Enabling energy transitions through integrated infrastructure development

Mike Theobald – Energy Transition - WSP

RECENT ENERGY LANDSCAPE

Rapidly developing portfolio of technologies for generating, delivering, storing and using energy, whether that is by molecule or electron.

Climate action and decarbonisation has finally gone mainstream, individually, institutionally and politically.

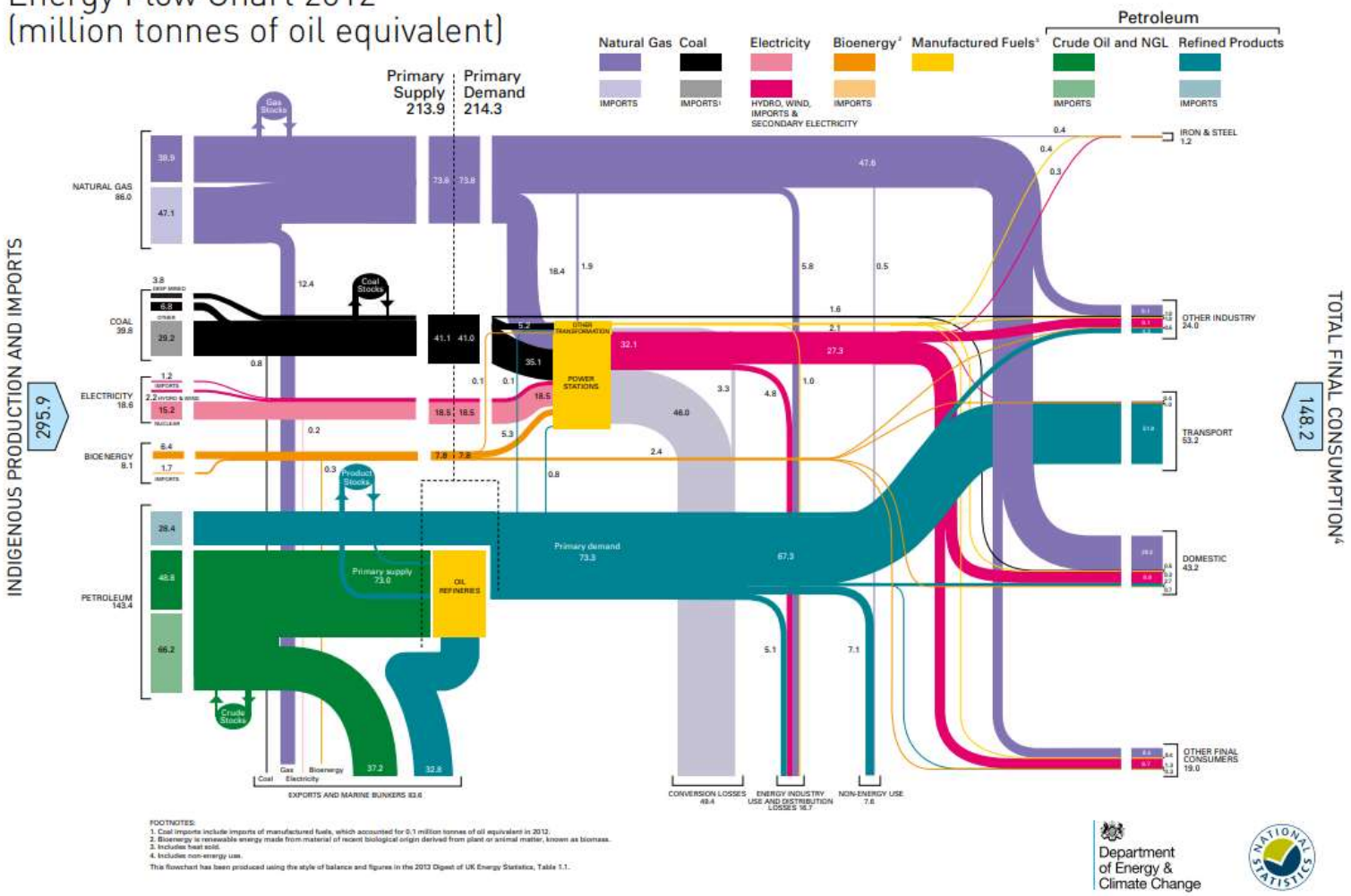
LCOE has been slashed to competitive levels across wind and solar

Investment into emerging technologies to either generate or abate has multiplied

The complexity of forecast energy flows is forcing integration for efficiency

Yet how far have we come operationally and what infrastructure needs to be enabled going forwards.

Energy Flow Chart 2012
(million tonnes of oil equivalent)



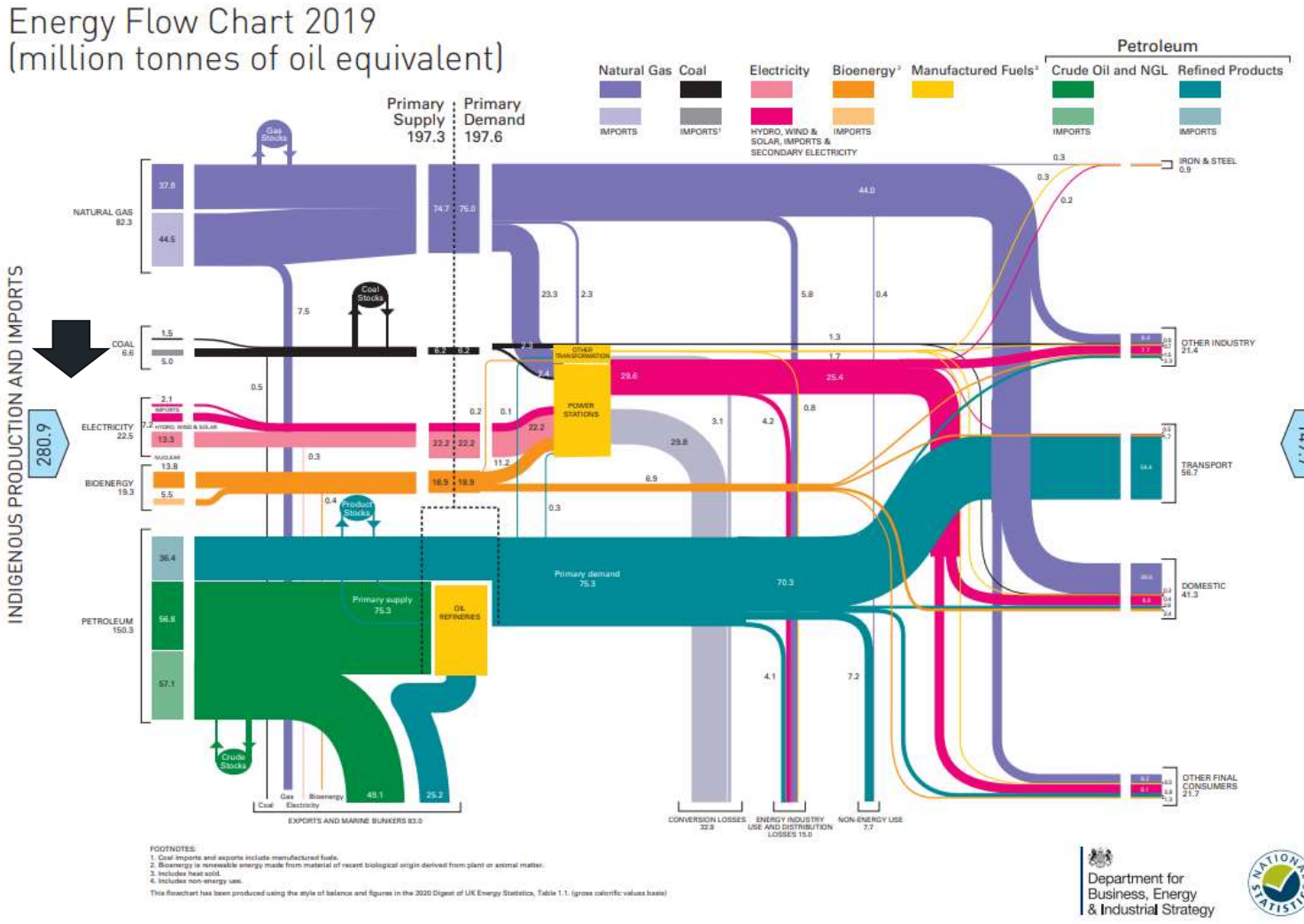
FOOTNOTES:
1. Coal imports include imports of manufactured fuels, which accounted for 0.1 million tonnes of oil equivalent in 2012.
2. Bioenergy is renewable energy made from material of recent biological origin derived from plant or animal matter, known as biomass.
3. Includes heat sold.
4. Includes non-energy use.

This flowchart has been produced using the style of balance and figures in the 2013 Digest of UK Energy Statistics, Table 1.1.

Department of Energy & Climate Change

Post COP 21 Paris Agreement Dec 2015 and IPPC AR5

Minor



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Scenarios to 2050

Fundamental question ‘what infrastructure?’

Ten Point Plan for a Green Industrial Revolution, the Energy White Paper, North Sea Transition Deal, Industrial Decarbonisation Strategy, Transport Decarbonisation Plan, Hydrogen Strategy, Heat and Buildings Strategy, Net Zero Strategy …. and tomorrow the Energy Security Strategy!

Fortunately some common themes and expected to be a ramp up of well understood technologies

Some general points for the next 10 minutes:

Even moderate increase in development may already be more than we can deliver.
Big emphasis on choosing the right levers for maximum outcomes.
Efficient infrastructure: cluster, cycle and re-deploy
Be outcome efficiency focussed, do you need heat or do you assume it is gas you need?
Keep to plan as much as possible.
We need quick wins urgently.

Scenario 1: High electrification

Doubling of UK electricity generation

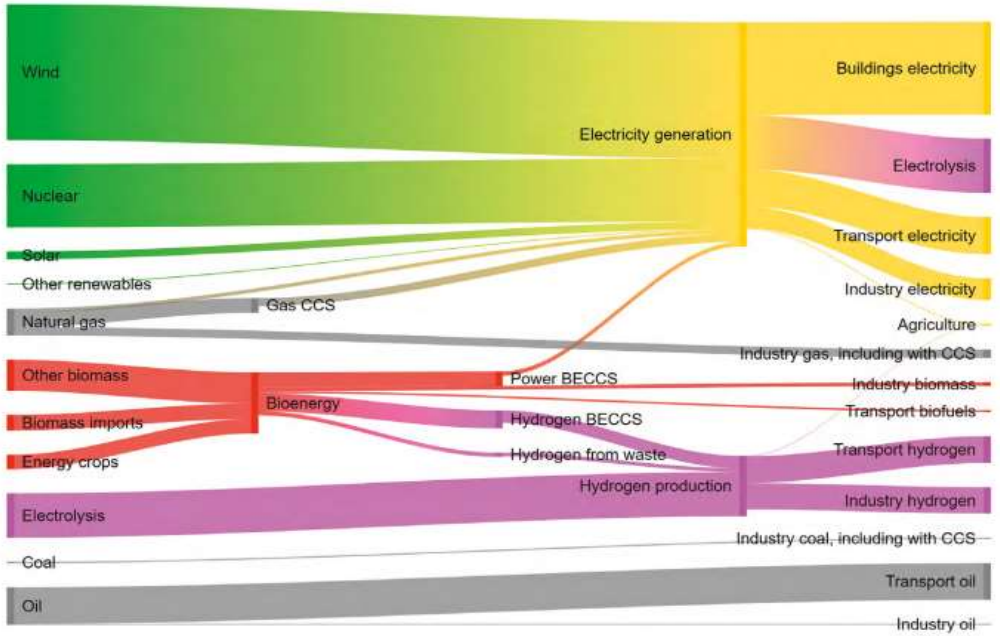
Predicated on big shift on transportation, building heating

H2 focussed on hard to decarbonise areas such as industrial heating.

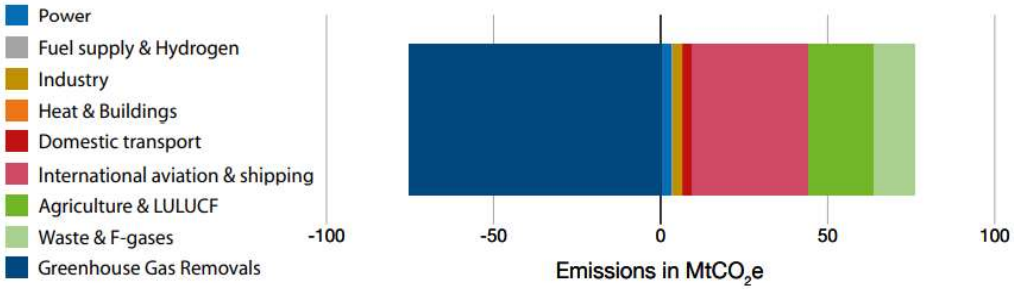
Electricity generation is almost fully decarbonised – CCUS, Nuclear and Renewables

Aligns well with current future energy source outlooks

2050 High electrification energy flow scenario



2050 High electrification residual emissions scenario



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Scenario 3: High innovation

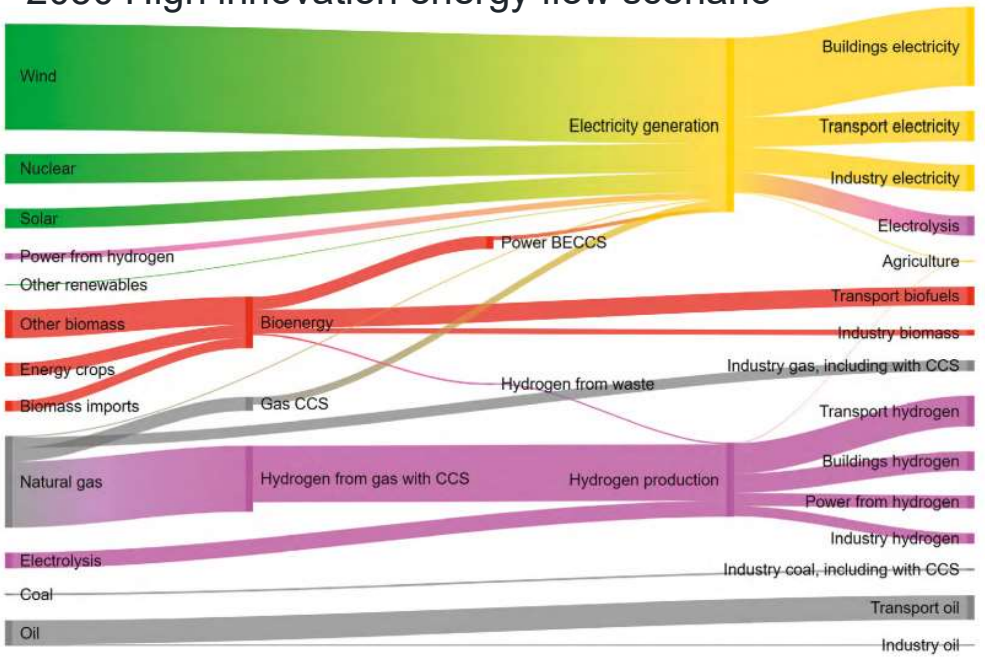
Increased CCUS for Power & DACCS
Sustainable aviation fuel development
but
Less decarbonisation of the transport, buildings, industrial and agriculture sectors.

Scenario 4?
Merge high electrification with improved innovation

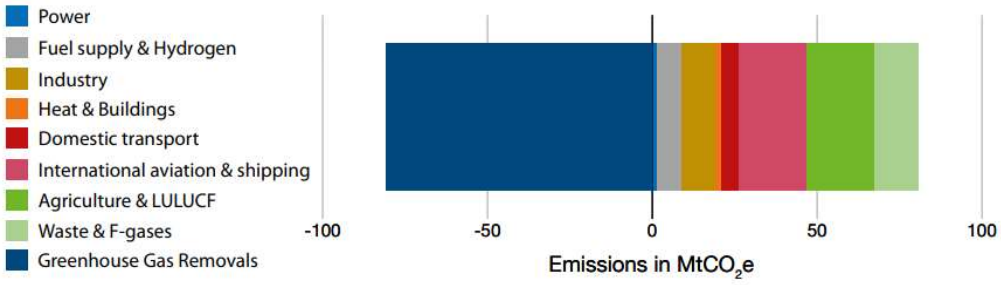
4a, Focus on proven and maturing flightpath technologies:
Nuclear
Offshore Wind
Solar PV

4b, Reasonably bullish on:
Floating offshore wind
New technology solar PV
Improvement in battery chemistry for BESS and transport
Natural resources to secure the Energy Transition

2050 High innovation energy flow scenario



2050 High innovation residual emissions scenario



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Hybrid Scenario 4 findings

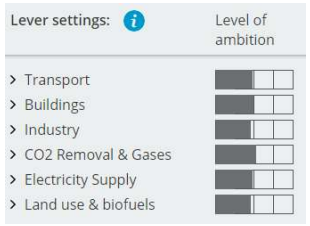
Levers associated with electrification – largest influence on emissions reduction. Green energy surcharge change when stability returns?

Oil and Gas in Scenario 4 continue to play a significant part but alongside step change abatement. Further and broader CCUS clustering needed.

Clear upsides for BECCS, Wind, Solar and Nuclear but timing is critical.

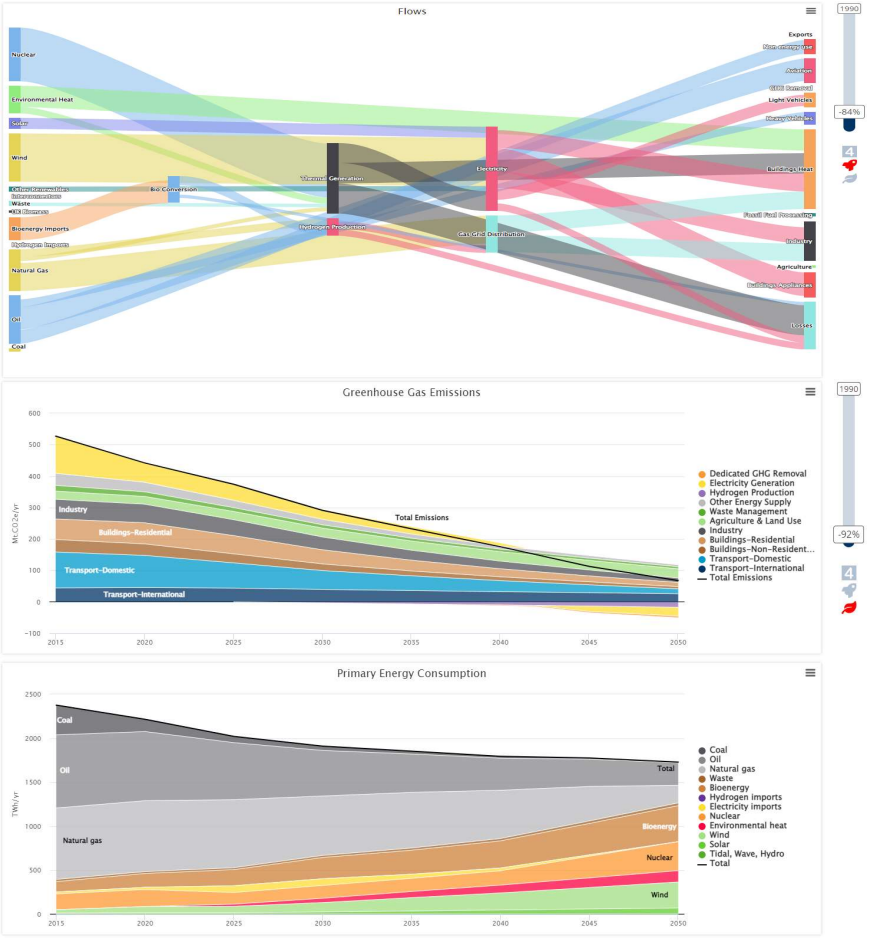
Emerging electrification technologies are able to displace ultimate build out of abated gas fired generation and potentially limit H2 adoption for non-industry heat related end uses.

Note: McKays CC is open access.

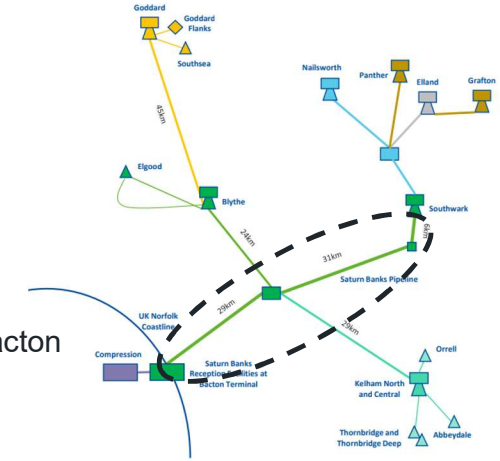


- 1: The least effort possible
- 2: Ambitious but reasonable
- 3: Very ambitious needing technical breakthroughs
- 4: The upper limit of what is considered plausible

McKays Carbon Calculator:



Infrastructure Delivery Factors



Bacton

<u>Ukraine / Russia</u>

Elevated energy security priorities influencing all the Net Zero scenarios

- Reactive change affecting existing plans

Chasing further up the late curve to Net-Zero 2050

- We are not in an early curve play

Secondary enablers and influences will rise to primary factors

- Ramifications are far from being known other than no return to recent global energy flows.
- Raw materials and high tech risk – some impacts can easily become short term exponential.

Homegrown priority

- Maximise what the UK can self deliver or alongside trusted partners with enhanced ETS
- Plough extra support behind the easier build out wins,
- Good example IOG recent First Gas, recommissioning SNS infrastructure to link stranded assets, saving years and cost on delivery.

Energy Security has to be aligned with Enabling Security that we have control of

Infrastructure Delivery Factors

Task Enormity

Energy Infrastructure rate of upheaval.

- Lots of planning, marginal operational progress relative to 2050 targets.
- Supply chain, sourcing
- Human resource is the rate limiting factor – skills training and developing people into this sector is going to be critical.

Technology bets

- Focus on what we know works, rinse repeat
- Pragmatic approach to energy is needed, sometimes the path of hardest resistance
- Pay attention to likely technological advances and build strategy to adopt in flight.

Summary

We need quick carbon wins to boost our climate pension account

Resource is going to be limited so rinse repeat and back efficient infrastructure

Conventional energy is needed for the energy transition – develop it efficiently and effectively

Likely announcements on Energy Security align with accelerated energy transition but high nuclear intent will change the shape significantly.

Emerging technologies have significant potential to positively disrupt.

Thank you

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