Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 105 (2017) 3656 – 3662

Energy Procedia

The 8th International Conference on Applied Energy – ICAE2016

Energy and Industrial Growth in India: The Next Emissions Superpower?

Dimitrios Pappas, Konstantinos J. Chalvatzis

Norwich Business School, University of East Anglia, Norwich NR4 7TJ, United Kingdom
Tyndall Centre for Climate Change Research, University of East Anglia, Norwich NR4 7TJ, United Kingdom

Abstract

India is often referred to as the next development superpower and is widely seen as a potential destination for large scale manufacturing hubs. In this work we draw comparisons between India, Indonesia and China and find that all countries have a carbon intensive energy sector. However, there is a staggering difference between industrial energy intensity between them where India and Indonesia require double the amount of energy to produce the same output as China. We look into the decomposed industrial sectors and find that iron and steel and non-metallic minerals present the highest energy intensity in India. We argue that a production transition from China to India and Indonesia would result in a dangerous global emissions growth which has to be countered with rapid adoption of innovative energy technologies and policies.

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.

Keywords: India; Indonesia; China; Energy Intensity; Industry; decomposition

1. Introduction

India is the second largest, by population, country in the world and first when examining its rural population which amounts to 67.6% of its total 1.267 billion people [1]. Arguably the spotlight of the world economy has been, and still is on China as a main driver of global development [2]. However, there is no doubt that as the Chinese economy has already started slowing down [3,4] India attracts attention as the next development superpower [5]. Solidifying these projections, India has attracted the world's highest Foreign Direct Investment (FDI) with a total of US$63bn, surpassing China for 2015 by a US$6.4bn margin [6]. India's prominence in the global agenda is not limited to development issues but extends to a wider range of policy affairs. Recently (December 2015) India demonstrated its capacity for global leadership in the climate change negotiations at the 21st UNFCCC COP21 [7].

In terms of GDP per capita, India has been growing on an average annual rate of 4.4% for the period of 1980-2014. However, the respective rate during the past decade has been 6.2% showing that India is in a

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.
doi:10.1016/j.egypro.2017.03.842

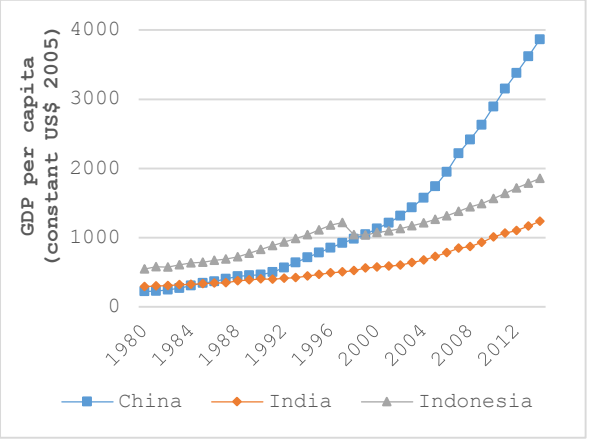


Fig. 1. GDP per capita timeline comparison (in constant 2005 US$) of India, China and Indonesia for 1980-2014. Data Source: [1]

fast growth period. IMF's world economic outlook update [8] estimates that the Indian total GDP growth reached 7.3% for 2015, projected to accelerate to 7.5% for the years 2016 and 2017. Despite the impressive growth rate, India's GDP per capita remains 3 times lower compared to that of China, with the latter experiencing approximately 1,700% growth, from US$220.7 in 1980 to US$3,865.9 in 2014. The Indian GDP growth remained positive throughout the global economic crisis of 2008-2012 despite the US and EU economies experiencing slow to negative growth rates.

2. Energy Intensity and Economic Development

India's total final energy consumption amounts to approximately 21,417 PJ [9] with approximately 300 million people still living off-grid [10]. Final energy consumption has increased by 186% during 1980-2012 and 61% recently in 2002-2012. However, despite India's consistent growth, China consumes more than 3 times more energy and faces several challenges for energy supply security [11]. Concluding to that figure, the final electricity consumption per capita between the 2 countries is evident of that difference, with China consuming 4.6 times higher electricity per capita [12]. India's power sector is predominantly based on indigenous fossil fuels and growing income trends are linked to growing demand for power supply [13]. India, being a major GHGs emitter, with a share of 6.5% of the total global emissions [14] is expected to become, along with China, the biggest energy consumer by 2030 in absolute terms [15]. India uses coal as a primary energy source for meeting its energy needs [16] and its consumption is bi-directionally linked with economic growth both on short and long-term outlook [17]. Countries with historically high reliance on coal can be locked in long-term pathway dependence [18] which is not straight-forward to surpass. However, technological innovation in the energy sector provides opportunities to reassess the role of technological options and their contribution to emissions [19].

Narayan [20], in the case of countries such as India, Indonesia and China has concluded that economic growth is directly related to increased energy consumption. When energy consumption, which is responsible for 60% of the total GHG emissions [21], is based on CO_2 intensive fuel mix, results in negative environmental impacts due to the CO_2 role in global warming which amounts to 70% of the GHG atmospheric concentration [22].

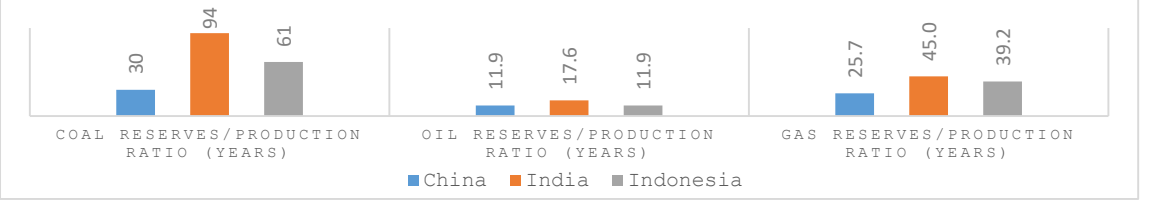


Fig. 2. Coal, Oil and Gas share of world total for China, India and Indonesia. [23]

At 94 years R/P ratio, coal is the most attractive energy production fuel for India's energy mix. Specifically coal-fired power stations represent 61% of the total capacity mix [24], and produce 70% of the total electricity generated in India [25].

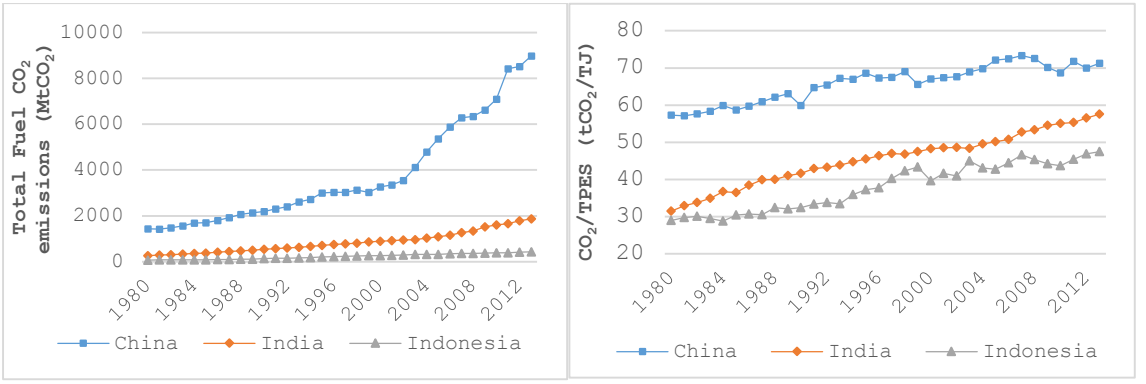


Fig. 3 & 4. Total combustible fuel CO_2 emissions (Fig.3) and total CO2 per total primary energy supply (Fig.4) timeline for China, India and Indonesia 1980-2013 [26]

The ratio between the consumption of gross inland energy and GDP is expressed as energy intensity [27], or alternatively as the ratio of energy consumption and economic output [28]. Therefore, it can be stated that energy intensity identifies the possible decoupling between economic growth and energy consumption; relative decoupling occurs when energy consumption is showing a steeper growth than GDP, and absolute decoupling when there is a growing GDP with stable or decreased energy consumption [29]. The improvement of energy efficiency, (i.e., which acts as a reciprocal to energy intensity) is a promising way of meeting emission targets which are set by climate policy, while it can help in the reduction of fossil fuel dependence and aid industrial competitiveness [30].

3. Economic and Energy Development in India

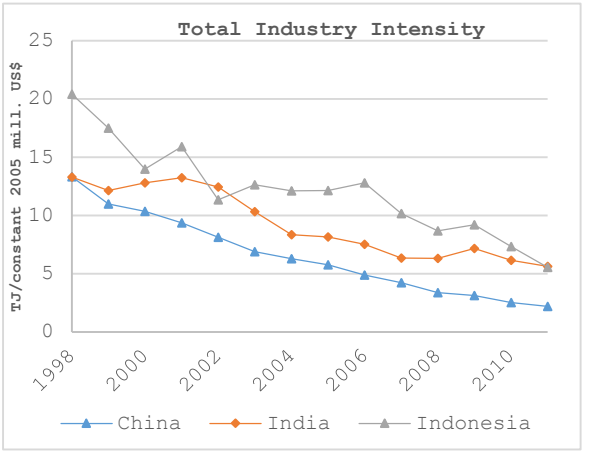
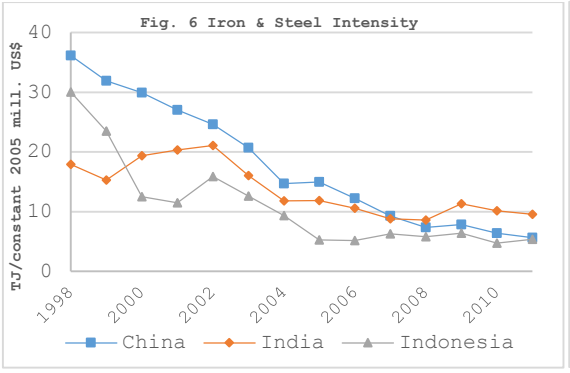


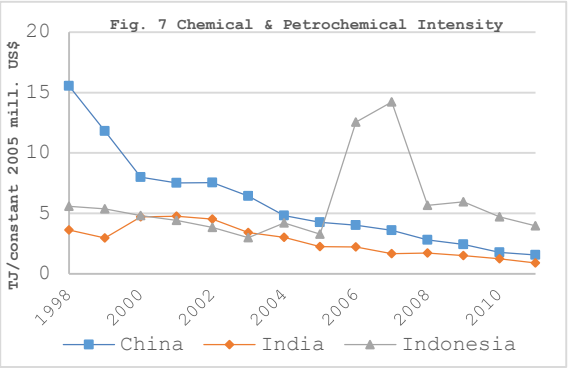
Fig. 5. Total industrial energy intensity timeline of China, India and Indonesia 1998-2011. Data Source: [32,33]

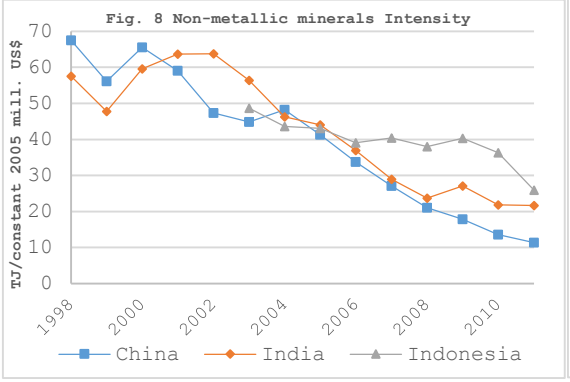
Industry and power sectors are the largest consumers of primary commercial energy in India [31] and among the most energy consuming industries in the country are aluminium, cement and iron and steel. Calculating and examining the energy intensity trends of India and comparing them with other major developing economies sets the evaluation basis of the past and existing energy-to-GDP intensity. The overall industrial energy intensity in India is more than double that of the respective figure in China (Figure 5). Specifically, the energy intensity of India has shown a continuous decline from 2001 onwards.

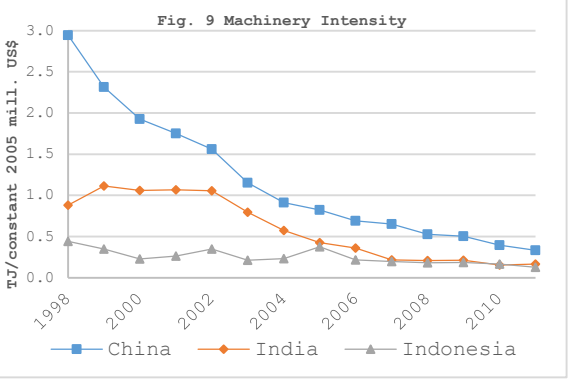
This declining trend is close to that of China which has been falling from 1999 onwards. However, India cannot compete with China in absolute terms, as China needs half the energy to generate the same economic output. It also presents the need for the respective activity sector to innovate in order to lower its energy generation costs and maximize the profit margin.

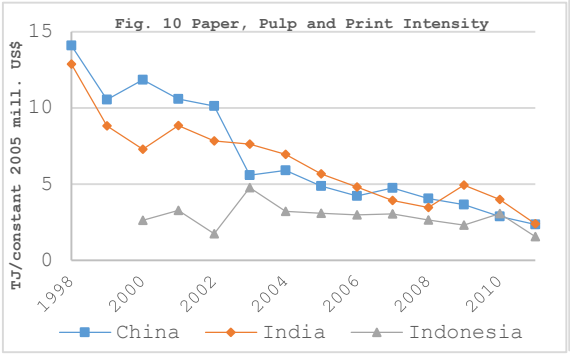
The industrial capacity of India is expected to continue its growth aided by programmes such as the "Make in India". The share of added value that originates from the industrial sector is expected to climb at 25% of India's total GDP by 2030 [34] from an approximate value of 8% in 2013 according to the World Bank WDI. Competitive advantages such as a large working-age population that reaches 70% of the total [35], low labour costs and social expenditures [2] while maintaining a significant innovation potential [36,37] give incentives to the manufacturers to turn their production focus from China to India. This is also the case with Indonesia, which presents a faster improvement rate in the recent years. This implies that a transition of industrial activity from China to India will result in excessive energy use and potential emissions growth.

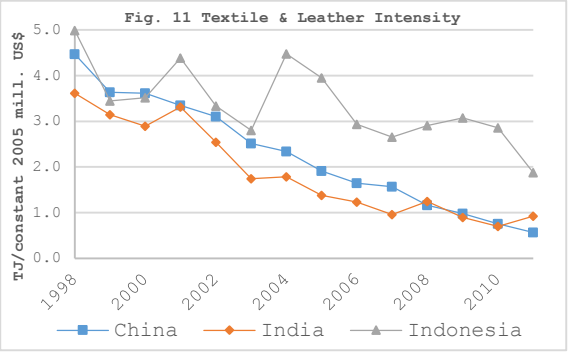












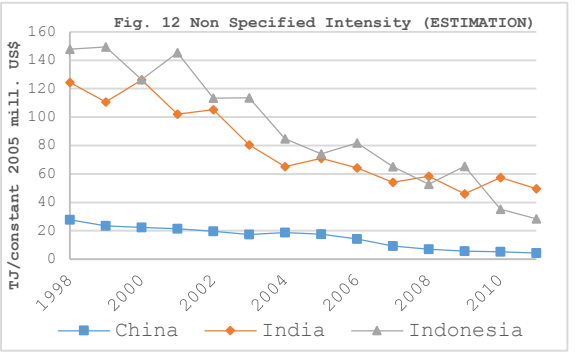


Fig. 6-12. Sectoral industrial energy intensity timeline of China, India and Indonesia 1998-2011. Data Source: [32,33]

However, not all industrial sectors are the same in terms of energy use and economic output and they do not present the same patterns in India and China. Highlighting their differences, a de-composition analysis is provided, presenting the most important industrial sectors of India, China and Indonesia (Figures 6-11). Moreover, we present the respective intensity of industrial sectors which are not specified in IEA datasets for the countries in question (Figure 12).

Evidently iron and steel and non-metallic minerals are the sectors in which India presents a significantly higher energy intensity than China. At the same time a large number of smaller industrial sectors (include in the "unspecified" category show India's energy intensity being higher than that of China. The transition of industrial output from China to India may come with substantial emissions burden in specific industrial sectors, as these are presented in Figures 6-12, if India does not move rapidly towards improvements of its energy and emissions intensity. As figures 13 and 14 demonstrate, industrial sectors such as the iron & steel, non-metallic minerals and the non-specified industry (incl. food & tobacco, wood and wood products, medical and transport equipment industries among others), hold the major share of the total industrial energy use, turning the focus of improvement upon them. Technological innovation can provide solutions to this directly but has to be supported by bold policies in the same direction [38,39].

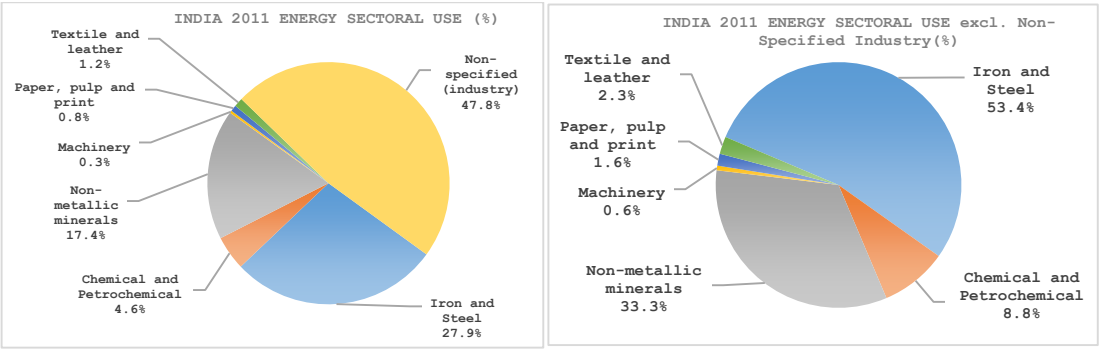


Fig. 13-14 Share of Indian total energy use by industrial sector for 2011. Data Source: [32,33]

4. Conclusions

We have looked into the disaggregated energy intensity of several industrial sectors in China, India and Indonesia and found that although generally India's industrial energy intensity is double that of China, it is specific the iron and steel and non-metallic mineral sectors and the unspecified industries that are responsible for that difference. It is essential that emissions control is being looked at predominantly within the industrial and energy sectors as improvements in other sectors, such as transport, mainly concern electrification which can be entirely ineffective without energy decarbonisation [40]. Furthermore, the Indian Government should continue with an ambitious programme of regulatory reforms that will trigger

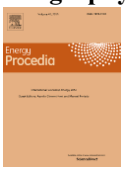
stronger private investment in renewables and energy storage [41]. Last but not least as India's electrification is expanding to an ever-increasing number of homes India has to consider public engagement with issues of domestic energy efficiency which can have a significant impact on sustainable growth [42]. Further research is necessary to enhance this decomposition analysis and reveal the specificities of all industrial activities in order to support an agenda for sustainable change in India. Finally, new research will be necessary to strengthen the link between energy intensity and expected emissions change in potential industrial migration between China and India and Indonesia.

References

[1] World Bank. World Development Indicators. UK Data Service; 2015. doi:http://dx.doi.org/10.5257/wb/wdi/2015-09-14.
[2] Grinin L, Tsirel S, Korotayev A. Will the explosive growth of China continue? Technol Forecast Soc Change 2014;95:297. doi:10.1016/j.techfore.2014.06.023.
[3] Yao K, Shrivastava S. China fourth-quarter GDP growth seen slowing to weakest pace since 2009. Reuters 2016. http://www.reuters.com/article/us-china-economy-gdp-idUSKCN0UQ12L20160112 (accessed February 11, 2016).
[4] IMF. Subdued Demand, Diminished Prospects, World Economic Outlook Update 2016:1–2. http://www.imf.org/external/pubs/ft/weo/2016/update/01/pdf/0116.pdf.
[5] Chan SP. India poised to become fastest growing large economy. Telegr 2015.
[6] Fingar C. India knocks China from top of FDI league table - FT.com. Financ Times 2016.
[7] Worland J. Why No Country Matters More Than India at the Paris Climate Talks. Time 2015. http://time.com/4144843/india-paris-climate-change/ (accessed February 11, 2016).
[8] IMF. World Economic Outlook Update - An update to the key WEO projections. IMF 2016. https://www.imf.org/external/pubs/ft/weo/2016/update/01/pdf/0116.pdf (accessed February 18, 2016).
[9] International Energy Agency. Summary Energy Balances: World Energy Balances, 1960-2013. 2014. doi:http://dx.doi.org/10.5257/iea/web/2014.
[10] Ferris D. Indian Microgrids Aim to Bring Millions Out of Darkness by David Ferris: Yale Environment 360. Yale Environ 360 2014. http://e360.yale.edu/feature/indian_microgrids_aim_to_bring_millions_out_of_darkness/2729/ (accessed February 24, 2016).
[11] Chalvatzis KJ, Rubel K. Electricity portfolio innovation for energy security: The case of carbon constrained China. Technol Forecast Soc Change 2015;100:267–76. doi:10.1016/j.techfore.2015.07.012.
[12] World Bank. World Development Indicators - Electric Power Consumption (kWh per capita). 2015. doi:http://dx.doi.org/10.5257/wb/wdi/2015-09-14.
[13] International Energy Agency. World energy outlook 2015 (executive summary) 2015. doi:10.1787/weo-2005-en.
[14] Olivier JGJ, Muntean M, Peters JAHW. Trends in global CO2 emissions: 2015 report. PBL Netherlands Environ Assess Agency Eur Comm Jt Res Cent 2015:1–78.
[15] WEO. World Energy Outlook. Int Energy Agency 2014:690 pp. doi:10.1787/20725302.
[16] Indian Ministry of Statistics and Programme Implementation. India Energy Statistics 2015. India Stat Yearb 2015. doi:Twenty first issue.
[17] Bhattacharya M, Bhattacharya SN. Economic growth and Energy consumption nexus in Developing World : The case of China and India 2014;4:150–67.
[18] Chalvatzis KJ. Electricity generation development of Eastern Europe: A carbon technology management case study for Poland. Renew Sustain Energy Rev 2009;13:1606–12. doi:10.1016/j.rser.2008.09.019.
[19] Zafirakis D, Chalvatzis KJ, Baiocchi G. Embodied CO2 emissions and cross-border electricity trade in Europe: Rebalancing burden sharing with energy storage. Appl Energy 2015;143:283–300. doi:10.1016/j.apenergy.2014.12.054.
[20] Narayan S. Predictability within the energy consumption–economic growth nexus: Some evidence from income and regional groups. Econ Model 2016;54:515–21. doi:10.1016/j.econmod.2015.12.037.
[21] International Energy Agency. Energy, Climate Change, & Environment. Executive Summary. 2014 Insights 2014.
[22] Shahbaz M, Solarin SA, Sbia R, Bibi S. Does energy intensity contribute to CO2 emissions? A trivariate analysis in selected African countries. Ecol Indic 2015;50:215–24. doi:10.1016/j.ecolind.2014.11.007.
[23] British Petroleum. BP Statistical Review of World Energy June 2015 2015:48. doi:bp.com/statisticalreview.
[24] Central Electricity Authority. All India installed capacity (in MW) of power stations - As of 31.01.2016 (Utilities). Gov India - Minist Power 2016. http://www.cea.nic.in/reports/monthly/installedcapacity/2016/installed_capacity-01.pdf (accessed February 25, 2016).
[25] Soni V, Singh SP, Banwet DK. Sustainable coal consumption and energy production in India using life cycle costing and real options analysis. Sustain Prod Consum 2015;6:26–37. doi:10.1016/j.spc.2015.12.002.
[26] International Energy Agency. IEA Statistics. CO2 Emissions From Fuel Combustion: Highlights. 2015. doi:http://dx.doi.org/10.5257/iea/co2/2015.

[27] Eurostat. Consumption of energy - Statistics Explained 2015. http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy (accessed March 13, 2016).
[28] Fan R, Luo M, Zhang P. A study on evolution of energy intensity in China with heterogeneity and rebound effect. Energy 2016;99:159–69. doi:http://dx.doi.org/10.1016/j.energy.2016.01.041.
[29] European Environment Agency. Energy intensity 2015.
[30] Ang BW, Mu AR, Zhou P. Accounting frameworks for tracking energy efficiency trends. Energy Econ 2010;32:1209–19. doi:10.1016/j.eneco.2010.03.011.
[31] Indian Ministry of Statistics and Programme Implementation. Energy Statistics 2015. New Delhi: 2015.
[32] International Energy Agency. Key World Energy Statistics 2015 2015:81. doi:10.1787/9789264039537-en.
[33] UNIDO. Indstat 4 Rev. 4 2016 Data Availability. 2016.
[34] PwC. Future of India The Winning Leap. Win Leap 2014:1–148.
[35] Chomik R, Piggott J. Asia in the ageing century: Part I – Population trends 2013:1–18.
[36] Thornton I. The fruits of frugal innovation. Green Futur Mag 2013.
[37] Cooper RG. The State of Product Development. Res Manag 2009;52:6.
[38] Zafirakis D, Elmasides C, Sauer DU, Leuthold M, Merei G, Kaldellis JK, et al. The multiple role of energy storage in the industrial sector: Evidence from a Greek industrial facility. Energy Procedia 2014;46:178–85. doi:10.1016/j.egypro.2014.01.171.
[39] Murphy R. The emerging hypercarbon reality, technological and post-carbon utopias, and social innovation to low-carbon societies. Curr Sociol 2014;63:317–38. doi:10.1177/0011392114551757.
[40] Hofmann J, Guan D, Chalvatzis K, Huo H. Assessment of electrical vehicles as a successful driver for reducing CO2 emissions in China. Appl Energy 2016. doi:10.1016/j.apenergy.2016.06.042.
[41] Zafirakis D, Chalvatzis KJ, Baiocchi G, Daskalakis G. The value of arbitrage for energy storage: Evidence from European electricity markets. Appl Energy 2016. doi:10.1016/j.apenergy.2016.05.047.
[42] Pothitou M, Hanna RF, Chalvatzis KJ. Environmental knowledge , pro-environmental behaviour and energy savings in households : An empirical study. Appl Energy 2016. doi:10.1016/j.apenergy.2016.06.017.

Biography



Dr Konstantinos J. Chalvatzis is a Senior Lecturer (Associate Professor) in Business and Climate Change at Norwich Business School and at the Tyndall Centre for Climate Change Research at the University of East Anglia. He is interested in technological transitions and futures in the energy sector and the role of innovation in systematic resilience.

Corresponding author at: k.chalvatzis@uea.ac.uk

Norwich Business School, University of East Anglia, Norwich NR4 7TJ, UK