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A Net Zero Principles Framework:

Fundamental questions for public policy analysis

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Introduction

The necessity of transitioning to net zero economies is widely recognised by the wider scientific (including social science) community, policymakers, business and the wider public. In response to advice from the Committee on Climate Change (CCC, 2019), the UK Government has set a target for a net zero carbon economy by 2050, with the Scottish Government having lined up with an earlier 2045 target (given Scotland's resource base and capacity for more rapid decarbonisation). Meeting these commitments requires that different departments of the government can effectively work both with each other, and the wider industry, public and research communities, to determine how best to achieve this transition, securing opportunities for economic and societal gain while minimising any potential negative impacts.

This raises a particular challenge in that the required research and knowledge base to support the net zero transition cuts across many disciplines and a diversity of expert and stakeholder communities, where multiple technical 'languages' are used, and different perspectives taken in setting and addressing questions. Thus, there is an urgent need to establish common frameworks and languages in setting and addressing the multitude of research requirements in an integrated and informative way. In this brief we consider what such a framework may look like if we take one of the key net zero challenges to be understanding the policy, political economy and societal consequences of any net zero action or 'pathway' to be. Here we present a 'first draft' of our 'Net Zero Principles Framework', with the aim of opening a dialogue across research, policy and industry communities to enable further co-creation.

I. The need to focus on policy, political economy and societal consequences

Our basic premise is that one of the key net zero challenges is understanding what the policy, political economy and societal consequences of any net zero action or 'pathway' may be. If negative, such consequences give rise to the 'barriers' so often cited as preventing deployment of technically feasible decarbonisation solutions. Thus, identifying and understanding such consequences, and pulling through solutions that can deliver politically and socially acceptable outcomes is in effect the means by which the required policy, regulatory and financial environment can be structured and aligned in a way that enables the net zero transition.

Our thinking is informed by challenges we have attempted to address in our own portfolio of policy-facing research. In our work to model the wider political economy consequences of a range of energy demand reduction and decarbonisation actions, we are increasingly challenged to consider the following questions: Who pays, how and when? Who gains, how and when? To what extent do or can gains be used to balance/compensate who ultimately pays? How do wider economy impacts and the answers to these questions evolve over time? What are the fiscal and distributional consequences? A crucial recurring theme is whether societal consensus (or a lack thereof) for different actions will be affected by and/or can be gained as a result of effectively consulting on and communicating the questions posed and the politically feasible answers.

II. Every action has two distinct stages

Our project portfolio focuses on the political economy impacts of potential 'Net Zero' actions. Here we draw from our work on residential energy efficiency, electricity network investment and the EV roll-out, and the societal value of pumped hydro energy storage to introduce and illustrate the proposed framework. We close with an initial consideration of carbon capture and storage (CCS). However, this is without proposing that the framework should be applied 'one option at a time'. Rather, our proposition is that adopting a common set of principles ultimately enables integrated policy analyses.

Figure 1. An evolving CEP 'Net Zero Principles Framework' for analyses of individual/combinations of net zero actions

ENABLING STAGE	INTERFACE	REALISING STAGE
Action that does not directly affect targeted emissions but which is necessary to enable emissions reductions	Enabling activity necessary to trigger realising stage	*Enabled action that reduces targeted emissions*
Transitory or permanent activity?		Efficiency gains/losses?
How does this impact producer/consumer expectations/responses?	Realising activity may begin quickly alongside enabling or require completion of enabling stage	How and to whom accrue to?
Finance model and who ultimately pays?		Crowding out/supply chain and market impacts?
Business models and regulatory framework?		Need for compensation/contribution?
User pays - bills, output prices?		Sustained, transitory and/or evolving impacts?
Socialising - public budget/taxation?		Shift in spending/sourcing patterns
Business/consumer/citizen responses?	Confidence of sustained return at realising stage may be necessary to secure participation in enabling	Higher domestic content?
Transitory investment as traditional 'demand shock'?		Direct and indirect impacts on emissions?
Potential price pressures/crowding out?		Who gains/loses (directly and indirectly)?
Can enabling activity deliver near term/immediate net income gains?	Or certainty of realising stage activity may be necessary	**Can realising activity deliver sustained net income gains?**
Other....		Other....

Cross-cutting issues

Who pays? Who gains and to what extent do gains balance/match who ultimately pays? How and evolution on both sides

Can societal consensus be gained? Informing development of political economy narratives

Fiscal and distributional considerations and consequences

Dynamic time path of adjustment (year by year)

What are the variables of concern for different policy stakehoder audiences and evaluations? Emissions? GDP? Employment? Earnings? Energy costs? Cost of living? Tax rates?

Wider political economy and policy landscape context - scenario counterfactuals, model configurations/assumptions etc.

The key characteristic of the suggested 'Net Zero Principles Framework' set out in Figure 1 is that we identify two distinct stages in any decarbonisation action. These stages are often conflated in studies that assess the impacts of energy or decarbonisation actions.

The Enabling Stage

First, we identify the **enabling stage**. To some extent most, if not all, decarbonisation actions require some form of investment activity (even if it is just time and thought, but more likely some form of equipment or system capability). This is an action that does not directly reduce targeted emissions (and may, in fact, increase them for a period of time) but which is required to enable the intended reduction.

The enabling stage may be permanent, or at least lasting as long as the subsequent realising stage. Beyond maintenance requirements that would cause the enabling and realising stages to interact, here we should consider system requirements. For example, the realisation of emissions reduction through carbon capture will require the operation and regulation of carbon transport and storage infrastructure to support emissions reduction through carbon capture.

On the other hand, the enabling stage may be transitory, only lasting as long as is required to enable triggering of activity to realise emissions reductions. For example, once a house is retrofitted, those providing insulation etc. complete the project and leave the householder to operate the new system.

In either case there will be questions around how enabling activity is financed and who pays, but also how the action impacts the wider economy. The latter will be important if the result is opportunities for early, even if transitory, economic expansion characterised by income gains. This may be a key issue for policymakers, not only if public finance is required, but also if there are distributional impacts within and across different timeframes that drive a wedge between those who have to bear costs and those who enjoy the benefits.

The Realising Stage

We label the second stage as the **realising stage**. This is when the action to reduce targeted emission actually occurs. The interface with the enabling stage included in Figure 1 will differ across different types of action. For example, as noted above, in terms of timing, it may be the case that the enabling stage, or some key element thereof, must be completed before the realising stage can begin.

In other cases, the two may run more or less simultaneously from the outset. Returning to the example of retrofitting to enable energy efficiency, while a programme of work to install insulation etc. in the existing housing stock may last for years, as soon as work for an individual household is complete, that household can begin to enjoy efficiency gains and reduce its emissions.

On the other hand, a more problematic element of the interface may be the extent to which activity in and/or returns from the realising stage need to be certain/guaranteed in order for full commitment to the enabling stage can begin.

However, where enabled action at the realising stage does begin, the reducing impact on emissions can be permanent, as can the local and system-wide socio-economic impacts. A crucial question in this regard is whether the emissions reducing activity involves economic efficiency losses or gains. Fundamentally, the question is whether the emissions reduction activity involves doing more with less, or vice versa. For example, the very nature of an energy efficiency gain should translate to the beneficiary enjoying the same level of production or consumption, or system operation using less physical energy.

However, the answer to this question will not always be 'yes'. For example, if industrial decarbonisation involves the use of more capital equipment (e.g. to capture CO_2 generated in production processes and/or use of heat), but this does not increase the value of output, there will in effect be a reduction in capital efficiency.

The key point is that any efficiency gains (losses) will result in an increase (decrease) in real income for the direct beneficiary. What happens across the wider economy depends the type of mechanisms triggered as a result. For example, if households enjoy increased real incomes as the cost of heating or mobility falls, they will have more money to spend. If they spend this in the domestic economy, an economic expansion will be triggered. This, in turn, will further affecting

incomes and prices throughout different markets and sectors across the economy.

The extent of such an expansion will be determined by factors such as how much of any increased spending is directed to domestic vis a vis imported goods and services. If an efficiency gain is realised in industrial sectors producers, this can enable production/systems to operate at reduced costs. This, particularly if benefits flow downstream, may trigger a productivity-led expansion in the economy, particularly if there is a positive impact on competitiveness.

On the other hand, realising stage impacts on efficiency may accrue at energy system level, for example in the case of pumped hydro energy storage. If this is the case, the ultimate impacts on the competitiveness of (industrial) or real income/spending power of (residential) users and, thus, any potential for economic expansion will depend crucially on the extent to which gains transmit to lower energy prices. Moreover, relative energy price effects may have a crucial impact on the prospects for other potential decarbonisation pathways. For example, the electrification of heat continues to be challenged by the price of electricity relative to gas.

One final but important point with regard to economic efficiency outcomes at the realising stage is that realising emissions reductions could involve productivity and competitiveness losses. This may be a particularly relevant consideration in the context of industrial decarbonisation. Costly capital requirements do not just occur in the Enabling Stage. Rather they extend to the Realising Stage, when, for example, capture equipment is operating capital that does not produce additional output. This effectively reduces capital efficiency, given that production of a given level of output becomes more costly. The outcome will be lower returns to capital employed. This may ultimately trigger a risk of plant closure/off-shoring. In the shorter term at least, the result would be upward pressure on prices, reducing competitiveness and triggering an economic contraction.

Generally, as illustrated in Figure 1, there are a range of cross-cutting issues, not limited to but often closely related to the question of who pays, who gains and the extent to which these diverge. This, and the nature of gains, losses and how they are perceived will impact the extent to which individual actors are prepared to participate, in what way, and over what timeframes. Whenever there are distributional and wider economy consequences, government will become a stakeholder (whether or not there is direct public sector involvement) in the context of fiscal and political implications.

III. Illustrating the framework

The framework in Figure 1 is a first step. Given the complexity and range of potential actions, pathways and potential issues arising in considering how the net zero transition can be achieved, its further development will ideally involve co-creation with a range of research and policy stakeholders. As a starting point, we are able to provide some further illustrations using some examples from own work (with direct reference to non-technical policy briefs) that underpin our initial Figure 1 formation.

Residential energy efficiency

We have considered the case of residential energy efficiency in Katris et al., (2020a) for the UK and in Turner et al. (2018) for Scotland. See Figure 2 below. As noted above, here the enabling stage involves requires retrofitting activity (insulation etc.) and/or purchasing equipment (e.g. a new boiler). In the UK, core funding for such activity is provided through the Energy Company Obligation, ECO, with costs 'socialised' through the energy bills of all consumers. This sits alongside loan finance and government grants for low income households (at least in Scotland).[i] However, the funding model will affect the level of enabling activity, the timing of project activity and, thus, the nature and extent of any wider economy expansion.

In both UK and Scottish contexts, our research suggests that the enabling stage alone can deliver sufficient near term returns in the form of increased GDP, employment and incomes to take the economy onto a higher trajectory that is ultimately sustained through the realising stage. However, the nature of the expansion, and the answer to the crucial policy question of who ultimately pays and gains, varies across time.

Initially, wider economy gains are triggered by construction and/or manufacturing sector and supply chain activity required to deliver retrofitting and/or producing equipment. However, this source of expansion does not outlast enabling project timeframes. The source of sustained expansion emerges through the spread of uptake and realisation of energy efficiency gains.

Figure 2. Evolving CEP 'Net Zero Principles Framework': applied to analyses of residential energy efficiency programmes

ENABLING STAGE	INTERFACE	REALISING STAGE
Action that does not directly affect targeted emissions but which is necessary to enable emissions reductions	Buildings and equipment need to be retrofitted or replaced to enable households to deliver energy services at lower cost	***Enabled action that reduces targeted emissions***
Transitory - where time frame crucial in context of Producer expectations and allocation of resources		Efficiency gains More efficient households reduce cost of running homes Demand led expansion, price pressures
Finance model and who ultimately pays? ECO, government grants, loans ECO 'socialised' through energy bills Socialising via taxation can deliver greater economic gains But greater risk diverted funds and negative impacts in some time frames Availability of funds may be key factor affected by economic/political landscape	As individual households receive retrofits/new equilpment they can begin to enjoy efficiency gains If households need to pay and/or bear costs of disruption, will assess but discount future savings on energy bills	Energy supply and export-intensive sectors may lose out Do those paying realise efficiency gains? Implications? Sustained expansion (incl. household real incomes) evolving through simultaneous enabling and realising Pontential shift in spending/sourcing patterns
Transitory investment as traditional 'demand shock' Expansion favours construction industry and supply chain		Can higher domestic content be achieved? Economic expansion means 'rebound' will be present
Retrofitting activity etc. is economic activity that can deliver immediate economic gains but only for as long as programmes last. Questions around who returns accrue to and when, is there rent-seeking behavour etc.?	Sustained wider economy returns and/or reductions in fuel poverty costs may be necessary if public support of retrofitting programmes required	Realising efficiency gains that deliver sustained reductions in the cost of delivering residential energy savings translate to sustained real income gains (if costs do not otherwise rise), which, in turn, delivers sustained demand-led economic expansion
Other....		Other....

Figure 3. Evolving CEP 'Net Zero Principles Framework': applied to analysis of electricity network investment to support EV rollout

ENABLING STAGE	INTERFACE	REALISING STAGE
Action that does not directly affect targeted emissions but which is necessary to enable emissions reductions	Uptake and operation of EVs requires range of enabling actions - not limited to network upgrades (also charging capacity, availability of affordable vehicles etc.)	***Enabled action that reduces targeted emissions***
Transitory - where time frame crucial in context of Price Control constraints		Efficiency gains EVs projected 'more miles per £' Demand led expansion - price pressures
Finance model and who ultimately pays? Regulator concerns vulnernable consumers User pays - direct and indirect impacts vulnerable consumers Socialising by other means not currently considered Key future direction - car mfr and different household responses	Enabling requirement at scale (rather than individual level) to to support EV roll-out and realising stage	More efficient energy supply could lower prices? Sustained net positive impacts evolve over time Key souce of gains: electricity supply stronger multiplier than petrol/diesel
Transitory investment as traditional 'demand shock'? Expansion favours construction supply chain, with import 'leakage' - total cost repaid greater than domestic investment spend	Key interface issues on regulatory front: Ofgem requirement not to invest network capacity ahead of need - i.e. EV demand required for regulator approval	Higher domestic content - depending on evolution electricity supply chains Economic expansion means 'rebound' will be present Main loser - conventional vehicles and fuelling Impacts on fuel duties - how might EV transport be taxed?
Network upgrade involves large scale construction activity that - depending on projects, timeframes and domestic content - could generate demand-led expansion. Questions around who returns accrue to, when and how	Other contexts (beyond network upgrade)?	Realising efficiency gains that deliver sustained reductions in the cost of delivering mobility translate to sustained real income gains (if other costs do not rise) But might impacts of electric fuelling supported by stronger domestic supply chains be the dominant source of sustained demand-led economic expansion?
Other....		Other....

The energy efficiency trigger at the realising stage is also the source of the greatest gains particularly, but not exclusively to lower income households. The subsequent demand-led expansion stimulates a different range of sectors in the economy, linked to how households spend their incomes. The results of our UK analysis suggests that a sustained boost to employment across the UK economy may equate to up to 20,000 jobs ultimately supported by ECO-funded activity across the UK economy. However, this type of economic expansion does tend to drive up prices across the economy. This has negative competitiveness impacts on some sectors.

Electricity network upgrades and the projected EV roll-out

We have considered the potential impacts of early (to 2030) projected EV rollout in the UK supported by one key enabling dimension, investment in required upgrades of the electricity network, in Turner et al., 2019a.[ii] See Figure 3. In this context, the enabling stage involves investment activity by electricity network operators in reinforcing network capacity etc. Ofgem regulates such investment activity in the UK, given that costs are passed onto electricity consumers through energy bills over the lifetime of the asset created. In terms of the wider economic expansion enabled, a key issue is that only about one-third of investment spending is directed to the UK. This stimulates the UK Construction sector and supply chain. However, the majority of spending is on equipment needs and this involves imports. Thus, consumers must repay more than is invested in the UK economy. Nonetheless, our results show potential, depending on the precise timing and spread of investment activity, for net gains from the outset, both in terms of GDP and employment, accompanied by possible small net gains in real income for lower income households in the near term.

As with the case of residential energy efficiency, however, the only source of sustained gains is the EV rollout itself. Our results suggest that, while efficiency gains in the form of reduced travel costs per mile will contribute to a sustained expansion both in activity across the wider economy and in household real incomes, this is not the main source of expansion. Rather, the key driver of lasting economic gains (including up to 3,000 jobs across the UK economy) from enabling the EV rollout to 2030 is likely to be our reliance on the electricity and its stronger domestic supply chains, compared to the reliance of conventional vehicles' reliance on import-intensive petrol/ diesel.

Pumped hydro energy storage

We have conducted a more limited study into the potential sources of societal and energy system value that may be generated by enabling increased pumped hydro energy storage into the UK's increasingly renewables dominated electricity system. This work is reported in Turner et al. (2019b), with key questions arising translated into the 'Net Zero Principles Framework in Figure 4. The enabling stage in this context can be clearly defined, involving a 5-6 year construction phase for a pumped hydro station. While this may be considered a relatively short source of 'returns' through, again, a construction sector and supply chain boost, the direct jobs boost estimated for a pumped hydro station such as the planned new Coire Glas facility in Scotland, is around 3,500 jobs. This equates to just over half the requirement associated with the construction of Hinkley Point, and supply chain multipliers effects could almost double that number. Thus, as with other capacity investments in the energy sector, enabling pumped hydro through station development could generate significant near term, albeit transitory returns.

At the realising stage, the extent and nature of any economy-wide returns is less clear. Pumped hydro is an example of region- and/or location-specific capacity that can play a key role in delivering an increasingly electric powered national energy system reliant on intermittent renewable generation. However, there would seem to be issues in terms of to whom and when efficiency gains may give rise to economic returns. This may be focussed within the energy system itself with returns to UK households limited to any consequent reduction in electricity prices. The principles of this case requires further investigation.

A final example: industrial decarbonisation characterised by costly capital – CCS?

The three examples emerge from cases studied in our own research that have provided the basis for our proposition of a Net Zero Principles Framework. We are currently conducting new research focussing on political economy of industrial decarbonisation. This enables us to consider how the framework may be applied to the challenge of CCS in the UK.

Figure 4. An evolving CEP 'Net Zero Principles Framework': applied to analysis of the value of pumped hydro energy storage

ENABLING STAGE	INTERFACE	REALISING STAGE
Action that does not directly affect targeted emissions but which is necessary to enable emissions reductions	Enabling activity necessary to trigger realising stage	***Enabled action that reduces targeted emissions***
Transitory - where this is limited to 5-6 year construction phase Localised jobs and supply chains may be key beneficiaries? Finance model and who ultimately pays? Relatively limited cost per project but overall regulator concern Costs passed onto bills over lifetime of asset Incentives for invididual station benefit where efficiency gain at system level? Transitory investment as traditional 'demand shock'? Expansion favours construction and supply chain Large scale construction requirements focussed on individual station projects Could trigger time limited, localised/regional demand-led expansion Other...	Realising activity requires completion of enabling stage Confidence of sustained return at realising stage required but full system benefit may not be recognised by plant level investor	Efficiency gains in delivery of electricity system particularly where characterised by high level of intermittent renewalbles How and to whom accrue to, over what timeframe? Societal returns will evolve as wider system devlops? Mechanisms to balance costs and benefits? Do consumers ultimately benefit from lower energy prices? Extent of wider economy impacts? Economic benefits likely to be greatest at energy system level Other....

Figure 5. Evolving CEP 'Net Zero Principles Framework': applied to analysis of 'costly capital' actions (with focus on CCS) for industry decarbonisation

ENABLING STAGE	INTERFACE	REALISING STAGE
Action that does not directly affect targeted emissions but which is necessary to enable emissions reductions	Costly capital solutions will have varying degrees of certainty and/or commitment on either stage to secure/guarantee the other	***Enabled action that reduces targeted emissions***
Transitory element - investing in e.g. CO2 capture machinery Level of expenditure and economy-wide impacts? Finance model and who ultimately pays? Capture equipment may simply be industry spend? In CCS context, bigger issue is transport and storage infrastructure Permanent cost implications Ownership, regulatory and business models? Who can/will play what roles under what conditions? Who pays (directly and indirectly)? Evolution? Industry/supply chain activity to support any investment activity can provide opportunities for demand-led expansion But main opportunities could emerge from any market/industry opportunity linked to transport & strorage, other 'CO2 management' industry opportunities, including hydrogen production Linking to need to sustain, evolve existing high value industries All - issues around who gains accrue to, how and when Other....	CCS the most challenging/complex? Is transport and storage enabling or realising? Much activity in transport and secure storage is not directly linked to level of emissions reduction? Where high levels of risk associated with inter-dependence of enabling and realising, key (evolving?) role for government in assuring decarbonisation outcomes and industry/economic well-being and prosperity	Costly capital - efficiency losses Industry doesn't value 'output of' capture equipment Reduced return to capital - price increases Policy intervention to avoid competitiveness loss? Who pays and how? Sustained loss in efficiency - off-shoring risk? Can capital costs reduce if risk reduced at interface? Shift in spending/sourcing patterns Up and downstream supply chain demand and price impacts? Impacts of potential policy actions to protect competitiveness? Who gains/loses (directly and indirectly)? Potential for sustained net negative economy-wide impacts whatever the approach to delivering realising stage where costly capital involved. Can potential net gains from enabling stage and/or other decarbonisation actions offset losses under different approaches? E.g. if 'tax payer' pays, can income and/or public budget gains linked to other actions compensate? Other....

In considering how the framework in Figure 1 may be applied to costly industrial decarbonisation in general, and CCS in particular, the key point is the extent to which the type of questions emerging in our general framework are relevant in addressing the challenge of decarbonising high value emissions intensive industries. Again, the crucial perspective in this regard is considering the challenge through a political economy and public policy facing perspective, where there a range of fiscal, distributional, economic well-being and just transition concerns motivating a desire to ensure that these such industries decarbonise in a way that ensures their continued contribution to our economy. Above we have argued that a key element of this challenge lies in considering the nature and implementation of any solution that introduces costly additional capital requirements to a firm's operational activity.

Our starting point in Figure 5 was to consider how the questions raised in Figure 1 for the Realising Stage apply to costly capital elements of industrial decarbonisation actions. Around this we raise a wider set of questions that are likely to emerge from an economics and public policy perspective at both the Enabling and Realising Stages, and the Interface between them. Several of the questions emerging in Figure 5 have been raised in the more general discussion in Section II above.

In Figure 5, we give particular attention to the context of CCS, a large-scale deep decarbonisation solution that has been the subject of much debate in the UK in recent years. Following a troubled and ultimately unsuccessful history largely linked to decarbonising power generation, the UK Government's 'CCUS Action Plan' (BEIS, 2018) now focusses on its potential role in industrial decarbonisation. One set of challenges lie in the infrastructure requirements to transport and store CO_2, in our initial consideration of CCS in Figure 5, and we reflect these under the Enabling Stage. However, there may also be opportunities for sustained economic gains in developing transport and storage activity in an industrial context.[iii]

On the other hand, a more fundamental challenge lies in the fact that value could be destroyed in industries that would be required to decarbonise by capturing CO_2. This would be the case if costly capital requirements were to result in a loss in competitiveness in a world that has not yet fully signed up to decarbonisation.

Figure 5 illustrates how application of our proposed framework allows a wider set of questions to be raised that link challenges of potential losses such as these in the context of opportunities for gain. In the case of costly carbon capture, we set this both within the wider CCS context (i.e. potential sustained gains from permanent enabling activity in the form of CO_2t transport and storage) and other net zero actions, where gains and losses in different time periods could offset one another if a broader net zero perspective is taken.

IV. Conclusion

We have introduced an initial proposition of a Net Zero Principles Framework, with the aim of stimulating discussion across research, policy, industry and wider net zero stakeholder communities, ideally to further develop the framework through a process of co-creation. Our perspective in setting out and applying the framework is very much a political economy and public one. However, this is an increasingly important lens through which to view and interrogate decarbonisation problems, given increased concern over the 'just transition' and broader fiscal and distributional challenges associated with our net zero ambitions.

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Endnotes

[i] In a recent working paper published by UKERC (see Katris et al., 2020b), we have considered how finance constrains in a Brexit context may impact not only funding but the extent of uptake of energy efficiency actions.

[ii] We are currently extending our EV work to consider, amongst other things, the projected EV rollout to 2050. Please contact the CEP team for information.

[iii] We have conducted some fundamental research on opportunities in this context - for example, see Turner et al. (2019c,d).

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