 light-bulbs could be comfortably replaced with CFL-bulbs.[3] If we assume this as the saturation level and apply a standard product dissemination curve to the present level of market penetration it will indicate that full dissemination will occur only after some 30 years.[4]

[2] *DELight, Domestic Efficient Lighting,* Jane Palmer and Brenda Boardman Energy and Environment Change Unit, University of Oxford, 1998.

[3] *DELight, Domestic Efficient Lighting,* Jane Palmer and Brenda Boardman Energy and Environment Change Unit, University of Oxford, 1998.

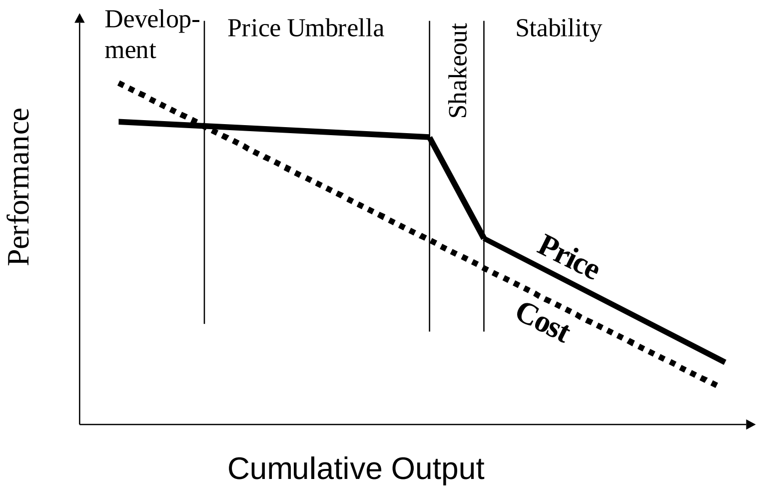
[4] Diffusion of innovations to the market follows the "Bass curve" where the penetration N_t at a given time t is calculated as: $N_t= N_{t-1}+p*(m-N_{t-1})+q*(N_{t-1}/m) *(m-N_{t-1})$
where m is the market potential; p is a factor for external influence (the likelihood that somebody start to use the product due to e.g. media influence); q is a factor for internal influence the likelihood that somebody start to use the product due to "word-of-mouth")



c) Volume growth and price/cost

When new products reach the market and gets accepted the growing demand and volume will start a process that attracts new inventors and producers. In this process the unit-costs for the products and hence the prices will be lowered. The phenomenon is captured in learning and experience curves and by measuring of the "progress ratio". This ratio indicates how much the cost/price will drop by each doubling of the cumulative production, i.e. a progress ratio of 84% shows that the cost/price has dropped 16% (100-84) by the doubling. [5]

Depending on the market organisation it might be difficult to observe the result of lowering costs for some time since such data are generally not available. Normally only the price can be recorded and before the market has totally accepted the product and attracted the necessary competition the market leader and inventor may want to recover their costs for development in such a way that price reductions are not to the immediate benefit of the customers.

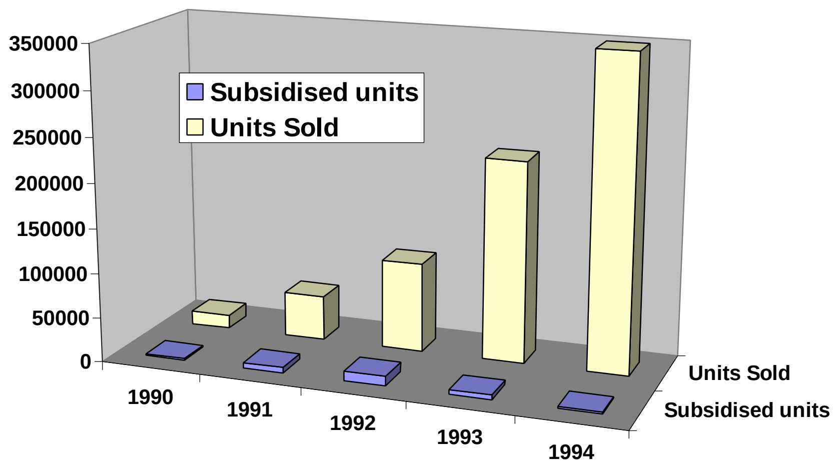


d) Attribution of impacts to measures

The changes on the market and the measures to which they can be attributed are of course in the main focus of interest. Statistics that record both has to be gathered in a fashion that

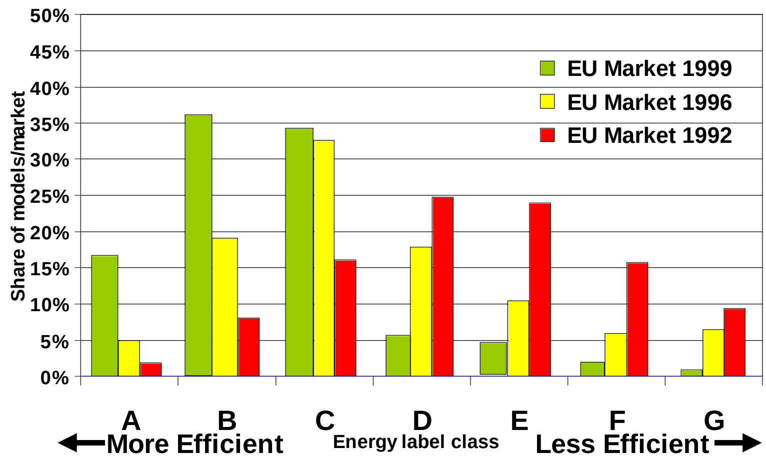
[5] *Experience Curves for Energy Technology Policy*, OECD/IEA, Paris, 2000.

allows comparisons. Such an evaluation has to be made also to cover the period following after the measures are terminated. The following example is from the Swedish example of Procurement, Quality Programme and related subsidies to HF-Ballasts in office luminaries.[6] The subsidy seem to have kicked-of a market response



e) Performance

Performance improvements are to some extent a result of a "natural" improvements on the market, but also dependent on programme activities. In Europe the labelling of household appliances and the associated recording of sales show such a drift from low performance to good performance over the years.[7]



Some issues related and often debated is to what extent there is a natural trend of improvement and what happens with the results of the improvements. Perhaps they are offset by a more extended use of the technology that gives higher productivity or is cheaper (the

[6] *Dynamics of Energy Systems. Methods of analysing Technology Change*. Lena Neij, Lund University 1999.
[7] *Energy Labels & Standards*. OECD/IEA. Paris 2001.

rebound effect)? Some calculations and some analysts argue that welfare development has been mostly driven by improvements in energy use and that these improvements have motivated more demand and hence required more supply of energy.

Key messages (so far)

Deployment of energy-efficient, clean technologies in competitive markets has two effects. It changes the physical properties of the energy system and provides learning among the market actors. This tandem of physical and learning effects both legitimises and provides objective and focus for energy technology deployment programmes.

The immediate *physical effect* may be reduced energy use for the same service, less emissions, higher comfort or reliability, better cash flows. As an energy policy instrument, the rationale for a public deployment programme is the achievement of such beneficial effects on the national energy system with scarce public resources and within a given time horizon. Volume growth and market penetration therefore become key indicators of successful deployment programmes. However, the scarce public resources cannot by themselves achieve the required growth and market penetration. Deployment measures need to engage private resources to overcome barriers, transform markets and improve technologies. Activating learning among market actors is the key to such engagement.

The *learning effect* appears in the next generation of the technology in the form of reduced prices and better technical performance, or in improved or innovative methods of marketing and application. The learning effect thus makes the technology attractive to larger and larger segments of the market, engaging more and more of private resources, expanding and rolling out the technology frontier and successively increasing the physical effect. For new technologies the learning effect between successive generations may be substantial, in mature technologies it usually manifests itself in better marketing and new applications of more energy-efficient and cleaner variants of the technology.

.....on a close look
Successful deployment begins by identifying the interests of many stakeholders and bringing them together to work for accelerated dissemination of a technology as well as improved performance and lower costs. Common interests of producers and consumers may be exploited by the removal of regulatory barriers, by improved communication between R&D providers and companies, by better market research to determine consumer attitudes and interests.

- It takes time to get full impact on the market, be prepared and put in monitoring that reads small but significant changes
- Distinguish between projects working on fragmented markets and those who target a “known” group of actors
- Aggregation of volume opens the fragmented markets but needs "operating agents"
- Successful programmes have often been adjusted during their execution due to experience from trial and (sometimes) error
- Fast tracks where the technology is well established but the applications need to be fitted (adjusted)
- Combination of programmes/policies for different purposes give stability and adds arguments for the change the projects advocate

- it is a combination of technology potential and customer acceptance that make the impact on the market and hence on the energy systems. Both terms of the equation are essential.

......and in a bigger perspective

Active deployment measures and policies have to be carefully crafted:

- *Coherent approaches*. Measures motivated by energy policy considerations are much more acceptable when they are also in line with policies for industrial development, environmental improvement and employment.
- *Improving feedback.* Feedback helps producers to use R&D resources better. It can help both producers and consumers to learn by doing.
- *Demand-driven measures*. Most consumers have little interest in energy issues per se, but would gladly accept energy-efficiency measures or renewable fuels as part of a package with features they *do* care about.

APPENDIX

Market Barrier Model. This is the standard deployment model, consistent with a neo-classical economic viewpoint stating that it is legitimate for governments to intervene in the market to remove or reduce barriers due to market failures. The legitimacy of intervention and the different type of barriers are discussed in *Enhancing the Market Deployment of Energy Technology – A Survey of Eight Technologies.*, OECD/IEA (1997). Deployment policies should remove or reduce barriers.

<table>
<tr><th>Barrier[8]</th><th>Characteristic[9]</th><th>Measures</th></tr>
<tr><td>Information</td><td>Must be available and understood at the time of investment of all types of goods and services</td><td rowspan="2">❑ Standardisation,
❑ Labelling,
❑ Reliable independent sources
❑ Calculation methods</td></tr>
<tr><td>(Transaction) Cost</td><td>Administration to make a decision to purchase and use equipment (overlaps with Information above)</td></tr>
<tr><td>Risk</td><td>❑ Perception of risk (The pay-back gap)
❑ Difficulties to forecast or control over an appropriate time period</td><td rowspan="2">❑ Verification of function (demonstration)
❑ Third party involvement (financing)
❑ Special funding
❑ Routines to make Life Cycle Cost (LCC) decision criteria in purchasing</td></tr>
<tr><td>Finance</td><td>❑ High first cost makes a threshold for investments
❑ Access to funds</td></tr>
<tr><td>Price distortion</td><td>Costs associated with production or use are not in the costs</td><td>❑ Regulation to internalise “externalities” or to remove subsidies
❑ Taxes, Levies</td></tr>
</table>

[8] *Enhancing the Market Deployment of Energy Technology*, IEA/OECD, Paris 1997

[9] There are many overlaps between the barriers, which is more clearly seen when stating their characteristic influence on decisions.

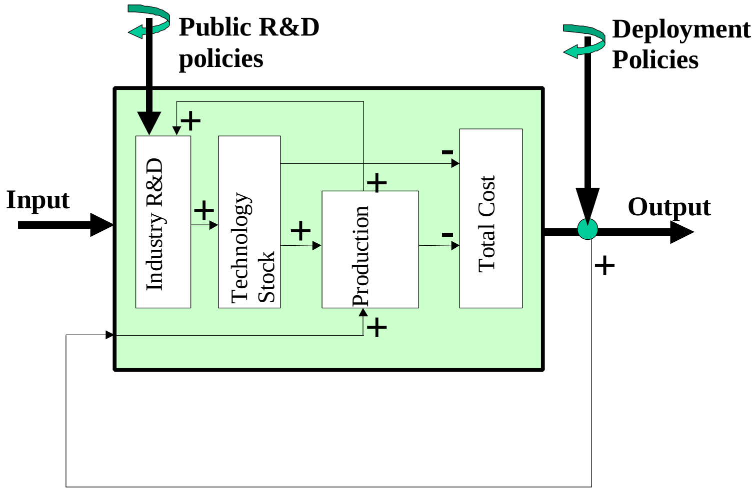
Market Organisation: **a) Split incentives**	Owner, designer and user are not the same.	Leasing
b) Biased calculation	Use of too short pay-back times in calculation	Introduction of Life Cycle Cost (LCC) routines in purchasing
c) Cost (of equipment)	Small volumes of new technologies with good performance can not compete	Learning and aggregation of volume for the new technology
d) **Tradition** in business	Established companies guard their market position and -share	Market liberalisation could force new solutions
(Inadequate, Excessive or costly) **Regulation**	Regulation based on business tradition and laid down in standards and codes not in pace with development	❑ Testing, demonstration ❑ Performance based regulation
Capital Stock Turnover Rates	Sunk costs or tax rules that requires long depreciation	❑ Tax rules ❑ Timing
Technology Specific	Often related to existing infrastructures both as regards the hardware and the institutional skill to handle it	❑ Focus on system aspects in use of technology ❑ Connect measures to other important business issues (productivity, environment)

R&D and Deployment Model. This model is used in IEA work *Experience Curves for Energy Technology Policy*, IEA/OECD Paris 2000. The is based on technology learning and uses results from systems engineering and control theory[10]. The model states that it is legitimate for governments to intervene in the market to avoid high future opportunity costs due to externalities and under-investments in learning, which may appear as a public good. Deployment policies should stimulate learning investments, including private R&D, setting up a virtuous circle between public and private R&D and deployment on the market.

Figure: Influences on the learning system from public policies[11]

[10] See e.g., Watanabe, C. (1999), "Industrial Dynamism and the Creation of a 'Virtuous Cycle' between R&D, Market Growth and Price Reduction – The Case of Photovoltaic Power Generation (PV) Development in Japan", in: C.-O. Wene, A. Voss and T. Fried (eds), *Proceedings IEA Workshop on Experience Curves for Policy Making – The Case of Energy Technologies*, 10-11 May 1999, Stuttgart, Germany, pp. 7-32, Band 67, Forschungsbericht, Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart, Germany.

[11] Ibid. p. 29



Determination of measures are made by studying existing technology, market structure (mainly suppliers) and costs, and then relate the observations to the potential for improvements

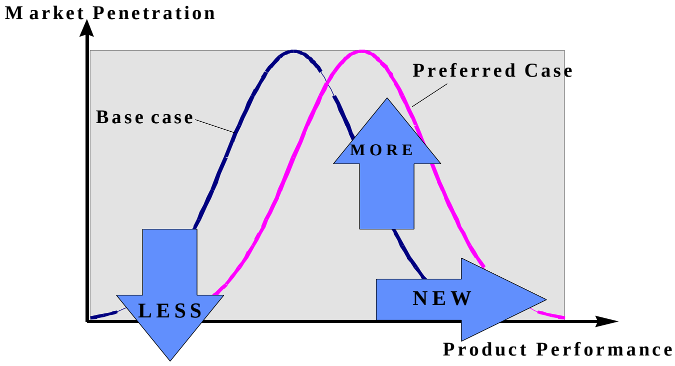
Determinants in a study of potentials[12]				**Policy Measure**
Technology / Solution	**Technology / Performance**	**Prospects to lower Cost**	**Risk (to take up production)**	
Exist	Defined (might however not be available in all possible applications)	Limited	Predictable (Low)	❑ Monitor technology development (to be prepared for new solutions) ❑ Survey applications (to find if there are un-exploited niches)
Few known	Demonstrated	Good	Moderate	Increase volume by deployment activities. Subsidies can be justified as "learning investments"
Not known	Anticipated	Not known	High	R&D funding

Market Transformation Model. The elements of this model are discussed in IEA work *Energy Efficiency Initiative*, Vol. 1, Chapter 5: Energy Efficiency Policies and Programmes, OECD/IEA Paris 1997. Underlying this model are concepts from industrial and evolutionary economics, and from the specific branch of economics which studies national systems of innovations[13]. In the national system of innovation, public bodies are legitimate market actors representing the public perspective. Deployment policies should transform markets by stimulating market actors to develop, invest in and use technologies with higher performance.

[12] Ibid. p. 31
[13] Concepts from the studies of national innovation systems forms a basis for the OECD project on "Technology, Productivity and Job Creation – Best Policy Practices" and the innovation systems approach is applied in the EC-DGXII project on "Innovation Systems and European Integration (ISE)".

The models focus on the possibilities to change the market preferences to demand for products/services with generally better performance, by introduction of **new** technologies with better performance, by selling **more** of existing high performance products/services and to sell **less** of low performing variations. The model acknowledges that customer/user attitude prevents some favourable options to be realised and some improved products/services from being released. Application of the model helps targeting those issues.

Figure: Market Transformation in terms of product performance.[14]

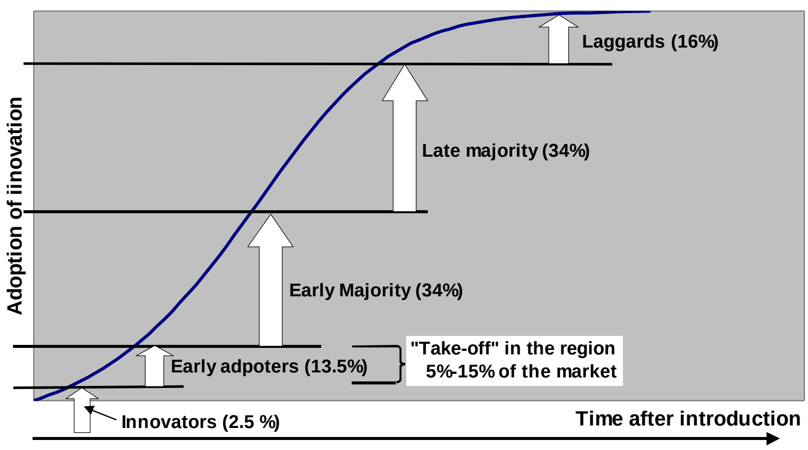


Transformation aim	Measures
NEW products	Targeting important niches (customers, products). Aggregating purchasing power
MORE good products sold	Focusing on good performance. Enable customer to find products and suppliers and to calculate consequences more accurately
LESS bad ones	Communicate performance quality aspects to users and suppliers

Targeting the audience for measures as described require knowledge about customer/user attitudes. The diffusion curve describes the market reactions, the up-take, of innovative products and services and especially enables a structured view on the individual attitudes and how those guide the response and the need for marketing and development of product (including distribution and product related services). [15]

[14] IEA DSM Implementing Agreement, Final Management report. Hans Westling, figure 6. Available on http://dsm.iea.org/
See also *Looking inside the box of market transformation*, Hans Nilsson, ACEEE 1996
[15] *Diffusion of innovations.* E.M. Rogers. New York 1995
Crossing the chasm: Marketing and selling technology Products to Mainstream Customers. G.A. Moore. New York 1991.

Diffusion curve

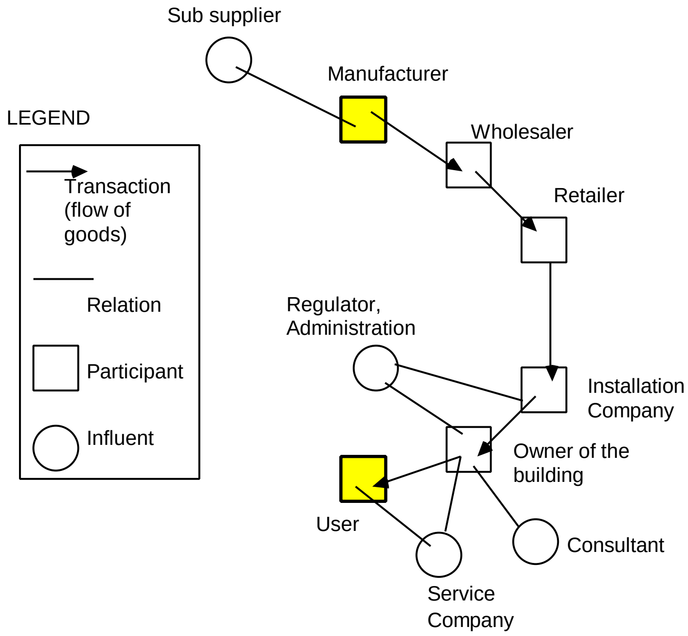


Adopter type	Characteristic	Role and size
Innovators, enthusiasts	Venturesome; Enjoys the risk of being on the cutting edge; Demands technology	Drivers of the technology market. Want more technology and better performance. (16%)
Early adopters, visionaries	Respectable; Integrated in the main-stream of social system; Project oriented; Risk takers; Willing to experiment; Self-sufficient; Horizontally connected	
THE CHASM (where marketing and distribution must radically change)		
Early majority, pragmatists	Deliberate; Process oriented; Risk Averse; Want proven applications; May need significant support; Vertically connected	Followers on the market. Want solutions and convenience. (68%)
Late majority, conservatives	Sceptical; Does not like change in general. Changes under “pressure” from the majority.	
Laggards, sceptics	Traditional; Point of reference is “the good old days”; Actively resists innovations	Could have economic or power interest from “status quo”

<u>The market place</u>

To fully understand the Market Transformation it is necessary also to recognise the actors involved in moving the goods into and on the market place, from the manufacturer to the user. Many of these could either as participants or as “influents” be partners and promote the change or be opposing it. Identification of stakeholders and their interests is an important part of a deployment project.

Figure: Participants in diffusion of technology (iconic model)[16]



[16] *Looking inside the box of market transformation*, Hans Nilsson, ACEEE 1996