Modeling the Diffusion of Energy Performance Contracting

Carlos Capelo
Associate Professor
Universidade Lusofona - FEG
Campo Grande, 376, 1749-024 Lisboa - Portugal
Phone: +351962831740
carlos.capelo@my.grupolusofona.pt

Abstract

The Portuguese Energy Policy considers the development of a commercially viable and competitive market for energy performance contracting (EPC) as a main mechanism to achieve the objectives of energy efficiency improvement. This paper proposes a study to investigate how to achieve widespread adoption of energy performance contracting by means of system dynamics modelling and simulation. To explore and gather insights on this question, a system dynamics model representing the system of the Portuguese EPC market at industry level will be created. The simulation of that model will provide a helpful basis for analysing and explaining the development of key variables, and accelerating learning on the managerial, organizational and political adaptation processes that foster the diffusion of EPC adoption. The first phase of this research project aims at identifying and analysing the key factors and critical cause-effect relations that drive the adoption of EPC. With this purpose, a qualitative content analysis on relevant documents was performed and a set of interviews was conducted. That data was analysed to capture the critical variables and its interrelation to formulate a preliminary representation of the system structure as stock and flow diagrams.

Key words: Energy Performance Contracting, Diffusion Simulation, System Dynamics

1. Introduction

Energy performance contracting (EPC) projects focus at the deployment of comprehensive solutions for improving energy efficiency. This type of contract would help to overcome financial constraints to energy efficiency investments by paying off initial costs through the future energy cost savings resulting from reduced energy consumption. However, as the present analysis points out, despite of government policies supporting EPC, the EPC market in Portugal is underdeveloped, far from its promised potential. An important question remains – what policies and managerial processes might expand the attractiveness of the EPC model and foster the diffusion of its adoption in the Portuguese market?

This paper presents the first steps of an exploratory study about de dynamics of the diffusion of EPC by means of system dynamics modelling and simulation. This research focuses on how to foster the development of an EPC industry in the Portugal. The key question is to understand the critical factors of the Portuguese EPC market and the dynamic interactions among those factors that will drive the adoption of EPC. To explore and gather insights on this question, a system dynamics model representing the system of the Portuguese EPC market at industry level will be created. The simulation of that model will provide a helpful basis for analysing and explaining the development of key variables, and accelerating learning on the managerial, organizational and political adaptation processes that foster the diffusion of EPC adoption. The main purpose is to recommend political and managerial actions that foster reinforcing processes towards a sustained diffusion of EPC.

The first part of this research project aims at identifying and analysing the key factors and critical cause-effect relations that drive the adoption of EPC. With this purpose, a qualitative content analysis on relevant documents was performed and a set of interviews was conducted to gather insights and discuss the experience of energy efficiency experts, national authorities, energy services companies (ESCOs) professionals and energy end-users regarding the development of an EPC industry in the Portuguese market. That data was analysed to capture the critical variables and its interrelation to formulate a preliminary representation of the system structure as stock and flow diagrams.

This paper has the following structure. Section 2 starts with a review of European and Portuguese energy policies that shape the context of the EPC market, defines the concept of EPC and gives an overview of the current status of the EPC industry in Portugal. Section 3 presents the objectives and methodology of the present research. Section 4 presents and interprets the data gathered about the factors affecting the adoption of EPC in the Portuguese market. Section 5 describes the first steps towards the development of a system dynamics model. Section 6 concludes and presents the following phase of the present research.

2. Closing the Efficiency Gap through Energy Performance Contracting

The Portuguese policy context

Under the Kyoto protocol, the European Union has agreed to reduce greenhouse gas (GHG) emissions. In 2006, the European Commission published the Action Plan on Energy Efficiency which aims to realize a 20% energy efficiency improvement by 2020 (EC 2006a). This objective was reinforced in 2007 when the European Commission defined her energy package for the twenty-first century. The package included a 20% emissions reduction target for greenhouse gases by 2020, among others, to be achieved by improving energy efficiency by 20% (EC 2007). Realizing this potential requires the introduction of effective energy efficiency policies on the European and the national level. According to many energy efficiency advocates and policy makers, most of this energy savings potential can be effectively realized through performance contracting of energy efficiency measures. The main mechanism to achieve this objective will be to improve the functioning of a commercially viable and competitive market for EPC.

In 20 May 2008, the Portuguese Government published the National Energy Efficiency Action Plan (RCM 80/2008). The objectives were to cut 10% in final energy consumption by 2015 and create and promote Energy Services Companies (ESCO's) and energy performance contracting (EPC). The recently published Portuguese National Energy Strategy (ENE 2020 RCM 29/2010) promotes energy efficiency aiming for a 20 % reduction in final energy consumption by 2020. That strategic plan reinforces that the development of the ESCOs and EPC market will be a priority, as this will create an energy efficiency industry with long term relevance (Fernandes, 2010; Zorrinho, 2010).

The Nature of Energy Performance Contracting

The Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-use Efficiency and Energy Services (Energy Services Directive) established the following terminology (Marino et al, 2010):

- "energy performance contracting" (EPC): a contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement;
- "energy service company" (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria;

Under an energy performance contracting, the ESCO defines and implements a project to deliver energy efficiency, or a renewable energy project, and uses the stream of income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the costs of the investment (Bartoldi et al, 2006).

In a typical energy efficiency project supported by an energy performance contract, the ESCO may: perform energy audits, project design and engineering, install new energy conversion, distribution and/or control equipment at the client site; finance this investment, or assist in obtaining finance for the client; operation and control of some equipment, monitoring and verification of performance in terms of energy efficiency; assume decision rights over a significant proportion of the useful energy streams and final energy services within the host site; assume decision rights over a significant proportion of the organisational activities required to provide those streams and services; assume property rights over some of the assets involved in the energy efficiency project; guarantee a particular level of savings in energy consumption or energy costs; take on the majority of the risks related to the performance of the energy efficiency project, including equipment performance risk, and credit risk.

The Economics of EPC

Under an economic point of view, the primary objective of energy performance contracting is to minimise the total cost of supplying energy services, given by the sum of production costs and transaction costs (Sorrel, 2007). Energy performance contracting is supposed to allow the client to minimise the total cost for the services that energy provides.

Production costs include the financing costs of energy efficiency project, the operation and maintenance costs, and the purchase cost of energy commodities. Transaction costs include the staff, consulting and legal costs associated with searching for a supplier, negotiating and writing the contract, monitoring contract performance, enforcing compliance, negotiating changes to the contract when unforeseen circumstances arise and resolving disputes (Sorrel, 2007). Production and transaction costs will be incurred by the client for the case of in-house provision of energy efficiency project as well as for the case of EPC. In the case of the latter, production and transaction costs will also be incurred by the ESCO.

The conditions for a viable energy performance contract are that (Sorrel 2007):
- the contract payments are less than the total savings achieved by the client;
- the contract revenues are greater than the total costs incurred by the ESCO;
- the total saving in production costs achieved through the contract must be greater than the total increase in transaction costs:

As it is expected EPC to reduce overall production costs but increase overall transaction costs, the saving in production costs is the key to a successful energy performance contract. EPC viability requires that the savings in production costs are sufficiently large to offset the transaction cost of contracting. Thus a client will engage in EPC if it can reduce its estimated and anticipated total cost at the time of making the decision (Buckley and Chapman, 1997).

EPC may achieve savings relative to in-house provision of efficiency energy project through the combination of scale advantages, competitive bidding, and performance incentives of outside providers (ESCOs):

- Economies of scale: Many organisations lack the scale to manage energy projects efficiently. As ESCOs specialise in energy management and contract with multiple clients, they achieve considerable scale economies (Sorrel, 2007; Globerman and Vining, 1996).

- Market incentives: If the energy efficiency project is managed in-house, the relevant staff will not be affected by the incentives of market competition. Competitive bidding will provide an incentive to ESCOs to maximize energy savings (Sorrel, 2007; Globerman and Vining, 1996).

- Performance incentives: EPC provides an effective incentive to ESCOs to maintain and improve performance over time. Although such incentives could potentially be provided by an internal management mechanism (Irrek et al., 2005), the effectiveness will depend upon the management ability to implement and maintain over time that incentive scheme.

Financing of EPC projects

Finance for an energy efficiency project through EPC refers to the source of capital for investment in new energy conversion and control equipment. In general three broad financing options for financing EPC project can be distinguished: energy user/ client financing, ESCO financing, and third party financing which may involve a single purpose entity (Thumann, 2009).

This study focuses mainly on ESCO financing as this concept is assumed a good introductory model in EPC developing markets because clients assume no financial risk (CTI, 2003; Dreessen, 2003). The ESCO financing model refers to financing with internal funds of the ESCO and may involve own capital or equipment lease. Under an EPC agreement contract the energy savings are split in accordance with a pre-arranged percentage. This percentage depends on the cost of the project, the length of the contract and the risks taken by the ESCO and the consumer. In this arrangement, the ESCO takes on the majority of the risks related to the performance of the efficiency project provision and credit risk as well.

Benefits of Energy Performance Contracting

The primary objective of EPC is to minimise the total cost of supplying energy services. Thus, EPC allows the client to achieve lower energy costs and may guarantee particular levels of service provision, such as lighting levels, room temperatures, humidity and 'comfort' at reduced cost.
In a conventional 'turnkey' energy efficiency project, the contractor is responsible for design, specification, construction and commissioning, and is paid on project completion. The contractor has neither the incentive nor the means to optimise the performance of the energy efficiency project subsequent to its delivery. In contrast, an energy performance contract establishes a link between contract payments and project performance and schedules these payments at intervals over a long-term period. This provides the contractor (ESCO) with a long-term incentive to optimize and maintain the performance of the energy efficiency project (Sorrel, 2007).

The approach involves the transfer of technical risks from the client to the ESCO based on performance guarantees given by the ESCO. In EPC payment is based on performance; a measure of performance is the level of energy savings.

ESCOs may have greater access to information, skilled labour and managerial expertise in the relevant areas and may leverage these benefits by having individual staff serve a number of clients. Such staff should be able to develop and apply specialist skills that would not be feasible within the client organisations and to rapidly disseminate learning benefits between different clients. (Sorrel, 2007)

EPC industry in Portugal – Present status

The present status of the Portuguese EPC industry was recently described by Marino et al (2010). The markets for energy services and efficient technologies have been developing since 2008, mainly supported by the energy efficiency programmes of the government. Some of those programs allocated important funds for the support of ESCO activities. Other program requires industries to perform energy audits and to present and implement energy efficiency project containing specific measures to reduce energy consumption. At present, the public procurement of new energy projects is assumed as the main driver for the growth in the EPC market in Portugal. Recently, the Portuguese government has established new procurement rules (DL 29-2011) in order to facilitate long term EPC agreements between ESCOs and public administration. With these programs and governmental commitments to support EPC, a strong boost in this sector was expected.

Despite of those policies supporting EPC projects, the Portuguese EPC market has been growing at a slow rate. Approximately 10 firms declare that they are ESCOs. Most of these companies are small. There are not many cases reported of EPC based projects. Some companies declare that are using EPC, though other types of non-performance based contracts are much more frequent (Marino et al, 2010).

3. Research Objectives and Methodology

Problem statement

EPC projects focus at the deployment of comprehensive solutions for improving energy efficiency. This type of contract would help to overcome financial constraints to energy efficiency investments by paying off initial costs through the future energy cost savings resulting from reduced energy consumption. However, as the present analysis points out, despite of government policies supporting EPC, the EPC market in Portugal is underdeveloped, far from its promised potential. An important question remains – what policies and managerial processes might expand the attractiveness the EPC model and foster the diffusion of its adoption in the Portuguese market?

Research objective

This research focuses on how to foster the development of an EPC industry in Portugal. The key question is to understand the key factors of the Portuguese EPC market and the dynamic interactions among those factors that will drive the adoption of EPC. Some specific questions are:

- Why is EPC perceived as an important solution for the improvement of energy efficiency?
- What are essential variables that determine the value of EPC?
- What are critical factors that inhibit or facilitate the diffusion of EPC?
- How do these factors interact with each other?
- What are possible intervention policies and managerial actions to foster the EPC adoption?

Methodology

To explore and gather insights on those questions, a system dynamics model representing the system of the Portuguese EPC market at industry level will be created. The simulation of that model will provide a helpful basis for analysing and explaining the development of key variables, and accelerating learning on the managerial, organizational and political adaptation processes that foster the diffusion of EPC adoption. The main purpose is to recommend political and managerial actions that foster reinforcing processes towards a sustained diffusion of EPC.

This paper describes the first steps towards the development of a system dynamics model representing the Portuguese EPC market system. The methodological approach for capturing the critical variables and its interrelation to be included in the simulation model considers the following data and methods:

- The current research builds on a review of existing literature on factors and barriers facing the EPC industry (Bartoldi et al, 2006; Goldman et al, 2005; Marino et al, 2010; OECD and IEA, 2007; Seefeldt, 2003; Soroye, 2010; Steinberger, 2009; Vine, 2005);

- The author conducted informal semi-structured interviews based on a questionnaire. The purpose of this survey was to discuss the experience of energy efficiency experts, national authorities, EPC professionals, academia, and financial institutions regarding the status and development of national EPC industry;

- Qualitative content analysis of documents and texts about this subject was also apply, seeking to identify perceived factors, barriers and cause-effect relations that might explain and drive the EPC market development. The texts surveyed include political, legal and regulatory documents, written interviews with government members, papers issued by national and regional energy agencies, communications presented in conferences and workshops on energy efficiency and EPC. Results reported in recent studies concerning this subject were also considered as secondary data (Marino et al, 2010).

The system dynamics model will be developed according to the standard modelling process (Sterman, 2000). The present research phase focuses on the step 1 (Problem Articulation) and step 2 (Dynamic Hypothesis) of the modelling process. The modelling step "Dynamic Hypothesis" comprises the development of a theory about the dynamics characterizing the problem in terms of underlying feedback and stock and flow structure of the system (Sterman 2000).

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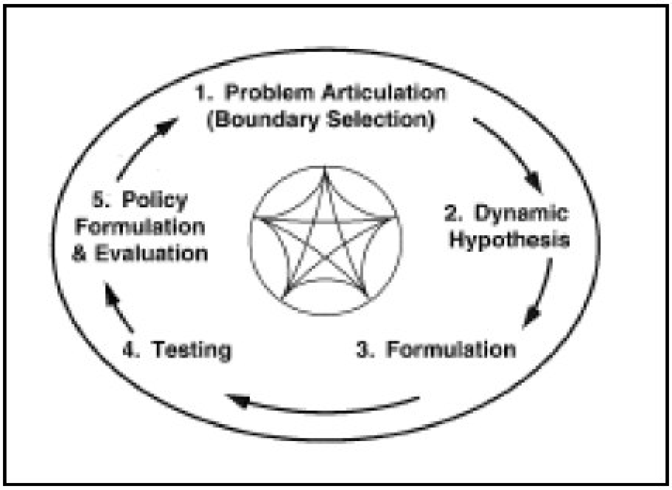

Figure 1: The iterative process of model development (Sterman, 2000)

The dynamic hypotheses and the preliminary representation of the system structure will be developed according to the following steps:

- Definition of model variables based on data surveyed.

- Formulation of influence and causal loop diagrams. Analysis of positive and negative feedback loops of the system. These diagrams show the critical variables and their interrelations that are involved in the treatment of the research problem.

- Preliminary representation of the system structure as stock and flow diagrams.

4. Adoption of Energy Performance Contracting

4.1 How EPC influences the success of a policy for energy efficiency

The data collected in the present study suggests that Portuguese policy makers understand that EPC may play a significant role in helping Portugal to reach current targets in the European Commission Directive for energy efficiency (2006/32/EC). The expectations of that positive contribution of EPC are routed in the causal relations described in diagram of figure 2. The diagram was built by using the data gathered in the present study and describes the perceived macro-economic impacts of EPC adoption in terms of national energy efficiency.

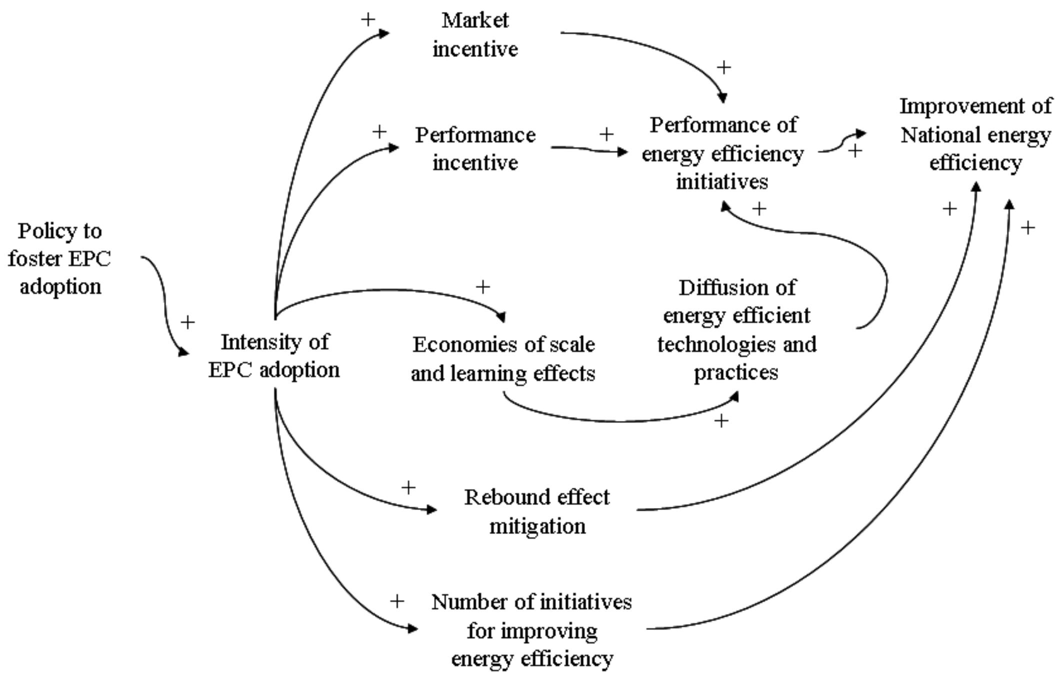

Figure 2 – Macro-economic effects of adopting EPC

The success of the national policy for energy efficiency implies to accomplish the improvement objectives stated in the PNAEE (Improvement of National Energy Efficiency). In order to meet those objectives, a great number of efficiency measures must be defined and implemented in public and private corporations (Number of initiatives for improving energy efficiency). Moreover, all those initiatives must be performing effective, which means that efficiency projects should effectively produce the estimated savings over time (Performance of energy efficiency initiatives). The success of energy efficiency efforts is also influenced by the rebound effect (Hertwich, 2005; Herring and Roy, 2007). Performance incentive, economies of scale and learning effects, and market incentive are factors that mediate the effect of the intensity of EPC adoption on the performance of energy efficiency initiatives.

Performance incentive
The EPC model is based on principles of the Performance Economy" (Stahel, 2006), which optimizes the use or function of goods and services, knowledge and capital. The economic objective of the EPC is to create the highest possible use value for the longest possible time while consuming as few energy as possible. Thus there is a performance incentive of ESCO to design and implement the energy efficiency project in order to maintain and improve performance over time.

Market incentive
In the case of energy efficiency projects being managed in-house, the staff assigned to the project will be shielded from the incentives of market competition and top management may lack adequate benchmarks to evaluate project performance. Competitive bidding for EPC services will facilitate benchmarking and provide an incentive to ESCOs to minimise project costs and maximize energy savings.

Economies of scale and learning effects
Many organisations lack the skills and scale to manage energy projects properly. ESCOs have greater access to information, and skilled staff in the relevant areas. Such staff is able to develop and apply specialist skills that would not be feasible within the client organisations and to rapidly disseminate learning benefits between different clients. Similarly, as ESCOs specialise in management and contract of energy projects with multiple clients, they achieve considerable scale economies. For example, ESCOs may obtain quantity discounts on equipment purchases by combining the needs of multiple client projects.

Diffusion of energy efficient technologies and practices
Since EPC contracts are continuously based on the current state-of-the-art, it would also accelerate the diffusion rate of the most efficient technologies. Thus, there is a common idea that EPC will foster constant innovation and will facilitate the diffusion of energy-efficient technologies and practices.

Number of energy efficient initiatives
The data collected suggests that EPC could minimize the number of energy efficient initiatives not accomplished due to technical and financial difficulties or long payback. For many private or public organizations, the up-front capital investment in efficient equipment seems to be a significant barrier. In such cases, EPC lowers the barrier of the higher costs of efficient equipment.

Factor of rebound effect mitigation:

Frequently, it has been observed that energy consumption increases after the implementation of an energy efficiency project. This phenomenon is known as the ‘‘rebound effect’’ (Hertwich, 2005; Herring and Roy, 2007). The use of more efficient technologies may decrease the attention to the level usage of energy services, and consequently the efficiency gains may be temporarily offset by usage increase for specific energy services. The dynamics of this effect is described in causal loop diagram of figure 3. The “rebound effect” is expected to be mitigated when energy performance contracting is adopted.

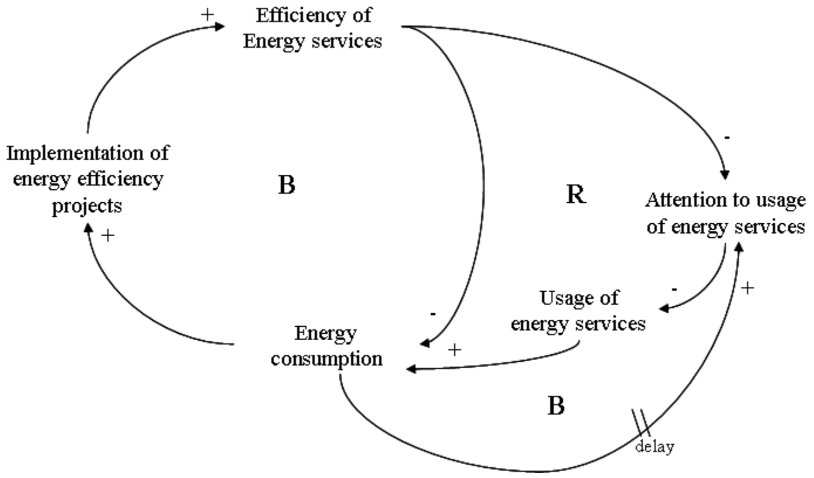

Figure 3 – Causal loop diagram representing the rebound effect

4.2 Factors effecting value of EPC

Figure 4 shows the interaction of the main factors affecting the cost and value of implementing energy efficiency projects through EPC model.

White certificates
Energy authorities have assumed that the introduction of White Certificates will influence positively EPC value and adoption.

Value of future savings
The value of future savings achieved through EPC will depend upon the values of future energy savings and costs of EPC.

Trend of energy price
The rising trend of energy prices, including energy taxation, is understood as a favourable key market driver for EPC. The steady rise in energy prices and taxes has decreased the payback time of energy efficiency investments and increased the demand of energy efficiency investments and therefore EPC. On the other hand, falling and volatile energy prices are expected to have a negative impact on EPC.

EPC market competitiveness
The value captured by ESCO will depend upon the competitiveness of the EPC market. Authorities fear that limited competition provides scope for inefficiency and monopolis-

tic pricing by the EPC contractor, which will be reflected in inefficiencies in contract execution.

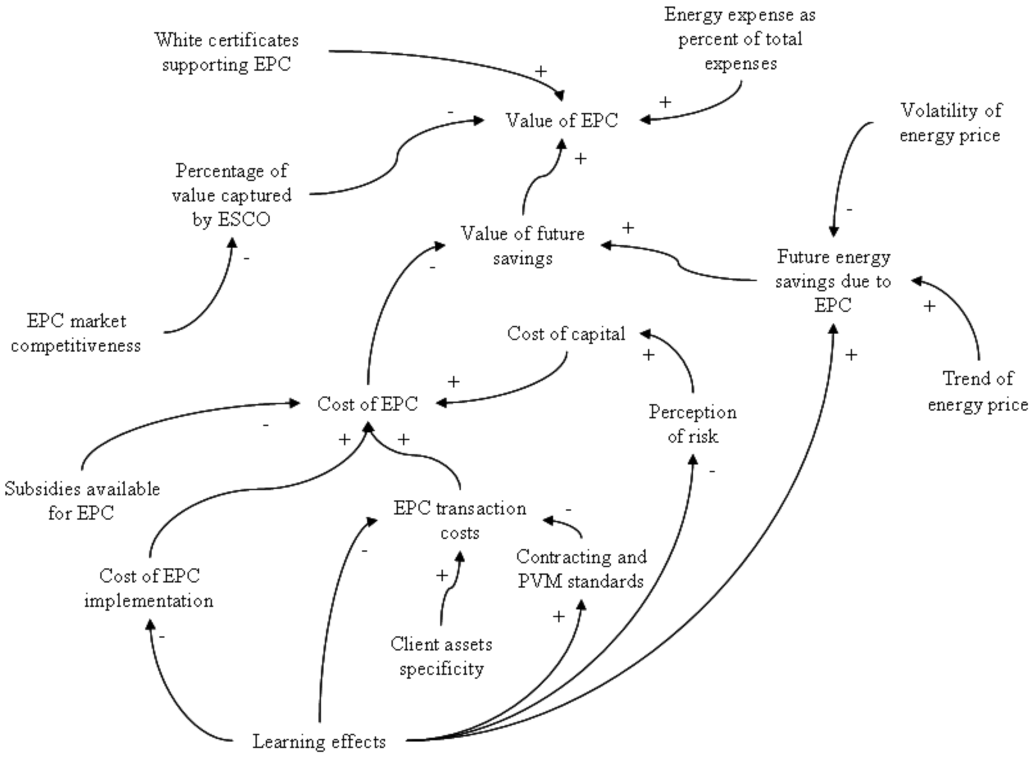

Figure 4 – Factors effecting value of EPC

Subsidies available for EPC

It is assumed that subsidies and government programs supporting energy efficiency projects and EPC may be necessary to foster the first moves of this industry.

EPC transaction costs

Asset specificity and standardization of performance contracting and verification determine the transaction costs which in turn influence the total cost and feasibility of EPC.
For small projects, EPC may offer large percentage energy savings, but the absolute savings are likely to be outweighed by the associated transaction costs.
The high level of detailed information required for performance contracting and verification is considered costly and time consuming, especially for projects of smaller scale. To reduce those costs to a reasonable level it is assumed that standards to support efficiently those tasks must be developed and applied. Moreover, it is expected that standardize contracts and measurement and verification procedures will help energy users and the financial community better understand EPC.
The specificity of client assets influence the transactions costs as the size and learning advantages of the EPC contractors should depend upon the nature of the technologies required to provide the relevant energy services. EPC contractors primarily have expertise in generic technologies. In contrast, most contractors do not have comparable expertise in specific process technologies, which will require high transaction by the ESCO in hiring and training staff, learning by doing and so on.

Perception of risk and cost of capital
Estimation of energy savings potential and performance verification involve volatility data which is an important source of risk. This perceived risk forces lenders to increase the cost of borrowing, which in turn erodes the intrinsic cost-effectiveness of EPC projects and lowers the overall level of available financial resources.

Learning effects and EPC capabilities
Learning effects in increasing EPC capabilities are often mentioned as important drivers for decreasing EPC cost elements and increasing the certainty of the estimated future savings.

4.3 Factors that affect the adoption of EPC

Figure 5 presents the main factors identified that affect the adoption of EPC. These include regulatory factors, such as legislation, public procurement rules and subsidies programs; market factors such as, economic value and competitive pressure; behavioural factors, such as the agency problem, aversion to outsource energy projects, aversion to technical risk, the familiarity with EPC contracting and procedures for performance measurement and verification, and ESCO reputation; and the effects of communication and word-of-mouth.

Competitive pressures
The effects of cost competition together with the need to improve cash flows and use off-balance sheet solutions for energy efficiency investments represented a strong factor for EPC in most firms surveyed.

Investment subsidies and program deadlines played a powerful role in making EPC attractive for many clients. Beyond providing a financial source, subsidy programs presented firm deadlines, which fostered a sense of urgency for action which drives EPC adoption.

Awareness and perception of EPC benefits
Low awareness and scepticism towards the potential benefits of EPC was one of the most commonly reported barriers to the deployment of EPC projects. Most potential clients are ignorant of the concept or are reluctant to adopt EPC. The subjects surveyed revealed a common view about the importance of disseminating information on the benefits of implementing energy-efficiency projects through EPC, particularly in situations where there are limited financial or technical capabilities (e.g. in public buildings). Such communication actions will help to build client confidence with EPC.

Standardization and Familiarity with EPC contracting and performance, measurement and verification (PMV)
The lack of standardization in EPC contracting and performance measurement and verification (PMV) of project savings is perceived as an important motive for mistrust in the EPC model both from clients and from financing institutions. Standardizing these processes will help end-users and the financial community better understand EPC. Also, transaction costs may be lowered by standardised contracting and PMV.

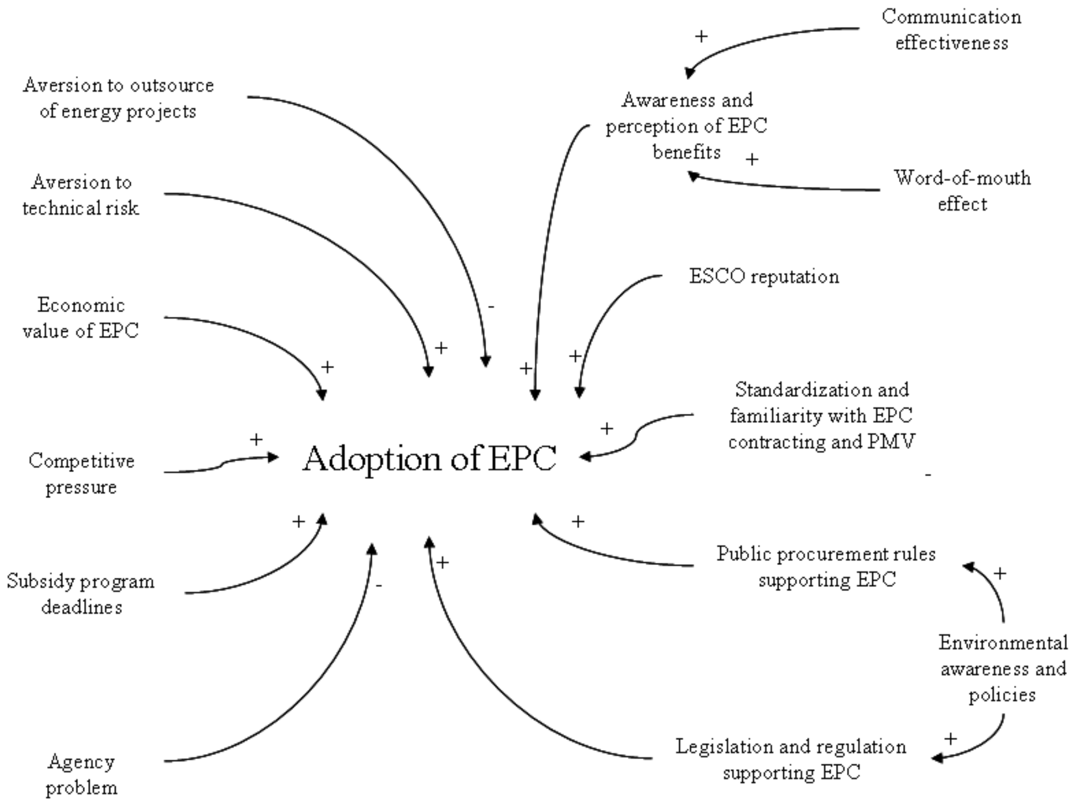

Figure 5 – Factors that affect the adoption of EPC

ESCO's reputation
The ESCO's track record can influence the EPC adoption. Many advocated an accreditation system for ESCOs to provide a qualified and reliable EPC project.

Legislation and regulation supporting EPC
Accordingly to subjects surveyed, environmental awareness and climate change policies have had a positive effect with the implementation of favourable legislative frameworks and concrete implementing measures, as well as gaining political support for EPC adoption. For example, the EU Directive on Energy End-Use Efficiency and Energy Services (2006/32/EC) has stimulated and facilitated investment in energy efficiency and fostered the development of EPC model by requiring Portuguese government to remove barriers to ESCOs. The European Performance of Buildings Directive (2002/91/EC) and its recast 2010/31/EU (EPBD) state the minimum requirements to the energy performance of new and existing buildings and introduce requirements related to national plans for increasing the energy certification of buildings. These Directives are faced as important EPC adoption drivers.

Agency problem
The "principal-agent problem" arises when the person that owns and invests in energy-saving technologies is not the person paying the energy bills. The case in which decision makers do not receive the benefits of energy savings was mentioned as being a considerable barrier to the adoption of EPC.

Aversion to outsource energy management
One factor reported that influences negatively the adoption of EPC it the aversion to outsource energy management, especially where in-house technical expertise exists.

Public procurement rules
Requirements for public procurement represent another potential barrier for EPC adoption. The public procurement procedures in use in Portugal are very complex and time consuming, which increments the transaction costs of EPC projects, undermining their viability. Portuguese laws regarding public market tendering must be designed to facilitate EPC adoption.

4.4 The Dynamics of the development of an EPC industry

The analysis of the data surveyed suggests some positive feedbacks that could support the development of an EPC industry if they were understood and considered by managers and policy makers. There are also positive feedbacks that support in house energy projects and established energy services and technologies providers. Figure 6 depicts many of these loops.

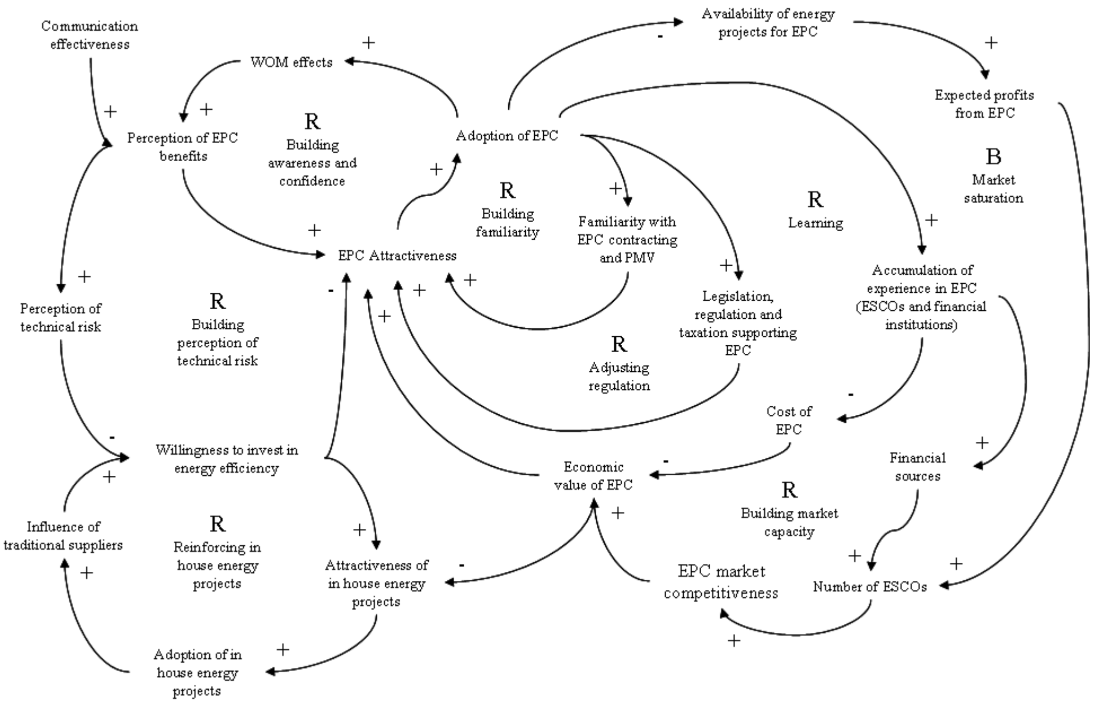

Figure 6 – Causal loop diagram representing the development of an EPC industry

Reinforcing in house energy projects
Clients have defined and implemented in house energy projects helped by energy consultants and suppliers of end-user energy technologies. This model is very familiar to the firms and enters positive feedbacks that support the attractiveness of in house projects model offered by established energy consultants and technologies suppliers. When

evaluating the EPC alternative, managers have difficulties in understanding their economics and benefits and they perceive it as uncertain and costly. Therefore, the safe decision is to continue using the in house model, which reinforces its familiarity and encourages further use in the future.

Building awareness and confidence
The benefits of EPC must be known and understood in order to improve its attractiveness. Also, the mutual trust between ESCOs and clients must be achieved, leading to increased comfort with EPC. The power of word-of-mouth marketing among clients would help meeting that objective. As EPC is first introduced, there is an intrinsic resistance to the unknown that is mitigated as more EPC is adopted and positive word of mouth concerning its benefits spreads. However the word of mouth loop only works if there are enough firms to spread the experience with EPC. If there are not enough new adopters it may further discourage other firms from adopting EPC.

Building perception of technical risk
One of the main EPC benefits is the transfer of technical risk from the client to the ESCO. New and more efficient energy technologies involve some technical and operational risks which may jeopardize future savings and the viability of the project. The perception of that risk will detract from the attractiveness of in house projects and will favour the EPC alternative.

Building familiarity
The initial poor attractiveness of EPC can probably be explained by the unusual business model. Once the adoption of EPC streams, ESCOs and energy end-users become familiar with EPC contracting and performance measurement and verification. This process of building familiarity increases the attractiveness of EPC.

Adjusting regulation
Some legal and regulatory problems will be revealed as EPC adoption evolved. Large ESCOs and energy efficiency organizations may use these insights to influence the shape of regulations that favour or lower the cost of EPC. These regulations result in increased economic attractiveness of EPC.

Learning and increasing of EPC capabilities
One of the most important positive loops is supposed to be the virtuous learning- accumulation of experience loop. This learning process will create and enhance the capabilities of the ESCOs and the financial institutions for implementing EPC projects. As ESCOs are engaged in EPC projects they gain further experience, most project processes become less costly and they improve their technical, financial, management and marketing abilities in order to develop the market. The lower cost of EPC increases its attractiveness and encourages further adoption. Also, the financial institutions will start seeing EPC businesses as a promising market niche and gradually improve their expertise when it comes to EPC projects.

Building market capacity and competitiveness
Thanks to the increasing economic attractiveness and accessibility to financing which is due to the learning effects, an increasing number of ESCOs enter the market.

Market saturation
Market saturation induces a negative loop that limits the growth of EPC industry capacity. The more the EPC adopters on the system, the less the potential projects and the lower the expected profits from EPC. That causes a process of market saturation and may discourage new ESCOs to enter the market.

5. Model Development

System Dynamics has a valuable track record for studies in the energy sector. The pertinence and legitimacy of using SD in such strategic studies stem from the ability of capturing structural mechanisms and feedback loops, which cause either success or failure. We intent to develop a simulation model to better identify and understand the factors that most determine the success in fostering an EPC industry. The purpose of the model is to help the definition of policies that will increase the adoption of energy performance contracting. The main model structure will include feedback relationships that represent the previous discussed dynamics.

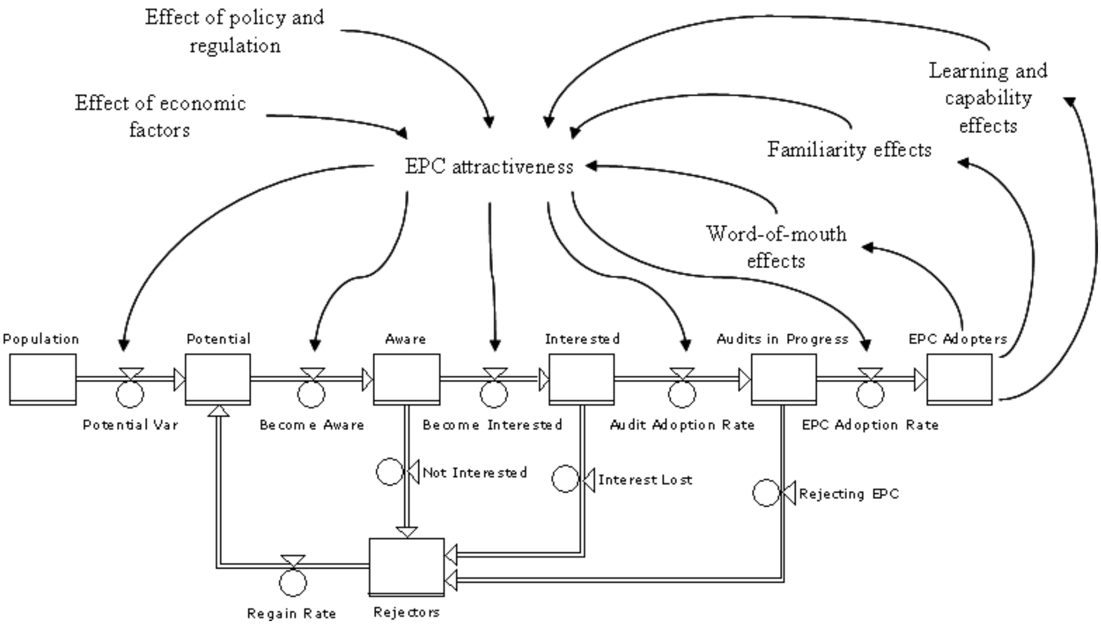

Figure 7 – Stock-flow model representing the EPC market.

The subject of the model is the development of an EPC business at industry level. The market consists of public or private buildings with potential for an energy efficiency project and may benefit from adopting the EPC model. The geographical focus of the model will be Portugal. Figure 7 shows a stock-flow diagram representing an initial conceptualization of the model. The EPC market is modeled as a series of stocks representing prospective clients at various stages in the adoption cycle. Clients move among various stages and it is important to understand how clients move between them. This client choice pipeline (Warren, 2008) is based on the Bass diffusion model (Bass, 1969) which was extended in order to more closely represent the process of marketing development. Based on interviews and previous studies, the stock of potential EPC adopters was disaggregated into “Population”, “Potential”, “Interested”, “Audits in Progress” and EPC Adopters.

The stock “Population” represents the total number of organizations that own commercial buildings. These organizations can possibly adopt EPC at some point in the future.

“Potential” consists of organizations that own buildings with economic potential for implementing an efficiency project with EPC considering the current technical and economic conditions. The stock Potential is replenished from the stock Population as economic, legal and technical conditions evolve and drive the increasing of the number of buildings with economic potential for implementing an efficiency project with EPC. These organizations are identified by ESCOs and are object of their marketing and sales effort to persuade them to learn more about the EPC model.

“Aware” consists of organizations that own buildings with economic potential for implementing an efficiency project with EPC and their decision makers are aware of the EPC model but have not decide adopting it. ESCOs apply sales effort to convince the decision makers of these organizations to learn more about EPC to be able to decide to adopt it.

“Interested” represents organizations that have expressed interest in adopting EPC. Once a potential client has become an Aware, they will form a favourable or unfavourable perception of the EPC and become either an Interested or a Rejector. As potential clients form a favourable perception of the EPC, they flow (Become Interested rate) from Aware to Interested. This flow is dependent on some components of EPC attractiveness, marketing and sales effort and word of mouth. As more organizations decide to adopt EPC, persons from those organizations will come in contact with persons from other organizations and spread word about their EPC benefits. It is assumed that many decision makers will not adopt EPC without heard about its benefits at other similar organizations.

“Audits in Progress” are organizations that have closed an initial EPC agreement for performing an energy audit. Potential clients flow from Interested to Audits in Progress (Audit Adoption Rate) as they are engaged in an energy audit agreement in order to design an efficiency project. The Audit Adoption Rate is dependent on some components of EPC attractiveness and sales effort. It is assumed that marketing and word of mouth are no longer determinant factors at this stage.

“EPC Adopters” are organizations that have contracted energy performance and implemented the associated energy efficiency project. Once the energy audit has performed, the ESCO presents the client an EPC offer. The clients flow (Adoption Rate) from “Audit in Progress” to EPC Adopters as they sign an EPC agreement and ESCOs install and to put into operation the efficiency project. The Adoption Rate depends on ESCO sales and engineering effort, and some components of EPC attractiveness. At this stage, it is assumed that word of mouth is not relevant.

There is a stock of “Rejectors” which are prospects that lost interest in adopting the EPC or decided not to adopt.

The simulation model to be developed will consider parameters that represent the existence of factors that might make some components of EPC more attractive and drive the adoption cycle: economic factors such as the energy price and the base cost of capital; government policies, financial incentives and legislation supporting EPC adoption. The model will allow one to adjust the intensity of those factors. The model will also consider the influence of advertising and word of mouth loop. It is expected that word of mouth and marketing will have a significant impact on some stages of EPC adoption. Additionally, other feedback loops will be included in model such as the processes of building familiarity and enhancing capabilities in dealing with EPC.

The following phase of the present research will involve the formulation of the equations that determine the rate of potential clients moving along the choice pipeline. Particularly, the time delays involved in each stage of adoption are of great importance in this process. Those equations will consider the factors identified in the qualitative survey that mostly influence the EPC adoption. The quantitative modeling will be based on prior research on the dynamics of the diffusion of innovative services and products.

6. Conclusion

This paper describes the first steps towards the development of a system dynamics model for exploring and learning about the diffusion of EPC. The present research phase focuses on capturing the critical variables and its interrelation to be included in the simulation model. With this purpose, a review of existing literature on factors and barriers facing the EPC industry was performed and relevant primary and secondary data were acquired through informal semi-structured interviews and qualitative content analysis of documents.
Numerous factors and cause-effect relations were identified that affect the adoption of EPC. These variables were analysed and considered in a qualitative modelling process which involved causal and stock-and-flow diagramming. The present phase produced a stock-and-flow diagram as a first qualitative conceptualization of the intent system dynamics model representing the diffusion of EPC at industry level.
Accordingly to the modelling process (Sterman, 2000), the following research phase will focus on the formulation and testing of the system dynamics model. That phase will address the quantitative estimation of parameters, relationships and initial conditions, as well as the test for consistency with the purpose and boundary.

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