

Research Article

The Road to a Downstream Emissions Trading System: Designing a Scheme Combining Motorist and Government Participation

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As downstream road transport has not been fully integrated into any emissions trading scheme, this paper proposes and evaluates the possibility of one by addressing the main barriers hindering its development. Based on this, a scheme which separates the “Cap” and “Trade” participation to motorists and local governments, respectively, is presented through a systematic review. We investigate how the scheme addresses the problems of cost, administrative burden, and fuel allowance allocation as they are all key factors that need equal consideration. We also justify the model’s unique structure and characteristics against the world’s largest scheme, the European Union Emissions Trading System (EU ETS), to ensure they cater to the three aforementioned issues barring its viability. It is concluded that, by amending specific policy attributes of a road-based emissions trading scheme significantly, it could be more practical both economically and administratively. Also, leveraging on existing institutional arrangements would allow for an economically feasible environment for the administration and management of such a scheme.

1. Introduction

Globally demand for and goods transport is increasing annually relative to the baseline [1]. In 2011, the transport sector alone generated 22% of global emissions, of which road-based transport was responsible for approximately 75%. Also, between the years 1990 and 2011, road transport emissions grew by 52% [2]. This rapid increase in the road transport sector emissions could be attributed to the growing fleet of conventional fossil fuel consuming vehicles with no widely used alternative available in the near future, another being the increased overall mileage driven as an inevitable factor of economic development. This makes the sector a pain point for policymakers as to the appropriate approach to reducing emissions from road transport.

With the advent of the 2015 Paris Agreement which over 179 nations ratified and committed to reducing their emissions based on their Nationally Determined Contributions

(NDCs), the need for an effective mechanism for road transport has never been as relevant as today. Literature has shown that more action needs to be taken to ensure anthropogenic emissions are reduced in the coming years, with action being recommended immediately [3, 4]. The mounting pressure from environmentally conscious stakeholders and the finite oil reserves are ever so apparent, with vehicle manufacturers attempting to find alternative energy sources that are more viable to exploit, hence the introduction of hybrid and electric vehicles.

However, to date, their numbers are yet to contribute to any significant emissions reduction. A more efficient vehicle inventory will technically reduce emissions only with the caveat that the inventory stays the same and the total kilometers driven also remain the same. These two variables, in the real world, cannot realistically stay the same and thus another solution is needed to control emissions from the sector.

The history of ETS can be traced back to the United Nations Framework Convention on Climate Change (UNFCCC) which successfully oversaw the adoption of the Paris Agreement in 2015. That same year, 17 ETSs were operational in 55 jurisdictions.

ETSs do not consist of the manufacture of emission allowances but instead introduce limitations to the right to pollute when previously they were unlimited. This restriction is the overall and or individual cap on fuel, depending on the preferred method of allocation. The cost on society is also reduced by the possibility of trading of emissions.

There are two main types of ETSs: Cap-and-trade (CAT) and baseline-and-credit (BAC). One key difference between BAC and CAT is that, under CAT, an overall limit on emissions is established and distributed to participants based on a predefined allocation method. A BAC-based ETS places individual limits on the participants and is usually pegged on a benchmark for the industry. However, CAT is much more commonly used, the EU ETS being a well-known example [5] while the Kyoto Protocol operates as a BAC.

The structure of this paper is arranged such that arguments for and against the viability of a downstream emissions trading system (ETS) for road transport are presented. Subsequently, a downstream ETS for road transport is proposed and developed by addressing the key barriers to its establishment in today's economies. In addition, the key elements such as the trading mechanism, the cap determination, institutional design, and other factors are investigated against the backdrop of the European Union Emissions Trading System (EU ETS). This is followed by a hypothetical example highlighting its operation.

2. Literature Review

A critical gap in climate policy is one that can ensure emissions are kept within a target limit [6]. Governments intending to minimize their contribution to climate change tend to adopt either an ETS scheme which lowers emissions by mandating an upper limit on the total allowable emissions and creating a market by allowing trading of emissions allowances, or through the introduction of emissions taxation [5]. Both of these instruments have been discussed in detail in literature in terms of their benefits, albeit mostly in a theoretical context [7, 8].

In an ETS, emissions caps are aggregated for the scheme (i.e., CAT) or determined individually for participants (i.e., BAC) [9]. Governments issue pollution allowances or permits to major industries which in turn trade these allowances with other entities based on who has a surplus or a deficit thereby creating supply and demand and subsequently, a market.

The other major policy instrument, a carbon tax, is an additional tax that is charged using the emissions from fuel as the measure [10–13]. The core disadvantage of this fiscal policy is that it does not guarantee environmental outcome; i.e., whatever the tax, people could still choose to pay that higher tax and keep polluting. In contrast, in an ETS, one is certain that the planned emissions cap will be met, whatever the price because there are a fixed number of allowances.

Thus, a price increase is not really an ETS problem, as the total number of credits will remain the same.

There are 3 levels of participants in any ETS: upstream, midstream, and downstream, explained by Watters and Tight in their 2007 paper suggested in the academic literature. The upstream approach targets fuel suppliers whilst the midstream approach holds vehicle manufacturers and transport system as the responsible scheme participants [14]. The weakness of an upstream approach is that the upstream industries could simply pass down the costs of complying with the ETS down to the purchasers. It would fail to incentivize the actual downstream emitter because fuel producers would transfer the opportunity costs related to the system down to the emitters as an additional cost making it akin to fuel taxation. This is mentioned by Bart as the reason that an upstream approach is similar to a fuel tax [6].

On the other hand, the downstream approach affects motorists directly as the end user. An advantage of a downstream ETS is that fuel retailers are unable to express the cost of the carbon credits in the final price of their products. Thus, when energy prices rise, it is assumed to be associated with the usual volatility of fuel prices and not a government intervention.

Nordhaus and Danish [15] attempted to design an ETS for the United States and concluded that a downstream system would be too difficult to manage due to the millions of vehicles that would have to participate. However, they proposed the use of a hybrid approach that would combine both upstream and downstream players in order to address this challenge. Another study by Winkelmann et al. also proposes a hybrid approach with fuel producers as the upstream actors and vehicle manufacturers as the midstream actors [16].

There are several types of allocation methods. Grandfathering is the allocation of allowances based on historical emissions [17]. This was evidenced in the first phase of the EU ETS which distributed free allowances based on the grandfathering method. This led to more allowances being distributed than were verifiably necessary which affected the integrity of the system altogether [18]. In turn, this resulted in drastic carbon price fluctuations attributed to the way allowances were distributed [19]. Benchmarking on the other hand is the allocation based on sector performance or a firm's current output [20]. Since the beginning of Phase 2 of the EU ETS, benchmarking has been the primary method of allocation in addition to auctioning of allowances. This is considered a high performing system compared to a purely grandfathering system [21]. Thus, the allowance method can determine the integrity of an entire ETS and must be one of the first considerations in the design of an ETS policy.

Unlike in air transport, an ETS for road transport will inevitably involve huge implementation costs due to the sheer number of vehicles in operation in any given jurisdiction. However, Raux [1] mentions that the administrative complexities and financial costs of a permit-based system can be reduced substantially using a "smart design". This is in addition to the involvement of local governments which could provide for a practical scheme.

Raux [1] discusses the key hindrances of introducing a market-based emissions trading system, being the millions

of vehicles to manage and the subsequent costs of trading together with the administrative resources needed. He does, however, mention that these problems can be approached more effectively today as a result of the available technology.

Even so, an ETS has been deemed more feasible for road transport if the point at which leverage is applied is not the millions of end users, but rather the more manageable number of fuel suppliers. The cost implication of having an enormous number of moving emitters makes the inclusion of the sector impractical. With regard to administration, ETSs would most likely be better served through more dedicated institutional infrastructure [9].

Jochem [22], in his 2009 study about an ETS for road transport in Germany, refers to a paper by Debold and Lux in 2006 which showed that the installation of chip card readers in each petrol station and the cost and distribution of the chip cards to the German public would cost approximately 1,300 euros and 1.50 euros, respectively [23]. At the time, the combined total of these material costs alone was equivalent to about 0.07% of Germany's GDP. This approach was also examined by Raux and Marlot [24] who analyzed the introduction of a decentralized car fuel consumption permit system for France and concluded that, due to the high transaction costs, it was not an ideal solution for implementation. As is with road-based fee schemes currently in operation worldwide, the overall financial and administrative resources required to run an ETS would initially be enormous but would nevertheless drop significantly with time [25].

The social acceptance of personal carbon trading schemes (which utilizes the same concept of the proposed downstream ETS model) may be perceived as being fairer to carbon taxes, even though this comes at the cost of administrative burden [26]. Lyons and Chatterjee mention how protests have shown that public opinion is crucial when it comes to an increase in the price of fuels [27]. The sensitivity to fuel price increases can be attributed to the dependency on motor vehicles as a mode of transport. Several countries have faced severe revolts by the public due to the increase of fuel prices including some in Europe in September 2000 when fuel prices rose significantly and in developing countries such as Kenya as seen in the August 2018 protests.

Therefore, the economic impact of introducing such schemes should be very gradual and should start as soon as possible when the damage is most manageable. This rationale justifies why it is necessary to incorporate a transport based ETS today since the results in the sector can be immediately felt. In terms of preference, a survey conducted by Harwatt [28] of 60 people (whose educational level was higher than the national average) showed that traffic participants in the UK would actually prefer a downstream trading system as opposed to a spike in fuel prices. He concludes that the impact on fuel demand might be stronger because the participants are more aware of their limit than the impact on demand through a sole fuel price increase [28].

ETSs have some powerful driving forces. In the USA, ETSs have been shown to be effective in lowering overall GHGs [29]. They have also been shown to improve not only economic but also green sustainability whilst lowering emissions [30]. Gilbertson and Reyes discuss the effective

use of the tradable permit system, which consists of a finite number of distributed permits that are gradually reduced thereby ensuring a reduction of total emissions [31]. This decrease is substantiated by an abatement cost which in road transport is limited (especially to existing vehicle owners) to better management of driving style, travel decisions, etc. For vehicle ownership, ETSs influence the shift towards newer, more efficient technology [32].

The success of an ETS is not only based on the emissions reduction, but also price volatility, revenues raised, and administrative issues [33]. Reference [5] assessed 17 ETSs in 34 national and 21 subnational jurisdictions including the EU ETS. It was found that the ETSs covered between 18% and 85% of all emissions in those jurisdictions and the prices of the allowances were 50% lower than the prevailing carbon taxes. California achieved a 4.81% reduction in emissions between 2013 and 2014 and 2.79% reduction between 2015 and 2017 [33]. The Regional Greenhouse Gas Inventory's (RGGI) performance was also a success with 40% of allowances not sold due to industries meeting efficiency targets. The Tokyo and Saitama ETSs have reported reductions in emissions until the recent shutdown of the nuclear plants which resulted in higher emissions from alternative coal fired plants [34].

The EU ETS has also been studied extensively with results showing emissions reduction of between 130MtCO₂ and 247 MtCO₂ during its first phase [35–37]. Emissions reductions were even greater in Phase 2 with several studies in France, Germany, and Norway suggesting a 6% reduction during Phase 2, i.e., 2008 to 2012 [38–41]. Consequently, ETSs have been expanding rapidly with the latest 7 ETS pilot schemes from China.

Still, as a market mechanism, an ETS has its flaws. For instance, Gilbertson and Reyes noted that there is a risk of allocating an excessive number of allowances which would not give the parties involved enough incentives to reduce their emissions. They go on to say that even in the case where allocation is done correctly at the upstream or midstream level, these additional costs would simply be trickled downstream, compromising the very purpose of the system [17, 31], hence, the importance of incorporating the source of demand in an ETS, i.e., motorists, and a proven allocation method such as benchmarking.

A transport ETS could be part of a larger overall ETS (as evidenced in aviation in the EU ETS, or fuel supply inclusion in the Western Climate Initiative schemes). In 2008, the addition of road transport in the EU ETS was discussed by the European Commission (EC) [42]. However, neither upstream nor downstream approaches were acceptable due to the lack of feasibility for end users and the administrative complexities, respectively. Nevertheless, in 2014, the EC noted that road transport remains a legislative possibility.

In 2015, Achtenicht [43] published a report that was contracted by both Adam Opel AG and BMW AG which discusses the feasibility of including a road-based transport in an ETS, more specifically, the EU ETS. They determined that, at the time, an upstream approach would be the most economical due to the smaller number of participants yet the least effective in emissions reductions which the downstream approach would be able to achieve.

Literature has shown addressing the cost implications and the administrative complexities, as is proposed for the California Cap and Trade scheme [44], could justify the inclusion of the downstream approach for the road transport sector. Also, with the 2012 addition of the airline industry in the EU ETS as the first step of integrating the transport sector, the liable entities being the aircraft operators (European Directive 2008/101), it is highly likely that a downstream solution may be achieved with road transport.

2.1. Current Limitations. To date, research has yet to develop an ETS for road transport [10] with full consideration of the administrative complexities and costs. Based on this, we develop the rationale for a feasible road transport-based ETS that addresses the hindrances of administrative and financial complexities.

3. Methodology

To fill these gaps, we systematically review and reconstruct the (i) cap and (ii) trade elements of a typical ETS model and; secondly, we establish the proposed model's institutional architecture and process flow, reinforced by an analytical literature study research methodology. The characteristics of the proposed model are compared with those of the EU ETS, and conclusions drawn on the likelihood of success of the new model.

There are two key reasons for choosing this example and excluding the other schemes such as the long-running United States (Regional Greenhouse Gas Initiative (RGGI)) and the China, Korea, and Japan schemes. First is the fact that EU ETS, which was established in 2005 and, until the China ETS becomes fully implemented, is by far the largest system globally and has developed significantly through several phases as opposed to China which started its ETS pilot phase in 2014 with plans to operationalize it announced in December 2017. Therefore, a closer focus on the EU ETS allows for a more detailed comparison and analysis. Secondly, the recent addition of aviation in the EU ETS makes it an ideal case study to cross-examine in a bid to justify the proposed scheme for road transport. Thus, the comparison of the EU ETS would provide more substance in answering the research question.

In what follows, the design of the ETS is substantiated through a qualitative assessment and involves justification of each proposed element using literature and the vast experiences of the EU ETS. Also, a hypothetical model is presented that illustrates the operation of a scheme of this type.

The ETS scheme introduced in this paper functions both like a BAC and a CAT in that an implicit overall cap is established on fuel using a baseline year with individual caps being determined by using fuel consumption data from the pilot phase of the scheme and redistributing the allowances minus the potential abatement factor. From the perspective of the local governments, each jurisdiction has a predefined overall cap allocated to it since the aggregate emissions at the end are fixed for each period.

Considering the above, ETSS could achieve the same objectives with the inclusion of downstream road transport

with the exception of some valid arguments that state ETSS' for road transport bring specific challenges. These include the i) cost implications of having millions of motorists trading in the scheme, the fuel/emissions allocation method to be used, and the need for administrative capacity. These are addressed below.

3.1. Cost Implications. With regard to the high transactional and operational costs, the EU ETS liable entities can opt to trade their permits through an agent. This method can be used to minimize the number of trading actors in a downstream road transport ETS. For the proposed scheme, the motorists, upon registering to participate, would have automatically appointed their respective local government as their agent to transact on their behalf for the trading of allowances which happens only once: at the end of an accounting period (more likely every year). This reduces the number of trading participants from potentially millions to less than a hundred depending on the country's devolved governance context. It also drastically reduces the frequency of trading transactions to one period.

The main justification for this crucial suggestion is the fact that both local and central governments have autonomous administrative powers and develop transport policies. The challenge they would face would be the constant administration and management of each participating motor vehicles that are constantly moving [45]. This can easily be overcome through the use of fuel cards (also known as loyalty cards) which are currently utilized in a wide variety of private and public sector applications.

It is important to note that the justification behind the appointment of a local government as a trading participant is not just to simplify the scheme and lower the costs. The premise behind this is that a local government inherently acts as a representative of its constituents; its nature makes it impossible for it to be disruptive or dominant and, therefore, it would be assumed to act as a viable proxy for trading purposes. In addition, using the smallest administrative unit allows for a more representative proxy acting on behalf of its constituents.

The premise for the proposed scheme is a fuel price only on a portion of one's consumption, depending on the quota for that party. There are many examples of such pricing mechanisms. This is similar to how, e.g., power pricing was done in Hungary (for social purposes); the first batch of consumed electricity would cost much less than the amount beyond that. People would benefit directly from managing their consumption better (which is in their control) and indirectly from the investments made by their local governments based on the revenues from the scheme. This comes at the expense of having motorists not being able to trade amongst themselves but allows the possibility of having a downstream ETS that is administratively feasible. Taxes, on the other hand, are fixed and do not reward motorists who drive less or improve their driving habits altogether.

On the contrary, the benefits incurred by the fraction of participants holding extra fuel allowances to sell would not create a significant abatement opportunity. In addition, several scholars have pointed out that the marginal abatement

costs of transport are actually greater when compared to other industries [46]. Heinrichs et al. also mentioned the high technical CO₂ emission abatement costs of motor vehicles [47]. The transport sector also has a low price elasticity for fuel and will become a net buyer of allowances [48] [49]. All these allude to the indifference of trading to the participating motorist. Thus, the benefit of receiving a discount on fuel and the indirect benefits of the government's investment of the revenues into offset projects will suffice as discussed later in the "offsetting excess emissions" section.

Another reason behind the proposed use of devolved local governments can be illustrated with the use of the EU ETS which covers around 115,000 local administrative units. This figure, even though it is higher than the approximately 16,000 EU ETS participants, is still far lower than the millions of motor vehicles registered in the EU. Putting local governments in charge of trading bulk allowances on behalf of motorists fulfills the theoretical condition necessary for a viable ETS because the government represents its people and thus is in control of its emissions.

Furthermore, participating motorists are allocated free fuel credits (allowances) through a fuel card, similar to those already existing in major fuel retailers. According to Raux [1], in a political context, the free allocation of allowances is the key difference between a market-based climate-policy such as an ETS and a tax and could improve overall acceptability. Abatement for the sector can be done in several ways such as changing one's driving style, reducing distance driven, alternate vehicle choice, and modes of transport.

Fuel stations would be incentivized to use a fuel card system in order to attract customers who can benefit from the discounted price of fuel, i.e., the fuel price excluding the carbon price. Since the fuel consumption data would be automatically available to the fuel retailers and also uploaded to a government server, fuel stations would simply need to include this information in their normal accounting and audits for verification purposes. The inclusion of fuel station entities in the design of the ETS allows for a cost-effective infrastructure and leverages on existing technological systems to reduce the operational costs substantially. Figure 1 shows the rationalization for segregating the cap and the trade elements to motorists and local governments, respectively.

3.2. Setting the Cap and Allocating Allowances. Having a cap which is verifiable is crucial in order to effectively limit overall emissions. If an ETS for downstream road transport is to be viable, allocation needs to be pegged on confirmed emissions of each entity as evidenced in phase II of the EU ETS [39, 40].

Therefore, the proposed ETS would commence with a pilot phase where no cap is allocated to participants. Instead, motorists would be incentivized to become participants because they would benefit from paying less by using the ETS fuel card as opposed to paying the retail price which would contain the carbon price included in it. During this pilot or trial phase, the fuel consumption data would be used as a benchmark to allocate individual caps to each motorist for the next phase. This eliminates the excess distribution as seen in phase I of the EU ETS during which allowances distributed were confirmed to be higher than in phase II [31].

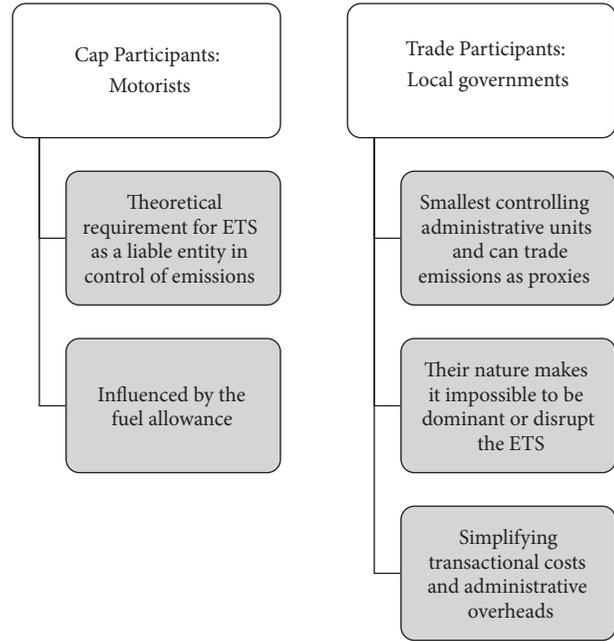


FIGURE 1: Significance of separating the "cap" and "trade" participation.

To avoid this, for the proposed scheme, a fixed cap on carbon emissions from road transport must be used based on the baseline period. Due to the sensitivity of the transport sector in terms of resistance of price increases by the public, it is deemed best to distribute free allowances based on actual historical mileage of each vehicle to minimize disturbance to the sector. However, the fact that trading is only done by local governments and not individuals means that fuel that has not been consumed is not traded by the motorist but is forfeited. The direct benefit to the motorist is the discount received when one meets the fuel quota (meaning one does not pay any more than they otherwise would have if the scheme had not been implemented).

The cap for the scheme is composed of an overall cap (OC) derived from the average yearly emissions during the baseline period ($X_{baseline}$) and the emissions abatement factor in year t (μ_t):

$$OC_t = X_{baseline} \times (1 - \mu_t) \quad (1)$$

A period of one or more years can be used as a baseline range and the pilot phase is conducted during this period where participants are allowed to use the ETS fuel card without a cap. This will avail per vehicle statistics on fuel consumption and determine overall cap which will then be used to distribute individual caps to each vehicle.

The abatement factor is determined by the government by considering its target for emissions reduction, the possible mitigation possibilities, and the marginal abatement cost within its jurisdiction. Some of the potential abatement measures are changing one's driving behavior or pattern, choosing different modes of transport or vehicles, better fuel type, etc. [10]. The step-by-step summary of the baseline allowance calculation is shown in Figure 2.

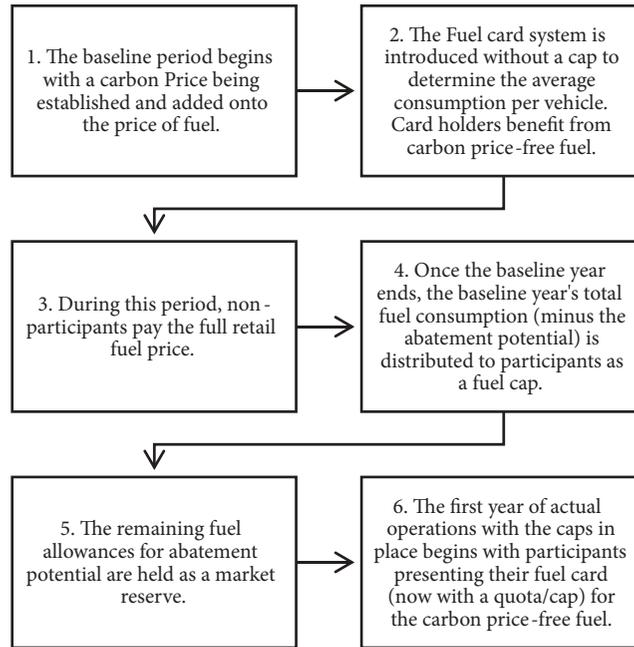


FIGURE 2: Baseline period—steps in determining the per-vehicle fuel allowance.

The EU ETS has proven that an ETS can actually reduce emissions. The first two phases of it showed that there indeed was a decrease in emissions in the participating study [50]. CAT schemes have generally shown positive outcomes within participating industries with the countries still experiencing growth in each phase of the EU ETS [9].

In the proposed scheme, caps are distributed per vehicle because each vehicle has its own utility to the people it benefits, in short, if a vehicle is used to drive 100 km in a month, that is, the baseline utility derived from it. This assumption makes it much easier to distribute emissions or fuel caps because it uses actual historical fuel consumption data without having to find the utility of the vehicle to each person it serves. Thus, every time a vehicle joins the proposed scheme and obtains a fuel card, its first year is used as the base year to measure its consumption and, thereafter, it is given a quota and an abatement reduction target (similar to that in the EU ETS).

Although the allocation of fuel allowances per vehicle would be based on actual per vehicle consumption, the resulting allocation for each vehicle would be its share of the total overall cap proportional to its baseline fuel consumption. This is shown below:

$$IFA_t = \frac{FC_{baseline}}{X_{baseline} \times (1 - \mu_t)} \quad (2)$$

The term IFA_t is the initial free allocation per vehicle. $FC_{baseline}$ is the average annual (or annual consumption depending on whether the trial period was one or more than one year) fuel consumption for a particular vehicle during the baseline trial period. $X_{baseline}$ is the total fuel consumption during the baseline period and μ_t is the potential abatement factor determined by the government based on its strategy

and mitigation target. However, the above equation can be condensed as shown in (3), whereby Oc_t represents the overall cap after considering the potential the abatement factor:

$$IFA_t = \frac{FC_{baseline}}{OC_t} \quad (3)$$

This method of allocation is suggested as a simple yet moderately accurate method of distributing allowances as it distributes them based on actual historical allowances. The accuracy is further enhanced by the availability of actual per vehicle consumption data from the use of the ETS fuel cards.

New entrants would be subject to the same allocation as existing participants except that they would have to first go through a “pilot” phase where the benchmark can be assessed [5]. During this period, they are allocated fuel allowances based on average benchmarks for their class of use, i.e., private, public service, freight, etc., for a certain period such as a year, after which they join the main scheme with allocations based on their baseline fuel consumption.

3.3. Administration. Thirdly, in terms of the administrative capacity of the road-based ETS, the institutional architecture would leverage primarily on existing institutions related to climate change and environmental governance. A central authority (CA) develops a road transport emissions reduction target for a given period [51]. The CA then chooses a baseline year and a method of allocating fuel allowances. Figure 3 shows the overall architecture of the proposed ETS highlighting the institutional structure.

Local governments would have representatives in charge of managing the system within their local jurisdictions and even more importantly to oversee the trading of surplus

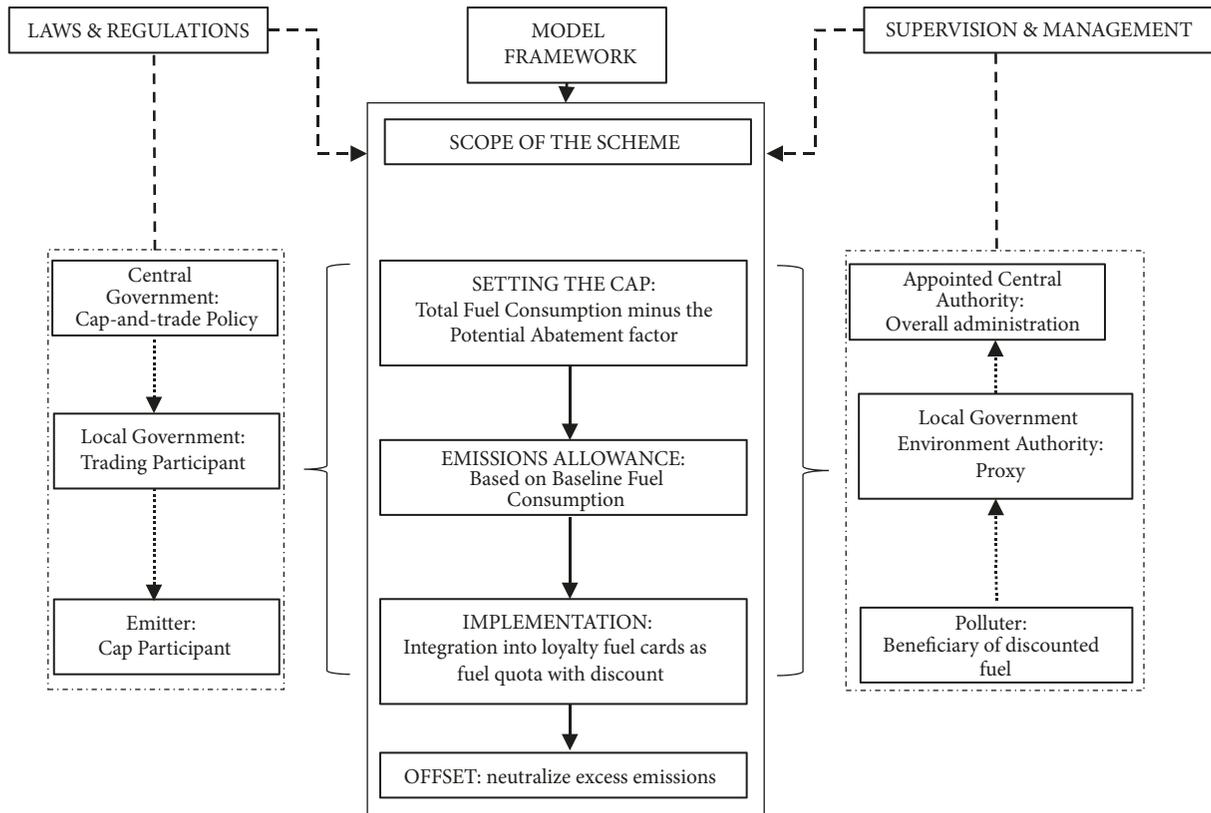


FIGURE 3: Overall structure of the institutional design.

and or deficit allowances at the end of every year. It is important to note that the majority of the transactional and system resources are maintained by fuel retailers and not the government. The government would simply ensure compliance and audit of the accounts. Therefore, the primary administrative responsibility of the government would be overseeing the compliance of the scheme and the trading of allowances between local jurisdictions.

In the EU ETS, all participating countries must account for emissions through a domestic registry [52]. In this case, the fuel retailers accounts would have to match those of the national registry as an audit process.

Thus, it is clear that the proposed ETS for road transport would require a substantially lower administrative resource for the government yet more resources from fuel retailers alike who stand to benefit from implementing the ETS scheme into their fuel cards as a complementary extension to their loyalty schemes. To further substantiate this method of joint administrative participation by government and fuel retailers, the initial setup costs could be financed by either the government in well-off developed countries or, in the case of developing countries, through bilateral or multilateral climate finance initiatives. Governments may also choose to subsidize the capital expenditure incurred in setting up the system by fuel retailers. Table 1 highlights the key characteristic differences between the proposed ETS as discussed and the EU ETS.

3.4. Trading Illustration. A basic illustration involving two local governments and two motorists is used to showcase the process flow of the proposed scheme. Since 95% to 99.5% of the carbon from fuel is converted to emissions when ignited [53], for simplicity we will assume that 100% of the carbon content contained within each litre of fuel will be converted to CO₂. In this model, it is also assumed that all travel takes place within the jurisdiction of that one country. In addition, the type of fuel is not distinguished with 1 litre of fuel assumed to contain 2.3kg of CO₂ upon combustion.

This illustration uses two motorists to show how the trading would take place in the proposed CAT scheme, with both motorists A and B assumed to join the scheme. As shown in Table 2, the total passenger transport fuel consumption stood at 100 litres (60 and 40 for each motorist) in the first year: the pilot period before the actual commencement, with this figure expected to grow every year without intervention.

Participation in the scheme is optional, with nonparticipants having to pay the full retail fuel price which includes the carbon price component. Otherwise, scheme participants would be able to enjoy a discounted fuel price using their allocated fuel allowances. Finally, the price per litre of fuel in year 0 is assumed to be \$1.

The process would, therefore, flow as follows.

Stage 1. Year 0, with a total fuel consumption of 100 litres, is taken as the baseline year and used as the overall cap. In terms of total emissions of CO₂ for the BAU scenario, this would be

TABLE 1: The proposed Scheme features compared with the EU ETS.

		EU ETS	Proposed ETS
General	Sectors	Energy, Industrial processes, Agriculture, Waste, Aviation	Road Transport (Motor Vehicles)
	Carbon Price Participation	Fluctuates Mandatory	Hybrid Voluntary
Size	Point of regulation	Downstream (polluter)	Downstream (polluter)
	Trade participants	Emitters (industries)	Local governments (proxy)
	Cap participants GHGs covered	CO ₂ , N ₂ O, PFCs	Emitter (Motorists) CO ₂ content of fuels
Allocation	Method	Grandfathering, then Benchmarking & Auction	Benchmarking (pegged on baseline consumption)
	Allowance value	Free/auctioning	Free
	Price protection	Market Stability Reserve	Government controlled
Flexibility	Offsets & Credits	CDM/JI	Offset Project Fund
Compliance	Accounting	MRV	Chip card system
	Enforcement	Penalty to emitter	Penalty to retail fuel stations
Others	Leakage risk	High	Low
	Sector linkage	Yes	Not recommended

TABLE 2: Example: Initial distribution of free allowances.

Motorists	A	B
Consumption in litres (baseline)	60	40
Allocation in litres (year 1)	57	38
Consumption in litres (end of year 1)	77	8

calculated as $2.3\text{kg/litre} \times 100\text{litres} = 230\text{kgCO}_2$. This figure would further be reduced based on the potential abatement factor. If 5% was to be used as this factor, the resulting cap would be 218.5kgCO_2 . In effect, this 5% abatement factor would lead to motorist A receiving 57 litres and motorist B 38 litres in year 1. This continued restriction (also called Linear Reduction Factor) with time is normally used in ETSs such as the EU ETS in phase 2 and 3.

Stage 2. Assuming motorists A and B are the only participants in the scheme, free fuel allowances are distributed between them using their average fuel consumption during the baseline period minus the abatement factor. Therefore, since each motorist would be possession of allowances worth 57 and 38 litres to use in year 1 in the form of credits contained within their fuel card, consumption above the allowance limit renders the card unusable until the next allotment.

A carbon price is then determined by the CA with 10 cents per litre of fuel being used for this illustration. This means the

retail price of fuel will rise from \$1 to \$1.10 per litre once the scheme is functional in year 1.

Stage 3. Assume motorists A and B use their fuel cards every time they visit a fuel station. Each time the card is used, the fuel credits (allowances) contained within the EMV chip are reduced until no credits are left upon which the card is no longer usable, and the motorists must pay the full retail fuel price (which includes the carbon price). The impact on fuel demand might be stronger because the participants are more aware of their limit than the impact on demand through a sole fuel price increase [28].

As shown in Figure 4, if motorist A uses all of his/her allowances and Motorist B has 30 litres worth of allowances left on his/her card, a market exists where trading takes place. The value of these extra allowances would be 10 cents multiplied by the number of allowances in litres; in this case, \$3.

Stage 4. At the end of year 1, each local government's final balance is evaluated. If it exhausted all its free fuel allowances for the year resulting in a deficit, it must purchase allowances from other local governments thereby exercising the "trade" element of the scheme on behalf of the constituents it represents. If it has remaining fuel permits, it must sell them to local governments with a deficit.

In this case, Figure 5 shows local government X needs to neutralize its emissions by buying 20-litre allowances from

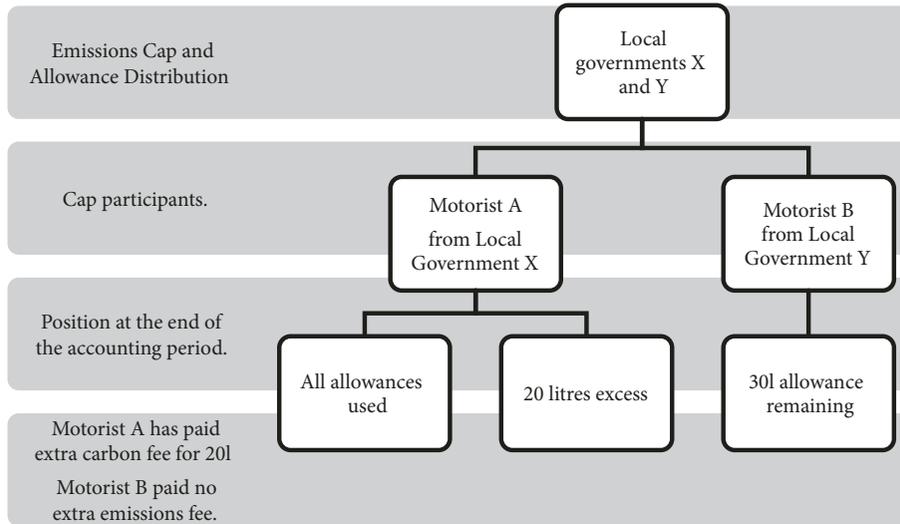


FIGURE 4: Motorists A and B’s fuel consumption at the end of the period.

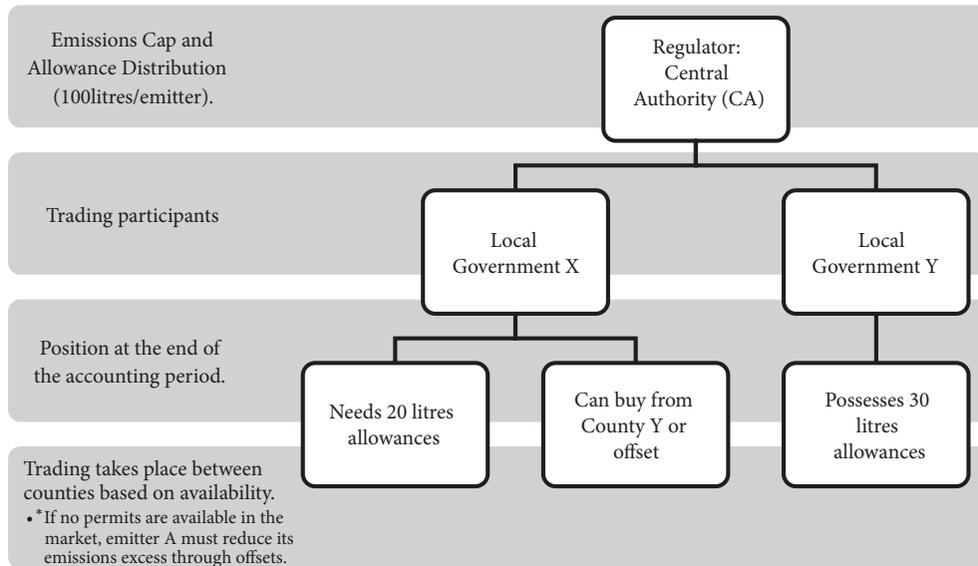


FIGURE 5: Local government X and Y’s trading environment.

local government Y which holds 30 litres worth of allowances valued at \$3. The transaction would simply be a purchase of 20 litres by X from Y. If the local government has a surplus in revenues from previous trading periods, it can decide to balance its emissions by investing in an offset project. However, this is not cast in stone and governments would be at liberty to decide the rules on offsetting based on their context.

4. Conclusions and Discussion

This study proposes a possible solution especially in the context of today’s technological possibilities whereby impracticalities only decades ago can be overcome through

leveraging on existing technologies and institutional infrastructure already in place to create a climate-based market.

A key issue to ETSs is not just the lack of concepts on how such schemes could function but also rather their political and social acceptability. A strong argument against a fuel cost increase through a carbon tax often leads to riots and unrest, which makes the idea less appealing. This is why free allowances have been proposed.

Regarding the geography of travel emissions, one would assume that, in a local authority-based scheme, residents of densely populated areas would travel less by car and those in rural areas more. However, the fact that the distribution of fuel allowances is done by benchmarking eliminates this problem altogether because people would

have fuel allocated based on their actual historical consumption.

In transport, some of the big themes are the (hoped for) move to electric vehicles and other lower-carbon technologies, the sharing economy (bikes, car clubs), mobility as a service, detailed personalized travel planning via apps, etc. On one side, the move to more efficient technology might still be outpaced by the sheer growth of road transport. Thus, a majority hybrid or electric vehicle inventory could face a nil-effect due to the potential increase in the number of vehicles and the increased mileage driven. Nevertheless, since an ETS's principal aim is to limit the overall emissions to an acceptable level, a risk of this nature is mitigated.

However, one drawback of this study, as with similar studies, is that it cannot validate the proposed ETS design through any existing empirical insights. This is obviously because no such scheme is currently in operation. Experimenting with a small sample could be one possible route [54]. Still, as Fawcett et al. mention in their article on personal carbon trading, this would be impractical [55].

Another gap in the study lies in the use of the fuel discount card. For example, if some participants have used up all their cheap fuel quotas, they would still need to use their fuel card to record subsequent fuel purchases in order to measure the exact level of the fuel deficit for the year. To keep using the fuel cards after exhausting the fuel credits, fuel retailers would have to be mandated to identify vehicles license plates and those that have been registered in the scheme must use their cards in order to be sold fuel. Another more stringent solution to this would be to make the scheme mandatory for all vehicle owners.

A future study would need to be conducted in order to determine the social acceptance of the proposed ETS. The main parties whose acceptability would be critical are motorists, who benefit from discounted fuel prices through a cap and indirectly allow their local governments to "trade" on their behalf. In addition, revenues from the scheme are invested in offset projects within their jurisdictions thereby creating a sort of "double benefit" for participants. This, coupled with the free allocation of fuel allowances, eliminates excessive burdens. Fuel retailers would leverage on their existing loyalty schemes or obtain governmental or climate fund support to cover the initial costs of the card systems in order to provide motorists with the fuel discount associated with the scheme. These considerations could increase the likelihood of social acceptability.

Data Availability

The data used to support the findings of this study are included within the article.

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Conflicts of Interest

The authors declare no conflicts of interest.

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