Referee #1

Overall comments Overall, this is a useful and important paper, and of high scientific quality and policy importance.

Many thanks for your thoughtful and helpful comments.

It would be good to include a table with sources and hyperlinks if consistent with the journal policy.

Yes, good idea.

- Changes made: I have added a table to the Supplement, "India activity data sources."

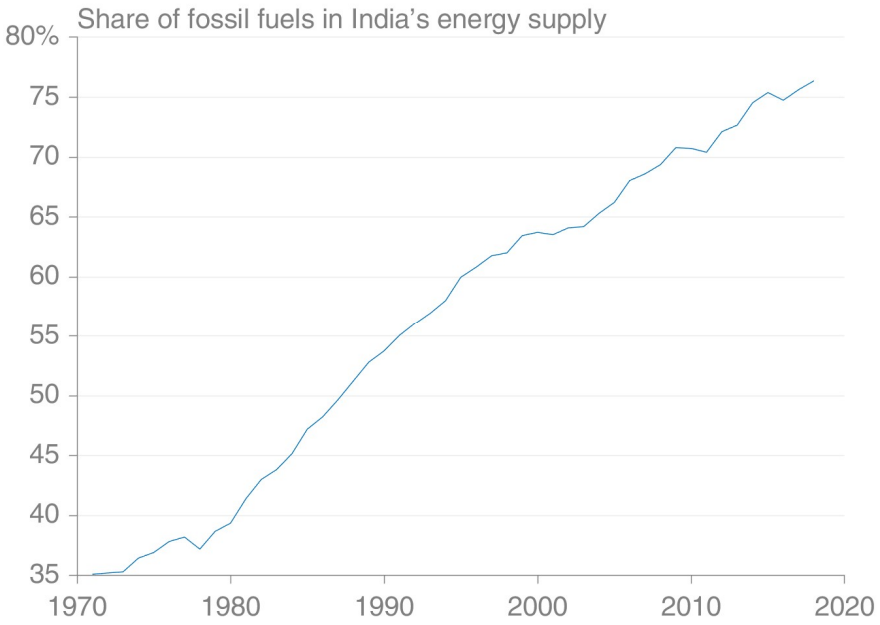
From a policy-making point of view, I believe it would be useful for the paper to make a few observations on the ways in which India's data presentation could be best improved. Frustration with the disparate sources and poor presentation are widespread among the policy community and providing guidance on improvement would be valuable.

- Changes made: Added paragraph to the Conclusions: "India publishes more energy data than many other developing countries, providing a wealth of information for management, policy analysis and scientific research. Nevertheless, there remains significant room for improvement in the quality of these publications. Possible avenues for such improvement include: (i) Publishing more data in machine-readable formats, rather than just as tables in PDF documents or in web-page tables, (ii) Providing a way for the public and researchers to ask questions about or report errors in data, establishing direct contact with those responsible for the data, to facilitate crowd-sourcing of quality assurance, (iii) Encouraging collaboration in data preparation and presentation across ministries to prevent errors creeping into reports, (iv) providing more documentation of reported data, (v) Reducing use of manual copy-pasting and typing, and automating as much as possible with both automatic and manual quality assurance, (vi) Standardising the use of important terms (e.g. 'consumption') across reports from different departments to prevent confusion, (vii) Making available older, non-electronic reports (e.g. Monthly Abstract of Statistics), online through use of digitisation."

Page 1, Lines 24-27: It is worth mentioning here that India's carbon intensity of energy supply has also increased over the last 10-15 years, as the share of hydro electricity has declined, the share of coal increased, biomass transition in the residential sector has progressed, and emissions intensive fuels in industrial final energy consumption has increased.

- Changes made: I have added a clause to the end of this sentence.
  "…including the transition from biomass to petroleum fuels, continuing the long-term increase in the share of India's energy supplied from fossil fuels (see SI Fig 41)"

where the new figure in the Supplement is as below



Page 1, Line 28: Better not to say "small renewables" as India has some of the largest utility scale solar parks in the world.

- Changes made: Changed "small renewables" to "variable renewables".

Page 1, Line 40: this list of references should include the India GHG Platform initiative: http://www.ghgplatformindia.org/

- Changes made: added a reference to the GHG Platform India.

Page 3, Line 25-27: it may be possible to get naptha consumption for production of durable commodities in the Annual Survey of Industries macro-data, and apply this ratio to monthly naptha consumption data.

I don't have access to this, so I've simply suggested it as a possibility.

- Changes made: Added text ", but may be discoverable using data from the Annual Survey of Industries (MOSPI, no date)"

Page 3, Line 37-40: It is known that the calorific value of Indian coal varies greatly between different coal grades, and is generally understood to be declining over time as the quality of domestic mined coal declines. Some discussion of improved estimates of the calorific value of Indian coal should be made.

I have tried to keep most of the detail of the methods in the Supplement, since they're so extensive. I have added the following text and figure to the Supplement.

- Changes made: Added to Supplement:

  Focusing on hard coal, Figure 17 compares a number of different datasets, demonstrating wide divergence in reported coal quality. It seems clear that coal quality overall has declined in the last 50 years, partly as a result of the significant increase in the share of lower-cost production from open-cast mines (77% in 1998/99 to 94% in 2018/19, according to the Coal

Directories), but the IEA's figures in the 1970s and 1980s are markedly different from those reported in all but the most recent Energy Statistics yearbooks.

It is unclear how the Energy Statistics derives average coal quality, but it appears that the IEA has used the annual data on production by coal grade, combined with average energy contents for each grade. This supposition is based on the author doing exactly that with the data provided by the Coal Directories: from 2013, estimates made this way match very closely to those of the IEA. Before 2013, India used a less-detailed grading system. The author's estimates for that earlier period assume that the average energy content did not jump dramatically upwards from 2012 to 2013, something that seems unlikely, and this leads to a difference with the IEA's estimates in that period.

In 2016, Coal India introduced quality assurance routines, sending samples to third-party laboratories for assessment of energy content, a scheme called 'Unlocking Transparency by Third Party Assessment of Mined Coal' (UTTAM). This scheme was introduced after repeated complaints by power station operators that received coal was of lower than the declared (and paid-for) energy content. With 51% sampling coverage in the 2017-18 year, UTTAM results showed that the average analysed energy content was 6% lower than the average declared energy content. Back-calculation of energy content from hard coal production in both energy and mass terms suggests that the Energy Statistics report has subsequently simply used this much lower average for the entire period reported (2006-07 through 2018-19 in the 2020 edition).

The UN Statistics Division's Energy Yearbooks report much higher energy contents in 2012 and 2013, with these numbers having been reported to them by Indian officials; subsequent values are taken from IEA reports (pers. comm., Leonardo Rocha Souza, 16 July 2020). This sharp drop in the UN data for India's energy content translates directly into a sharp drop in production from 2012-13 to 2013-14, which propagates directly to CDIAC's estimates of emissions from solid fuels for India.

Given the insufficient sampling until the introduction of the UTTAM scheme in 2016, it is impossible to say with any uncertainty what the energy content of India's hard coal was

before then, but it is unlikely that the constant low value used by the Energy Statistics yearbook is correct.

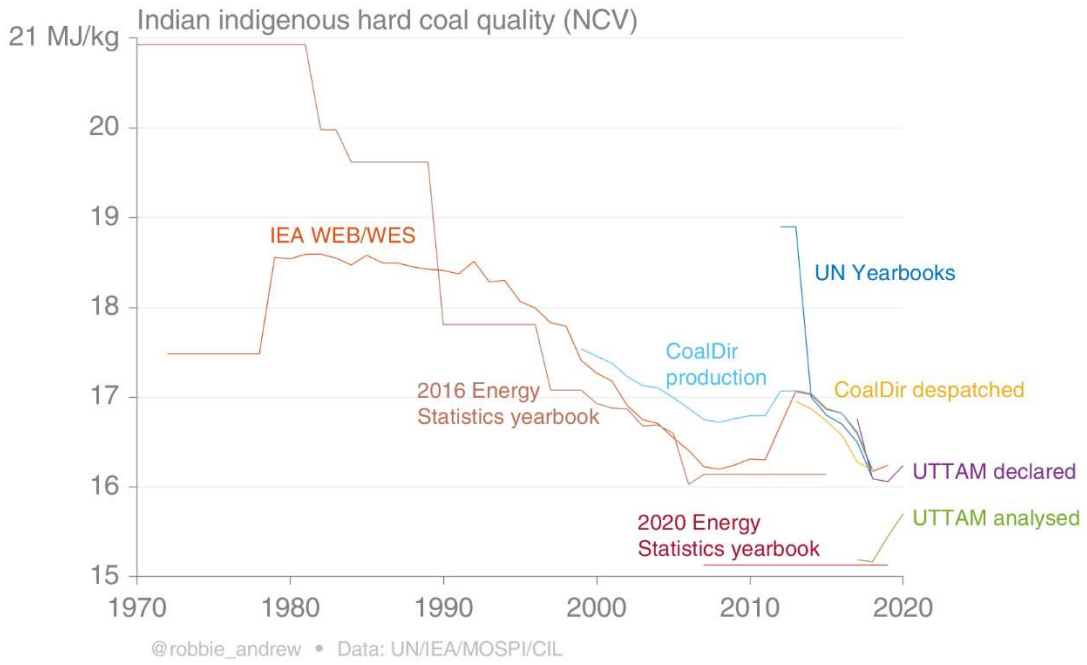


Figure 17: Comparison of energy content of Indian hard coal from various datasets. Data plotted for the Coal Directory ('CoalDir') are the author's estimates derived from data on production by grade. IEA WEB/WES is the World Energy Balances (energy units) and World Energy Statistics (mass units).

Page 4, Lines 23-26, and Page 5, Line 1: it is worth noting that the observed monsoonal seasonality for coal, cement and oil is due in part to the same reason: economic activity in industry and construction declines during monsoon, implying reduced power demand and transport requirement. In additional residential electricity consumption declines as the temperature drops.

Yes, good point, although I don't see a reduction in total electricity demand during the monsoon season. In 2015–2018 it wasn't until October or November that demand dropped as winter temperatures arrived. A drop in residential consumption because of reduced AC use is presumably offset by increases in other sectors' demand. See the figure towards the end of the Supplement.

- Changes made: Added the following sentences: "These emissions patterns largely result from the effects of the monsoon's heavy rains, driving a decline in industrial, construction and transportation activities. Coal emissions are also driven down by the displacing effect of higher power generation from both hydropower and wind during the monsoon season."

Page 7: Lines 11-18: It would be good to discuss in a little detail, which errors may have cancelled. In addition, it would be good to explore the BUR to look at what emissions factors have been used for Indian coal, and how these compare with those used in this paper.

With regard to error cancellation, I already had the following text "it is known that the emissions estimates generated here exclude some carbonate sources" and add a further clause for some additional information.

- Changes made: Added clause "while emissions from naphtha oxidation here might be overestimated"

As for the BUR, I have added the following paragraph to the section in the Supplement that discusses energy contents.

- Changes made: Added paragraph to Supplement:

  Emissions from coal in India's Second Biennial Update Report (BUR) are derived using country-specific energy contents and emission factors (GOI, 2018). The Report is unclear as to whether these factors, reported in tables 2.3 and 2.4, are only used for domestic coal, or whether they are averages for total coal supply, including imports. Imported coal is of higher quality than India's domestic coal, and this likely explains why the energy contents provided in table 2.3 for coking and non-coking coal (23.66 and 18.26 MJ/kg, respectively) are somewhat higher than those reported by the IEA for domestic coal (20.50 and 16.69 MJ/kg). The BUR's reported energy content of lignite, which is entirely domestic, is 9.80 MJ/kg, very similar to the IEA's 9.55 MJ/kg, and somewhat lower than the Energy Statistics' value of 11.37 MJ/kg.

Page 8: Lines 6 -16: This paragraph confused headwinds and tailwinds to coal supply with headwinds and tailwinds to coal demand. "difficulty in acquiring land and environmental permits, local protests, difficulty obtaining finance" relates to coal supply, while "large economic shocks such as 2016's demonetisation, 2017's GST introduction and 2020's COVID-19 pandemic" relate to coal demand through channel of general macroeconomic growth. I believe the latter is much more important to understanding the deviation from forecast demand. In this regard, the paper could cite briefly some of the macroeconomic literature explaining India's growth slowdown (for example: https://www.hks.harvard.edu/centers/cid/publications/facultyworking-papers/india-great-slowdown)

I do agree that this paragraph discusses headwinds and tailwinds of both supply and demand, but that was in fact intentional. However, since the previous paragraph is very specifically about demand, this transition was not made clear to the reader.

- Changes made:
  Added "in both demand and supply of coal" to the first sentence of the paragraph.
  Added "the shadow bank crisis starting in 2018 (Subramanian and Felman, 2019)"

Page 10, Lines 23-26: As discussed above, calorific value and emissions factor estimates for Indian coal may lead to significant uncertainties and are worth reviewing here.

Changes made: Added text: "This is perhaps the largest source of uncertainty, particularly the energy content of domestic hard coal, for which data have been scarce and inconsistent, and broad sampling efforts in recent years pointing to significant errors, with data from 2016-17 suggesting declared average coal quality was 10% higher than the true value (see Supplementary section: Coal energy content). More work is required to generate a more reliable time series of coal quality in India, but in the absence of additional historical sampling of coming to light, estimates will have to be made."