**Reviewer #1:**  
  
This paper presents pathways for the European energy system under different stringencies of climate targets and different constraints on the availability of Russian gas. The pathways provide policy implications and energy system developments which could reduce dependency on Russian gas, meaning it is of significant current interest to the broader energy community. In terms of originality, the authors compare the longer-term implications to current literature on the impact of reducing reliance on Russian gas from the European Commission and the IEA which largely focus on nearer-term pathways to 2030. The bulk of the literature has been on the shorter-term impact of reduced Russian imports and therefore a longer-term outlook of the potential impacts, particularly in combination with different climate policies, provides highly relevant insights. Of particular importance is that in the Paris-aligned 1.5oC scenario, the rapid reduction in gas demand provides a pathway for a) meeting the Paris goal of keeping temperatures to 1.5oC and mitigating some of the worst impacts of climate change, b) reducing dependence on fossil fuels and the corresponding volatility of internationally traded prices, c) increasing energy security, and d) moving early can reduce power system costs etc. in the longer term. More discussion that a gas bridge is incompatible with a Paris aligned scenario would be useful, particularly given the authors highlight that gas has been highlighted as a "transition fuel" by the EC.  
  
The authors are to be commended on developing these scenarios and report in a short space of time. I believe with some revisions this paper can provide a useful and topical contribution to the literature around gas market uncertainties, geopolitics, and energy system decarbonisation.  
  
However, in my opinion, several improvements could be made.  
  
There is limited discussion on the supply-side around specific gas market and wider energy system uncertainties and dynamics:  
  
\* Limited/no discussion on supply diversification. For example, the ability to increase/decrease take-or-pay contracted gas from Central Asia, North Africa, Middle East, and spot LNG imports from North America and elsewhere. The point about lots of existing infrastructure (regasification) being concentrated in Southern European gas markets (e.g. Spain) is a very important one, but the discussion could really do with widening in the modelling (i.e. is additional regasification capacity out to 2050 built, and if so where and when, and what are the risks of these assets being stranded, particularly in a 1.5oC scenario). Additionally, domestic European gas production is not discussed at all, especially Norway, as the supply side of gas markets is largely overlooked;

We could add the possibility of investing in regasification plants (represented by a link and a store of LNG at higher price than gas) and check if this is installed and become stranded assets.

\*Add a Sensitivity section

\*Discuss this in text (Is LNG used? Does it become stranded assets? How much does the system cost change?, perhaps emphasize 1.5 vs 2ºC) and add plots to supplementary.

Move Coal price sensitivity here.   
  
\* If the focus is on the long-term, including different levels of European energy system decarbonisation, then there needs to be more discussion, at least in a supplementary document, on the assumptions being made around the growth/decline of different technologies, otherwise it is difficult for the reader to determine the feasibility of the results:  
o As with all IAMs, the speed at which different technologies are allowed to grow/decline are hugely important parameters and play a fundamental role in shaping the scenario outputs. The 2019-2030 growth rates for the deployment of solar PV are feasible in terms of historical European growth rates (~ 20% for solar between 2010 and 2017), however more data on assumptions around other technologies (including wind, e.g. offshore wind looks to be growing at about 30% per year between 2019 and 2030) would be useful.

Add discussion to the main text and Supplementary on (a) the assumptions of growth rates (unlimited), (b) compare the required growth rates in our model with historical growth rates

Make a plot in the Supplementary with growth rates in the model + historical values

<https://www.nature.com/articles/s41560-021-00863-0>

<https://twitter.com/EmberClimate/status/1509802821838946320?t=knDcnqP7ogYstocjtAQz0g&s=19>  
  
General comments and suggestions to improve this work  
The authors are to be commended on developing these scenarios and report in a short space of time. I believe with some revisions this paper can provide a useful and topical contribution to the literature around gas market uncertainties, geopolitics, and energy system decarbonisation.  
\* Carbon budgets:  
o Are the quoted numbers for 1.5oC (25.7 Gt) and 2oC (73.9 Gt) cumulative to 2050 or 2100?

Describe in the text, cumulative to 2050 because carbon neutrality is assumed from there on  
o Only one of the carbon budget choices is Paris aligned and is hugely challenging (and highly unlikely) without vast amounts of NETs or significant demand-side reductions (which the model cannot consider as far as I understand). An additional scenario exploring a Paris aligned carbon budget (e.g. 1.5 at 50% or 1.75 at 66%) would be useful.

Consider if we want to do this, I think with 2 carbon budgets the story is clearer

\* What constraints are there on the growth and decline of different technologies?

Describe in the text

o The gas consumption decline for the 1.5 degree looks to be ~ 18% per year (from 4700 TWh in 2019 to ~ 500 TWh in 2030) and there is no discussion around this. Without any discussion it is difficult to make a judgement on the validity/feasibility of this result.

Add discussion  
o There is huge uncertainty around the deployment and decline of new and existing technologies but some discussion around, for example, historical rates of transitions would be useful to validate the results

This will be covered by previous comment.

o No discussion around constraints on fossil fuel production (e.g. growth and decline of natural gas production)

Add one sentence  
\* Especially the 1.5oC, but also the 2oC, will be sensitive to assumptions around the availability of biomass - whether this be a global total or an assumed European level with domestic production and imports (e.g. wood imports from North America) - these could be made clearer by explicitly stating what the biomass potential is in TWh

Add one sentence  
\* Option to use residual heat from industrial processes/power plants to heat solid sorbent solution in DAC processes - for transparency it would be good to have actual numbers in terms of capture (from negative emissions technologies (DAC and BECCS) and from conventional carbon capture and storage), i.e. what is the cumulative or annual capture in Gt CO2 which keeps Europe within the prescribed carbon budgets

Add this discussion

\* The lack of demand side elasticities is also significant yet only mentioned once. In the IEA Net Zero Report and in many scenarios exploring net zero/1.5oC (e.g. IPCC Special Report on 1.5oC) the role of demand reduction is really significant, either through behavioural changes or demand elasticities due to the rising prices of energy service demands heavily reliant on fossil fuels with limited low cost technology alternatives such as aviation travel.  
Add a couple of sentences discussing this.   
  
  
  
  
**Reviewer #2:**  
  
The presented manuscript discusses the implications of phasing-out Russian natural gas imports in Europe. The manuscript is relatively well-written and easy to follow. Obviously, the topic is timely. Given that the modeling framework is well-established and not novel, the added value of this work must reside in the application/case study, which I'll focus on in my review.  
  
First, the premise that the EU won't be able to find alternatives for natural gas imports, whereas coal and oil imports will be entirely replaced by alternative suppliers, is odd. I would - at least - have expected a more detailed analysis to justify this claim, plus a sensitivity analysis w.r.t. the availability of alternatives.

Mention here the extra sensitivity scenario with LNG.  
Mention the sensitivity analysis with the price of coal, we can add a similar sensitivity analysis with the price of oil but also mention that due to the exogenous transformation of land and maritime transport, this is not expected to have significant impact on the results.

Either run sensitivity or discuss in the Supplementary

Second, as the EU needs to take action now, it is unfortunate that you don't provide more detail for the years 2022-2025, but rather focus on the medium- to long-term implications. The challenges (when it comes to facing out Russian gas, oil and coal) are manifesting them today and in the next few years.

Answer that we decided to focus on the mid and long-term implications as others are doing the analysis on the short-term.

Third, the counterfactual 2°C scenario is, in my opinion irrelevant, as it is not in line with EU and MS policy. This is also evident from the numerical results, see e.g., the computed shadow price for CO2 emissions, which is well below the emission allowance futures that are being traded in EU ETS. Similarly, it's a pity that the computed prices aren't compared to today's values.

Answer to reviewer that the 2C is in fact compatibly with EU policy. Add the historical prices in the CO2 price figure, as in <https://github.com/martavp/budgets/blob/main/plot_CO2_price.py>   
  
In conclusion, I have the impression the authors rushed through this analysis in order to be the first to come out with a study on this topic. In such an important matter, I would, however, recommend a more detailed, nuanced analysis.

We agree that it is important, we have added more detailed and nuanced analysis.  
  
  
  
  
**Reviewer #3:**  
  
The authors model the difference in an European energy system, taking into account potential gas supply constraints to Europe. While the paper is of course very timely, I do not see that it generates sufficiently new insights into our understanding of the European energy system to warrant a publication in Joule.

Mention novelties: (1) high temporal, spatial and model with detailed representation of all gas consuming sectors, (2) gas-limited constraint, (3) combined analysis with climate ambition

Review the text describing insights and add them into here.

In particular, the transition pathways with our without limiting gas are very similar, and the main difference is between the 1.5°C and 2°C pathway, which is an extensively studied topic - and is not addressed in depth in the paper.

Use sensitivity to discuss difference between 1.5 and 2C, mention also build rates.

Furthermore, you do not provide any insights into how those systems may adapt apart from - to put it bluntly - "things are built quicker".

Comparison with build rates

Furthermore, the difference between the scenarios with and without gas limits are minor and not structurally explored in the paper to discover interesting features.

We have improved this.

I still think the paper is a valuable contribution to the policy discussion, but you may have to find a different outlet than Joule for it. I however encourage the authors to work more extensively on their results and aim at a resubmission. I think there are e.g. very important distributional impacts from a limitation on gas supply, which you could explore which your model, as I understand that it allows to derive regional differences in impacts. Furthermore, as you are able to provide prices, you could assess in more detail winners and loosers of such a change.  
This is one of the major hurdles to get the paper accepted, and somehow, I agree with the reviewer. I think we should try to get a deeper and more useful understanding of the differences. I suggest we try to implement the following:

1. Temporal figures (like current Fig S8) for: (a) heating supply in services rural/ residence rural/services urban decentral/residence urban decentral/urban central + electricity

The aim here is to answer the question: how does the system deal with winter peaks in heating and electricity demand does when gas is/is not available?

1. Spatial Figures showing pie charts for different countries. For instance, we can adapt the scripts in plot\_network and plot the difference in cost between the scenario with/without gas limit.

The aim here is to answer the question: Which countries see major differences caused by the gas limit? do all the countries see the same changes in technologies?

Some minor comments:  
- Legend of Fig. 2 g), h): unclear how capacities differ between scenarios, i.e. which line belongs to which scenario (dashed/solid)?  
Improve this figure: (a) remove hydro, it is exogenous. (b) make it stepwise, (c) add legend to identify with/without gas, (d) check what happen when we have a more realistic decommissioning of nuclear power plants

- "A ~~marginal~~ cost of 21.1 Eur/MWh for gas is assumed. The constraint on gas availability introduces a shadow price on gas, when demand is higher than supply. The gas price depicted in the figure is the sum of the marginal price and the shadow price."  
I think there is an error in terminology.

(1) The term "marginal price" is unknown to me.  
(2) The price of the ressource is therefore marginal production cost + shadow rent.  
Agree, we need to be more careful with terminology, but this is an easy fix.   
- Please observe that apparently you do not have a full gas market model, as you do not include all gas consuming sectors directly in the model. Therefore, I am not sure how to interpret the prices. One would probably have to assume that somhow the amount of gas going to the modelled energy sectors is fixed by definition and that other sector adaptation processes will not affect the equilibrium price. This should at least be explicitly stated somewhere.

Include a description of which sectors consuming gas are included/missing in the model and add a sentence similar to that proposed by the reviewer.