EVOLUTION OF BUSINESS MODEL IN RAILWAY INDUSTRY IN THE PRESENCE OF ENERGY MANAGEMENT SYSTEM

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ABSTRACT

The future railway distribution system, expected to follow the evolution of the smart grid, is a large system with huge amount of value flows (e.g. information, electricity, cash) which regarding to new actors and new roles in the system needs new business models. The mapping of some of value flows in both conventional and new business models will be shown in this paper to present a comparison. Similarly, the canvases of one/two main actors have been also given for both models. The business models for both mapping methodology and canvas model methods will be described in the paper. Finally based on one real case study information, cash flow analysis will be presented according to the business model introduced.

INTRODUCTION

Nowadays trains are merely energy consumers, but the tendency is to change towards railways smart grids, where the energy consumption profiles are optimized in real time in coordination with other trains and substations. The development of the railway smart grid is pushing forward a change in the paradigm in the electricity management in railway sector, which enriches interactions among the agents and gives rise to new business models. This business model evolution in railway industry has been developed in the FP7 EU project MERLIN (http://www.merlin-rail.eu/). MERLIN for the first time has proposed, implemented and demonstrated an integrated approach to energy management in railway systems to achieve a more sustainable and optimized energy usage in European electric mainline railways. This implies that energy consumers, producers, and storages are not isolated elements, but players of the global energy game. The proposed energy management system (REM-S) to achieve MERLIN operational objectives has hybrid centralized-decentralized architecture [1]. Given that the generic load "railway system" interacts with the public grid and the electricity market, a similar time framework for the energy optimization is applied in REM-S, encompassing Day-Ahead, Minute-Ahead and Real time operation modes [1].

In conventional railway industry, the involved roles and actors are quite independent, and the value flows among them are normally unidirectional. In order to integrate them in the railway energy management system, the fundamental connection method should be modified to accommodate new partners, such as electricity market operator, and to enable bidirectional value flows among all actors, such as information flow, electricity flow, etc. Therefore, the business activities in the new railway system are expected to differ from the existing business models of the railway industry. Concerning conventional actors in the railway industry remain active, but in REM-S they should be able to communicate and interconnect to one another. In addition, some new roles are introduced by REM-S.

In this paper mapping methodology and business model canvas are used [2-4] to analyze new business models for the railway systems, in presence of the new actors proposed by REM-S. To investigate the business activities in railway industry, a questionnaire prepared by MERLIN researchers was filled out by MERLIN Partners who have different roles in the railway industry e.g. Railway Operator (RO) and Infrastructure Manager (IM). The questionnaire surveys daily operation, relationships, ownership categories, revenue & cost, etc. for different actors in railway industry. The novel business model which will be presented in this paper is based on the gathered information through the questionnaire. After describing both conventional and novel business models, one cash flow analysis will be presented at the following which shows the beneficiary of using the proposed business model.

CONVENTIONAL RAILWAY BUSINESS MODEL

In the conventional business model, the railway market structure simply consists of four main actors:

- Railway Operator (RO);
- Infrastructure Manager (IM);
- Energy Supplier;
- Grid Owner.

Mapping Model

Based on information gathered from MERLIN partners the relationship among railway actors are mapped in Figure 1. In this model, the business values are almost unidirectional flowing. In the electricity market, the energy flows from the energy supplier to its customer, namely the IM, through the access authority from the electricity grid owners. Then the energy flows from the

IM to the RO, as the operation of rolling stocks requires a large amount of electricity. Additionally, during the braking of the train the regenerated energy is flowing back to the electric grid. So the electricity flow between RO & IM is bidirectional. The cash flows in the reverse direction, as the payment for the service or the commodity. The cash also flows from IM and energy supplier to grid owner, as the charge of using the grid.
The flows in Figure 1 are representative of the most common situation in the market today, i.e. the energy supplier delivers electricity to the RO through the IM; however, Directive 2012/34/EC, establishing a single European railway area [5], ensures equitable and non-discriminatory access to infrastructure electrical equipment for all ROs and therefore leads to the opening of the railway market presence of different and many traction current suppliers. This implies the possibility for a RO to buy directly energy from energy suppliers other than the IM.

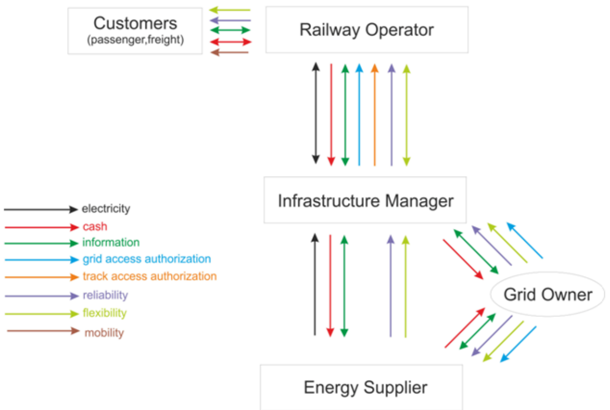

Figure 1: Mapping of Conventional Business Model

Canvas Model

Considering the individual actors in the business model and based on canvas model structure, Figure 2 illustrates the conventional canvas model of IM.
Due to the stationary nature of infrastructure facilities, the customer selects the infrastructure based on the regional demands, as there is only one IM for each region. The service such as track access and electric grid access is usually attained through long-term cooperation, whilst the service such as maintenance and electricity supply is always provided in request. The value proposition to the customer comes from the reliable infrastructure access (track and power), as well as the operation metering information. The reliability is guaranteed by preventive & corrective maintenance service and necessary investment. Therefore, the cost contributions for the IM are recurring cost, such as electricity bill, infrastructure investment, regular maintenance, and other common costs as a company, such as administration cost and assets. Furthermore, the revenue from the customers mainly comes from the sale of energy and access service.

Similar to IM canvas analysis, same analysis has been done for RO. The RO usually possesses both the rolling stocks and the access to the track networks, and its business activity mainly focuses on the transport service. Therefore the most important partner of RO is IM, which offers the infrastructure access. Correspondingly, the cost of RO mainly consists of the payment to this partner, namely the fee for infrastructure access. Other costs like personnel cost, train cost or energy cost are in the next priority.

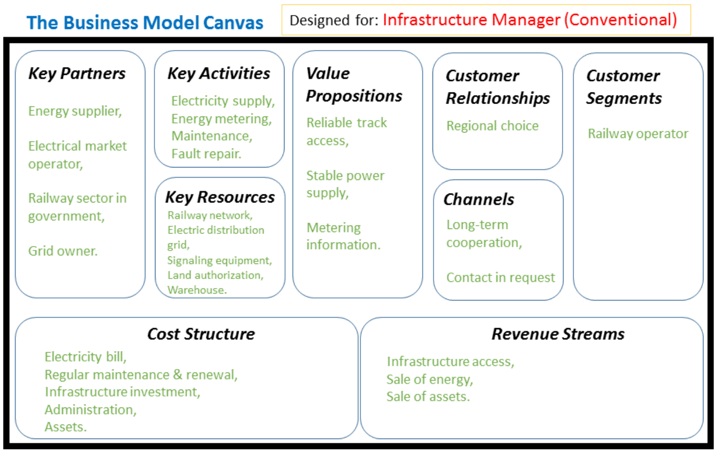

Figure 2: Conventional Canvas Model of IM

NOVEL RAILWAY BUSINESS MODEL (IN THE PRESENCE OF REM-S)

In the novel business model proposed here three main actors (REM-S actors) have been added:

- Electricity Market Operator (EMO)
- Energy Buyer Decision Maker (EBDM)
- Energy Dispatcher

Mapping Model

By introducing the REM-S actors, the novel business model is modified with some new elements, shown in Figure 3.
Compared to the conventional model, the new mapping diagram looks more complex owing to the introduced new role. A new value, efficiency optimization, has been added to the overall mapping. In the conventional business of all companies, almost none of the surveyed partners have any independent department for efficiency improvement. In the proposed model, the optimal efficiency is realized by the sum of the functions carried out by the REM-S.
The values in this model can be both unidirectional and bidirectional. The information flow between the two partners is always mutual transmitting. In the novel model, the feedback electricity from braking energy leads to some new information exchange and a new value flow from RO to IM. To guarantee attaining a sophisticated decision, the RO and the IM offer the

detailed energy planning and the resources´ information. The REM-S actors collect these essential data and figures out the optimal energy purchase solution. Then they inform RO and IM of the optimal efficiency approaches. This efficient operation helps RO and IM to save energy costs, so they pay the REM-S actors for these approaches. Apart from the information communication, the actors may also provide some prize/ punishment as incentives for global optimal operations.

In the view of railway industry, the satisfaction of the customer demand is always the top priority. Introducing novel railway architecture, the values transferring with the customers have not been obviously changed.

In the novel model the electricity can also flow from the IM back to the energy supplier, as the regenerated energy flows from trains through railway infrastructure to the supplier. The information exchange between REM-S actors and energy supplier contributes to the optimal planning of energy purchase. Moreover, the values exchange between energy supplier and RO is existent; nevertheless the electricity always flows through the IM, namely IM is always involved. Besides, the other values, e.g. the information flow and cash flow between RO and energy supplier, can be both linked through EMO and direct connection.

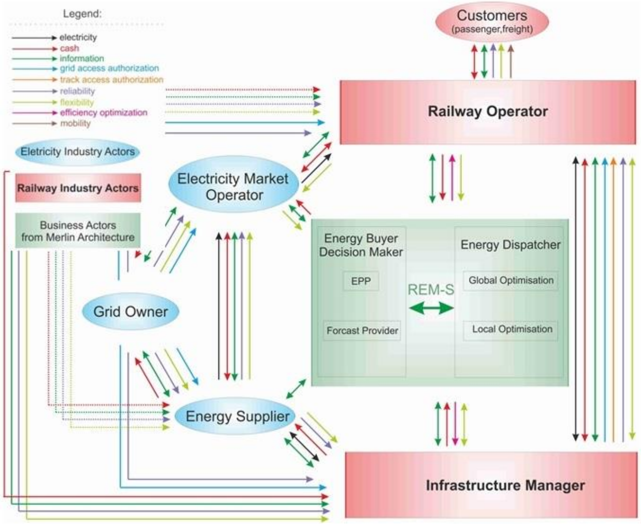

Figure 3: Mapping of Novel Business Model

Canvas Model

Comparing canvas model of IM for conventional model and novel model, the customer segments remain similar. Namely, the RO is the main customer. With central control, the business activities of infrastructure may also be distributed by the central control, which contributes to the global efficiency optimization. Therefore, the Energy Buyer Decision Maker, which sends out the control price commands, becomes a key partner for IM.

In addition, the smart grid technology enables IM to efficiently and economically operate the storage equipment, especially by trading electricity at the peak of consumption profiles. This facility also introduces a new part of revenue for the IM.

At RO novel canvas model, a new customer segment has been introduced: electricity market. The electricity market comes into being due to the liberalization process of energy industry. It can be a customer for RO because of the braking energy feedback from the trains to the electricity market. The central control/distributed control behaves as the channel to reach the customer.

CASH FLOW ANALYSIS

This chapter based on a specific case for which power and energy measurements are available, illustrates the main cash flows related to the novel business model.

For this study case, the following assumptions have been made: (i) REM-S is fully implemented and is able to provide all the features included in MERLIN, allowing the operation to be optimized (energy minimization) and (ii) the two existing railway operators (referred to as RU_1 and RU_2) have deployed the REM-S equipment in part of their fleet (partial adoption). Also, according to the measurements take in the on-field tests conducted in Malaga (commuter railways) overall energy consumption reductions of 11% have been considered due to the action of the REM-S, with no significant changes in the power peaks in the traction substations.

RU_1 buys the energy from the energy supplier1 and RU_2 buys the energy from the IM. RU_1 has been assumed to consume 65% of the total energy consumption, while RU_2 is responsible of the other 35%. The total power term has been distributed among the RUs proportionally to their aggregated power peak. RU_1 and RU_2 have been assumed to have an aggregated power peak of 80% and 60%, respectively, of the total power peak of the infrastructure (1,88MW). The power term included the cost of the contracted power and the extra cost due to exceed it, according to the national regulations in Spain.

RU_1 and RU_2 are assumed to have equipped 80% and 75% of their fleet, respectively. Rest of the trains are assumed non-manageable by the REM-S, which means they cannot respond online to the REM-S instructions.

In this study case, a remuneration (in addition to the existing IM fees for the optimization of the electrical infrastructure) to the IM has been considered by means of a mark-up, which is part of the benefits (costs savings) achieved by the RUs thanks to the smart operation. This mark-up reduces the total saving obtained by the RUs (for instance deducting a percentage from the savings), but is an incentive to the continued improvement of the smart operation systems.

Based on these hypotheses, the economic flows have been calculated (see Figure 4 and Table 1). In Figure 4, the terms PercSpotM1 and PercSpotM2 refer to the percentage of the energy managed by energy suppliers Supp1 and Supp2, respectively, purchased in the electricity market.

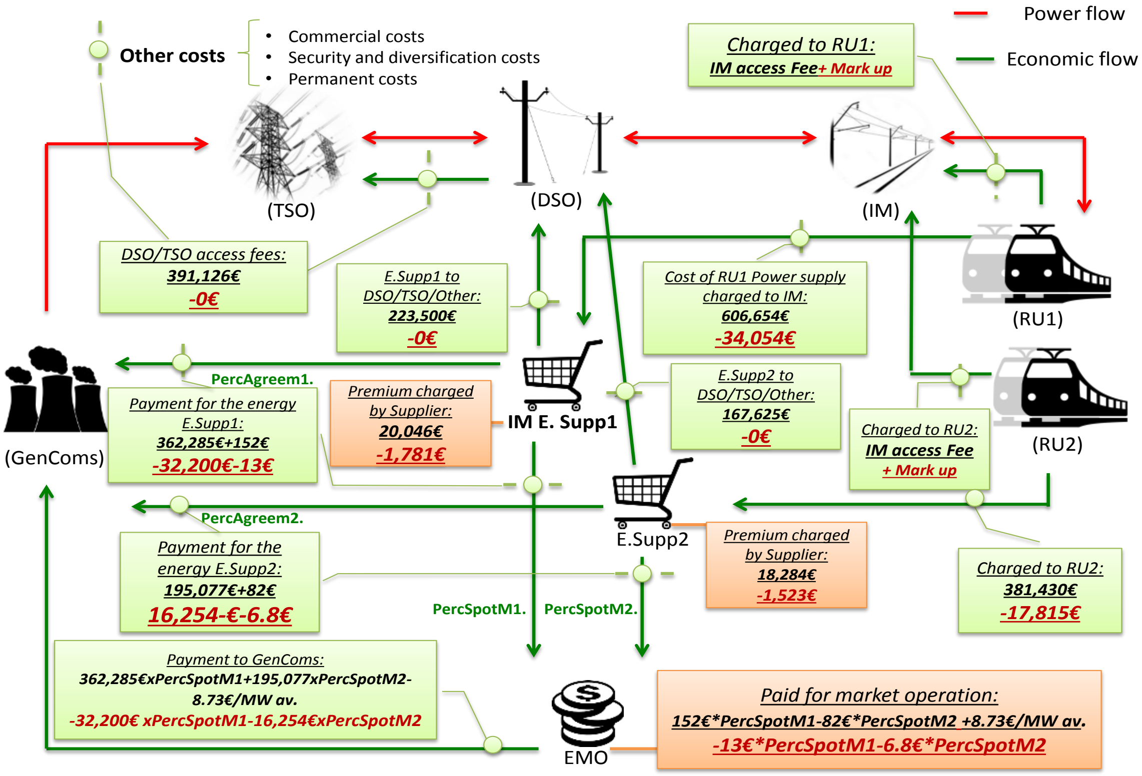

Figure 4: Economic flows in case study

Table 1. Economic flow analysis in this study case

	(€)
Total cost of the energy and power RU1	572.599,6 €
Total cost of the energy and power RU2	363.614,7 €
Cost of the energy consumed by RU1	330.085,9 €
Cost of the energy consumed by RU2	178.822,2 €
Payment form E.Supp1 to DSO/TSO/Others	223.500,9 €
Payment form E.Supp2 to DSO/TSO/Others	167.625,7 €
Premium charged by E.Supp1	18.264,4 €
Premium charged by E.Supp2	16.761,4 €
Payment form E.Supp1 to EMO	138,9 €
Payment form E.Supp2 to EMO	75,2 €

Total savings Case 4	**121.449,8 €**
Percentage of savings (ref. baseline case)	**11,48%**

Overall savings of 11.48% (121,449.8€) are achieved by using REM-S, compared to a baseline scenario (which consists a single operator, no energy supplier apart from the IM and no REM-S used to optimize the operation).

CONCLUSION

At this paper the business model for the railway system under REM-S architecture is identified and visualized. The methodology, business process mapping and business model canvas, have been utilized to reveal the relationship between different actors in the system. This approach enables the decision makers to possess an overall view about how different partners behave together in the same project and how various values are exchanging or flowing between each other. Through business model canvas, the nine blocks outline the key points of all business aspects. This canvas has summarized the model in one diagram, which helps the decision maker to compare different models efficiently. It has also highlighted the modified elements in the new approach.

At the last chapter cash flow analysis has been done at real case study regarding the novel business model described in the presence of REM-S. The analysis shows 11.48% overall savings with the new approach, which is a significant improvement.

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