Best Practices in Technology Deployment Policies

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ABSTRACT

This project was initiated to identify factors associated with the success of programs to develop markets for energy-efficiency technologies/measures or for introduction of renewable energy sources. The project addresses the design and execution of technology "Deployment Policies". It does not, however, analyze if such a policy would be preferable before others. One finding of this work is that energy-efficiency programs are highly contextual and cannot easily be transferred among countries and/or sectors; nonetheless, there are common success factors, and measures that have these characteristics can be repeated or transferred. One approach to designing an effective program is to combine successful elements of several policy models. Truly successful programs have been developed over a long period, combine several policy issues (i.e. are coherent), use feedback mechanisms to reflect on their results (i.e. capture the learning effects), and are demand driven which releases the force of aggregated purchasing volumes.

The Concept of Deployment

Ideas about how and why to improve energy efficiency have evolved in recent decades, as reflected in the changing emphasis of the "umbrella terms" "energy conservation", "demand-side management" and "market transformation" (Wilhite et al. 2000). The IEA Committee for Research and Technology (CERT) wrote to inform their Energy Ministers at their meeting 1999, that "…it is vital that ministers do not underestimate the scale of the effort that will be needed to meet the Kyoto commitment. In the absence of any additional action, greenhouse gas emissions will rise more than 20% above 1990 levels; i.e. to meet the Kyoto target the "real" gap to be bridged in 2008-2012 is on the order of 30%. Only today's commercial and near-commercial technologies will contribute to reducing emissions in this time frame. While these technologies make it possible to meet the Kyoto targets, under business-as-usual conditions, they will not be deployed on a sufficient scale for the targets to be met. Current trends in technology adoption are insufficient to meet the Kyoto targets. Policies and measures to accelerate technology deployment will be required."

This statement highlights two important issues:

- That significant potential exists for improving energy efficiency and use of renewable fuels through accelerated application of known technologies (rather than research and development related to new technologies), and
- That these existing technologies require "deployment," a military term that conjures up images of large-scale movement of resources

If large-scale actions are to succeed in a market economy where "command and control" regulation is out of the question, programs must be designed to create or respond to demand, which requires an understanding of how consumers behave and express their needs. Scarce public resources cannot by themselves achieve the required growth and market penetration. Deployment measures need to engage private resources and activating learning among market actors is the key to such engagement. As market participants gain knowledge and experience, this "**learning effect**" influences the next generation of a technology in the form of reduced prices and better technical performance or in improved or innovative marketing and applications. The learning effect thus makes the technology attractive to growing segments of the market, engaging more and more private resources, expanding and rolling out the technology frontier and successively increasing the physical effect.

Some observers argue that "After twenty years of Energy Demand Management we know more about Individual Behavior but next to nothing about demand" (Wilhite et al. 2000). If this is true, how can we devise a program that relies on demand for its success? The IEA secretariat analyzed cases from existing Technology Deployment Programs to see whether critical success factors could be identified. The analysis comprises 22 cases, from 10 of the 26 IEA member countries, see table 4.

Generally case studies have the strength that they represent the reality in contrast to laboratory or field test material. However, it is difficult to generalize from case studies, which also reflect specific local traditions, cultures, politics, etc. as well as conditions that change with time.

The Deployment Mind-Set

The programs analyzed were developed based on three different general concepts of what was hindering deployment of energy-efficiency technologies:

1) that the general framework for markets was inadequate, i.e., that a market barrier prevented introduction or diffusion of energy-efficient technologies;
2) that manufacturers needed new opportunities to improve products and/or manufacture them on a larger scale, and research and development (R&D) resources should be better utilized;
3) that strategic partners were needed to orchestrate the effort to increase market penetration of energy-efficiency measures.

These three concepts correspond to three different and well-established models: the Market Barrier Model, the R&D and Deployment Model and the Market Transformation Model, all of them summarized below.

Market barrier model. This is the standard deployment model, which is consistent with a neo-classical economic viewpoint that it is legitimate for governments to intervene in the market to remove or reduce barriers that result from market failures. The legitimacy of intervention and the different type of barriers are discussed in IEA/OECD (1997), which emphasizes that deployment policies should remove or reduce barriers.

Barriers and their Characteristics:

- (Lack of) **Information:** Information must be available and understood at the time of investment in all types of goods and services
- (Transaction) **Cost:** A decision to purchase and use equipment requires some effort

- **Risk:** Consumers perceive that an energy-efficiency measure may not pay for itself or has a long payback period. The performance of a technology cannot be predicted or controlled over a time period that consumers perceive as appropriate.
- (Lack of resources for) **Financing:** High "first cost" is sometimes a threshold for investments. Lack of access to funds prevents investments even if they are profitable
- **Price distortion:** Costs of energy production or use are not reflected in energy rates.
- **Market Organisation:**
  - **a)** **Split incentives** Owner, designer and user of the technology are not the same.
  - **b)** **Biased calculation** Payback times used in savings calculations are too short.
  - **c)** **Costs** (of equipment) Small volumes of new technologies with good performance can not compete economically with incumbent technologies
  - **d)** **Tradition in business** Established companies guard their market position and market share
- (Inadequate, Excessive or Costly) **Regulation:** Regulation based on traditional business practices and established in standards and codes does not keep pace with development
- **Capital Stock Turnover Rates:** Sunk costs or tax rules that require long depreciation
- **Technology Specific:** These are often related to existing infrastructures both as regards the hardware and the institutional skill to handle it

The R&D and deployment model. This model is based on technology and organizational learning and uses results from systems engineering and control theory (IEA/OECD 2000). The model states that it is legitimate for governments to intervene in the market to avoid high future opportunity costs resulting from externalities and under-investments in learning. Deployment policies should stimulate learning investments[1], including private R&D, setting up a virtuous cycle between public and private R&D and deployment on the market (Watanabe).

In this model, measures are chosen based on studying existing technology, market structure (mainly suppliers) and costs, and then relating the observations to the potential for improvements, see table 1.

The market transformation model. The elements of this model are discussed in IEA/OECD (1997b). Underlying this model are concepts from industrial and evolutionary economics, and from the specific branch of economics which studies national systems of innovations (Edquist et al. 1997). In a 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 improved performance. This model is based on three pillars: **product performance** (see figure 2); **user attitude** toward novelties (see figure 3 and table 2); and **distribution of goods** to the market (see figure 4).

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[1] Learning investments are the extra resources needed to enable a product to mature to a level where it can compete successfully on its own merits and yield future profits. Analytically described by the area between prices for the challenging technology and the incumbent, see fig. 1.

Table 1. Technology Characteristics and Assumed Changes from Policy Measures

Technology (Solution)	**Performance** of technology	**Possibility of lowering Cost**[2] of technology	**Risk** (to take up production)
Existing and proven	Defined (might however not be available in all possible applications)	Limited (since the learning ratio[3] is related to cumulative production)	Predictable (Low)
(Some solutions) **Known**	Demonstrated (in some applications)	Good	Moderate
Not Known	Anticipated	Not known	High

Figure 1. Interplay between Niche Markets and Experience Curve for a New Technology That Is Challenging the Incumbent Technology[4]

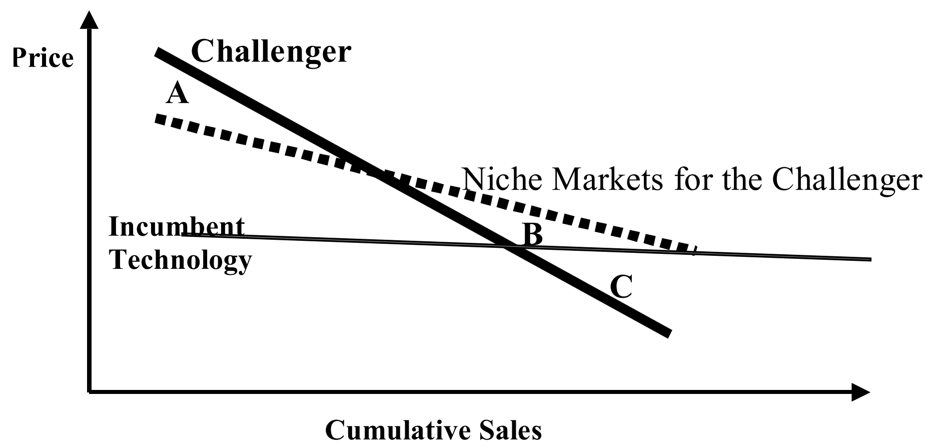
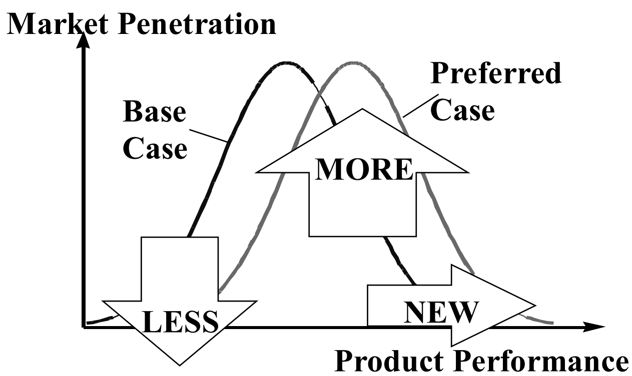


Figure 2. Market Transformation in Terms of Product Performance



Source: Nilsson 1996 and Westling 1999

[2] See figure 1

[3] The "learning ratio", LR. This ratio indicates how much the cost/price will drop by each doubling of the cumulative production, (IEA/OECD 2000).

[4] NOTE that double logarithmic scale makes the digressive curves appear linear.

The model acknowledges that customer/user attitude prevents some favorable options from being realized and some improved products/services from being released. Application of the model helps target those issues. The diffusion curve describes the market reactions, the up-take, of innovative products and services. The model also enables a structured view of the individual consumer attitudes and how those guide the response to a product and the need for marketing and development (including distribution and product related services), (Moore 1991 and Rogers 1995).

Figure 3. Diffusion Curve

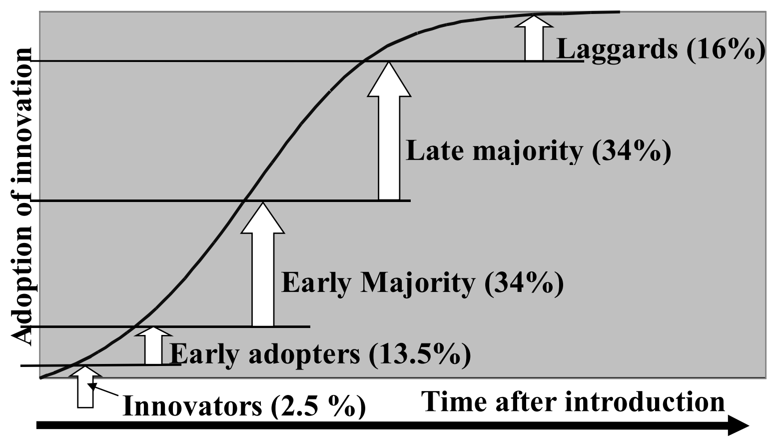
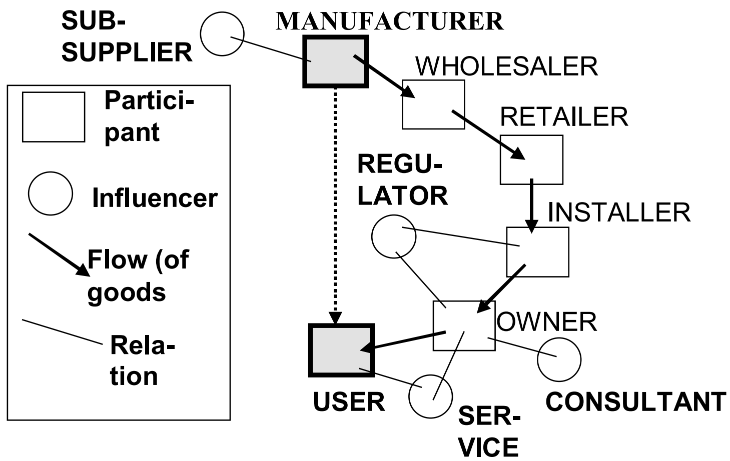


Table 3. Customer Categories and Attitudes

Adopter type	Characteristic	Role and size
Innovators, enthusiasts	Venturesome; Enjoys the risk of being on the cutting edge; demand 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	
THE CHASM (where marketing and distribution must radically change)		
Early majority, pragmatists	Deliberate; Process oriented; Risk Averse; Want proven applications; May need significant support	Followers on the market. Want solutions and convenience. (68%)
Late majority, conservatives	Skeptical; Does not like change in general. Changes under "pressure" from the majority.	
Laggards, skeptics	Traditional; Point of reference is "the good old days"; Actively resists innovations	Could have interest in "status quo". (16%)

To fully understand the Market Transformation Model it is also necessary to recognize the actors involved in the chain for distribution of goods into and within the marketplace, from manufacturers to users. Many of these actors could, as either participants or “influencers” of the market, promote or oppose change. Identification of stakeholders and their interests is an important part of any deployment project. (Nilsson 1996)

Figure 4. Participants in Distribution of Technology



Source: Nilsson 1996

Triangulation to Find the Target

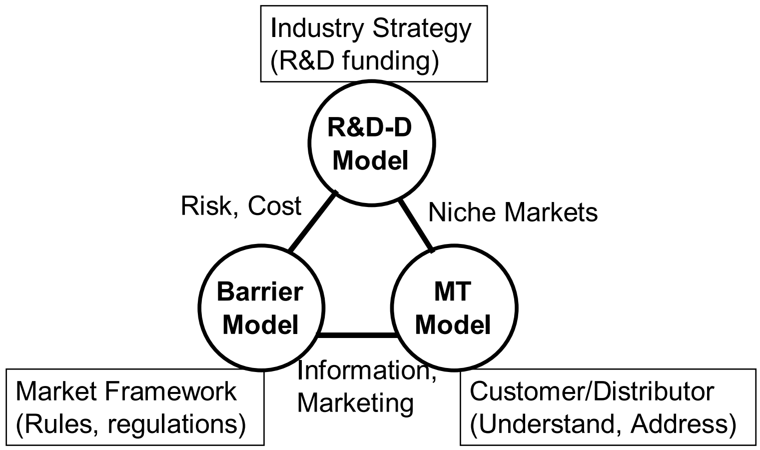
Sometimes deployment programs heavily emphasize one of these three different models. Focusing on any one of the three models means that elements of what makes a technology program effective will be obscured or neglected. In order to effectively analyze the roles and competence of the actors who are key to a program’s success, consider the time factor and the “learning effects” involved in deploying a program, it is necessary to use elements of all three models. Even though most programs in the cases are distinctly shaped with one model in mind there are elements of the others in almost all of them. A framework that combines all three models has therefore been 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 (see figure 5). Deliberate successive applications of them all gives deepening insights about programs and enables us to isolate success-factors both in analysis and in program design (see table 4).

If we take this combination of models and measures one step further it is possible to construct a more detailed view than the three basic models only, see table 5 where the combinations have been grouped into eight Program Aspects.

Program Aspects

- **Serve** the customer; The Customer/User is assumed to need assistance to make qualified choices among (primarily) existing technologies.
- **Incentivise** the customer; The customer is assumed to need motivation to make better use of known and good technologies that are not sufficiently disseminated even though the customers are aware of them

Figure 5. Combined Model Complex



- **Protect** and educate the customer; The Customer may not observe the full consequences of using less efficient technology. The wide use depends often on established routines and habits that are not questioned.
- **Manifest** the demand for change**;** Technology, and niche markets for its use/adaptation, has been identified/observed. Aggregation of purchasing power and financing of a learning process (manufacturers learn by doing, customers learn by using) will stimulate these markets to demand the technology.
- **Vitalize** conservative business structure; When the market is dominated by traditional products not always favorable to the customer/user. Activities to improve competition (by e.g. deregulation) can vitalize market actors.
- **Re-consider** existing regulations and rules; Legislation and regulation that is primarily adapted to current system can hamper a wider application even of more efficient technologies.
- **Appreciate (**the financial) framework/conditions; A (too) slow capital Stock Turnover might prevent new technologies to enter markets and into systems. This is especially problematic when the system is locked into a limited set of technologies.
- **Recognize** systems aspects; A technological solution does not only have impact on the issue it is basically designed for but on the entire systems output. Recognition of the totality of the system (energy, comfort, productivity, environment etc.) is sometimes necessary to understand and handle the technology shift.

Criteria for Success

Decision-makers who institute deployment programs want to see significant results as rapidly as possible. Although this focus is understandable, it is important to understand what is possible within a given time frame and, most important, to measure program impacts accurately. The aim of deployment programs is usually to make lasting impact on the market. Impact can be measured in volume of devices manufactured/sold, market penetration of devices, lowering of cost and improving performance, or combinations of these criteria. The following criteria were used in the cases.

Table 4. Models and Measures

		Barrier type described in case													Technology R&D+D Target					Market Transformation Purpose				Target group					
Origin[5]	Short Name	B1 Information	B2 Transaction COST	B3 Risk	B4 Finance	B5 Price Dist.ortion	B6 MarOrg Split	B7 MarOrg Bias	B8 MarOrg Cost	B9 MarOrg Trad.	B10 Regulation	B11 Cap stock	B12 Techn. Spec	Barrier type mentioend	R1 Existing technology	R2 Few Known solutions	R3 Not known solutions	R4 Niche Market addressed	R&D+D Target mentioned	MT1 NEW	MT2 MORE	MT3 LESS	Market Transf. Purp.	Mta INNOVATORS	MTb EARLY ADOPT.	MTc EARLY MAJORITY	MTd LATE MAJORITY	Mte LAGGARDS	MT Target group identif.
A	Biomass-DH	X			X		X		X	X				5	X			X	2		X		1	X	X				2
A	Thermoprofit	X	X											2	X				1		X	X	2			X			1
C	Renewable Energy, REDI	X		X		X	X	X	X	X				7		X			1		X		1			X	X		2
DK	Buildings Label	X	X											2	X				1		X		1	X	X	X	X	X	5
SF	Diesel-CC												X	1			X	X	2	X			1	X					1
D	Solarbau			X						X				2		X		X	2	X			1	X	X				2
D	250 MW Wind												X	1		X			1		X		1			X			1
J	Photo Voltaics								X	X			X	3		X	X	X	3	X			1	X	X				2
NL	Heat rec. Vent	X	X								X		X	4		X			1	X			1			X			1
NL	PV Covenant						X		X	X			X	4		X			1	X			1	X	X				2
NL	Renewables		X		X									2	X				1		X		1	X	X				2
S	HF Lighting		X					X	X					3		X			1	X			1		X				1
S	Heat Pumps								X	X				2		X			1	X			1		X	X			2
S	EAES (Baltic)				X						X		X	3	X				1		X		1			X			1
UK	Best Practices		X	X										2	X				1		X		1			X	X		2
US	Natural gas								X				X	2			X		1	X			1		X				1
US	Sub-CFL									X				1	X				1	X			1			X			1
US	Clean Coal												X	1		X			1	X			1	X					1
US	Ind. Assess. Cent.	X	X											2	X				1		X		1			X			1
US	Effic. Motor							X	X				X	3		X			1		X		1		X	X			2
IEA	Solar PACES	X		X		X			X		X			5		X		X	2	X			1	X					1
EC	EnergyPLUS			X	X		X							3	X	X		X	3	X			1		X	X			2
	SUM	7	7	5	4	2	4	3	9	7	3	0	9		9	12	3	6		12	10	1		9	11	12	3	1	

[5] Austria (A), Canada (C), Denmark (DK), Finland (SF), Germany (D), Japan (J), Netherlands (NL), Sweden (S), United Kingdom (UK), United States (US), European Commission (EC)

Table 5. Actors and Models Related to Targets and Instruments

Actor relations	Government relation to industry				Industry relation to user		User relation to government		
Policy area and model	Barrier removal				R&D budgets		Market Transformation activities		
TARGET									
Techno-logy[6]	E	E	NK	K	E	K	K	E	E
Market[7]	M	M	N	N	M	N	N	M	L
Policy instrument	Rules of the game				Business organisation		Customer relations		
Program aspect	Recon-sider regula-tion and rules	Recog-nise System function		Appre-ciate financial Frame-work	Vitalise business structu-re	Manifest demand	Incenti-vise user	Serve the user	Protect the user

Volume Growth

Establishment of a market for "new" products takes considerable time. Example: Compact Fluorescent Lamps (CFLs) have been a target product of many energy-efficient technology programs during the past decade. The accumulated output of CFLs doubled almost six times between 1988 and 1999. Yearly sales in 1999 were on the order of 500 million units worldwide, which represents a tenfold increase in sales over 1988 figures. It is assumed that the total number of CFLs installed is approximately 1,300 Million units (IAEEL 2000).

Volume and Market Penetration

In spite of the impressive volume growth for CFLs as noted above, market penetration of CFLs is generally low. The total volume for light bulbs is estimated to be 10 - 15 Billion units per year, which means that CFLs have a market share of between 0.5 and three percent.

Households across the European Union have an average of 24 light bulbs each. Thirty-two percent of households had CFLs in 1997, and the average number of CFLs in households that had them was 2.8 (Palmer and Boardman 1998). Market penetration is, on average, less than five percent; in households that owned at least one CFL, it is a bit above 10 percent.

Evaluation of CFL applicability with the current configuration of fixtures and lighting show that an average of eight light bulbs per household could be comfortably replaced with CFLs (Palmer and Boardman 1998). If we assume this figure represents the saturation level and apply a standard product dissemination curve to the current level of market penetration, we find that full dissemination will occur only after approximately 30 years.[8]

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[6] Existing Technology (E), Known (K), Not known or proven in industrial scale (NK); see table 1

[7] New products to market (N), More of good products (M), Less sold of bad products (L), see figure 2

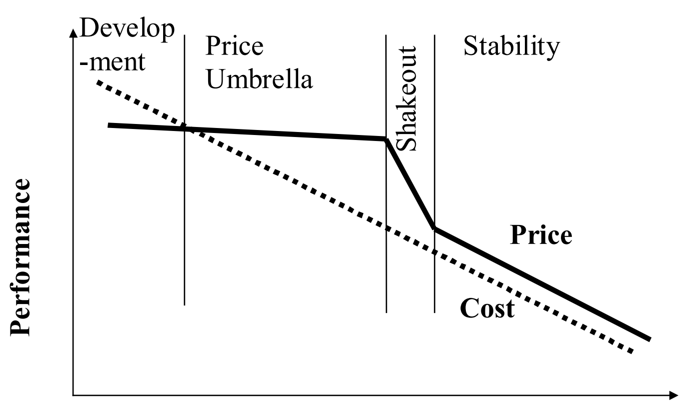
[8] Diffusion of innovations to the market follows the "Bass curve," in which the penetration N_t at a given time t is calculated as: $N_t = N_{t-1} + p*(m - N_{t-1}) + q*(N_{t-1}/m)*(m - N_{t-1})$, where m is the market potential, p is a factor for external influence (the likelihood that a consumer will start to use the product because of, for example, media

Volume Growth and Price/Cost

When new products reach the market and are and producers. As a result of 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 "learning ratio", LR. This ratio indicates how much the cost/price will drop by each doubling of the cumulative production, (IEA/OECD 2000).[9] Typically the LR is in the order of 15-20%.

Depending on the market organization it might be difficult to observe the result of decreasing 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, (see figure 6).

Figure 6. Phases in Market Actor Actions for Technology Introductions



Performance

Performance improvements are to some extent a "natural" part of the market but also depend on program activities. In Europe, labeling of household appliances and associated recording of sales show a drift from prevalence of poorly performing technologies to more efficient ones over the years (IEA/OECD 2001). The market share of the most efficient models (Class A) has increased from two to 16 percent in seven years whereas the market share of the least-efficient appliances allowed today (Class E) has dropped from 24 to five percent.

Attribution of Impacts to Measures

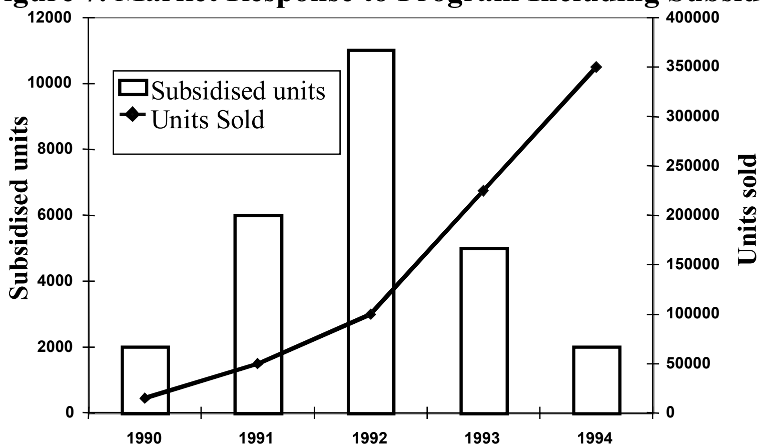
Market changes and the measures to which these changes can be attributed are a main focus of interest. Statistics that characterize both must be gathered in a fashion that allows

influence), and q is a factor for internal influence (the likelihood that a consumer will start to use the product because of word of mouth). In this case q=0.015 and p=0.23

[9] In the referred book the concept of progress ratio (PR) is used. PR=100-LR.

comparisons. The period after a program has ended should also be evaluated. The following example of program impact assessment is from the Swedish Procurement Quality Program and related subsidies to High Frequency-ballasts in office luminaries (Neij 1999). The subsidies seem to have initiated a market response (see Figure 7). Whether this response can be attributed to the subsidies alone or is also, at least in part, a result of other parts of the program (Quality Assurance and Procurement) had to be addressed; the program addressed this issue by interviewing participants. Participants in the interviews said the first reason for their interest in this new lighting product was that it was "flicker-free," which improved comfort relative to existing products.

Figure 7. Market Response to Program Including Subsidies



Lessons Learned

Deployment Programs are not quick fixes. It takes time, years and even decades, to deliver the full-scale results. Unfortunately many program managers seem to be driven by requirements to deliver substantial market changes within only a few years.

The tandem of physical and learning effects both legitimizes and provides objective and focus for energy technology deployment programs. The immediate physical effect may be reduced energy use for the same service, lower emissions, greater comfort or reliability or improved cash flow. These effects are important to highlight. The induced learning effect is however the most important and markets are developed by learning

Several challenging new technologies could enter the market and improve the energy systems if they are allowed to develop and get through the learning process. They might need support to "ride down the learning curve" and be able to compete successfully on their own merits. Support to such technologies should be regarded as "learning investments", and not as subsidies, since they pay off in the future. Technology Deployment Program should be continuously monitored and the responsible should be prepared to make changes and alterations in the program to reach the goals, as opposed to be evaluated for a "go-no go" decision. Determination and use of realistic success-criteria is extremely important.

Most of the potential for improvement in energy efficiency is hidden in units of energy use that are so small that consumers do not heavily weigh the energy costs that could be saved. Moreover, many of the technologies disseminated by deployment program are used in a variety of different circumstances in which saving energy is often not a key objective (see Table 6).

Table 6. Consciousness about Energy Depends on Who the Consumer Is

Unit size	Frequency of Change	Basis for choosing replacement	Energy and savings as objective	End-Use Activity Type
Very small (20-100 W)	Often	Habit	Never	Household lamps
Small (100-1000 W)	Regular	Routine	Occurs	Small appliances
Small (1-10 kW)	Normal	Planned	Important	Commercial maintenance, (e.g. motors)
Big by unit size or aggregation (10-5000 kW)	Not often	Calculated	Important	Industrial & Commercial. Retrofit (e.g. lighting)
Huge (> 2 MW)	Seldom	Investment	Depends	Production and process technology (e.g. casting)

We need to know much more about demand (Wilhite et al. 2000). Combining the viewpoints of the models used, as a basis for technology deployment programs is one good start in this research.

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