Testing the integration of political discourses into the socio-technical map of urban mobility

Gerardo Marletto[1*], Chiara Ortolani[2]

[1]*DiSEA and CRENoS – University of Sassari*
[2]*DICEA – University of Rome "La Sapienza"*

Abstract

With this paper we want to verify if the integration of political discourses into the socio-technical map (ST-map) will help to achieve a better understanding of the past, present and future innovation processes affecting the societal function of urban mobility.

We test the modified ST-map in two cases: 1) The revision of the 2030 scenarios of urban mobility that were proposed in Marletto (2014), and 2) The retrospective analysis of the Freiburg (D) case.

The two tests prove that with the integration of political discourses the ST-map improves its ability to represent the dynamics of urban mobility (both past and future). In particular, the modified ST-map shows that there is a mutual dependence between the actual policy approach to urban mobility, and the ability of competing networks of influencing the arena where different political discourses face each other. Moreover, it is apparent that more sustainable practice may eventually emerge only if a new network of innovators is able to scale up a cumulative causation process involving legitimacy, empowerment and supporting policies.

Keywords: Urban mobility; Political discourse; System innovation; Sustainable mobility; Scenario analysis.

1. Introduction

With this paper we want to verify if the integration of political discourses into the socio-technical map (ST-map) will help to achieve a better understanding of the past, present and future dynamics of urban mobility.

The ST-map was proposed by one of us as a graphical tool that – notwithstanding its simplicity – is able to synthesize all relevant information on the innovation of urban mobility (Marletto, 2014): technologies, business models, networks of innovative actors and their strategies. In particular, the ST-map was used: a) to represent the current situation of urban mobility, and b) to envisage three alternative 2030 scenarios ("Auto-city", "Eco-city" and "Electri-city"). The ST-map has also been acknowledged by other scholars as a tool that can help understanding the dynamics of urban mobility (Marx et al., 2015).

In the above paper the relevance of the political dimension of innovation processes was acknowledged; in particular, 2030 scenarios resulted from some "socio-technical

* Corresponding Author: Gerardo Marletto (marletto@uniss.it)

transition pathway" (Geels and Schot, 2007) along which innovative actors sustained the co-evolution of techno-economic and socio-political changes. But no political elements was shown directly in the ST-map, thus hindering a crucial constituent of what should have been understood, that is, the generation of innovations.

We fill such a gap by integrating the political dimension of innovation into the ST-map. In particular, we position all relevant systems and actors of urban mobility also with reference to the prevailing "political discourses" (Hajer, 1995; Hajer and Versteeg, 2005). Indeed, we believe that the concept of political discourse is the best suited to represent how competing networks of innovative actors influence collective meanings and values, public debates, political agendas and, eventually, the generation of actual policies.

We test the modified ST-map in two cases: 1) The revision of the 2030 scenarios of urban mobility, and 2) The analysis of the Freiburg (D) case.

The remaining of the paper is organized as follows: in Section 2 the essential basic concepts of the socio-technical approach to system innovation are presented; in Section 3 we explain in brief how a ST-map can be drawn and how it can be used to build alternative scenarios; in Sections 4 and 5 we deliver the analysis of the two test cases; in Section 6 we offer some conclusions to the reader.

2. The socio-technical approach to system innovation: basic concepts

2.1. Socio-technical systems and their supporting networks of innovators

The seminal book of Frank Geels (2005) is the basic reference to the socio-technical (ST) approach to the analysis of system innovation. In this approach any social function – such as feeding, housing, mobility, supply of energy, healthcare, etc. – is fulfilled by one or more ST systems. Each ST system is a (a more or less) stable configuration consisting of a network of supporting social agents and a structure of material and immaterial constituents (infrastructures, knowledge, rules, financial resources, etc.).

Usually one ST system holds a dominant position, that is, it is very stable and strongly influences the dynamics of the whole social function, and of other stable (but subaltern or residual) ST systems. In particular, dominant positions usually generate path-dependence and lock-in phenomena at the level of the whole societal function which in turn hinder the emergence of new ST systems. Only ST "niches" are partially or totally protected from the selection pressure generated by the dominant ST system. Taking advantage of any kind of barrier (geographical, technological, commercial, institutional), ST niches are essential for the incubation and experimentation of innovations, and for the gradual structuring and empowerment of a new ST system. Before that possibly happens, ST niches feature – by definition – low levels of both stability and power (Schot and Geels, 2007; Smith and Raven, 2012).

As stated above, a network of supporting social agents is a relevant constituent of a ST system. These social agents must be considered as innovators whenever they are interested in changing the ST system they belong to. Even when a ST system is defending its dominant position through innovation its supporting actors – also called "core actors" (Smith et al., 2005) – must be considered as innovators. Social agents that are interested into the emergence of a new ST system should always be considered as innovators; these innovators – often starting their activities in ST niches – are also called "enactors" (Suurs et al., 2010). Networks of innovators contribute not only to technological or commercial novelties, but also to changes taking place in the political dimension of a social function.

There is a strict relation between agents' power and their ability to generate effective political innovations. In particular, core actors of a dominant ST system feature high levels of power and legitimacy and they are able to use their endowments to influence the dynamics of politics and policy. On the contrary, enactors must scale up a cumulative process between empowerment, legitimation and networking in order to gain a stable role into the public debate and possibly to influence the direction of change of agendas and actual policies (Avelino and Rotmans, 2009). This is why some scholars describes the competition between networks of dominant core-actors and networks of enactors as a "battle over institutions" or – in order to stress that social agents' interests and political narratives are entrenched – as a "battle over discourses" (Hekkert et al., 2007; Kern, 2011).

It is also apparent that the whole "demography" of networks of innovators is relevant to understand the dynamics of a social function: the creation of a new network from scratch; an individual agent joining a network or migrating from a network to another; the merging, splitting and re-assortment of networks; etc.. Inter alia, all the above implies that the dynamics of a social function is generated by both cooperative and competition mechanisms, taking place within and between networks of innovators, respectively.

2.2. The political dimension of transition pathways: adaptation vs take-over

The dynamics of ST systems may be grouped into two large families: the adaptation of a dominant ST system and the establishment of a new dominant position. Niches play a relevant role in both kinds of dynamics: in the case of adaptation, niches may cluster with the dominant ST system; in the case of the establishment of a new dominant position, niches contribute to threaten the dominant ST system and possibly take it over.

Geels and Schot (2007) have provided a typology of ST transition pathways in which the role of innovators is explicitly considered. Haxeltine et al. (2008) explain such a typology in terms of "transformative mechanisms" that allow innovators to have access to new material and immaterial endowments through the creation or reconfiguration of their networks. As shown in Table 1, four transition pathways can be considered.

In the case of the adaptation of a dominant ST system the economic and technological dimension of the ST transition pathway are more relevant: innovators who are able to implement commercial and technological innovations are the main drivers of change. The political dimension is less relevant, yet active. Core actors of the dominant ST system invest their endowments: a) to keep gaining support (or a weak pressure) from the dominant approach to policy, and b) to counteract the voice of enactors and core actors of other ST system into the public debate. If necessary, the dominant network may try to absorb some opposing or competing social agents in order to: benefit from their pressure for innovation; weaken their potential disruptive effects; and avoid the risk that they coalesce with others (Walker, 2000).

The political dimension of the ST transition pathway becomes more relevant than the economic and technological ones when a dominant position is taken over. The emergence of a new – and potentially dominant – network of innovators results from a cumulative process that may be triggered by one or more of the following factors: the migration of a stable ST system from another societal function; the coalescing of many niches and subaltern ST systems; the increasing empowerment of a ST system that –

after reaching a dominant position in a single location – migrates to other geographical areas. With the exception of the former case, techno-economic innovators may not have a leading role since the beginning: only when business opportunities become apparent they start playing a more active role. In all other cases grassroots political innovators play a relevant role, especially in the starting steps of the transition. Afterwards, socio-political and techno-economic enactors realize that their actions and goals are consistent and may be coordinated; this why a network of innovators is gradually created that is able to scale up the cumulative causation process between the enlistment of an increasing number of members and the growing influence on political institutions. At the beginning of this process political legitimation is the main target, then explicit advocacy and direct lobbying become more and more important, also with the purpose to destabilize the existing dominant position. Before achieving durable credibility and a stable influence on agendas, formal norms and policies, the emerging network must be able to affect shared cultures, political discourses and ideas, and informal rules. When successful, the ST transition pathway reaches a tipping point and ends up with the whole societal function locked in a new ST system, whose dominant position is supported by new dominant policies.

Table 1: Socio-technical transition pathways: an overview.

	Adaptation of the dominant ST system		*Creation of a new dominant position (takeover)*	
Transition pathway	Transformation	Reconfiguration	Substitution	De-alignment and re-alignment
Innovators' main strategy	Core actors react to external pressures	Integration of new actors into the supporting network of innovators	Core actors of other ST systems take over and change the dominant ST system	A network of enactors establishes a new ST system while the dominant ST system is destabilized by external pressures
Main transformative mechanisms	Internal adjustment and maintenance	Absorption of new actors	Competition between the dominant ST system and a new ST system	Clustering and empowering of niches and subaltern systems

Source: Adapted from Geels and Schot (2007) and Haxeltine et al. (2008).

3. From a socio-technical map to alternative scenarios

3.1. How to build a socio-technical map in four steps

Step 1 – Determine what is the field of analysis

The socio-technical (ST) analysis of system innovations applies to societal functions, such as feeding, housing, mobility, etc.. It is just at such an overall level that societal changes generated by system innovations can be more easily analyzed and understood. In particular, all relevant political changes that make a transition pathway viable take place at the level of societal functions (if not at the level of the whole society). When a ST-map is applied to societal sub-functions its analytic potential is reduced; in these cases it is apparent the risk to focus on techno-economic innovations, while political changes are mostly considered exogenous (Marletto et al., in press).

Societal functions – and all systems and niches that provide it – usually reproduce on multiple scales, that is, simultaneously at the global, national and local level. Moreover, the dynamics at different scales may show some misalignment. The ST-map is able to represent such a space complexity by combining the global picture with national/local specificities (see below, Step 2). Moreover, the ST- map can also be used to analyze how a societal function changes in a specific local area: these very local ST-maps are useful to understand why local configurations (dominant positions; systems and niches; policies; etc.) differ from global ones.

<u>Step 2 – Identify the relevant systems and niches and their networks of innovators</u>

Once determined which is the societal function to be analyzed, it is usually easy to identify all systems that contribute to its provision, and – for each of them – who are the main members of their supporting network of innovators. It must be remembered that innovators can be: Authorities, companies, other organizations (such as political or trade associations), grassroots movements, media, etc..

The dominant system (if any), other systems, and niches are represented differently into the ST-map.

Also local systems and niches – when relevant – can be represented in a specific way. In this case the graphical representation of their supporting network of innovators is lost, and this information must be given in the accompanying text.

<u>Step 3 – Draw the two dimensions of the ST-map</u>

The ST-map is framed by two dimensions.

Dimension 1 represents the relevant political discourses on sustainability, that is, how the current and future sustainability of the analyzed societal function is interpreted by innovators. The standard articulation of sustainability in its environmental, social and economic constituents should be remembered when looking for political discourses. Political discourses may be represented in the ST-map with a claim in order to make them more understandable to the reader.

Dimension 2 of the ST-map represents the techno-economic competences that are leveraged by innovators to promote change. Such competences may refer either to business or productive models. In other cases, technologies may be considered.

<u>Step 4 – Position systems, niches (and the dominant policy) into the ST-map</u>

Systems and niches previously identified can now be positioned with reference to the two dimensions of the ST-map. Such a positioning represents to which political discourse and to which techno-economic competence mostly refers the network of innovators of any given system or niche. Systems and niches may be unequivocally centered on one political discourse and on one techno-economic competence, or they; instead, they may refer to two (or more) political discourses and techno-economic competences.

Also the dominant policy can be represented into the ST-map. Its positioning must be interpreted as that of systems and niches. It must be stressed that when the dominant policy is inside a system (usually the dominant one) that means that a networks of innovators has been able to influence (and possibly to “capture”) the political dimension of the whole societal function.

3.2. From maps to transitions

The ST-map can be used to represent either the current situation of a societal function or its prospective or retrospective dynamics. In the latter case the history of a societal function can be represented through a sequence of ST-maps, each referring to a single moment of (relative) stability of the societal function.

Things are more complex when ST-maps are used to envisage the future evolution of a societal function. In these cases, the analysis of the current potential for change is used to build (usually more than one) scenario. Consistently with the ST approach to system innovation, such a potential is to be found in those ongoing techno-economic and political changes that can trigger and make viable the 'demography' of systems and their supportive networks. In particular, the result of the transition from current to future settings of the analyzed societal function can be represented in the ST-map as:

- the shift of existing systems and niches,
- the empowering of niches becoming systems,
- the empowering of systems becoming dominant,
- the disappearing of existing niches and systems,
- the destabilization (and possible disappearing) of dominant systems,
- the emergence of new niches and systems (possibly reaching a dominant position),
- the disappearing or emergence of a dominant policy,
- the entering of systems from outside the societal function,
- the absorption of new members in a network of innovators (possibly coming from other systems or societal functions),
- the clustering of (either existing or new) systems and niches.

4. Test 1: urban mobility from the current situation to 2030 alternative scenarios

4.1. The current situation of urban mobility

<u>Systems of urban mobility</u>

The individual car is largely acknowledged as the dominant ST system of urban mobility, not only for its striking share of the mobility market (more than 80% of total journeys in all developed countries, and an ever increasing modal share in emerging economies), as for the ability of its supporting network (where big global automotive and oil companies are the main core-actors) to influence institutions, policies and the society as a whole (Marletto, 2011).

Public transport systems are usually considered as subaltern to the individual car system, because of low modal share (often less than 10% of total mobility) and limited influence on national policies. Even if with some relevant exceptions (see below) public transport remains associated to the image of "transport for the poor" (Dennis and Urry, 2009). The most relevant actors in the supporting networks of these systems are local: public transport companies, and urban and regional Authorities. At the urban and regional level these systems are usually able to obtain a significant amount of public resources which are used to build dedicated infrastructures and subsidize services.

The bicycle is the other subaltern – if not marginal – system of urban mobility: in Northern America, Europe and Australia its average share of trips is negligible, that is, around 2%. Starting from the mid-70s the bicycle has experienced a revival supported by local and national coalitions of public actors and grassroots movements, both aiming at higher level of users' health, urban livability and environmental quality. In some countries these coalitions have been able to gain an influence on national policies too: in The Netherlands, Denmark and Germany more than 10% of today mobility is assured by bicycles, and in some pro-bike cities of these countries bicycles serve more than 25% of total trips (Pucher and Buehler, 2008).

Sharing schemes are a multitude of niches and systems which provide members with access to a vehicle for short-term useSharing has experienced a rapid extension from cars to bicycles, with the Parisian "Velib" bike-sharing scheme as the most relevant example. Worldwide the most recent figures count more than 1,000 cities hosting a bike-sharing scheme (with around 1.25 million bicycles) and almost five millions carsharing[1] members (with more than 100,000 vehicles) (MetroBike, 2016; Shaheen and Cohen, 2016). It must be stressed that most of the pioneering experiences of carsharing were initially supported by non-profit actors (e.g., ShareCom in Switzerland – then merged in Mobility – and Cambio in Germany) and then evolved into commercial initiatives.

In several world urban areas successful local niches and systems of integrated mobility have generated a reduction of the use of individual cars down to 40% of total mobility (or less). In this areas, all alternatives to the individual car – public transport, sharing schemes, "soft mobility" (that is, bicycles+pedestrians) – are integrated by hard and soft measures of urban planning and transport policy. Examples of already established systems of this kind can be found in some capital cities too, such as Amsterdam, Bogotà, Copenhagen, Paris, Stockholm.

Discourses on (sustainable) urban mobility

Today urban mobility is considered unsustainable because of its negative environmental, social and economic impacts. Most of these negative impacts are associated to the use of cars as an individual mean of urban mobility; this is why the political debate on the sustainability of urban mobility is mostly centered on the (excessive) use of cars in urban areas. And it is just the car that stays center stage of one of the political discourses on urban mobility: 'Mobility as a driver of development' (or 'Modernization'). Indeed, the car is considered as a driver of positive impacts: because of the huge investments and jobs it brings along, and because it bestows to all individuals the privilege of free circulation that used to be the privilege of the rich.

Also another political discourse on urban mobility mostly focuses on the car, in particular on its negative impacts: 'Mobility as a generator of harmful impacts' (or 'Sustainability'). In this case the attention is towards all actions that can reduce the negative impacts generated by urban mobility, and in particular by the excessive use of individual (internal combustion) cars.

A further political discourse on urban mobility actually derives from a wider debate on urban planning: 'Mobility as a determinant of the quality of urban spaces' (or 'Urban livability'). The organization of urban space has changed since motorization diffused in cities: what was freely accessible it has been strictly regulated; what was a living space, it has become a transport infrastructure. As a result the quality of urban spaces has worsened. This is why a worldwide movement reclaiming quality urban spaces also aims at limiting or banning motorized traffic – in particular in residential areas – and at promoting non-motorized mobility (e.g., through pedestrian areas, traffic calming measures, car-free neighborhoods, paths reserved to pedestrians and bicycles, etc.).

[1] In the UK carsharing schemes are known as 'car clubs' and carsharing is a synonymous of car pooling, i.e. the shared use of a car owned by one of the travelers.

The last political discourse we consider here is also the oldest one: ‘Mobility as a right’ (or 'Welfarism'). Today the public provision and subsidization of collective transport services is diffused worldwide. This is the result of a process that started at the beginning of the last century in European and Northern America cities, where public transit systems were realized in order to ensure to all citizens the right to mobility. These urban transport services were (and still are) considered as a constituent of the welfare state, and as such they have been involved in the more recent debate on the privatization and liberalization of public utilities, but with more limited changes than in other sectors (e.g., energy and telecom).

These discourses are not completely independent of each other. Because of the diffusion of individual cars in developed and emerging countries, the political discourse of ‘Welfarism’ has become less and less relevant: for only a marginal share of urban residents public transport is the only alternative to get around. Also because of this change, public transit is more and more viewed as a mean to aim at urban sustainability and livability. Moreover, the discourses of ‘Sustainability’ and ‘Urban livability’ feature a large overlapping, in particular because urban areas where motorized traffic is banned or limited, are also areas with reduced level of air pollution, accidents and noise. Also the discourses of ‘Sustainability’ and ‘Development’ partially overlaps, but only when actions for sustainable urban transport incorporate huge investments and jobs. This is not the case of actions for ‘Urban livability’ that are mostly realized through soft measures.

The socio-technical map of today's urban mobility

All the elements that are considered relevant for the reproduction of the societal function of urban mobility are represented in the following ST-map (Figure 1). The ST-map of urban mobility does not refer to a specific urban situation; on the contrary, an explicit attempt is made to deliver an analysis representing all the (both global and local) dynamics that are relevant at a global scale.

The ST-map of urban mobility is based on two dimensions:

- Discourses on urban mobility described above are listed along the horizontal dimension;
- Business models are listed along the vertical dimension. Three typologies are considered (from bottom to top): 'Sell vehicles'; 'Rent vehicles'; 'Manage transport systems'.

The positioning of ST systems and niches of urban mobility with respect to such two dimensions reflects the relevant knowledge that ST systems and niches of urban mobility leverage in order to foster technological, organizational and political innovations.

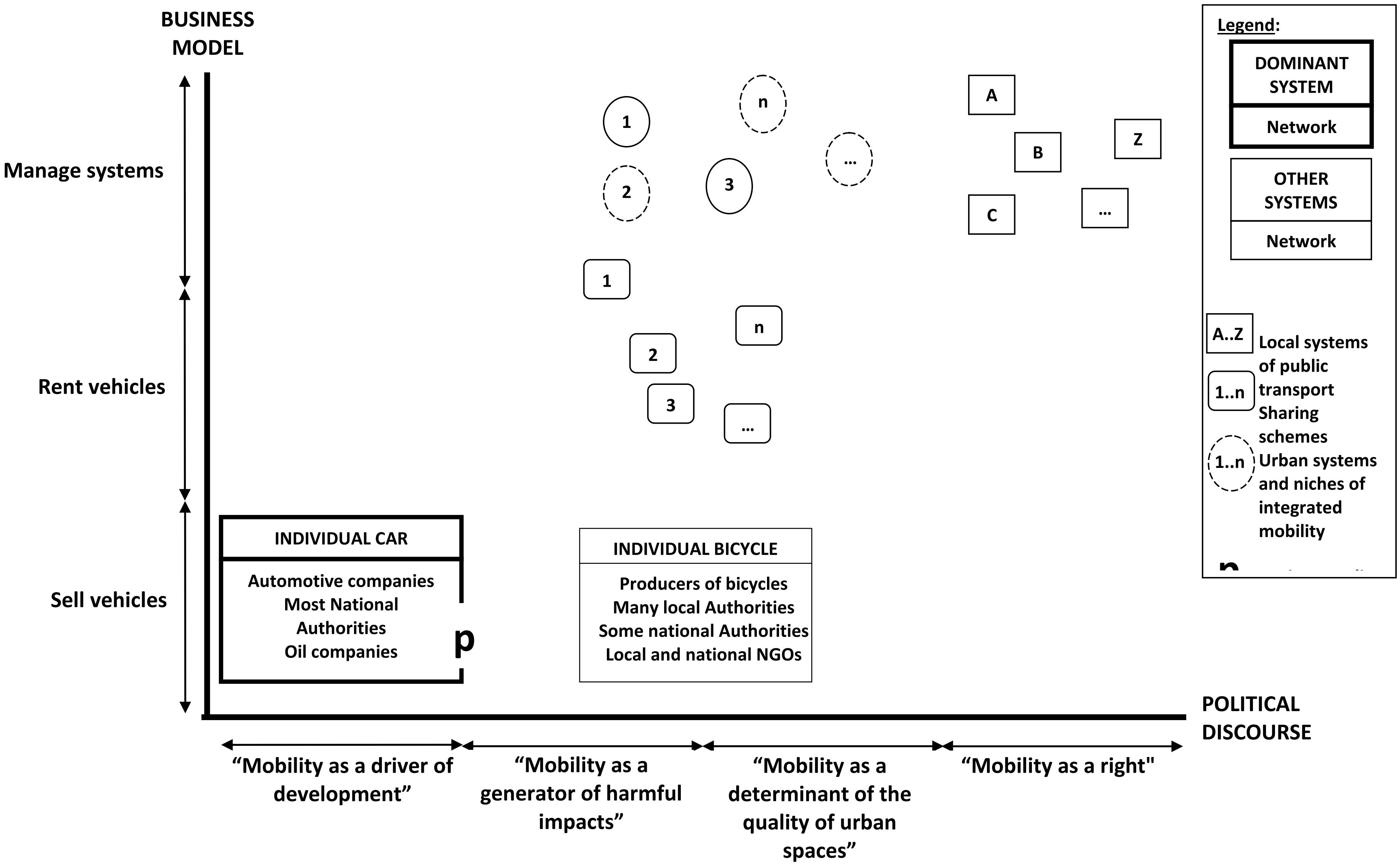

Figure 1: The socio-technical map of urban mobility: current situation.

4.2. The future of urban mobility: auto-city, eco-city or electri-city?

The potential for change

The societal function of urban mobility as a whole is under the pressure of a twofold quest for global sustainability and urban livability.

Starting from its dominant position, the 'individual car' system is already looking for an effective answer to such demand for change. Innovation strategies refer to: more efficient internal combustion; downsizing; “hybridization”; full electric propulsion; carsharing; vehicle-to-grid (V2G). Producers of batteries – and other electric and electronic components – play a more and more relevant role in the trajectory of electrification (Orsato et al., 2012; Wells et al., 2012; OECD et al., 2014). Most of these innovation are supported by national policies for “ecological” cars.

Another relevant endogenous dynamic refers to the increasing number of cities where a transition to a new system of integrated mobility is gaining ground, or even – in the most dynamic areas – is already accomplished. This is mainly the result of the ability of local networks of innovators to influence the urban policy arena, by fostering a new political discourse that hybridize sustainability and urban livability issues, and by obtaining a radical change in actual policies. A not secondary constituent of this political process is the involvement of public transport that moves away from the political discourse of 'mobility as a right'. In some cases (e.g., Netherlands, Switzerland) these innovators has gained political legitimacy at the national level too.

The last – but highly relevant – potential for change is coming from the entry of electric operators (producers of electricity and managers of electric grids) into the societal function of urban mobility. These actors already feature high level of competences, resources and legitimacy; in particular, they are able to found their actions on a successful hybridization of the political discourses of 'modernization' and 'sustainability'.

Also the actors involved in the development of a full self-driving car should be considered (Lari et al., 2015).

Specific transition pathways will be triggered and deployed if one or another of the above potential for changes will prevail.

Transition pathway to scenario 1 – ‘Auto-city’

This first transition pathway emerges from the reconfiguration of the existing ‘individual car’ dominant system and is generated by the absorption of new industrial actors, in particular producers of batteries, that may bring along the crucial competence to develop the electric car and to respond to shift of dominant policies from 'modernization' to 'sustainability' and 'urban livability'. (Elzen et al., 2004; Dennis and Urry, 2009). At the same time oil companies should lose their position as a core-actor or eventually change their core-business, while managers of electric grids may enter the coalition supporting the system.

Along the transition pathway the business model remains focused on selling cars to individual consumers, but – if also carsharing schemes are steadily integrated – it could be extended to the 'rent' option too.

If one looks at a likely ending-point of this first transition pathway (see Figure 2) the ‘individual car’ system keeps its dominant position on urban mobility.

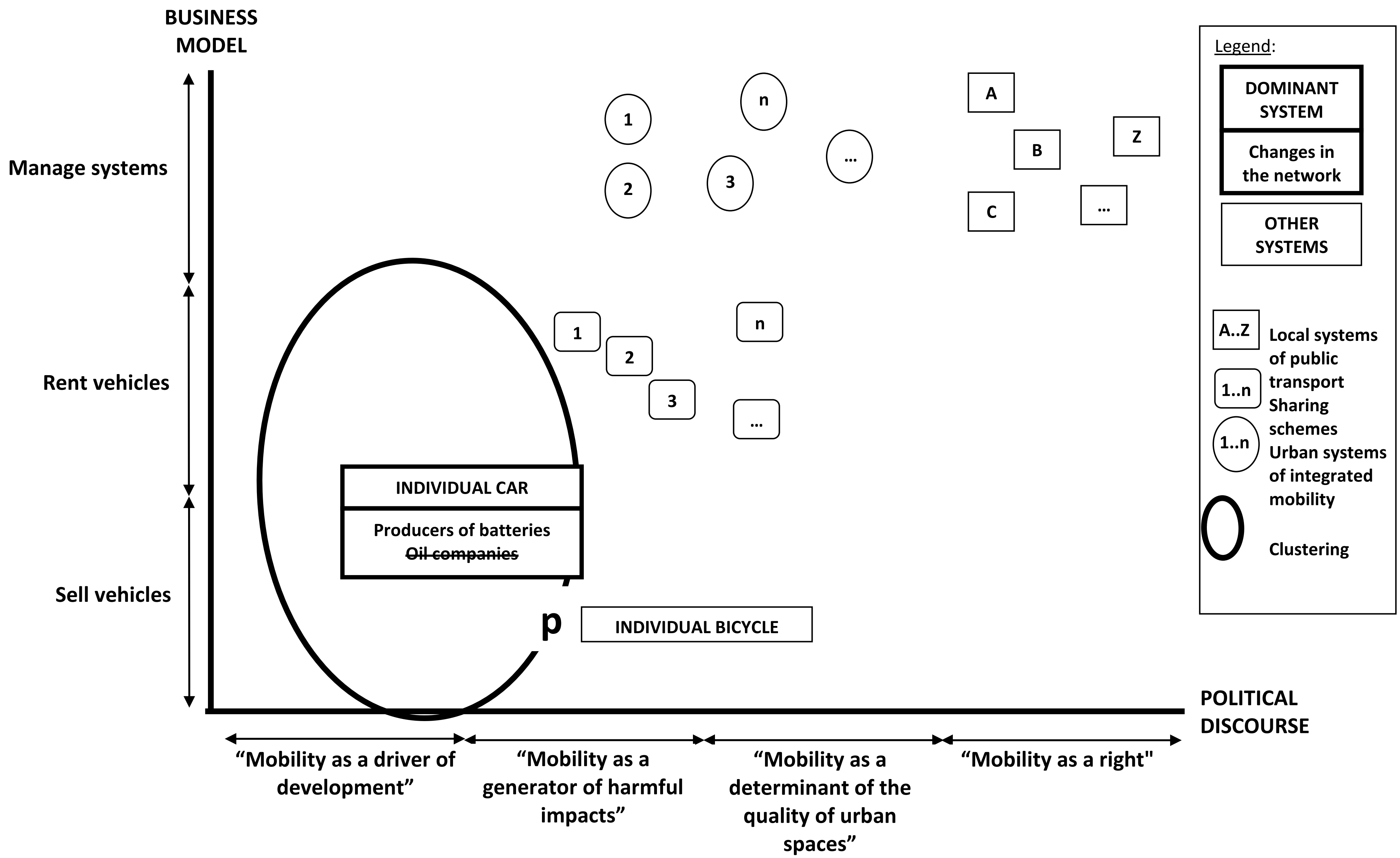

Figure 2 – The socio-technical map of urban mobility: 2030 'Auto-city' scenario

Transition pathway to scenario 2 – ‘Eco-city’

In this transition pathway coalitions of urban networks support a new political discourse of urban mobility and foster the creation of new urban systems of integrated mobility (Vergragt and Brown, 2007). Along the pathway the main transformative mechanism in place is the clustering – first locally and then nationally – of existing and emerging niches and systems of mobility. In particular: more and more local public transport systems move away from the political discourse of 'mobility as a right', and the individual bicycle system gradually moves from the 'sell' to 'rent' business model. Producers of EVs are gradually absorbed into the system, mostly as suppliers of all kind of vehicles for sharing schemes and fleet operators; providers of ICT devices for individual transport planning are absorbed too (Dijk et al., 2013). Moreover, Google – or other non-automotive producers of self-driving cars – may enter this new network as providers of new (fully floating) carsharing schemes.

Figure 3 represents the ending point of this transition. In 2030 stable national coalitions of local networks support the reproduction of urban systems of integrated mobility, while the individual car is in a subordinate position, supported by the few surviving world automotive companies.

Transition pathway to scenario 3 – ‘Electri-city’

In this transition pathway local and national electric operators are interested in the adaptation of their systems to the diffusion of EVs, because they aim at the new frontier of smart grids (SGs). SGs are able to exchange electricity with distributed energy resources, also in order to increase grid stability and reduce demand-supply unbalances, in particular in the case of renewable sources (Mullan et al., 2012).

The positive results of first local tests fuel the interest of operators coming from different sectors: not only managers of electric grids, but also producers of batteries, suppliers of ICT components and – last but not least – producers of plug-in cars. Also as a result of the increasing pressures of all these operators on political institutions, national schemes to support SG+EV systems are implemented in several countries (Leurent and Windisch, 2011). Moreover, already established purchase subsidies are restricted to plug-in electric cars only and are integrated with investments on old and new infrastructures (e.g., metropolitan railway networks and SGs).

The final scenario emerging from this transition pathway is represented in Figure 4. This is the result of a successful “takeover bid” on the ‘individual car’ system which is launched by enactors (then core-actors) coming from another societal function.

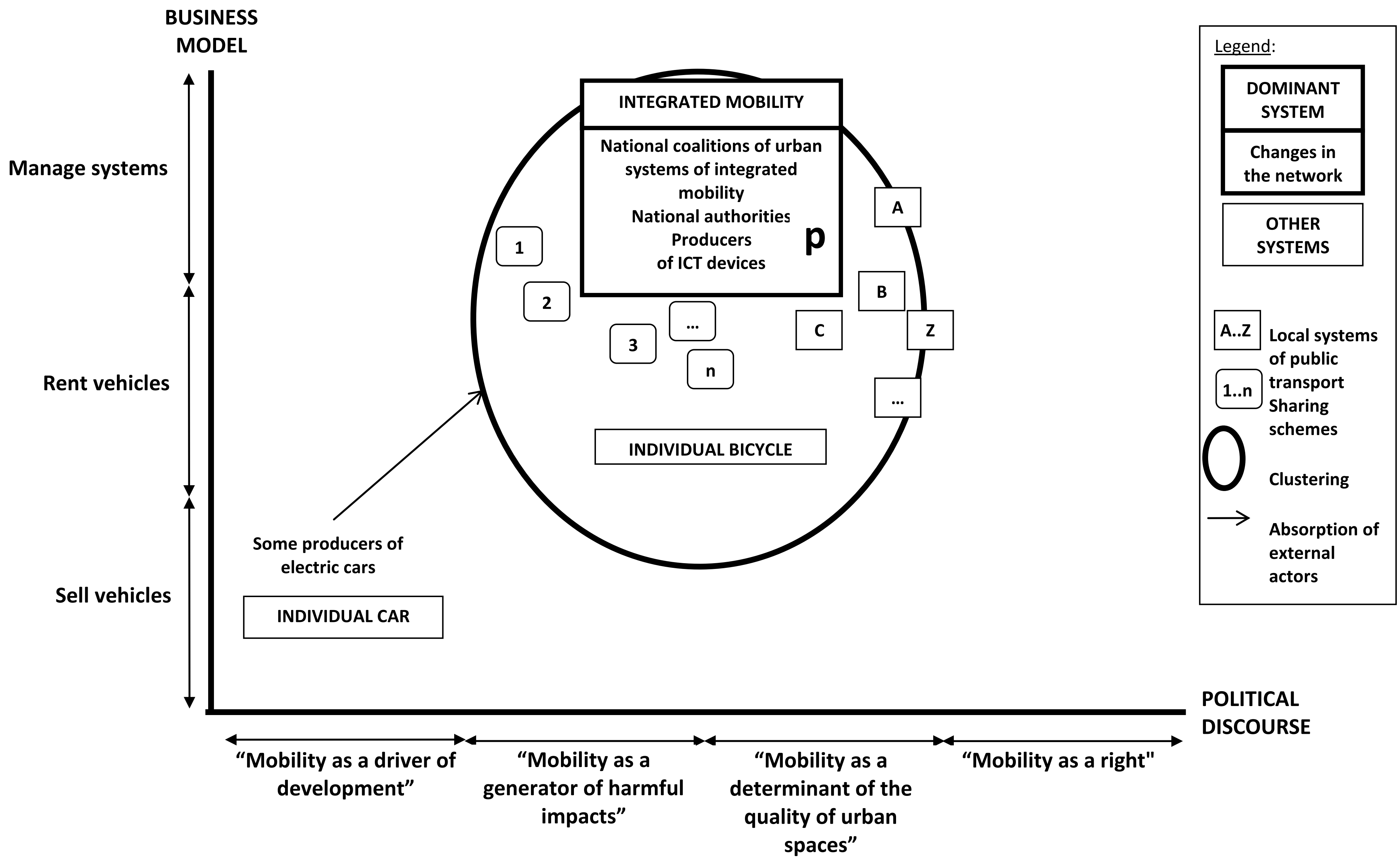

Figure 3 – The socio-technical map of urban mobility: 2030 'Eco-city' scenario

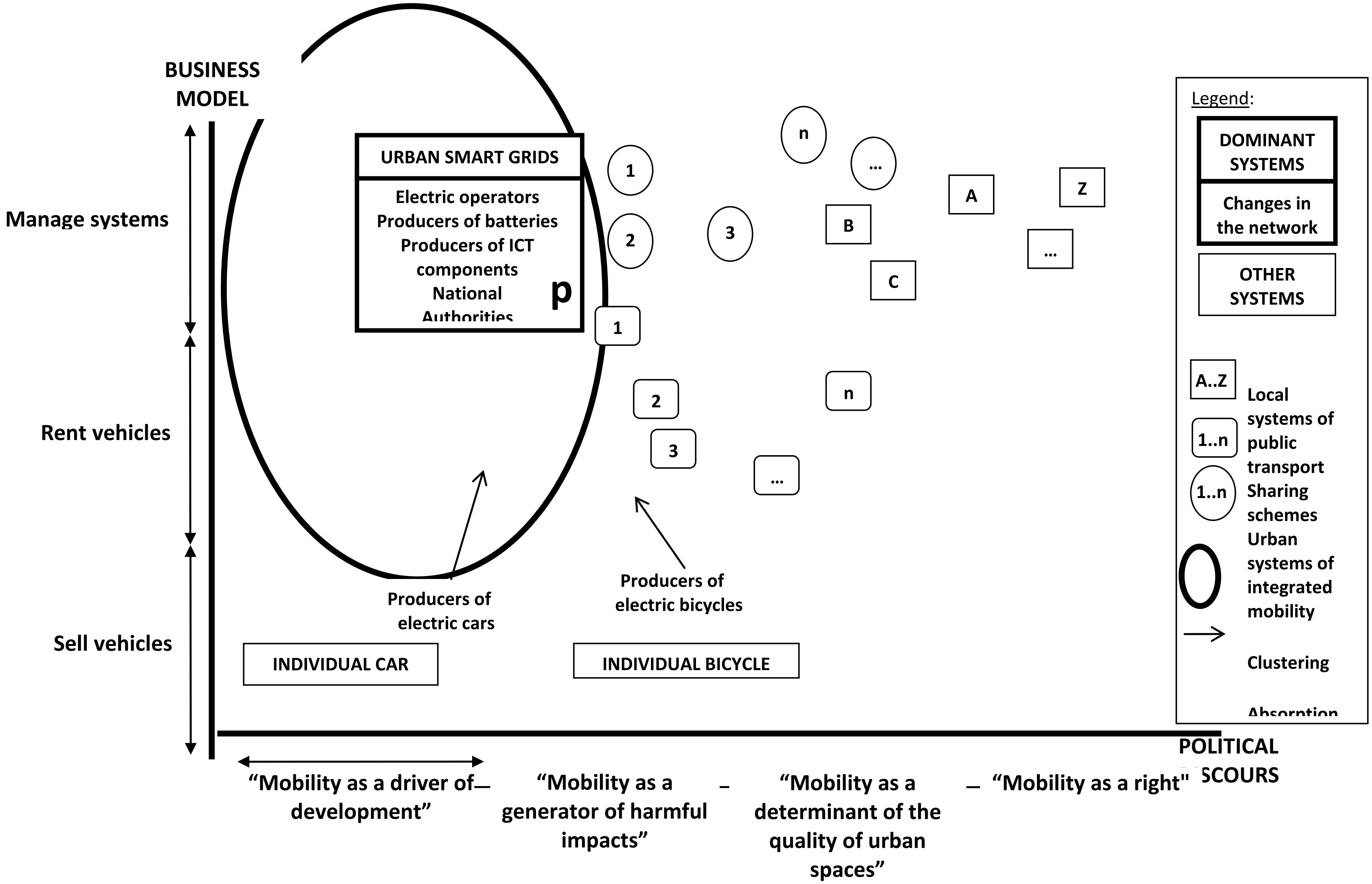

Figure 4 – The socio-technical map of urban mobility: 2030 ‘Electri-city’ scenario

5. Test 2: Freiburg from ‘Auto-city’ to ‘City of short distances’ (1945-2010)

Freiburg is a city of 153.06 km^2 of extension including a 40% of forests. It is located in the southwest of Germany, at the edge of the Black Forest and a few kilometers from France and Switzerland. Freiburg has 225,000 inhabitants, including 30,000 students; its District has 650,000 inhabitants (Haag, 2013). Approximately 95,000 people work in Freiburg and 65% of workers use the cars to move to or from the city (Beim and Haag, 2010; 2003 data). The city has experienced over the years, a systematic growth of both outbound and inbound commuters. The city also attracts about 3 million tourists per year.

Freiburg is quite flat and there are no significant barriers to cycling and to the operation of a tram network. Since 1990 Freiburg stopped following the same increasing pattern of car use of Germany and the USA; as a result, the modal shares of public transport and cycling have increased (Table 2). This transition will be analysed with a sequence of ST-maps, each representing a significant historical moment of the mobility system of Freiburg.

Table 2 - Modal split of urban mobility in the city of Freiburg

Year	*Walking*	*Cycling*	*Public transport*	*Car (drivers)*	*Car (passengers)*
1982	35%	15%	11%	30%	9%
1989	24%	21%	18%	29%	7%
1999	24%	28%	18%	24%	6%
2001	24%	28%	18%	30%	

Source: Banister, 2005; Beim & Haag, 2010; Freiburg City Council, 1999

5.1. The growth of motorization (1945-1969)

We can find the basis for the transition pathway of Freiburg in a series of subsequent events beginning at the end of World War II. In 1944 the 80% of Freiburg was destroyed by an air raid. The reconstruction began in 1947: all destroyed areas were rebuilt by following the principles of continuity with the past, and quality. Policies also promoted the use of private cars. Even if the traditional materials and design of buildings and medieval irregular narrow streets were maintained, the old historic squares were transformed in parking lots and a direct connection between the Autobahn and the city center was built. In 1949 in Freiburg there were only five small streets in the city center where the car could not enter; walkability was not considered as a constituent of the urban mobility system; pedestrians were not considered by policies. (Crowhurst Lennard and Lennard, 1995; Buehler and Pucher, 2011; Medearis and Daseking, 2012; Kelemen R. D., 2015)

Furthermore, after the end of the World War II, the *Wirtschaftswunder* (economic miracle) occurred: inflation was low and there was a rapid industrial growth. In this context, the population of Freiburg grew and it was necessary to build new settlements at the borders of the existing old city. As well as throughout Europe and the USA, the Freiburg 1955 Land Use Plan focused on the urban expansion made possible by the use of private cars. New settlements were characterized by large streets and parking lots. At the same time, tram lines were progressively abandoned and buses (though less efficient) were preferred. As a result, public transport was less and less important and –

as the ST-map of 1969 shows – it no longer represented the dominant transport system (Figure 5). At the same time, car ownership and use increased: in 1950, in Freiburg there were much more cars and light trucks than in West Germany (28 vs 18 per 1,000 inhabitants, respectively); from 1950 to 1970, air pollution, traffic fatalities, and traffic congestion increased. (Pucher and Clorer, 1992; Buehler and Pucher, 2011; Kelemen, 2015)

5.2. The change begins (1970-1979)

At the end of the 60's a change of direction affected Freiburg transport policies. The second Land Use Plan was never approved. It was car-oriented as the first: just for this reason a long debate among citizens, council members and administrations took place. In the 70's, it was finally shelved (Buehler and Pucher , 2011). As a result, the city of Freiburg – unlike most other German cities – has never destroyed the historic center to improve the accessibility of cars: the modernist phase did not leave its strong footprint in the planning of urban structure (Beim and Haag, 2010).

The first Integral Traffic Plan was drafted in 1969. In this plan, even if the dominant system of transportation was the individual car (Figure 6), the needs of non-motorized inhabitants were respected. Another step into the direction of the 'Eco-city' model occurred in 1971: the Network of Cycling Routes Plan was drawn up and approved by the City Council. Since this first step cycling increased its importance in Freiburg transport policy. In 1972, Freiburg municipality decided to maintain and expand the tram network; this action was based on modern concepts: separate tracks, priority traffic light junctions, a higher average speed. In 1973, the Freiburg city center has been transformed into a pedestrian area. This urban intervention helped to develop a new urban culture characterized by two elements: the preservation of the old town and the increase of cycling and walking. (Beim and Haag, 2010).

The opening to pedestrian and cycling mobility, and public transport was due to several environmental and social problems caused directly by the car-based system. In addition, two events (the building of nuclear power plants and the 1973 oil crisis) brought public opinion to look with interest to the energy matter and to take side in a strong way in favour of a reduction of energy consumption in all sectors. In this context, the policies based on land use change and car-oriented urban transport no longer found a wide consensus. Furthermore, the participatory and inclusive model at the base of the struggle of Freiburg citizens fight against the nearby Wyhl nuclear power plant had an overall influence on local political practices; in particular, the City adopted a policy approach based on collective discussion where citizens may take part in collective decisions. A very important role was played by the interaction between students and large organizations such as the Chamber of Commerce. (Patterson, 1986; Bratzel 1999; Karapin, 2007; Beim and Haag, 2010).

In 1979 the Second Integral Traffic Plan was drafted and approved by the City Council. In this plan, unlike the previous one, pedestrians, bicycles and public transport had the same importance as individual cars, but still they were not considered as parts of an integrated system of urban mobility (Beim and Haag, 2010). This is why in the 1979 ST-map there is no dominant policy (Figure 6).

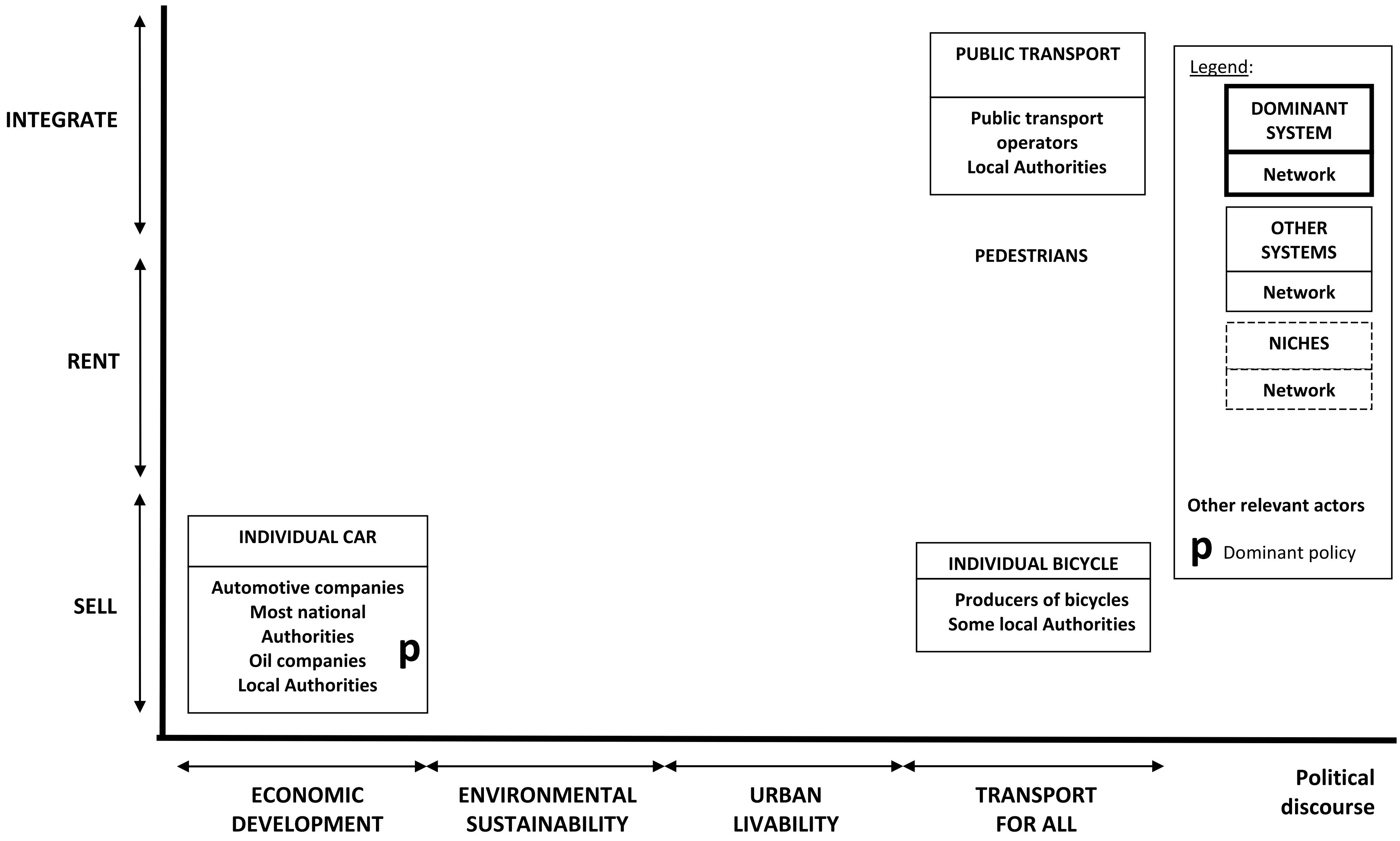

Figure 5 - The socio-technical map of the 1969 Freiburg mobility system

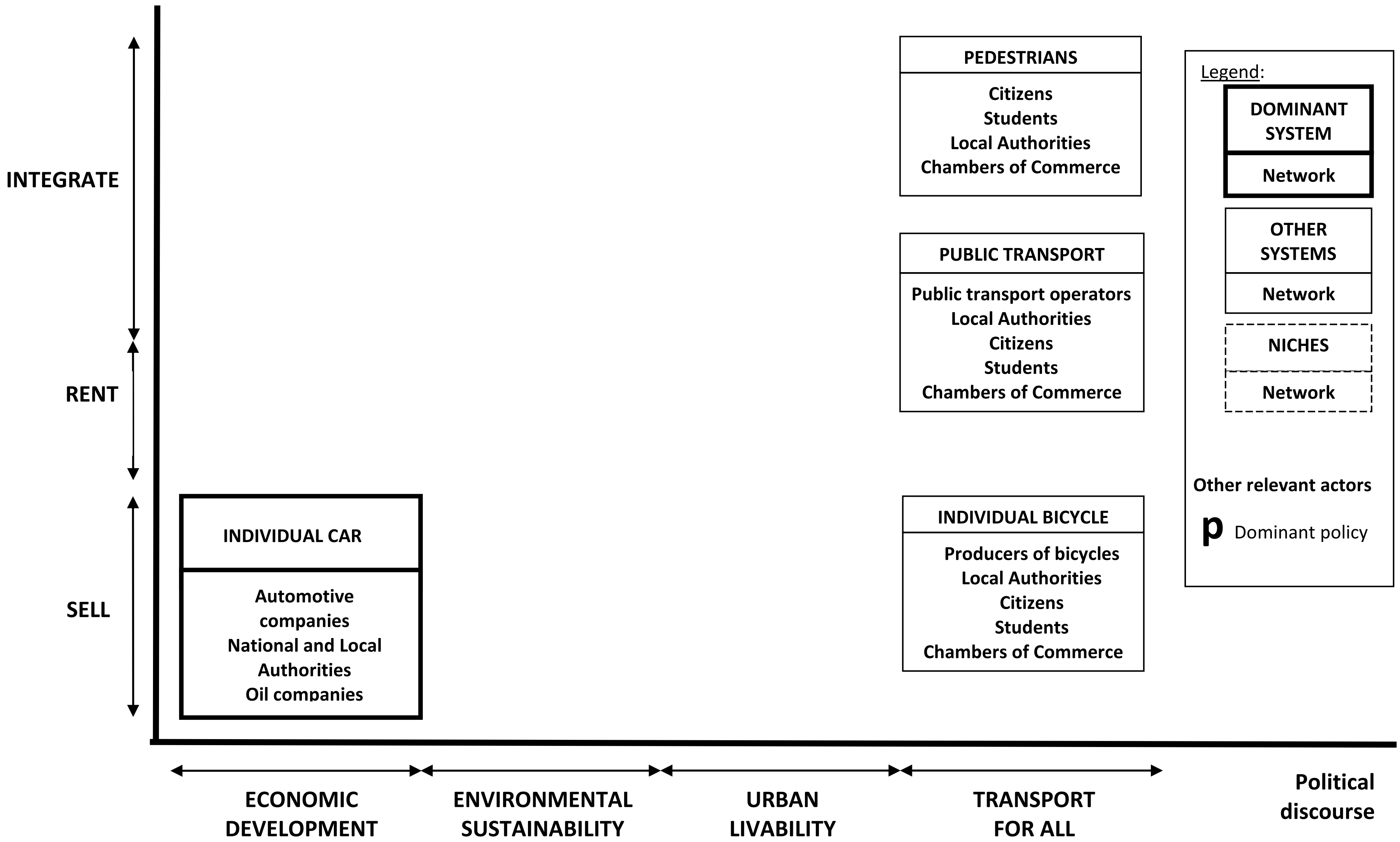

Figure 6 - The socio-technical map of the 1979 Freiburg mobility system

5.3. The 'City of short distances' (1980-2010)

In 1989, the third Integral Traffic Plan was approved. It aimed at reducing car use through the promotion of environmental friendly transport modes and the implementation of some restrictions to car traffic (Beim and Haag, 2010). This is the first Freiburg Plan that considers urban liveability as the main policy goal. Only in the two following Integral Traffic Plans environmental sustainability was considered as a policy goal (Figure 7).

With the Integral Traffic Plan of 1999, Freiburg took a further step towards the 'Eco-city' (Freiburg City Council, 1999). Besides reducing car traffic, it considered the overall transport system in which, public transportation, walking and cycling, worked in an integrated manner (Beim and Haag, 2010).

Also in the Transportation Plan in 2002 the main goals were to improve urban liveability, environmental sustainability, public transport and accessibility conditions for pedestrians and cyclists. Transportation policies were integrated with urban planning and tall he above goals were calibrated to the conditions of population growth and regional development. As a result, many measure have been implemented to reduce car use. The best known was the introduction, in 1984, of a low-cost monthly ticket called "urban environmental protection ticket" that turned into a regional ticket afterwards (FritzRoy and Smith, 1998; Beim and Haag, 2010). Around 86% of all journeys by public transport in Freiburg are made by the owners of monthly or annual tickets. Other measures (provided for in 2010) to increase sustainable transport included: traffic management policies, such as the further extension of the tram network, development of cycling infrastructure and improvement of walkability; land use policies, such as the better use of urban areas with brownfield investments and the functional mix of neighborhoods. (Beim and Haag, 2010)

All the above plan and interventions have contributed to create the currently dominating integrated system of urban mobility also called the 'City of Short Distances' (Figure 7).

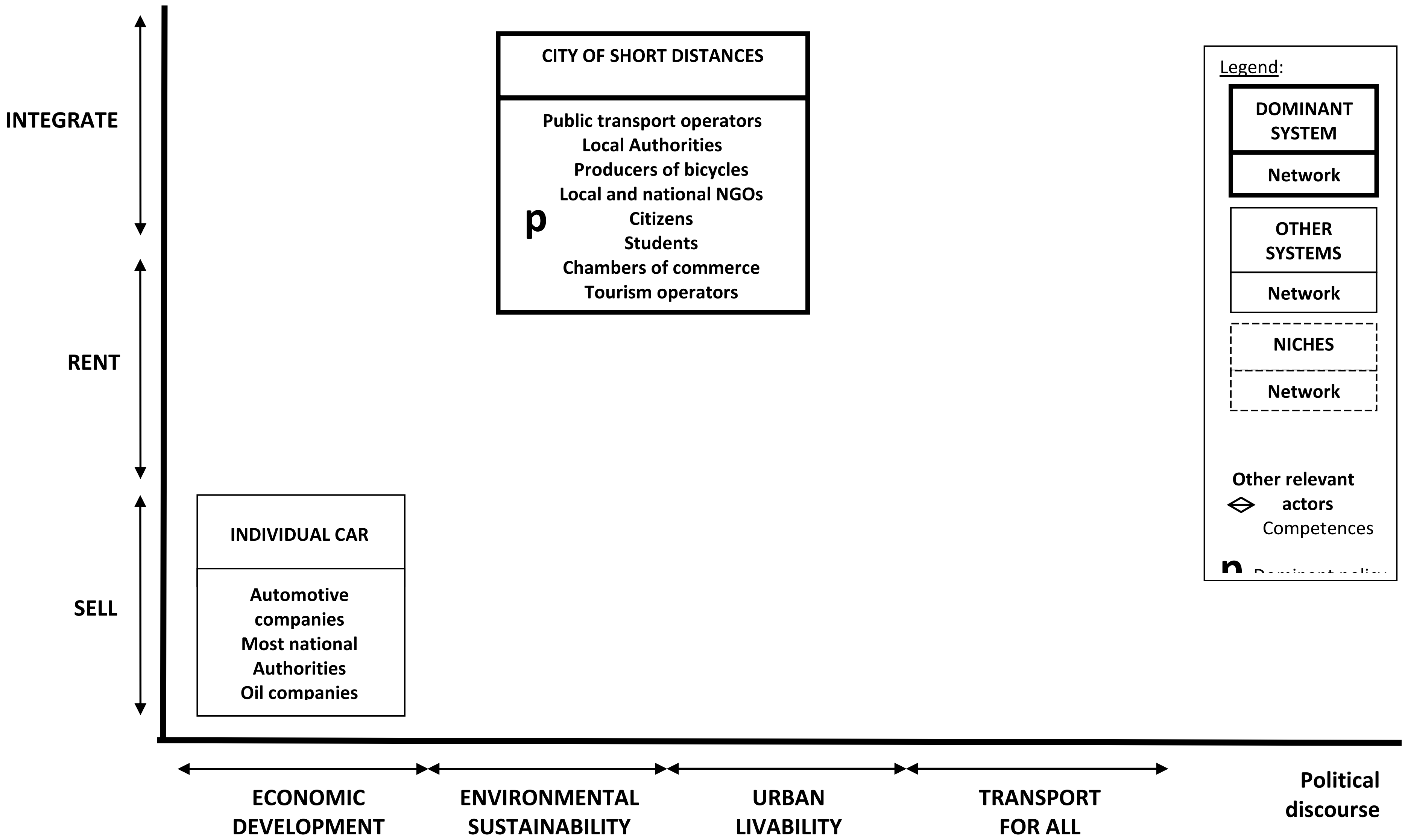

Figure 7 - The socio-technical map of the 2010 Freiburg mobility system

6. Conclusions

With this paper we wanted to verify if the integration of political discourses into the socio-technical map (ST-map) will help to achieve a better understanding of the past, present and future dynamics of urban mobility.

Starting from Marletto (2014) we have modified the representation of the current situation of urban mobility (at a global scale) and the three alternative 2030 scenarios. We show that with the substitution of the axis of technology with the axis of political discourses the heuristics of the ST-map increases. In particular, we see that all 2030 scenarios are more robust because changes are also based on the direct connection between networks of innovators, political discourses and actual policies. The Auto-city and the Electri-city scenarios now result from two alternative interpretation of the political discourses of economic development and environmental sustainability: as the production and sharing of (electric) cars, and as the building of smart grids (connecting renewables and electric cars), respectively. The Eco-city scenario is possible only if a multitude of local networks supports the shift towards the political discourse of urban liveability and the actual integration of all alternatives to the individual car.

We also analysed the processes that have made Freiburg an Eco-city, instead of a car-based city (Auto-city), as most European cities are. In particular, we focussed on the relationship between decisions of the State and Freiburg local Authorities and between local administration and citizens, specially referring to the participation of citizens to the decisions of the local administration. A further relationship on which we focused is among the policies related to mobility, land use planning and energy. We found that just the dynamics of these political relationships – embedding a very specific political discourse based on the interpretation of mobility as a constituent of urban liveability, but also as a focal point of energy and environmental issues – generated a "city of short distances" where the car plays a secondary role.

The two tests prove that with the integration of political discourses the ST-map improves its ability to represent the dynamics of urban mobility (both past and future). In particular, the modified ST-map shows that there is a mutual dependence between the actual policy approach to urban mobility, and the ability of competing networks of influencing the arena where different political discourses face each other. Moreover, it is apparent that more sustainable practices of urban mobility may eventually emerge only if a new network of innovators is able to scale up a cumulative causation process involving legitimation, empowerment and the support bestowed by actual policies. The case Freiburg stresses that citizens' participation to public decisions can be an internal motor of such a process.

The two tests – and in particular the study of the case of Freiburg – also signal the need to achieve a better understanding of the role played by policy cultures, practices (and, in some cases, innovators) coming from other sectors than urban mobility (e.g., urban planning, energy, housing, etc.). This should be the scope of further analysis, with a specific attention to other (local) success stories of sustainable urban mobility.

References

Avelino F, Rotmans J (2009) Power in Transition. An Interdisciplinary Framework to Study Power in Relation to Structural Change. Eur J Soc Theory 12: 543–569.

Banister D (2005) Unsustainable Transport: City Transport in the New Century. Routledge: London and New York.

Bleim M, Haag M (2010) Freiburg's way to sustainability: the role of integrated urban and transport planning. http://www.corp.at/archive/CORP2010_56.pdf. Accessed 04 April 2016

Bratzel S (1999) Conditions of success in sustainable urban transport policy – Policy change in 'relatively successful' European cities. Transp Rev 19:177–190.

Buehler R, Pucher J (2011) Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital. International J of Sustainable Transp 5: 43–70.

Daseking W (2016) Green neighborhood in Freiburg. Lecture held within the course of Urban Planning. University of Rome "La Sapienza".

Dennis K, Urry J (2009) After the car. Polity Press: Cambridge.

Dijk M, Orsato RJ, Kemp R (2013) The emergence of an electric mobility trajectory. Energy Policy 52: 135–145.

Elzen B, Geels FW, Hofman PS, Green K (2004) Socio-technical scenarios as a tool for transition policy: an example from the traffic and transport domain. In: Elzen B, Geels FW, Green K (eds) System innovation and the transition to sustainability. Edward Elgar: Cheltenham.

FitzRoy F, Smith I (1998) Public transport demand in Freiburg: why did patronage double in a decade? Transp Policy 5: 163–173.

Friburg City Council (1999) Verkehrsentwicklungsplan (Transport development plan). http://www.freiburg.de/pb/site/Freiburg/get/documents_E-794160118/freiburg/daten/verkehr/vep/VEP%20Analysebericht.pdf. Accessed 30 March 2016.

Geels FW (2005) Technological Transitions and System Innovations: A Co-evolutionary and Socio-Technical Analysis. Edward Elgar: Cheltenham

Geels WF, Schot J (2007) Typology of sociotechnical transition pathways. Res Policy 36: 399–417

Greene G (2004) The End of Suburbia: Oil Depletion and the Collapse of The American Dream. The Electric Wallpaper Company: Canada.

Haag M (2013) Sustainable Transport Initiatives in Freiburg. EcoMobility Congress: Suwon. http://ecomobility2013.iclei.org/fileadmin/user_upload/ecomobility2013/Presentations/P2_Haag.pdf. Accessed 26 May 2016.

Hajer M (1995) The politics of environmental discourse. Oxford University Press: Oxford.

Hajer M, Versteeg W (2005) A decade of discourse analysis of environmental politics: achievements, challenges, perspectives. J Env Policy Plann 7: 175-184.

Haxeltine A, Whitmarsh L, Bergman N, Rotmans J, Schilperoord M, Köhler J (2008) A conceptual framework for transition modelling. Int J Innov and Sustain Develop 3: 93–114

Hekkert M, Suurs RAA, Negro S, Kuhlmann S, Smits R (2007) Functions of innovation systems: a new approach for analysing technological change. Technolog Forecast and Soc Change 74: 413–432

Karapin R (2007) Protest Politics in Germany: Movements on the Left and Right Since the 1960s. Penn State University Press.

Kelemen RD (ed) (2015) Lessons from Europe? What Americans Can Learn from European Public Policies. CQ Press: Thousand Oaks (CA).

Kern F (2011) Ideas, institutions, and interests: explaining policy divergence in fostering `system innovations' towards sustainability. Environ Plann C: Govern Policy 29, 1116-1134

Lari A, Douma F, Onyiah I (2015) Self-Driving Vehicles and Policy Implications: Current Status of Autonomous Vehicle Development and Minnesota Policy Implications. Minn J Law Sci Technol: 735–769.

Lennard SHC, Lennard HL (1995) Livable cities observed: a source book of images and ideas. Gondolier Press Book: New York.

Leurent F, Windisch E (2011) Triggering the development of electric mobility: a review of public policies. Eur Transp Res Rev 3: 221–235.

Marletto G (2011) Structure, agency and change in the car regime. A review of the literature. Eur Transp 47: 71–88.

Marletto G (2014) Car and the City: Socio-technical transition pathways to 2030. Technological Forecasting and Social Change 87: 164-178.

Marletto G, Franceschini S, Ortolani C, Sillig C (in press) Mapping Sustainability Transitions: Networks of innovators, Techno-economic competences and Political discourses. Springer-Verlag: Berlin.

Marx R, Marotti de Mello A, Zilbovicius M, Ferreira de Lara F (2015) Spatial contexts and firm strategies: applying the multilevel perspective to sustainable urban mobility transitions in Brazil. Journal of Cleaner Production 108: 1092-1104.

Medearis D, Daseking W (2012) Freiburg, Germany: Germany’s Eco-Capital. In: Beatley T (ed) Green Cities of Europe–Global Lessons on Green Urbanism. Island Press: Washington.

MetroBike (2016) The Bike-sharing World – Year End Data 2015. The Bike-sharing Blog. http://bike-sharing.blogspot.it/2016/01/the-bike-sharing-world-year-end-data.html. Accessed 16 May 2016.

Mullan J, Harries D, Braunl T, Whitely S (2012) The technical, economic and commercial viability of the vehicle-to-grid concept. Energy Policy 48: 394–406.

OECD, Rocky Mountain Institute, IEA (2014) EV City Casebook. OECD: Paris. http://www.cleanenergyministerial.org/News/2014-ev-city-casebook-profiles-50-big-ideas-in-electric-mobility-448. Accessed 16 May 2016.

Orsato DJ, Dijk M, Kemp R, Yarime M (2012) The Electrification of automobility. In: Geels WF, Kemp R, Dudley G, Lyons G (eds) Automobility in transition? A Socio-technical analysis of sustainable transport. Routledge: Abingdon.

Patterson WC (1986) Nuclear power. 2nd Edition. Penguin Books: Harmondsworth.

Pucher J, Buehler R (2008) Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. Transp Rev 28: 495–528.

Pucher J, Clorer S (1992) Taming the automobile in Germany. Transp Q 46:383–395.

Schot J, Geels FW (2007). Niches in evolutionary theories of technical change. A critical survey of the literature. J Evol Econ 17: 605–622

Shaheen S, Cohen A (2016) Innovative mobility carsharing outlook, Winter 2016. Transportation Sistainability Research Centre, University of California, Berkeley. http://tsrc.berkeley.edu/sites/default/files/Innovative%20Mobility%20Industry%20Outlook_World%202016%20Final.pdf. Accessed 16 May 2016.

Smith A, Raven R (2012) What is protective space? Reconsidering niches in transition to sustainability. Res Policy 41: 1025–1036

Smith A, Stirling A, Berkhout B (2005). The governance of sustainable socio-technical transitions. Res Policy 34: 1491–1510

Sperling D, Gordon G (2009) Two Billion Cars. Driving toward sustainability.

Suurs R, Hekkert M, Kieboom S, Smits R (2010) Understanding the formative stage of technological innovation system development: the case of natural gas as an automotive fuel. Energy Policy 38: 419–431

Vergragt PJ, Brown H (2007) Sustainable mobility: from technological innovation to societal learning. J Clean Prod 15: 1104–1115.

Walker W (2000) Entrapment in Large Technology Systems: Institutional Commitment and Power Relations. Res Policy 29: 833–846

Wells PE, Nieuwenhuis P, Orsato DJ (2012) The Nature and Causes of Inertia in the Automotive Industry. In: Geels WF, Kemp R, Dudley G, Lyons G (eds) Automobility in transition? A Socio-technical analysis of sustainable transport. Routledge: