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Governance of Biofuels for Transport in Europe: Lessons from Sweden and the UK

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Summary

Biofuels for transport are attracting considerable support from the European Union. However, the complexity of the biofuels industry and the diversity of actors create significant challenges for policy-making and governance. This paper explores the role of governance in the development of the biofuels industry in Europe focusing on Sweden and the UK. The purpose of this paper is to investigate the similarities and differences of governance activities in these countries, and to identify lessons for policy-makers on how to establish and expand (sustainable and competitive) biofuels for transport. Sweden and the UK are selected as they provide contrasting pictures of the biofuels industry in Europe.

Key terms

Bioeconomy: An economy where the basic building blocks for materials, chemicals and energy are derived from biomass. It is also referred to as the bio-based economy, which underlines a shift away from the existing fossil-based economy.

Governance: This concept refers to the act of governing rather than government. Governance involves multiple public and private actors in debates, conflicts and power struggles as well as interactions between international, national, regional, and local levels.

Policy-makers: Broadly, policy-makers encompass people with power to influence or determine policies and practices at international, national, regional, or local levels. This covers people directly involved in government and in the process of governance.

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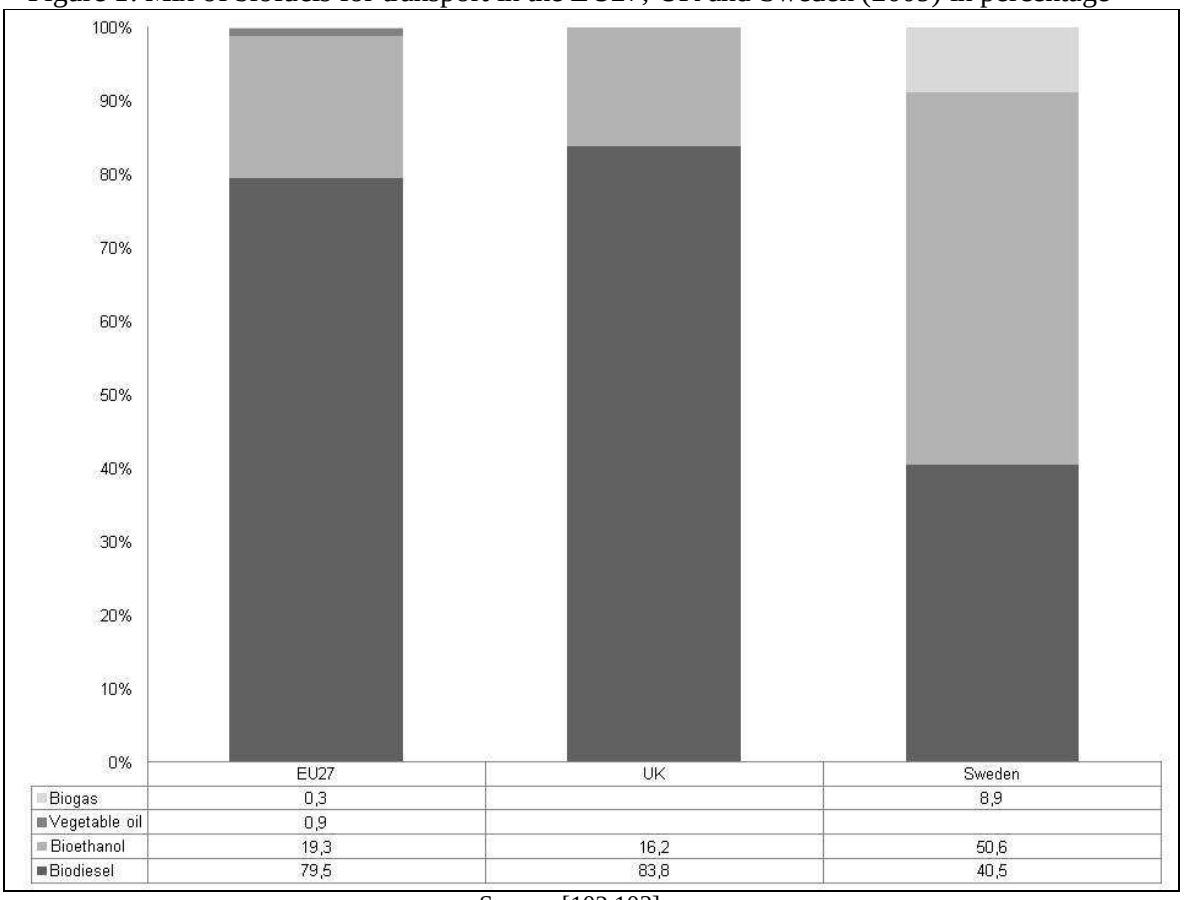
1. Introduction and background

Biofuels have been promoted by the European Union (EU) through the Biofuels Directive [1], which is ending in 2011. This support is continued by the Renewable Energy Directive [2] that defines binding targets for renewable energy in the overall energy mix of 20% and 10% renewable energy in the transport sector by 2020. The majority of the target for the transport sector is likely to be achieved by biofuels. In the National Renewable Energy Action Plans submitted by Member States, estimates suggest that biofuels will represent around 9% of the total energy consumption in transport in 2020 [101]. Over 30% of the biofuels utilized in the EU in 2020 are expected to be imported [101]. At present, almost 80% of the biofuels utilised in the EU is biodiesel, and the remainder is predominantly bioethanol, (pure) vegetable oil and biogas [3]. However, there are differences in the mix of biofuels in Member States (see Figure 1). There are also varying levels of progress on the utilisation of biofuels for transport by Member States [3]. In 2005 biofuels achieved a 1% share of fuels for road transport in the EU27 and only Germany and Sweden achieved the 2% target under the Biofuels Directive for 2005 [4]. However, development has progressed and estimates suggest biofuels in road transport have increased to 4.7% in 2010 for the EU27 [102,103]. While the use of biofuels is increasing in the EU, the 5.75% target defined in the Biofuels Directive for 2010 has not been achieved (see Figure 2).

This paper explores the governance of biofuels for transport in the EU focusing on Sweden and the UK. The purpose is 1) to investigate the similarities and differences of governance activities affecting the biofuels industry in Sweden and the UK, and 2) to identify lessons for policy-makers on how to establish and expand (sustainable and competitive) biofuels for transport. This paper argues that the markets for biofuels in Europe are completely dependent

on governance and policy support. This paper is based on a literature review, interactions with bioenergy industry associations on the emerging bio-economy in Europe and the challenges facing biofuels for transport, and attendance at conferences related to bioenergy where informal and candid discussions with representatives from industry, academia and government were possible. These research efforts provide the basis for this paper.

Figure 1: Mix of biofuels for transport in the EU27, UK and Sweden (2009) in percentage



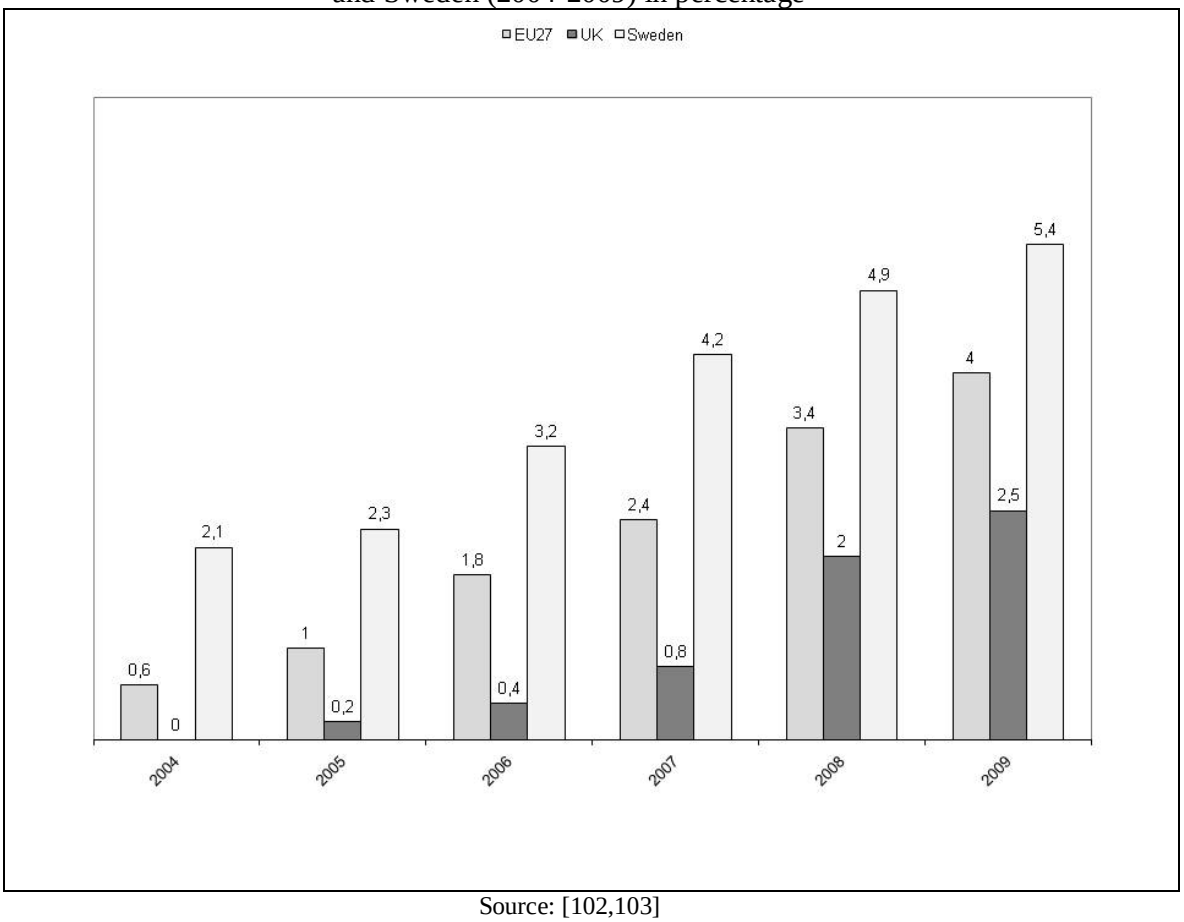
	EU27	UK	Sweden
Biogas	0,3		8,9
Vegetable oil	0,9		
Bioethanol	19,3	16,2	50,6
Biodiesel	79,5	83,8	40,5

Source: [102,103]

It is important to highlight some of the practical differences between Sweden and the UK. These countries have different historical, cultural, political and economic backgrounds as well as different geographic conditions. The UK population is approximately 60 million, while in Sweden the population is approximately 9 million. In terms of biofuels, the UK has less land available for biomass production than Sweden and requires more biofuels to meet

relative targets. However, both countries are confronted with the challenges of reducing greenhouse gas (GHG) emissions and shifting away from dependence on oil in the transport sector. In the perspective of Europe, Sweden and the UK provide interesting and important contexts to explore the governance of biofuels for transport, particularly because of their different situations.

Figure 2: Share of biofuels for transport in the EU27, UK and Sweden (2004-2009) in percentage



Source: [102,103]

1.1 Sweden

In Sweden, the development of alternative fuels for the transport sector (including both fossil fuels, such as natural gas, and renewable fuels, such as biofuels) has been on the agenda since the 1970s stimulated by the oil crises [5]. Policy support for bioenergy and biofuels for

transport has been in place in Sweden before the EU Biofuels Directive and it has provided the driving force for the development of the biofuels industry. Bioethanol is produced domestically (predominantly from wheat) and there are imports from Europe (utilising a variety of feedstocks) and Brazil (based on sugarcane). Most of the bioethanol is used for blending with petrol as E5 (5% bioethanol blended with petrol) and the rest is utilised in public buses and as E85 (85% bioethanol and 15% petrol) in flexi-fuel vehicles. There is production of biodiesel in Sweden based on locally available feedstocks as well as imports (predominantly from the EU), and most biodiesel is used for blending with diesel. Biogas is produced in many local municipalities in Sweden (based on food and industrial wastes, sewage treatment, by-products from bioethanol production, and crop residues) and it is increasingly used in public buses and bi-fuel vehicles [6]. While there is a potential to increase biogas production, it will remain a niche market if only based on wastes. There are important research challenges to explore if energy crops for biogas can be combined in parallel with maintained food production (as well as how to utilise all available wastes) [7].

What distinguishes Sweden in the EU is the implementation of high-level blending of bioethanol. Presently, around 1,400 of Sweden's 4,000 service stations offer renewable fuels, predominantly E85 [8]. There are some 4,2 million vehicles on Sweden's roads and approximately 200,000 (or almost 5%) can use renewable fuels, especially flexi-fuel vehicles designed for E85 [8]. Service stations offering renewable fuels and sales of vehicles that can use renewable fuels are growing in Sweden. As there are limitations on the supply of first generation biofuels and an increasing emphasis on sustainability for biofuels, Sweden is investing into developing and commercializing second generation biofuels [8,9]. Furthermore, both Sweden and the UK have transposed the sustainability criteria for biofuels defined in the EU Renewable Energy Directive into national laws. Finally, E10 (10%

bioethanol blended with petrol) is expected to replace E5 in Sweden in the near future, which will increase the market share of bioethanol significantly.

1.2 UK

While the absolute use of biofuels in the UK is higher than Sweden the share is lower, and there is no high-level blending of biofuels for transport in the UK. Biodiesel is produced domestically and imported based on a range of feedstocks. It is mostly available in low-level blends, such as B5 (5% biodiesel blended with diesel). Bioethanol was not used for transport before 2005. However, consumption has quickly expanded and investments in production are underway. Bioethanol is only utilised in low-level blends, such as E5. Similar to Sweden, imports play a substantial role in the UK [10]. For example, between April 2010 and January 2011, 80% of biofuels were imported into the UK, the most widely reported feedstock and country of biodiesel was soy from Argentina (24% of biodiesel supplied), and the most widely reported feedstock and country of bioethanol was sugarcane from Brazil (25% of bioethanol supplied) [11]. Concerns over sustainability issues related to biofuels production, particularly imported biofuels, have been heavily debated in the UK, especially after the publication of the Gallagher Review, which investigated biofuels and sustainability [12,13].

The UK has slowed down biofuels introduction (because of sustainability concerns) by reducing the rate at which low-level blending obligations increase. Furthermore, there has been debate in the UK over the implementation and limitations of the sustainability criteria for biofuels as they are defined in the Renewable Energy Directive. Despite these issues, there are at least two points about the UK progress on biofuels that deserve attention. First, investments in production facilities for bioethanol will make the UK the third largest

producer in the EU [104]. The largest producer is France and Germany is the second largest producer. France, Germany and the UK will account for more than 50% of bioethanol production in the EU in the near future [104]. Second, the UK has implemented sustainability reporting for biofuels since 2008, which is voluntary but it is becoming mandatory following the EU sustainability criteria for biofuels.

1.3 Technologies and feedstocks

It is not the intention of this paper to provide a thorough overview of technologies and feedstocks in the context of expanding biofuels for transport in Europe. However, it is important to highlight some key issues and on-going debates on biofuels – as policy-makers need to evaluate the prospects for emerging technologies and availability of feedstocks. A major challenge for the biofuels industry is to shift towards advanced biofuels that can be produced from feedstocks that are associated with efficient land use (commonly called second generation biofuels) and to avoid increasing production of biofuels based on agricultural crops that use considerable land (which refers to first generation biofuels) [14]. For example, in Sweden, the conditions for biomass production (particularly woody biomass) are favourable, and there are promising technologies to produce second generation biofuels in the demonstration phase, including bioethanol based on lignocellulosic materials [14]. However, the shift to commercialisation and widespread production of second generation biofuels remains complex, and specific to different countries. It is also particularly difficult to assess technologies individually as the production of biofuels is likely to be incorporated into the biorefinery concept, which is based on bringing together combinations of technologies to produce a range of products (including energy, materials and chemicals) [14].

Another major challenge for the biofuels industry is the availability of feedstocks. For the UK, this is a constraint on the domestic production of biofuels, and it is therefore a concern for policy-makers deciding whether or not to support the expansion of biofuels. Furthermore, there is a clear link between different technologies and the types of feedstocks that can be utilised when it comes to biofuels. For example, it is argued that due to limited availability and competing demands for feedstocks, first generation biofuels in the UK are likely to produce approximately 3.7-6.6% of the energy needed in transport by 2020 [15]. However, projections suggest that second generation biofuels – based on 1 million tonnes of woody biomass, 2 million tonnes of wheat, and 4.4 million tonnes of household, commercial and industrial wastes – can meet up to 4.3% of energy demands in the transport sector by 2020 [15]. These examples depict the challenging decisions confronting policy-makers in the UK and Sweden (and across Europe) in regards to the diversity of technologies being developed, the biorefinery concept, and the availability and costs of feedstocks for biofuels.

2. Theory and approach

In this paper, policy-making and governance are considered complex processes that involve multiple actors in debates, conflicts and power struggles [16]. Biofuels for transport are under intense discussion in Europe and have attracted the attention of a diversity of actors since increasing the production and use of biofuels affects a range of sectors and activities. These actors have different interests and values, and they aim for different goals and outcomes of policy-making and governance [17]. This paper defines governance in two ways. First, it refers to the different tiers at which governance takes place and the interactions between the tiers, which for Europe encompasses cities and local municipalities, national governments,

and the EU bodies and authorities [18]. Second, it refers to the myriad of networks between public and private actors that shape governance and policy-making [19].

This paper applies transition management as a new governance approach for sustainable development to explore the development of biofuels in Sweden and the UK [20]. Based on tenets for complexity-based governance, Loorbach 2] defines a framework for transition management that distinguishes between four different types of governance activities – strategic, tactical, operational and reflexive. Complexity-based governance draws attention to the importance of understanding how systems work as a precondition for effective management and long-term thinking as a foundation for shaping short-term policies and actions [20,21]. Five key factors for the governance of biofuels for transport in Europe are derived from the framework for transition management as well as the research efforts conducted for this paper (see Table 1). The key factors have therefore been developed deductively and inductively.

Table 1: Transition management and key factors

Transition Management	Key Factors
Strategic activities refer to problem structuring, envisioning, and the establishment of the transition arena [20].	**Visionary plans** involve setting long-term goals and defining how to move towards desired outcomes. Visionary plans related to biofuels can "travel" across spheres and levels and bring together coalitions [21].
Tactical activities refer to coalitions, images, and transition agendas, encompassing rules and regulations as well as organisations and networks [20].	**Policy frameworks** are needed to create favourable conditions for investments in biofuels [22]. Policy frameworks involve a mix of policy instruments, including complementary actions.
	Stakeholder networks refer to the need to interact, network and collaborate to develop the biofuels industry. "Prime movers" and industry associations are particularly important [23].
Operational activities refer to mobilising actors and executing projects and experiments often with a short-term horizon [20].	**Local actions** focus on the important role of cities and local municipalities in promoting biofuels for transport [18] as well as learning processes and climate governance.
Reflexive activities refer to evaluating, monitoring, and learning related to policies and actions as well as societal change [20].	**Sustainability schemes** relate to all types of governance activities on biofuels for transport. They are both a driver and constraint, and underpin the future of biofuels [24].

The key factors can be considered as elements within the different types of governance activities. For example, policy frameworks and stakeholder networks are elements within tactical activities. Loorbach [20] lists a range of elements under the different types of governance activities. The key factors investigated in this paper represent only some of these elements. However, this paper suggests the five key factors are fundamental for the development of the biofuels industry in Europe. Focusing on these key factors, this paper attempts to delineate lessons for policy-makers on how to establish and expand biofuels for transport. While there are a multitude of actors involved in the governance of biofuels for transport, policy-makers remain key players and are therefore in focus. Finally, the analysis and discussion of the key factors in this paper encompasses insights from cities and local municipalities, the national governments in Sweden and the UK, and EU actors.

3. Analysis and discussion

3.1 Strategic activities: Visionary plans

There are many visions in Europe that are relevant to biofuels for transport. This paper makes two points. First, biofuels for transport are identified in EU visionary plans within and across multiple sectors (including energy, transport, and agriculture) as well as in visions and ideas about the future in response to concerns over climate change and peak oil. Second, there is growing "excitement" about the concept of the emerging bioeconomy in Europe in which visions depict an economy where the basic building blocks for materials, chemicals and energy are derived from biomass. In Sweden, the dominant visions related to biofuels are breaking dependence on oil and fossil fuels [25] and developing a low carbon society [105]. In the UK, the dominant visions are establishing a low carbon economy [26] and reducing GHG

emissions in the transport sector (particularly through low carbon vehicles) [27]. What is evident in these visionary plans is that the role of biofuels differs significantly.

In 2006, the Swedish Government announced an impressive policy target – to create the conditions necessary to break dependence on oil and fossil fuels by 2020 [25]. This announcement attracted considerable attention from across Europe (and the world). While the Swedish Government has changed from the "left" to the "right" since then, the commitments to breaking dependence on oil have endured – although the timeframe has shifted to 2030 and focused on the transport sector. It is important to reflect on what this commitment means in reality. There will be oil in the transport sector in Sweden in 2030. However, the Swedish Government is working towards a situation where consumers will have "real" choice when purchasing vehicles and fuels, thereby breaking the complete dependence on oil that currently exists in the transport sector. What also makes the visionary plans in Sweden to break dependence on oil compelling is that Sweden has achieved considerable reductions in the use of oil since the 1970s [28]. The announcements by the Swedish Government to shift away from oil, and promote renewable fuels (especially biofuels), is therefore a continuation of a national strategy. Furthermore, a Swedish Knowledge Centre for Renewable Transportation Fuels has been established to help realise these visionary plans. There are also many local municipalities in Sweden, which have defined ambitious visions on breaking dependence on oil and fossil fuels (e.g. fossil fuel free municipalities) as well as climate change (e.g. climate municipalities), which reinforces the national efforts in Sweden.

Interconnected with breaking dependence on oil and fossil fuels are the ambitions in Sweden to become a low carbon society [105]. The Swedish Government has defined key goals to move towards a low carbon society, including: to decrease GHG emissions by 40% by 2020

(compared with 1990) for activities excluded from the Emissions Trading Scheme (ETS) in the EU; to reduce to zero Sweden's net GHG emissions by 2050; to increase renewable energy to 50% of Sweden's energy use by 2020; to increase renewable fuels in the transport sector to 10% by 2020; and to improve energy efficiency by 20% by 2020 [29]. The Swedish Government also supports strengthening the ETS in the EU. These goals place Sweden at the forefront of climate mitigation and adaptation in Europe (and the world) and provide a considerable stimulus for biofuels for transport.

In the UK, the Committee on Climate Change [26] announced in 2008 that the world needs to reduce GHG emissions by 50% by 2050, and that while a global agreement encompassing developing countries is vital, leadership by industrialised countries is required. The Committee on Climate Change [26] stated that a "fair" global deal demands the UK to reduce GHG emissions by 80% by 2050 – effectively establishing a low carbon economy. For the transport sector, biofuels can potentially play an important role. However, the contribution of biofuels to a low carbon economy is not clear because of the uncertainty over sustainability [12,26]. Furthermore, it appears that hydrogen and electricity are viewed more favourably than biofuels in the UK [30,31]. The visions of a low carbon economy in the UK are therefore rather ambiguous on the role of biofuels – both in the short-term and the long-term.

In 2008, the Gallagher Review, which investigated biofuels and sustainability, raised critical concerns and called for slowing down the introduction of biofuels to the UK [12]. In parallel, the publication of the King Review, also in 2008, positioned low carbon vehicles in the political and public "spotlight" [32]. This paper argues that the Gallagher Review and King Review influenced ideas about the future of transport in the UK, and that the King Review presented visionary plans that prioritise electricity and hydrogen (as well as promoting energy

efficiency and influencing consumer choices) over biofuels for transport. There are two significant assertions on biofuels in the King Review. First, the review suggested moving the short-term focus on biofuels towards a long-term strategy on transport [27]. Second, in the context of growing international trade of biofuels [33], the review urged caution before comprehensive sustainability safeguards are in place [27]. The King Review has effectively aligned low carbon vehicles with electricity and hydrogen.

3.2 Tactical activities: Policy frameworks

Since 2003, Member States have worked on the implementation of the Biofuels Directive. In order to meet their respective targets, Member States have employed a range of policy instruments [34]. Tax incentives have been applied by many Member States to promote biofuels, such as in Sweden [35]. The relatively significant taxes on diesel and petrol in the EU facilitate the utilisation of tax reductions. Alternatively, or in combination with tax incentives, obligation systems can be introduced to ensure that certain amounts of biofuels enter the market, such as in the UK [35]. Complementary actions encompass tax incentives for flexi-fuel vehicles and bi-fuel vehicles, green procurement policy, increased availability of filling stations, and public relations activities. Lucia and Nilsson [35] observe that complementary activities are only employed by a few Member States. However, the significance of these activities in creating markets for biofuels is often underestimated. This paper argues that complementary activities have played an important role in promoting the biofuels industry in Sweden [23,36].

Sweden has attracted considerable attention for its achievements on biofuels, especially in regards to high-level blending of bioethanol. However, there are debates on the cost-effectiveness of high-level blending and how to support biofuels. Looking to the near future,

Hillman and Sanden [37] explore how policy choices can affect the development of renewable fuels for transport in Sweden from 2007-2020. As suggested, renewable fuels can be promoted through a range of policy instruments. In particular, Hillman and Sanden [37] argue that the balance between tax exemptions stimulating the market (primarily for first generation biofuels) and funding for research and development programmes (focused on second generation biofuels) can have considerable implications for renewable fuels. Finding the balance is a challenge for all Member States. Improving and developing first generation biofuels is also important. Overall, the experiences in Sweden suggest that creating markets for biofuels takes time and effort – demanding significant support in many forms. Furthermore, the development and commercialisation of second generation biofuels is critical to further expanding markets for biofuels. In many ways, the different opinions on the cost-effectiveness of high-level blending depends on if biofuels for transport are perceived as playing a significant role in future transport systems.

With approximately 200,000 vehicles that can use renewable fuels, especially flexi-fuel vehicles designed for E85, Sweden is a "leader" on high-level blending of bioethanol in the EU [8]. As stated, around 1,400 of the 4,000 service stations in Sweden offer renewable fuels, predominantly E85 [8]. To place Sweden in perspective, there are approximately 2,200 E85 pumps in operation in the EU [38]. This shows the advanced state of the market for bioethanol in Sweden. The increase in E85 pumps in Sweden has been strongly stimulated by the "pump law" – an obligation placed on service stations of a certain size to provide renewable fuels [38]. This paper highlights two impacts of the "pump law". First, it ensures access to biofuels, namely E85, across Sweden, which is crucial to consumers purchasing flexi-fuel vehicles. Second, it reduces uncertainty and sends a strong signal to the key stakeholders in the market and consumers that biofuels are a "real" alternative to oil.

A considerable difference between Sweden and the UK is that the focus in the UK has been on the supply of biofuels for only low-level blending in contrast to Sweden where the strategy has been on developing the market for biofuels – biofuels supply (both domestic production and imports), distribution systems, and compatible vehicles [17,39]. While the production of biofuels is increasing in the UK, there is only a market for low-level blending. In contrast, Sweden has developed a market for both low-level and high-level blending. There are two points that suggest the market in Sweden will continue to expand. First, the introduction of E10 to replace E5 in the near future will greatly increase the market share of bioethanol in Sweden. Second, the availability of E85 across Sweden and the growing sales of flexi-fuel vehicles suggest that high-level blending of bioethanol is firmly established. However, the policy support in place in Sweden is critical to the stability of the markets for biofuels.

The Renewable Transport Fuel Obligation (RTFO) is the foremost policy instrument to promote biofuels for transport in the UK. The RTFO places an obligation to supply renewable fuels in the transport sector. The conditions in the UK have changed markedly. Initially, the UK was characterised by “go and stop” policy commitments. However, the increasing ambitions of the RTFO and the introduction of sustainability requirements show that the approach on low-level blending is rather comprehensive. The RTFO has been quite an effective policy instrument to “create” demand [34]. If the RTFO remains in place, there will be a market for biofuels. Looking to the near future, there are two key points to consider about the UK. First, there are minimal efforts to introduce high-level blending of biofuels, which constrains the role biofuels can play in the transport sector. Second, it appears that the UK considers the 10% target in the Renewable Energy Directive as subject to review. These positions suggest the policy support for expanding biofuels in the UK is rather uncertain [30].

3.3 Tactical activities: Stakeholder networks

The complex nature of the biofuels industry (involving different resources and feedstock suppliers, different logistics providers and options, a range of technologies and systems, and a diversity of end-products and end-uses) make the need to interact, network and collaborate between key stakeholders vital towards reducing risks and uncertainty, and increasing the political legitimacy of biofuels [40]. Stakeholder networks and industry associations are important to the development and diffusion of biofuels for transport. This is observed in both Sweden and the UK where it is clear that establishing trust between actors (including biofuels producers and suppliers, trade associations, oil companies, automobile manufacturers, local municipalities, national governments, public agencies, NGOs and research organisations) that do not normally interact or cooperate is important for a biofuels industry to function and grow [23].

This paper argues that stakeholder networks play a central role in the development of bioenergy markets. During the initial market creation for bioenergy in the 1980s and 1990s in Sweden, the interactions between key stakeholders were distinctly collaborative. There was an organised and concerted effort across production chains towards establishing markets for bioenergy and an overarching lobby organisation – the Swedish Bioenergy Association. Furthermore, biofuels for transport have been promoted by the Swedish Ethanol Development Foundation, established in 1983, which was renamed the BioAlcohol Fuel Foundation in 1999. Since 1994, the Swedish Association for Green Motorists has also played a role in promoting biofuels. Erik [23] argues that the stakeholder networks coordinated through the Swedish Bioenergy Association were pivotal to the initial market formation for all types of bioenergy. This lobby organisation created “internal” trust in

production chains, and also improved the “external” political legitimacy of the bioenergy industry [23]. Furthermore, in 2011, the Swedish Knowledge Centre for Renewable Transportation Fuels was established to promote increased cooperation between academia and industry, create a knowledge platform, and apply a systems approach to contribute to the development of renewble transportation fuels, focusing on biofuels [106].

Looking at stakeholder networks in the UK, this paper makes three claims. First, the interactions between key stakeholders in the bioenergy industry in the UK are often fragmented. In fact, there is notable competition between actors, including companies, universities and networks for scarce resources and political attention [23]. Second, knowledge and information flows between companies, universities and networks are limited and poorly coordinated. Third, the lack of social acceptance of bioenergy in the UK is a considerable obstacle for bioenergy developments [41]. All renewable energy sectors are merged under the Renewable Energy Association in the UK. However, this paper argues that the complexity of bioenergy and the limited social acceptance of bioenergy by the general public in the UK demand a dedicated lobby organisation, rather than the broad scope of the Renewable Energy Association.

Shifting from the national context to the local level in the UK, Erik [23] argues that “prime movers” for the bioenergy industry mostly establish networks that are oriented around specific projects. In fact, the networks created at the local level are often an attempt to improve the social acceptance of specific bioenergy projects by the general public and key stakeholders [42]. While networks of this nature are deemed important to bioenergy, Erik [23] suggests there are minimal interactions between networks established at the local level, and so the national context for bioenergy in the UK remains a challenging environment for

the bioenergy industry. Ericson [43] argues the experiences from Sweden suggest that key stakeholders and "prime movers" – across both the local level and the national level – need to be engaged to successfully utilise biofuels in the transport sector, and that cooperation between actors is vitally important for a biofuels industry.

It is observed in the UK that there are more developed stakeholder networks around the theme of low carbon vehicles with a considerable focus on energy efficiency and consumer choices in the transport sector as well as electric and hybrid vehicles. Established in 2003, the Low Carbon Vehicle Partnership is an action and advisory group that aims to accelerate the shift to low carbon vehicles in the UK [32]. This organisation involves over 200 members from diverse backgrounds including automotive and fuel supply chains, vehicle users, academic institutions, and civil society. The Low Carbon Vehicle Partnership has worked with key stakeholders on developing consensus around the sustainability issues for biofuels. However, biofuels for transport are not the priority of this organisation. Instead, electric and hybrid vehicles are in focus, which is closely related to the recommendations from the Gallagher Review and King Review. There are some groups that engage a range of key stakeholders working with biofuels, including: the Renewable Transport Fuels Group of the Renewable Energy Association in the UK; and the Expert Advisory Group for the RTFO, which was established to provide technical advice, input and expertise on issues around carbon savings and sustainability of biofuels for transport.

3.4 Operational activities: Local actions

Local municipalities are responsible for many aspects of transport systems and planning issues, and the position of cities in climate governance has also gained increased attention

[44,45]. Interestingly, many of the policies and actions related to biofuels that are implemented by local municipalities are a response to efforts by the EU and national governments. Silvestrini et al. [18] examine the implementation of the Biofuels Directive in Europe focusing on Germany, the UK, Italy and Finland by looking at the role of cities, namely Berlin, London, Milan and Helsinki. The implementation of EU directives and strategies officially only involves national governments. However, cities and local municipalities can facilitate the efforts of national governments to meet EU targets through voluntary actions and perhaps more importantly they can "experiment" with policies and actions, demonstrate examples of "solutions", and contribute to building up the social acceptance and political legitimacy of biofuels.

The scope for actions by local municipalities is defined by their jurisdiction and responsibilities, and their financial independence. However, local municipalities are often able to establish more ambitious goals than national governments, which are particularly evident in relation to climate governance [44,46]. Silvestrini et al. [18] show that Berlin, London, Milan and Helsinki have all played important roles in reducing GHG emissions by participating in research and demonstration projects and by using biofuels in their fleets, and promoting biofuels in public buses. When local municipalities own or partly own transport and energy companies (such as in Sweden) the possibilities to influence investments and GHG emissions is increased substantially. In relation to finances within local municipalities to invest in biofuels, it is observed that in Sweden the Local Investment Programme (LIP) from 1998-2002 and the Climate Investment Programme (KLIMP) from 2003-2008 have played a role in supporting the activities of local municipalities on renewable fuels [24,39].

Looking to the UK, Silvestrini et al. [18] identify a range of voluntary actions in London that support EU targets on biofuels for transport, based primarily on green procurement policy. For example, there is a project in London to utilise used cooking oil for fleets by cleaning and processing it into biodiesel. Trial testing different blends of biodiesel on public buses is also underway. And finally, an EU project called the Biodiesel Network (BioDieNet) has developed a network of actors to stimulate the market for locally produced biodiesel from used cooking oil. The BioDieNet project also connected London with cities and regions across the EU working on biodiesel [42]. Overall, the activities in London are strongly focused on biodiesel through green procurement policy and networking activities.

Interestingly and extremely relevant for biofuels in the EU is that horizontal networking between cities is allowing an exchange of knowledge and experiences, and contributing to learning processes around biofuels for transport [18]. This is especially demonstrated in London, where horizontal networking is often connected to EU financed projects [18]. Another example is Stockholm, where the local municipality coordinated the EU project called Bioethanol for Sustainable Transport (BEST), which focused on the market introduction of bioethanol. The BEST project initiated the introduction of vehicles and infrastructure for bioethanol and stimulated (practical and policy) learning processes and horizontal networking across cities and regions in Sweden, Germany, the UK, the Netherlands, Spain and Italy as well as Brazil and China [38,43].

There are further examples from Sweden that highlight the role of local municipalities in the promotion of biofuels for transport. The larger cities, like Stockholm, Gothenburg and Malmö, are all working heavily with biofuels and biogas in transport. Furthermore, smaller cities, like Kristianstad and Växjö, also have initiatives on biofuels and biogas [47]. Biogas

produced from wastes is particularly prominent in local municipalities. There is further potential to expand the niche market by utilising all available wastes (and potentially through energy crops) [7]. A common theme in the activities on biofuels in both the larger and smaller cities in Sweden is communication and interaction with the general public and key stakeholders. Biofuels are also closely connected with local municipalities trying to provide leadership on climate change (e.g. climate municipalities) and breaking dependence on oil and fossil fuels (e.g. fossil fuel free municipalities). For example, it is particularly observed in Stockholm that the local municipality frames its activities on biofuels in terms of climate governance.

3.5 Reflexive activities: Sustainability schemes

The efforts by the EU all point towards increased emphasis on the sustainability of biofuels and incentives for the development and commercialisation of second generation biofuels. Discussions over the sustainability of biofuels are evident in both Sweden and the UK. However, it is predominantly in the UK where there are significant criticisms of biofuels, particularly around GHG emissions and land use changes [12,48]. Interestingly, the social acceptance of new facilities for biofuels production is also a barrier facing the expansion of biofuels in the UK. This involves two sides. The first is the reactions of the general public located near new facilities or affected by developments related to biofuels, particularly the transportation of biomass. The second is how the general public across the UK perceives and responds to expanding the production and utilisation of biofuels for transport, particularly in relation to reducing GHG emissions and land use changes. In the debates on sustainability, social acceptance is perhaps the most “underrated” challenge for the biofuels industry, not only in the UK, but also across Europe [49].

In response to the intensified focus on production chains for biofuels, the EU has established binding sustainability criteria for biofuels, which are enforced under the Renewable Energy Directive [2]. The sustainability criteria include that biofuels for transport should deliver GHG reductions of at least 35% compared to fossil fuels, rising to 50% by 2017, and 60% by 2018 for new production facilities, and that they should not be obtained from land with high carbon stocks or high biodiversity [2]. Furthermore, there is an incentive for advanced biofuels (namely second generation biofuels, particularly from lignocellulosic materials). These will count double towards the EU targets for renewable energy in the transport sector. This is in addition to the acceleration of the development and deployment of second generation biofuels under the Strategic Energy Technology Plan [107]. Nevertheless, Member States expect in their National Renewable Energy Action Plans only a modest contribution of advanced biofuels towards the 2020 target [101]. Additionally, the Fuel Quality Directive sets a target for a 6% reduction of the carbon intensity of fuels for road transport in the EU by 2020 [50]. Reducing carbon intensity can be achieved by different options, but it is widely expected that the majority of the target will be realised through biofuels. The Fuel Quality Directive is designed to be consistent with the Renewable Energy Directive.

In the UK, the RTFO has involved sustainability reporting since 2008, including carbon savings as well as environmental and social issues [51]. However, Upham et al. [52] argue that key limitations are the inadequate inclusion of macro issues, such as indirect land use change, and that the RTFO focuses on encouraging the supply of biofuels at the expense of sustainability. These criticisms are related to how sustainability reporting is structured in regards to capturing all the impacts associated with production chains for biofuels. Dealing with the macro issues – especially for imported biofuels – is a considerable challenge for

governance. In Sweden the discussion on sustainability has not been as prominent as the UK (although still significant) with biofuels predominantly coming from the EU and Brazil – sources often considered as sustainable. The UK has approached the sustainability discussion by assuming that biofuels are not sustainable unless there is evidence. This has been a key difference in the governance of biofuels and sustainability between Sweden and the UK. However, on the proposal of the European Commission (EC), the EU has incorporated sustainability criteria for biofuels into the Renewable Energy Directive.

Both Sweden and the UK are implementing the requirements of the Renewable Energy Directive in their national laws. However, there are several obstacles associated with this process. First, it will be a challenge for Member States to implement and interpret the Renewable Energy Directive consistently, and respond to an evolving legislative environment, including increasing GHG thresholds and the possible inclusion of indirect land use change in the future. The growing debate over land use change associated with biofuels suggests that the EU will need to continue to address this critical issue. Second, a challenge for the biofuels industry in the UK and Sweden (and across the EU) is to collect the information required under the Renewable Energy Directive in an effective and efficient manner. Overall, while there are short-term challenges to overcome, it appears that the long-term viability of the biofuels industry demands robust sustainability standards.

Börjesson et al. [53] argue that it is impossible to measure the sustainability of biofuels without taking into consideration the scale and pace of growth. This is an important issue for policy-making and governance around biofuels for transport. It is not just a matter of setting out sustainability criteria for biofuels. How markets for biofuels develop and grow is critically important. Furthermore, it is clear that the efforts to ensure the sustainability of

biofuels will require resources and on-going attention, and it is important to positively engage key stakeholders (especially NGOs) in the development of sustainability schemes for both stability and legitimacy [48]. Not least to improve and maintain the social acceptance of biofuels for transport. The emphasis on the scale of markets for biofuels also brings into focus that biofuels are not able to fully replace oil. Rather biofuels need to be integrated into a broad strategy for the transport sector.

4. Conclusion and reflections

This paper explores the role of governance in the development of the biofuels industry in the EU through five key factors, which are linked to the governance activities – strategic, tactical, operational and reflexive – as defined by in the framework for transition management [20]. The comparison of Sweden and the UK provides constructive insights into the similarities and differences of governance activities shaping the biofuels industry in these countries (see Table 2). Overall, the lessons for policy-makers that emerge from this paper on how to establish and expand (sustainable and competitive) biofuels include:

- Visionary plans can play an important role in mobilising a range of actors, inspiring actions, and linking short-term efforts with long-term strategies. In Sweden, both the national level and local level are deeply involved in visions to break dependence on oil and become a low carbon society. The activities by local municipalities reinforce the national efforts on biofuels in Sweden. The UK has also established ambitious visionary plans around reducing GHG emissions, but there is uncertainty around the role of biofuels.

- Networking and building “trust” within and outside a biofuels industry is important. A key message for policy-makers is that it takes time and targeted support to build up stakeholder networks. What differentiates Sweden and the UK is that alternative fuels and bioenergy have been promoted in Sweden since the 1970s. This has helped to establish stakeholder networks and industry associations for all types of bioenergy in Sweden, which provides the building blocks for the growing biofuels industry in Sweden.
- The tax exemptions for biofuels in Sweden and the obligations to supply biofuels in the UK are the foundations for the biofuels industry. While the biofuels industry in Sweden is more advanced and robust than in the UK, the markets for biofuels in both Sweden and the UK remain fragile because of the dependence on policy support. Ensuring stability in policy frameworks is important.
- Improving first generation biofuels and investing in research and development programmes for second generation biofuels as well as support for demonstration and commercialisation is imperative for the development of markets for biofuels. Second generation biofuels are critical to the future of biofuels in the EU in terms of reducing GHG emissions and meeting sustainability standards as well as increasing production volumes of biofuels through efficient land use. Without second generation biofuels, the markets for biofuels will be severely constrained.
- Both low-level and high-level blending is needed if biofuels are to play a significant role in transport systems. In Sweden, the high-level blending of biofuels through E85 and flexi-fuel vehicles has generated visibility for biofuels, which is important to the development of the biofuels industry. Furthermore, the focus on markets in Sweden in terms of biofuels supply, distribution systems, and compatible vehicles provides

opportunities for further growth. The focus in the UK on only low-level blending is limited.

- Sustainability reporting and monitoring of production chains for biofuels is required to meet certain standards in terms of GHG savings as well as environmental and social perspectives. However, it should not be underestimated how challenging it is to establish sustainability schemes that ensure adequate standards are achieved while not placing excessive economic and administrative burdens on the biofuels industry. Furthermore, sustainability schemes will need to evolve as biofuels for transport are developed and expanded. Policy-makers need to remain alert to these issues.
- Positively engaging key stakeholders (particularly NGOs) in the on-going development of sustainability schemes is important for stability and legitimacy as well as international trade. While increased engagement of the general public and key stakeholders will not guarantee support for biofuels (particularly in the short-term), it is a prerequisite for establishing and maintaining a sustainable and competitive biofuels industry (in a long-term perspective).

The framework for transition management has facilitated both the analysis and discussion in this paper about the governance of biofuels for transport. However, there are three points that require further attention. First, biofuels are attracting considerable debates and conflicts that can destabilise the biofuels industry [54]. An increased focus on the political character of governance is needed in transition management that delves into power struggles [55]. Second, transition management concentrates on the predevelopment phase of transitions [56]. However, it can be argued that biofuels are shifting into an acceleration phase. Transition management needs to show the relationship between the predevelopment phase and acceleration phase of transitions as well as provide further insights into managing the

acceleration phase. Third, the contrasting pictures for the biofuels industry in Sweden and the UK can be linked to the historical contexts of these countries [57]. Since the 1970s Sweden has developed bioenergy and biofuels with governance activities playing a decisive role [58]. In contrast, the UK has limited experience with bioenergy or biofuels [59]. This makes a considerable difference for governance activities, especially in regards to political legitimacy, stakeholder networks, and industry associations. Clearly, there are ample opportunities for further research and action in the field of biofuels, particularly around the political character of governance, the shift from the predevelopment phase to the acceleration phase, and the implications of the historical context of countries.

Table 2: Experiences from Sweden and the UK on biofuels for transport

Transition Management	Key Factors	Sweden	UK
Strategic activities	**Visionary plans**	The dominant vision in Sweden is breaking dependence on oil and fossil fuels, which is complemented by efforts to become a low carbon society. This is a continuation of a national strategy, supported by many local municipalities. Biofuels are presented as integral to shifting away from oil.	The dominant vision presented in the UK is developing a low carbon economy, which is linked to low carbon vehicles. There is considerable uncertainty in the UK if biofuels are an important element of future transport systems. Electricity and hydrogen appear to be favoured over biofuels.
Tactical activities	**Policy frameworks**	In Sweden, strong and consistent policy frameworks for biofuels are observed. The parallel efforts on biofuels supply, distribution systems, and compatible vehicles, have provided foundations for a growing market for biofuels. The "pump law" ensures access to biofuels as well as reduces uncertainty and sends a strong signal to key stakeholders and consumers about high-level blending.	Initially, the UK was characterised by "go and stop" policy commitments. However, the increasing ambitions of the RTFO combined with sustainability criteria suggest the approach on low-level blending is rather comprehensive. In contrast to Sweden, there are minimal efforts on high-level blending, and the market for biofuels is not as robust as it is in Sweden.
	Stakeholder networks	Since the 1980s, there has been an organised effort across production chains towards establishing markets for the bioenergy industry and an overarching lobby organisation. "Internal" trust in production chains has been achieved as well as improved "external" political legitimacy. The BioAlcohol Fuel Foundation and Association for Green Motorists have facilitated interactions around biofuels for transport.	The interactions between key stakeholders in the bioenergy industry in the UK are often fragmented and individualistic. There is competition between actors for scarce resources and political attention, and there is no dedicated lobby organisation. There are more developed stakeholder networks around low carbon vehicles with a focus on electricity and hydrogen, which are promoted by the Low Carbon Vehicle Partnership.

Operational activities	**Local actions**	Looking at Stockholm, which is a "leader" on biofuels for transport in Sweden and Europe, the local municipality coordinated the EU project on Bioethanol for Sustainable Transport (BEST). It focused on the market introduction of bioethanol in Europe, and stimulated (practical and policy) learning processes and horizontal networking across cities and regions.	Focusing on London, there are a range of voluntary actions on biofuels for transport. The activities in London are strongly focused on biodiesel (utilised in fleets and public buses) based primarily on green procurement policy and networking activities. An EU project called the Biodiesel Network (BioDieNet) has developed a network of actors around biodiesel.
Reflexive activities	**Sustainability schemes**	In Sweden, debates on sustainability of biofuels have not been as "fierce" as in the UK. Both Sweden and the UK have transposed the EU sustainability criteria into their national laws. There are efforts in Sweden to develop and commercialise second generation biofuels in order to meet stricter sustainability conditions and increase GHG savings.	The RTFO has involved sustainability reporting since 2008, including carbon savings as well as environmental and social issues. However, the limited inclusion of macro issues and international trade of biofuels remain significant concerns. Social acceptance of new facilities for biofuels production is also viewed as an issue facing the expansion of biofuels in the UK.

5. Future perspective

Straightforwardly, Sweden is positioned to move towards breaking dependence on oil in the transport sector by 2030 with biofuels playing a "primary" role. However, this is premised on the commercialisation of second generation biofuels. The UK is confronted with different conditions to Sweden, and it appears that biofuels will play a "secondary" role in future transport systems with the focus instead on electricity and hydrogen. Robust sustainability schemes will be important for both domestic production and imports of biofuels. However, it is the imports of biofuels that will particularly attract increased scrutiny. For the EU and all Member States, an approaching challenge is what happens beyond 2020 when the target for 10% renewable energy in the transport sector is achieved. Low-level blending of biofuels can play the major role in achieving this goal. However, moving beyond this goal will demand high-level blending of biofuels and international trade with increased imports of biofuels to the EU (as well as a broad strategy for the transport sector). The experiences from Sweden

and the UK are therefore valuable for planning the future development of biofuels and the emerging bioeconomy in Europe.

6. Executive summary

- *Introduction and background:* The role of governance in the development of biofuels for transport in Europe is paramount. However, the complexity of the biofuels industry and the diversity of actors create significant challenges for policy-making and governance.
- *Theory and approach:* This paper investigates five key factors for the governance of biofuels for transport in Europe, encompassing visionary plans, policy frameworks, stakeholder networks, local actions and sustainability schemes.
- *Analysis and discussion:* Sweden and the UK provide contrasting pictures of the biofuels industry in Europe and insights for policy-makers on how to establish and expand (sustainable and competitive) biofuels for transport.
- *Conclusion and reflections:* Biofuels are likely to play a "primary" role in breaking dependence on oil in the transport sector in Sweden, while in the UK it appears that biofuels will play a "secondary" role with the emphasis on supporting low carbon vehicles utilising electricity or hydrogen.

7. Financial disclosure

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