

Essays on information and climate change: financial theory applied to climate change policy and low carbon investments

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As we move to a low carbon energy system we need to decide who are the best agents for efficiently deploying the vast amounts of capital required, as well as how those agents should receive the information that tells them what to do and how to do it.

In the mainstream energy sector, particularly in the utility sector, the model which has evolved over recent decades is one where agents of investment and management are not directly instruments of government, but are to varying degrees in the private sector or operate as if they are.

In an international context, the UK is an extreme case, where there is almost no government ownership of utilities. Only some sub-sectors of the utility market are directly regulated by government or pseudo-government bodies (grids are directly regulated by Ofgem for instance); and most of the sector consists of private companies with government signalling its (and hence society's) desires via a suite of arms-length price and regulatory measures.

Other countries have been less 'capitalist' or 'free market' in their approach to ownership, regulation and incentives. But in most cases today, even government owned entities in more 'statist' economies attempt to operate as if they were private sector companies, and most governments attempt to pass on a majority of their signals via incentive mechanisms designed to look and feel like markets.

Hence when we look at the characteristics of trading systems and similar mechanisms we are studying the approaches which governments, in service of society, take in order to incentivise the deployment of private capital, through private agents, who would not otherwise receive such signals as they are not naturally provided by the free market.

References:

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2. See the classic paper on this (Modigliani & Miller, 1958).

To understand how private actors respond to these new economic signals created via public policy, we need to go back to basics and understand how private actors actually account for and respond to such measures. Understanding this will help policy makers create more efficient and effective policy frameworks able to deliver the investment needed to create a low carbon energy system.

Which side of the balance sheet?

One fundamental instrument of finance and accounting is the balance sheet. The balance sheet simply says that a company's assets minus its liabilities must equal its equity. Assets are comprised of the value today of the future cash inflows to the company, while liabilities are the value today of the company's future cash outflows (its commitments to pay). Liabilities come in real and financial forms and so we can re-arrange the balance sheet, so that:

$$\text{Real Assets} - \text{Real Liabilities} = \text{Financial Liabilities} + \text{Equity}$$

This re-arrangement differentiates between those liabilities in the real economy and those which are undertaken for financing purposes. The latter largely being debt. It is a fundamental premise of financial theory that in a perfect market it is impossible to create value through financing² (i.e. on the right hand side of the balance sheet) and hence that all value is created in the activities of a company in the real economy (expressed as the real net assets on the left hand side of the balance sheet). The right hand side of a balance sheet (financing) is hence meant to be the

servant of the left (real economy), merely providing the finance required to sponsor value creating activity in the real economy.

In a market where companies naturally received a signal to make clean energy and emissions reductions investments and those investments were value creating in their own right, then it would look no different to that of any other company. However, this is not the current state of affairs. There is an un-priced externality called climate change, which without policy is not reflected on the balance sheet. It needs such a policy intervention in order to prevent a simple tragedy of the commons occurring to the whole planet.

This externality is currently given a price in a variety of ways. The best known in the climate arena are cap-and-trade schemes for emissions and green certificates (i.e. renewable portfolio standards or renewable energy certificates) for renewable energy and various other devices. These systems tend to reward activities in the real economy which involve either the reduction of emissions or the creation of cleaner energy or related products, and hence send a signal to the agents of investment to deploy capital in low carbon investments rather than high carbon ones.

A carbon credit or green certificate in any of their forms is a real future flow of cash to the company which is reducing its emissions or creating green energy. Hence these are real assets and hence reside on the left hand side of the balance sheet.

These assets are created by the future cash flows being paid by energy consumers or taxpayers. In the case of the EU Emissions Trading Scheme (EU ETS³) or the UK Renewables Obligation (RO⁴) the costs are paid by the end consumer as they are passed through into the costs they pay for their energy. Now a fundamental feature of accounting is that all assets have a liability, the 'real asset' of paying a company to deliver emissions reductions is the 'real liability' for the energy consumer who is paying for the transition.

References:

3. See (Ellerman, Convery, & de Perthuis, 2010), (Gallo, et al., 2009) and (Lararowicz, 2009) for reviews of the various carbon trading markets including the EU ETS.
4. See (Kildegaard, 2008) for a review of the role of green certificate systems like the RO.
5. See their report in (UN, 2010).

The €30–40bn per year of value in the EU ETS or the £1–1.5bn or so of value each year in the RO is not financing, it is not financing anything, instead it is the creation of new property rights (European Union Allowances (EUAs), Renewable Obligation Certificates (ROCs) or under the Clean Development Mechanism of the Kyoto Protocol Certified Emissions Reductions (CERs)) which provide economic incentives in the real economy for the purpose of stimulating investment in real assets and internalising the externality, which is the future detrimental effects on the planet of dangerous climate change. This real asset having been created, it is then the financial community's job to actually finance those assets.

Clearly then, the activities that are generally called 'climate change finance' are not finance at all, but instead new property rights created in the real economy. If it were finance it would get a financial return, which it does not in most cases: EUAs, ROCs, CERs are all just costs created to provide a real asset which private agents can use to pay for low carbon activities.

The area of climate change finance is one of the great debates of the present. Following the UNFCCC meeting in Copenhagen in 2009 a High Level Panel was formed by the United Nations expressly with the task of developing ideas for where \$100bn per year of climate change finance for the developing world will come from, from around the year 2020 onwards⁵.

One problem with this process is that the developing world thinks that this \$100bn per year will be real economy cash flows, or in other words, payments for taking a low carbon rather than a high carbon pathway in their development. This clearly is not *finance*, it is a subsidy, or a signal for agents of investment to do things a different way.

If the \$100bn per year is financing, then it will require a return, because then it would be on the right hand side of the balance sheet. In that case, we, in the developed world, would be looking to give the developing world money to *invest* in an area where there might not be the real economy signals to do so.

This distinction is incredibly important in the debate about the role of private sector capital. Proper climate change financing will come from the private sector and the financial community, however the private sector is clearly not going to create the real assets which internalise the externality because if they did (or could) it would not be an externality or market failure in the first place.

The financial sector will provide the investment capital needed to finance \$100bn per year of newly created real assets, but they cannot create them themselves. Hence if the \$100bn per year is to create real property rights which send signals to economic agents in the pursuit of a lower carbon pathway, then the private sector has no role (except perhaps as a conduit for some of the money – like the cashier at the local petrol station collects your fuel taxes).

In sum, there is an un-priced externality which in the process of being appropriately priced, will create new assets in the real economy that will be paid for by the populous at large in some way; agents will react to the incentive to make low carbon investments and then the finance sector will provide the financial wherewithal for the right hand side of the balance sheet.

In the wake of the financial crisis of 2008–9 a strong narrative has emerged around the need to intervene on the right hand side of the balance sheet, as the failure of capitalism meant that economic low carbon investment opportunities would be impossible to finance without an intervention. It is, however, very hard to construct a reasonable argument that in the economies where most emissions originate there is an endemic capital shortage.

After all, even though developing countries often face barriers to securing investment, particularly foreign direct investment, unprecedented economic growth is nevertheless still being successfully financed in many developing countries. This may not be the case in many least developed countries, but for most developing and emerging economies there is little evidence to support the view that there is a shortage of capital. What there is, however, is a shortage of economic low carbon projects that can then be financed. It is the left hand side of the balance sheet which is absent, not the right.

Despite this, interference with the right hand side of the balance sheet is justified in some circumstances and it is

important to understand why institutions such as the World Bank, International Finance Corporation, European Investment Bank and various others exist. The rule of law; the ability to identify distinct economic agents; and the establishment of enforceable property rights are essential to the well-functioning system the arguments above have relied upon. Without them assets cannot be quantified because there is not a legal system under which to assert the right to the future cash flows. Public bodies are often used to leverage private finance where these things are poorly defined or hard to enforce. This might be the case where countries have poorly defined legal systems or interestingly in the case of climate change mitigation, where property rights are poorly defined or difficult to exercise security over. This latter case might occur in the case of energy efficiency investment, for instance, where it can be hard to differentiate the cash flows of the energy efficiency intervention from those of the host emitter.

Finally, where property rights related to emissions abatement are well defined in law, then the right hand side of the balance sheet should require no intervention and in fact the need for such intervention almost certainly signals poor execution of the policy in the real economy. We need to very clearly establish in the minds of policy makers the distinction between the two sides of the balance sheet and that they should spend most of their time concentrating on the left hand side.

Asset mismatch in trading systems

“A tonne is a tonne” is one of the battle cries of those who promote the creation of incentives that create the real assets for emission reducing companies. It is a statement of the physical fact that a tonne of CO₂e (carbon dioxide equivalent) saved anywhere in the world has the same physical impact in terms of reduced warming as one saved somewhere else.

However, this has led to the creation of market in emissions reductions which appear to be mismatched in time with the investments required in order to reduce emissions. As we will see in this section, the application of financial theory to understanding investment behaviour is fundamentally dependent on the definition of the asset which is being analysed and that asset's characteristics.

Markets in emission reduction, clean energy investment, and indeed electricity itself, are based on rules made and signals sent by policy. The nature of the power system is such that the rules for trading and pricing power have to be made up in a way that they are not for other markets. The power grid constrains physical arbitrage such that without rules a functioning market would not evolve.

When systems of incentives and price discovery, such as power markets, the EU ETS, CDM or the RO are defined, then one of the key characteristics of these markets is the period over which the market settles and hence price forms. In the case of the UK power market the market settles every half hour, in that the supply and demand for power on the system must balance commercially every half hour⁶. The RO settles every year: that is that the demand for RO Certificates (ROCs) is set every year and companies have to comply every year and hence a settlement price is determined based on demand and supply for every year. For the EU ETS, compliance is at the end of a period, so while allowances are submitted and allocated every year, compliance occurs at the end of that period, as is the case with the Kyoto Protocol.

All of these markets settle over very short periods compared to the lives of the large-scale emission reduction investments that companies might make. For the purposes of illustrating the point, let me use the example of a hypothetical idealised market for carbon credits which settles every year.

The real asset or new property right which has been created in such a system is a carbon credit, which is valid for one year, and whose price is dependent on the supply and demand for such credits in any given year. There is, of course, a market in subsequent years which again settles in those years depending on supply and demand.

References:

6. The grid is actually kept in balance in real time during these 30 minutes period, but that is an unnecessary level of detail for the purposes of this paper.
7. This by implication assumes an emissions intensity of gas-based generation of 0.5 tonnes CO₂e and for coal-based generation of 1.0 tonnes CO₂e, which is about right given standard operating assumptions.
8. This can be expressed mathematically as:

$$\text{Asset Value} = \sum_{t=1}^N \frac{\text{Carbon Credit Price}_t}{(1+r)^t}$$

where:

r	Cost of capital
Carbon Credit Price _t	Value of a carbon credit during any year in the future _t
N	Life time of the asset

This is a perfectly good market for stimulating short term changes in carbon emissions. If there is the capacity to change the carbon saving in the economy on an annual basis, then there is an exact match between the property right created in law and the economic benefit of the action of reducing emissions. Within a power system where coal and gas stations are both present then a tonne of emissions reduction can be created instantaneously by reducing coal-based generation by approximately 2MWh and increasing gas-based production by the same 2MWh in order to keep the system in balance⁷. It is easy to see here how the real asset created by policy, matches the real action which it stimulates in the real economy. Also, the signal sent in that given year, which is the trading of the credit, is to exactly reduce emissions (at a certain price) in that given year.

Now, however, consider an investment in a wind farm or solar park or any other capital intensive infrastructure. The investment being made is mainly upfront, and there is almost nothing that can be done to change the cost of the investment over its lifetime. Hence the cost of the asset being financed is defined at the point of an investment decision and is whatever a wind farm, solar park or other piece of infrastructure costs to build at that time.

The value of the asset (in our simple conceptual world) is the value of the future carbon credits from which it benefits, causing there to be emissions reductions in the power sector. Hence the value of the real asset is equal to the discounted sum of the carbon credits which represent the emissions savings over the useful life of the investment⁸.

The actual asset being invested in and its value are clearly not directly related to the property right which has been created in law in our conceptual carbon credit market. The value of the actual asset being invested in is dependent on the value of N of the real assets created to internalise the externality, with these N real assets spread over an extended period of time (N years), whereas the investment in our infrastructure project is made substantially based on the cost of that investment at a specific point in time (i.e. the start of its productive life).

This fundamental mismatch creates a number of issues.

Firstly, the rules of the carbon market may change over the lifetime of the investment which makes dependency on those N future assets quite risky. Secondly, the year-by-year price formation mechanism for carbon credits in this system may have no relation to that required to stimulate the wind farm investment we postulated. If the marginal tonne of annual carbon abatement is from fuel switching, then its cost relies on the spread between gas and coal prices (as well as the relative efficiencies of the two forms of production) and it is hard to assert how this is in any way related to the costs of building a wind farm, solar farm or any of the other things we have described. Similarly if in the UK power market the marginal unit of generation in any given year comes from an existing coal or gas station, it is not at all clear how this sets a meaningful price related to the cost of potential future forms of power like nuclear power, wind or carbon capture and storage (CCS).

One way to bridge the mismatch is for forward markets to evolve in the newly created asset classes⁹. For instance, there is a hope that there will be a forward market in carbon

credits, which extends over the life of the actual physical assets involved and hence a forward market closes the asset duration mismatch which we have identified above.

Unfortunately there are very few markets in the world which trade forward with any liquidity more than a few years. Those that do, tend to do so because the asset can be stored and hence there is a no-arbitrage relationship between the spot price of the asset and the forward price, which is based on the prevailing interest rate and the convenience yield. An important misconception that many policy-makers have (and a few financiers too) is that the forward price (where it exists) is an estimate of future price. It is not, instead the no-arbitrage price is based on the spot price today and the interest rate and the convenience yield¹⁰.

This means that just because price is formed in a certain way today and it is possible to store the asset, does not mean that price will be formed that way or at that level in the future.

Some assets created to internalise the climate change externality can be stored to some extent (e.g. ROCs and EUA can be banked), but again there is still a mismatch between what forms the price on an annual basis today, the price of the asset investment today, and the likely price formation in the future. The simple truth is that due to uncertainty as to future policy and the capital required to back trading positions, there is no substantial forward trading of the instruments we care about in climate change incentives, and such instruments are unlikely to ever join the very exclusive rank of financial instruments which do trade forward many years in reliable volumes.

References:

9. See (Blyth, Bunn, Kettunen, & Wilson, 2009) and (Bunn & Gianfreda, 2010) for discussions on forward pricing in these markets.

10. This can be expressed mathematically as:

$$F_{t+n} = S_t e^{(r-c)n} \neq E_t[S_{t+n}]$$

where:

- F Forward price
- S Spot price
- t time today
- n time period in future
- r risk free rate (on a continuously compounded basis)
- c convenience yield (on a continuously compounded basis)
- E denotes an expectation at a given time t

Some people like to make analogies between carbon credits and other policy-created property rights and shares traded on the stock market. It is not uncommon to hear people talk about trading carbon credits as being like trading shares. Carbon credits, EUA, CERs, ROCs, and power are not like shares, they are like dividends. The wind farm or solar farm is equivalent to the share. This is a particularly important distinction.

Shares (or bonds for that matter), which for many companies are traded quite liquidly on many markets around the world, are in effect a right to receive cash-flows from a company (for a share in the form of dividends) which are uncertain over time. Hence the value of that share today is equal to the discounted estimates of the dividends over the remaining life of the company (for real companies this is often taken as forever, for companies comprised solely of projects it might be finite). Dividends are paid out every year and their value is unknown. Carbon credits and related instruments are similarly created every year by an investment in an emission reducing enterprise and are of uncertain value, but holding the asset which creates the emissions reduction creates the right of the holder to receive the credit (ROC, EUA or CER). As a result, carbon credits do not trade like shares because they are like dividends and the analogous asset to a share is the wind farm, solar farm or other emission reducing enterprise.

We have seen that the real assets created as new property rights by policy, in order to incentivise investment in the infrastructure we need in the low carbon energy sector, are generally mismatched with the assets which they are meant to incentivise investment in. An instrument which has annual (or even shorter) price formation and settlement is clearly not matched to the investment in an asset which has a long life, but whose investment cost dominates upfront.

We will now move on to discuss this issue of high upfront costs of low carbon infrastructure investments, and what this means for the financial characteristics of investments, and for the policy design of mechanisms intended to create the incentive to make those investments.

Average and marginal costs

The average cost of energy generated from a given investment is generally calculated as the cost of all the inputs required to create the energy including the initial capital investment, with that capital investment recovered at a reasonable cost of capital over the estimated useful lifetime of the asset. The marginal cost is the avoidable cost of generating the next unit of energy, paying no attention to any cost already incurred or cost which is not variable with the output of the plant.

In the case of a traditional hydrocarbon-based energy system we are used to thinking about the average cost of a coal or gas-fired power station as being the estimated cost of fuel, operating and maintenance cost, and the cost of the initial investment recovered at a reasonable cost of capital over the useful lifetime of the station. The marginal cost of the station is usually thought of as the fuel cost and possibly some elements of the operating and maintenance cost which vary with individual units of output.

Low carbon energy generators generally have very low marginal costs as their fuel is free (sun and wind, for instance) and they have a high upfront investment cost. This means that low carbon investments have a much higher ratio of average to marginal cost.

If we are to incentivise investments in a low carbon energy system we need to provide payments which reflect this very different average to marginal cost ratio.

In addition, low carbon investments in the energy system cannot react to price signals. In the case of hydrocarbon-based generator, it can turn off or otherwise change its behaviour in the market, based on the information content of an annually or hourly settled instrument. However, to an inflexible generator with low marginal cost the market information at this level of granularity is of no use; it cannot act on it.

This issue is increasingly recognised in system design and hence, we have systems of feed-in tariffs or regulated returns in many markets which have a low ratio of marginal to average costs in order to ensure that there is proper capital recovery and a reason to invest.

If society is to support investment in a low carbon energy system, then we need to make sure that someone is suitably incentivised to keep the system operating at its full capacity over its lifetime. The payment of the average cost of generation by performance (i.e. by units of electricity or emission reductions) has the benefit of giving the economic agent in charge the ongoing incentive to ensure the performance of that capital investment over its life. It is therefore a good idea to remunerate low carbon investments based on their continued efficient performance, but it is not a good idea for the price to vary substantially after the initial investment has been made, as this price variation creates no information or incentive which can be acted upon by the agent.

Another average and marginal cost issue is the extent to which investment decisions can be incentivised by other price signals. This is best illustrated by an example.

The rules for connecting new generators to the UK power system have historically been designed to create an incentive to locate in areas where there is a deficit of generation compared to demand. If the form of generation one is trying to incentivise is readily transportable, does not need much space, or if the marginal costs of the grid system absorbing this new power is low, then this approach makes sense.

However, this approach has caused no end of heart-ache for the UK wind industry, as it has tended to penalise those who wish to locate their wind farms in windy places with low population densities, like Scotland. The system is now under review and rightly so.

In the days when renewable energy was a marginal industry and we might have wanted to put an occasional small wind farm on the system, then the previous system made perfect sense.

From a system perspective we would want to accommodate such projects at the lowest marginal investment cost and hence it would make more sense to squeeze them into the grid in southern England, than to invest in grid in the north of Scotland for the sake of a few new megawatts. Today, however, the marginal investment that the UK is trying to make is sufficient to power between a third and a half of its electricity system with renewable energy. The investment is

now of national significance and the only way to realise such scale is to make substantial investments in the whole system. In this case it makes more sense to do this in a way which accesses the greatest renewable resource (for example Scottish and offshore wind) than to penalise those same places.

We have seen in this section that a low carbon energy system has quite different financial characteristics to a hydrocarbon-based one, in particular with respect to the average and marginal costs of the investment. Systems that pay by performance are essential in creating the incentive to realise the ongoing value of the initial investment, but variations in price provide no information or incentive for an inflexible asset the majority of whose costs were expended at the point of initial investment. We have also seen how the size of the investment programme which we are trying to execute changes the marginal investment cost of the activity and hence can again influence the rules under which we should incentivise and signal investment preferences.

Price versus quantity

It is hard to design an approach which allows both price and quantity to be free variables and then have confidence in an equilibrium position being attained that can successfully deliver an environmental outcome.

The design of incentive or signalling mechanisms in environmental property rights and emissions abatement has therefore focussed on setting either the price or quantity and letting the interaction of the agents of investment (the market) cause the free variable (quantity or price) to be set. As a result, in most continental European systems for subsidising renewable energy, price is fixed through a fixed or formulaic feed-in tariff and then the quantity of investment and hence renewable energy production is allowed to vary freely. In systems such as the European Emissions Trading Scheme (and the design of most cap-and-trade schemes), the quantity of allowable emissions (the cap) is set and the price is allowed to find its own level.

The economic theory of deciding which approach to take involves the relative slopes of the damage and emissions functions¹¹. So, if the damage function is very steep and the emissions curve is shallow, then regulate quantity. For example, the costs of not emitting mercury into a lake are small, but the damage of even small emissions of mercury into a lake are big, and hence simply state that you cannot emit mercury into the lake.

Similarly, if the damage function is shallow, and the cost of abatement is steep, set a price. So some argue that the marginal impact of an extra tonne of carbon dioxide emitted into the atmosphere is small, but the abatement cost could be very high and so we should set a price we are prepared to pay and let the quantity of emissions vary. This is the main economic argument against the use of cap-and-trade systems and for carbon taxes instead (a tax being a way of setting a price on emissions but not the quantity).

Any cursory look at the actual application of these different approaches around the world leads to two observations. Firstly, that the economic arguments are not followed. We have cap-and-trade systems for instance, and secondly that no policy maker ever seems happy setting price or quantity and letting the other vary.

There is a good reason for this: that is that price times quantity equals money, and it is the total cost of any system which policy makers, consumers and tax-payers care about. Hence we observe quantity regulation being put in place where prices have been set (For example, Spanish feed-in tariffs) and price setting is being introduced in systems designed to set quantity (For example, the UK's carbon floor price for the EU ETS).

One of the further issues which quantity-based systems have is the asset mismatch issue which we highlighted earlier. In a price-based system one can say that a certain project gets a certain price for a fixed period. In contrast, a quantity-based scheme needs to settle, usually on a relatively short time-frame, otherwise there is nothing to force price formation. As a result, quantity-based schemes will only provide short term price signals.

As a result of this settlement process, quantity-based systems also tend to have higher volatility, higher uncertainty and higher information content than price-based systems. As mentioned, high price volatility, and hence high information content is actually not much use to high capital expenditure, low operational cost low carbon investments because of their inability to react to such changes in price¹².

There are at least two examples of systems in the environmental arena where both price and quantity are free variables. One was the original UK Renewables Obligation (which is now a feed-in-tariff by another name). The original RO set a quantity of money to be spent in any given year on renewable energy in the UK and hence allowed price and quantity to come to an equilibrium constrained by the market only containing a certain amount of money. This has some advantages: it pragmatically recognises that all price-based systems seem to need quantity control and vice versa. However, it does again require annual settlement in order to create price formation across the market.

The other example is the CDM, where a combination of the UN Executive Board and the rules for offsets in the various countries around the world control the volume, and a combination of governments and the price mechanisms in those various countries set the price.

Conclusion

We have discussed the fact that when people say 'climate change finance' they do not actually mean finance at all. In almost all cases the mechanisms that are put in place to 'finance' the transition to a low carbon economy are actually incentive regimes which signal society's desire for low carbon investments to the agents of investment in the energy sector.

In almost all cases they achieve this by the creation of a new property right, such as a carbon credit or a renewable energy certificate, which is a real asset, and hence on the left hand side of the balance sheet.

References:

11. See (Hepburn, Regulation by Prices, Quantities or Both: A Review of Instrument Choice, 2006) for an excellent review of the economic theory.
12. See (Klessmann, Nabe, & Burges, 2008) for a review of the issues in exposing thing-based investments to market signals.

It is the job of government to create in law these new assets, and it is then the job of the financial markets to finance them (the right hand side of the balance sheet). Climate change policy makers seem determined to confuse the two sides of the balance sheet, but it should be abundantly clear to all, that the private sector will not create the property rights required to signal society's desire for a low carbon economy, and hence that must be government's role. It is not clear that government has anything but perhaps a light facilitating role on the right hand side of the balance sheet.

In the move from a high carbon to a low carbon energy system, the nature of energy generation investments will change to one of low absolute marginal costs and a high ratio of average to marginal costs. The inflexibility of low carbon generation and its inability to respond to information means that information rich incentive systems that work well for conventional high carbon generating assets are wasted on low carbon ones.

It therefore seems appropriate that low carbon generation be incentivised via price-based (fixed price) incentives or signalling arrangements, which recognise the fact that long-term price certainty is more valuable than the price volatility and information that only benefits high carbon generation.

Where information is crucial for low carbon investments, we need it provided in periods which are relevant and this will lead to relatively short settlement periods, quantity-based systems, and where information is not relevant then it makes sense to have price-based systems which match the asset lives of the investments involved.

Almost nothing in this essay has been about financing, instead it has been about how we design the economic ecosystem of incentives which can best fit the investments we need economic agents to make if we are to succeed in developing low carbon energy system.

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