Responsibility, Representation and Participation: Bureaucratic Steering of Biofuel Research

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This article seeks to trace the implicit notion of responsibility in the bureaucratic steering of biofuel research in India—as a useful entry point to think further on framework of Responsible Research and Innovation (RRI) in India. It concentrates on a specific aspect within the RRI framework in particular—public engagement and concerns for greater participation. By engaging with R&D in biofuel technologies in India, the techno-bureaucratic steering of its trajectories and the emphasis on public engagement within RRI frames, this article seeks to bring focus on how S&T governance in India could in principle be made more responsive to societal needs by motivating positive developments in line with public needs.

Keywords: RRI, biofuel research, synthetic biology, public participation, India

Introduction

Synthetic and Systems biology has come to be recognised by policymakers in this decade as the key approach in the development of novel technologies for biofuel production in India. S&T research on biofuel production in India, including in this turn to synthetic and systems biology, is directed and steered through bureaucratic action, as elaborated later in this article. This article seeks to understand the notions of responsibility that underpin this techno-bureaucratic direction for fostering scientific research to supplement fossil fuels with biofuels, as a useful entry point to think further on the framework of Responsible Research and Innovation (RRI)
in India. It concentrates on public engagement and concerns for greater participation in particular, which is generally recognised by now as central to the idea of responsibility in future-oriented approaches to S&T governance (Konrad, Van Lente, Groves, & Selin, 2017; Owen, 2014).

There is a fair amount of recognition that RRI as a framework is not explicitly, or ‘directly traceable’, within the formal Indian S&T policy architecture (Srinivas, Kumar, & Pandey, 2018), even as policymakers are seen to have used the concept of ‘responsibility’ in ways ‘to further national development goals and socio-economic development’ (Srinivas et al., 2018, p. 73). What is the underlying notion of responsibility that can be traced as implicit in the bureaucratic steering of biofuel research in India? Literature within science and technology studies (STS) has focused on how the domains of science and politics are not unambiguously demarcated, and where the material and technological world are seen as shaped with often implicit and undefended visions of order and progress (Irwin, 2008). The lack of explicit substantiation of the notion of responsibility in the bureaucratic steering of scientific research on biofuels in India and the implicit concept of political representation that underpins such exercise of responsibility, together call for the attention on public engagement in this article. What visions of progress are implicitly assumed to be ‘responsible’ in the bureaucratic steering raises questions about public engagement and participation in the direction of scientific research.

As an important contemporary theme in the governance of science and technology, such attention through the RRI framework, in turn, also provides an appropriate vantage point to direct the attention of STS on the innovation systems geared towards biofuel production in India, beyond the by now well-rehearsed moves in technology governance discourses, namely technology assessment, risk assessment, uncertainties and identifying unintended consequences. By engaging with R&D in biofuel technologies in India, the techno-bureaucratic management of its trajectories and the emphasis on public engagement within RRI frames, this article also seeks to bring focus on how S&T governance in India can be made more responsive to societal needs by motivating positive developments in line with public needs. ‘Moves toward RRI’ has been understood as ‘a further development of two-way public engagement with science’, allied to ‘blossoming of dialogic activities on issues involving science’ (Stilgoe & Guston, 2017; Stilgoe, Lock, & Wilsdon, 2014). Resisting the reversion on the emphasis on public engagement as ‘stubbornly motivated’ by deficit models that sees the practice of public engagement as a legitimating and trust-building strategy (Chilvers & Kearnes, 2015; Stilgoe & Guston, 2017; Wynne, 2006), this article also seeks to emphasise the current limitations in public engagement within anticipatory governance of S&T in India.

**Policy for S&T Research in Biofuels in India: A Historical View**

S&T research for development of the three generations of biofuels in India have been greatly directed by bureaucratic steering, where the normative mooring of such steering can be located within the discourses of ‘national interest’ of fuel.
self-sufficiency and import substitution, and ‘wise use of agricultural resources’ hyphenated within agricultural waste, which will be elaborated later in this section. What notions of responsibility can be located in the justifications for this direction, and whether room for any public engagement and deliberation that seeks to guide this exercise of bureaucratic steering exists within such implicit notion of ‘responsibility’ is explored here.

Since the invention of internal combustion engines, liquid biofuels such as alcohol/ethanol and vegetable oils have been used as automotive fuels before the price advantage caused a shift towards petroleum products in the early twentieth century (Kovarik, 2013). The Indian Power Alcohol Act of 1948 sought to provide a legal framework for the development of the power alcohol industry in independent India, and envisaged sale of petrol with an admixture of power alcohol wherever feasible. While the law was not enforced, energy security in terms of achieving national self-reliance through finding an alternative to crude-oil import has remained a persistent narrative that has shaped the science and policy on biofuels in India, as elaborated later in this section.

Historically, R&D of biofuel technologies in India has been embedded within the discourse of agriculture, waste and energy (Maheshwari, 2008). Renewable biomass, including agricultural residue and waste, have been seen as central to the pursuit of producing biofuels for vehicles, underlining an emphasis on sustainable use of agricultural inputs including arable land and water. The Government of India (GoI) resolution of 2002 explicitly recognised the objective of promoting biofuels as ‘to give {a} boost to {the} agriculture sector and reduce environmental pollution’, and reiterated the role of agriculture and agricultural land in the establishment of the ‘biofuel complex’ (MPNG, 2002). In 2003, the committee constituted by the Planning Commission on the development of biofuels in India noted that ‘(a) mong the various competing processes, bioethanol from lignocellulosic biomass appears to have economic potential. Crop residues such as rice straw, bagasse etc. are not currently used to derive desired economic and environmental benefits and thus they could be important resource base for bioethanol production’ (PC, 2003). Subsequently, the National Policy on Biofuels 2009 had also emphasised the importance of using agricultural and similar wastes and supported developing biofuel production trajectories from lignocellulosic biomass. The 2009 policy had committed to undertake ‘(i)ntensive R&D work … for first generation biofuels and emerging technologies for second generation biofuels including conversion of ligno-cellulosic materials to ethanol such as crop residues, forest wastes and algae, biomass-to-liquid (BTL) fuels, bio-refineries, etc. (emphasis supplied)’ (MNRE, 2009).

Belying the possible impression from these policy documents that an emphasis on waste-based approach of deriving energy from cellulosic biomass is a recent trend, S&T institutions in India have had a long engagement with research on ‘wastes and residues of agriculture’. These engagements were non-linear and witnessed constant shifts and repeated reframing of the agriculture, waste and energy discourse in India. Conventional accounts of biogas development for rural India

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include endeavours to incorporate agricultural waste such as rice and wheat straw, even as the narrative of traditional source of animal dung dominated endeavours on biogas production in India. The *kachara* gas plant (*kachara* denoting garbage or waste) developed by Goswami and Choudhary in the 1960s, was a ‘straw-biogas plant which can compete with the existing gobar gas plant’ (*gobar* denoting cattle dung; Goswami, 1989). By emphasising the heterogeneity of the waste available for rural households, they reframed the problem of biogas to energy in terms of the types of available inputs:

Biogas has been produced hitherto only from cow dung, but sufficient cow dung is available only to the rural rich. Seven or more cattle head required for a supply of dung for a family size digester are owned only by about 8% of rural families. Therefore, fibrous plant wastes must constitute the raw material for biogas. (Goswami, 1989)

This shift to agriculture, waste and energy in the discourse was sought through arguments about the ‘appropriate technology’ that shall cater to social conditions of surplus waste available for rural households with marginal resources.

Explorations to utilise residual agriculture biomass was not however limited to the production of biogas. A report prepared at the Indian Institute of Technology (IIT) Delhi in 1979, reviewing the status of biochemical engineering education and research in India during the period of 1958–1978, hinted at other R&D trajectories. Various projects listed in the report indicate early efforts to use agricultural wastes for production of biofuels at an industrial scale, including ‘production of ethanol from bagasse hydrolysate by rapid fermentation technique’ at IIT Delhi; ‘alcohol from starchy material from jackfruit seed and shatti tuber’ at Jadavpur University; ‘alcohol from cellulosic wastes, acetone-butanol from molasses’ at HBTI Kanpur; and ‘development of fast fermenting yeasts for fermentation of molasses to alcohol’ at Haryana Agricultural University (IITD, 1979). Professor T. K. Ghose, then a faculty at IIT Delhi, is considered a pioneer in India who emphasised the significance of cellulose as an alternative energy source. He established the ‘Biochemical Engineering Research Centre’ (BERC) at IIT Delhi in 1976, in collaboration with the Swiss Federal Institute of Technology, Zurich. In February 1977, BERC organised India’s first international course-cum-symposium on ‘Biochemical Engineering and Bioconversion of Cellulosic Substances into Energy, Chemicals and Microbial Protein’. BERC was by then recognised as a key research centre by the National Steering Committee on ‘Fuels from Biomass’ constituted in 1978 by the Department of Science and Technology (DST), GoI. Major DST-sponsored research projects undertaken by BERC in the 1980s included (a) microbial conversion of methane to methanol and (b) bioconversion of cellulosic wastes to ethanol. Even at the global level, ‘BERC was the first to publish results of studies on ethyl alcohol {ethanol} from cellulose as an international communication’ (IITD, 1980).

An important factor that globally sustained R&D to produce biofuel was the oil shocks of the 1970s. In the USA, President Nixon launched ‘Project Independence’
in 1973 to establish energy self-sufficiency by 1980. Responding to the second oil shock, President Carter signed the Energy Security Act in 1980, which gave a major fillip to alternative energy research in the USA. In India too, as Maheshwari explained,

The circumstances defined the research problem. Because of the oil crisis following the 1970 Gulf War, the funding agencies were soft on projects on bio-conversion of cellulosic ‘wastes’ such as rice and wheat straw, stover (leftover maize leaves and stalks after harvest), bagasse (leftover fibrous waste after extraction of juice from sugarcane), waste from paper mills etc., into alcohol. (Maheshwari, 2008)

Nonetheless, a cost-effective way for pre-treatment and enzymatic hydrolysis of lignocellulosic biomass for conversion into simple fermentable sugars has remained elusive due to the basic gaps in attendant scientific understanding. Following global cues, however, the S&T research efforts for converting lignocellulose into ethanol in India had subsided by the late 1980s. As Maheshwari commented: ‘Though eager to solve the fuel problem, many researchers were forced to shift focus elsewhere until molecular biology tools had become sophisticated, sequence resources were to become available and plants with reduced lignin could be produced’ (Maheshwari, 2008). It is only through the last decade that such tools were developed, prominently within the framework of synthetic biology approaches, towards production of biofuels from agricultural residue and waste.

**Bureaucratic Incentives Towards Deploying Biofuel Technologies**

There has been significant bureaucratic push to deploy first-generation ethanol and second-generation biodiesel technologies, including through the setting of targets of biofuel-blended vehicular fuels in the market. A prominent example is the Ethanol Blended Petrol (EBP) programme of the GoI that has required minimum procurements by the Oil Marketing Companies (OMCs). In September 2002, GoI directed that petrol blended with 5 per cent ethanol shall be sold in nine specified states and four union territories, with effect from January 2003 (MPNG, 2002). The scope of the EBP programme was expanded in 2006, whereby the GoI directed the OMCs to sell a similar blend of ethanol and petrol in twenty specified states and four union territories with effect from November 2006, ‘subject to commercial viability’ (MPNG, 2002). In January 2013, GoI directed the OMCs to ‘(s)ell Ethanol-blended-petrol with percentage of ethanol up to ten percent … to achieve five per cent ethanol blending across the Country as a whole’ (MPNG, 2013). Earlier in December 2009, the National Policy on Biofuels had already set ‘(a)n indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol, by 2017’ (MNRE, 2009). It is revealing that Indian sugar mills only supplied about 665 million litres of molasses-derived ethanol to the OMCs to be blended in vehicle fuel during the financial year 2016–2017 (Reuters, 2017).
A recent study conducted by Sujata and Kaushal demonstrates that, ‘(a)t present the preparedness is not there to achieve even a 5% blend nationwide, let alone 20%’ (Sujata & Kaushal, 2017). This, the study reiterated, is largely because India heavily relies on ‘first-generation’ biofuels; primarily ethanol derived from molasses (a by-product in sugar industry that is also used as an ingredient in human food, cattle feed, and dietary supplements). A 2012 policy paper by ICAR’s National Centre for Agricultural Economics and Policy Research, suggested that ‘(b)oth production and area under sugarcane will have to be more than doubled to achieve 10 per cent blending target’ set for the EBP programmes, if these programmes were to exclusively rely on molasses derived ethanol (Raju et al., 2012). Such a strategy of doubling production and production area would be unsustainable as it will lead to substantial change in the pattern of land use and increased pressure on water tables given the water-intensive nature of the crop. Globally, varieties of feedstock are used for production of bioethanol including corn in the USA, sugarcane juice in Brazil and beet in some European countries. However, reliance on food crops grown on arable land starkly brings into play fuel vs food security debate in India. Use of first-generation biofuels is therefore not seen as a feasible and sustainable strategy for a country like India, underpinning the gaps in attempting the development and deployment of petrol blended with ethanol derived from molasses. Thus, it is apparent that the EBP programme has not achieved anywhere near its identified targets until date.

The inability in reaching similar targets in the development and deployment of biodiesel is even starker. In April 2003, the report of the committee on development of biofuel constituted by the Planning Commission recommended the launching of a National Mission on Bio-Diesel with the objective of achieving blending of high speed diesel (HSD) with 20 per cent biodiesel by 2011–2012. The committee proposed a large-scale plantation programme of *Jatropha curcas*, over an estimated 11 million hectares of waste and degraded land in and around forest areas. The report contended that

(t)here are many tree species which bear seeds rich in oil. Of these some promising tree species have been evaluated and it has been found that there are a number of them such as *Jatropha curcas* and *Pongamia Pinnata* (‘Honge’ or ‘Karanja’) which would be very suitable in our conditions. (PC, 2003)

The non-edible oil seeds of *Jatropha curcas* were recommended as feedstock source for production of second-generation biodiesel in India. The proposal envisaged a first phase by 2006–2007 to demonstrate plantation and cultivation on 0.4 million hectares. A self-sustaining expansion of the programme from 2007 was envisaged as a second phase to achieve a 20 per cent blending target by 2011–2012.

Several states including Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh actively responded to the proposal and initiated establishing Jatropha and Pongamia plantations. Various commercial entities too undertook this grand vision of establishing plantation for biodiesel over vast tracts of land; including Reliance Life Sciences, the Chhattisgarh State Renewable Development Agency (CREDA),
Indian Oil Corporation Ltd (IOCL), Hindustan Petroleum Corporation Ltd (HPCL), Bharat Petroleum Corporation Ltd, D1 Williamson Magor Bio Fuel Ltd (FE, 2005; Modi, 2007; Singh, 2008). However, none of these endeavours have succeeded. In March 2017, the Cabinet Committee on Economic Affairs approved closure/winding up of IOCL and HPCL joint venture companies with CREDA (since they are public sector companies). The official GoI communiqué noted ‘(d)ue to various constraints such as very poor seed yield, limited availability of wasteland, high plantation maintenance cost etc. the project became unviable and Jatropha plantation activities were discontinued’ (PIB, 2017). By 2017, India’s Jatropha-based ambition to introduce large-scale biodiesel blends had met a spectacular failure.

Beyond the chiasmic gap between targets set for deployment of these two technologies and its realisation, its deployment have also been generally recognised as unsustainable and unfeasible in recent years (PIB, 2017; Raju et al., 2012; Sujata & Kaushal, 2017), notwithstanding bureaucratic incentives and directions. In both these instances, concerns about environmental sustainability, food security and the social viability of diversion of land and other resources essential for food production are evident. The National Policy on Biofuels 2009 sought to address these tensions by affirming that ‘(i)n {the} future too, it would be ensured that the next generation of technologies is based on non-food feedstocks’ (MNRE, 2009). In the case of diesel (which has higher annual consumption rate in India compared to petrol), introduction of biofuels has proved even more intractable. Beyond insider consultations, deliberations through formal public fora are almost absent in these bureaucratic attempts to direct first and second generation bio-fuel research. The pursuit of national interest and energy self-sufficiency in the vehicular fuel policy through development and deployment of biofuels also includes a stated policy preference for ecologically sustainable trajectories of bio-fuel production that shall use agricultural residue, as opposed to divert scarce resources of land and agricultural inputs that are currently used to produce food.

It is in these contexts of spectacular gaps between stated targets and the deployment of the first- and second-generation biofuels steered by the policymakers that the current bureaucratic direction of R&D in biofuel towards synthetic biology approaches needs to be placed. The Department of Biotechnology (DBT) is spearheading a major energy biosciences R&D programme in the country to realise the goals set in the National Policy on Biofuels. The Vision 2020 document, discussed in the next section, which is the new compass for the DBT and aims at development of next generation biofuels was prepared through a consultative process restricted to an expert group of scientists. Through these shifts, attempts at public engagement have been minimal, and the wider participation to guide the bureaucratic direction of R&D scant.

**Synthetic Biology in Biofuel Technologies**

The focus on development and deployment of biofuels in India and elsewhere has shifted to synthetic biology approaches in the last decade. The ‘Bioenergy Road
Map Vision 2020’ prepared by the DBT in 2012 explicitly aimed at ‘producing new biofuels through synthetic biology’ (DBT, 2012). The shift has to be placed within the context of the general recognition of the unsustainability and non-feasibility of the previous generation of biofuel technologies.

This shift was facilitated through a series of policy measures, and collaborations with the industry in India, and elsewhere. In an editorial for *Science* in June 2006, Chris Somerville emphasised the necessity of considerable resources to establish a cellulosic biofuel industry: ‘(i)t may be necessary to create a mission-oriented project similar to the Manhattan Project’ (Somerville, 2006). Endorsing his views, Donald Kennedy, Editor-in-Chief of *Science*, suggested that the best course would be to abandon endeavours to derive ethanol from corn and sugarcane or biodiesel from palm oil (i.e., first-generation biofuel) and instead singularly focus on conversion of cellulosic biomass into biofuels. But he also reiterated the technical challenges attendant in this shift: ‘(p)lant lignins occlude the cellulose cell walls; they must be removed, and then the enzymology of cellulose conversion needs to be worked out’, a technical project that lost bureaucratic support in the 1980s’ (Kennedy, 2007).

The technical challenge was now pursued through a series of collaborations with the industry and universities. An early response was through a large industry–academia collaboration, whereby the oil-major Bharat Petroleum committed $500 million for research in bioenergy over a decade, in 2007. This collaboration established the Energy Biosciences Institute (EBI) in partnership with the University of California, Berkeley, the University of Illinois Urbana–Champaign and Lawrence Berkeley National Laboratory early the next year (Sheridan, 2007). The EBI, under the leadership of Chris Somerville, had the synthetic biology pioneer Jay Keasling also on board as the programme coordinator. He successfully advocated the use of cellulosic sources for production of cheap ‘advanced biofuels’, as a shift away from the approach of blending bio-ethanol towards developing advanced drop-in biofuels. Whereby the EBI affirmed that ‘[s]ynthetic biology is a core function with the EBI’. In 2007, the U.S. Department of Energy (DoE) also announced an investment of $375 million to create three new bioenergy research centres (BRCs).

In India, the DBT has run a dedicated ‘energy bioscience’ programme. In response to initiatives on biofuels in the USA, former DBT Secretary M. K. Bhan launched India’s first bioenergy centre at the Institute of Chemical Technology (ICT), Mumbai, in December 2008; with an initial funding of ₹250 million (about $5 million; Lali, 2016). Subsequently, the DBT roped in an industrial partner (through an MoU with Indian Oil Corporation Ltd. in August 2011) to establish a second bioenergy centre at Faridabad with an initial cost of ₹530 million (about $10 million; IOCL, 2011). In March 2012, a third bioenergy centre was established.
by DBT at the International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi. A Pan-IIT bioenergy centre, as a virtual centre was set up in 2015 to establish the fourth DBT bioenergy centre, which consists of 32 investigators affiliated to different Indian Institutes of Technology (IITs) at Bombay, Kharagpur, Guwahati, Jodhpur and Roorkee (PIB, 2015). More than 100 lead scientists in India were brought together through these four DBT bioenergy centres to support R&D efforts towards development of cost-effective next generation biofuels, demonstrating the substantial material and human investment by bureaucratic policymakers in the development of this specific trajectory of biofuels production.

Among the prominent objectives to establish these DBT bioenergy centres were ‘develop technology for second generation bio-fuel’ and ‘perform cutting edge research using Synthetic and Systems biology approaches towards the development of novel technology for bio-fuel production’ (PIB, 2014). Synthetic biology approach has thus come to occupy a key role in biofuels R&D in India. That the DBT energy bioscience is the only structured programme in India that specifically funds synthetic biology research is also a significant indicator of the preference for such a trajectory among the policymakers. The synthetic biology approach for research in second generation biofuels has been directed at (a) bioprospecting novel enzymes and engineering microbial platforms for its non-native production, (b) to engineer microbes for fermenting pentose sugars present in agricultural lignocellulosic biomass that cannot be fermented by traditional yeast, (c) engineer E. coli that can ferment glycerol, a low-value by-product of biofuel industries, into fuel compound like ethanol and (d) engineer E. coli strain for biological conversion of short chain fatty acids into various advanced drop-in biofuels including butanol. Synthetic biology approaches have also been applied towards third-generation biofuels including (a) altering microalgae for enhanced fatty acids and lipid production and (b) engineering cyanobacteria (blue-green algae) for biofuel production.

Scientists at the EBI and BRCs in the USA have carried out significant degrees of genetic modification in alternative feedstock such as switchgrass and sorghum in order to produce more sugars and less lignin. Further, microbes that can produce drop-in biofuels using these GM feedstock were also developed through extensive genetic modification. Synthetic biology approaches have played a key role in engineering metabolic pathways, for instance, in creating microbes that can make isopentenol (a petrol/gasoline replacement), bisabolene (alternative to diesel) and pinene (a precursor to jet fuel; Temple, 2018). Nonetheless, technical problems still persist. The original proponents are still in business but more sanguine: Chris Somerville of the EBI concluded, ‘Our summary opinion about the state of technology for lignocellulosic biofuels is that important problems remain unsolved but the field has made substantial and underappreciated progress in the last decade’ (Youngs & Somerville, 2017). Similarly, Keasling, who continues to head the JBEI, acknowledged: ‘we probably underestimated it and probably oversold it, too’ (Temple, 2018).

India too has not achieved any cost-effective demonstrable success in its effort to produce second- and third-generation biofuels using synthetic biology approach.
However, DBT-ICT centre at Mumbai has developed a novel 2G-ethanol technology for lignocellulosic biomass, which uses patented pre-treatment processes capable of turning any agricultural residue feedstock into ethanol, with claim of low capital and operational expenditure (Lali, 2016). A demonstration-scale plant built at a cost of ₹350 million (about $5.2 million) was inaugurated in 2016. According to the Ministry of Petroleum and Natural Gas, ‘Oil PSUs … are planning to set up twelve (12) 2G Ethanol Bio-refineries across 11 States …. The estimated investment for the 12 Bio-refineries is ₹100 billion’6 (PIB, 2016). Large-scale infrastructures are being instituted even as the earlier significant installations like Jatropha plantations are being dismantled. Further, the DBT-coordinated Indo-US Joint Clean Energy Research and Development Centre (JCERDC) and associated Biofuel Consortium has identified high biomass sorghum, pearl millet and bamboo as sustainable feedstock for advanced lignocellulosic biofuels (DBT, 2016). Synthetic biology-driven low lignin feedstock strategy may thus push for cultivation of GM sorghum in India. On the other hand, third-generation biofuels derived from micro and macro algae through a synthetic biology route would demand large-scale onshore and offshore cultivations. These developments can not only significantly shift agriculture, waste and energy discourse but also substantially alter agricultural practices in India. In this context, the recently approved National Policy on Biofuels 2018 notes that ‘(s)ustained and quantum non-availability of domestic feedstock for biofuel production … needs to be addressed’ (PIB, 2018). Making a major shift by categorising food surplus as raw material ‘(t)he Policy allows use of surplus food grains for production of ethanol’ (PIB, 2018). The ‘biofuel complex’ through synthetic biology-driven R&D and policy measures is therefore likely to reframe agriculture and energy discourse, affecting the public at large.

The potential impacts on ecological and agricultural spheres, including on millions of farmers and farm labourers, diversion of ‘surplus food grains’, introduction of GM food crops deemed technically necessary for the new generation biofuel technologies to work and effects related to on/off shore cultivation of algae are significant. However, there has been scarce attempts at public consultation or public engagement regarding the research trajectories on biofuel that should be pursued in India. The considerable gaps between stated targets of technologies and the inability to translate them during their deployment, in the previous generation of technologies, did not result in wider public engagement exercises. Given the emphasis on wider public engagement exercises in RRI frameworks, whether an explicit engagement with RRI frameworks may have persuaded policymakers to elicit guidance through public engagement exercises on how techno-bureaucratic spheres steer the development of S&T on biofuels in India is a moot point.

Responsibility, Representation and Participation in Research and Innovation

It is in the context of considerable gaps between directed development targets and the relatively negligible extent of deployment of earlier biofuel technologies (be it the blending of petrol with molasses-derived ethanol or the establishment of large
scale Jatropha plantations for biodiesel), as also recognition that they are unsustainable and non-feasible, that the current bureaucratic steering of biofuel production through synthetic biology approaches needs to be placed. Bureaucratic steering of research and development in the aforementioned technological trajectories in biofuels has been carried out through specific combinations of science and policy—where prescriptions in formal policy documents are combined with incentives to conduct scientific research in specific trajectories through grants, facilitation of private–public and industry–university collaborations, and setting of targets of consumption of downstream products—aimed at establishment of ‘biofuel complex’. What is the notion of responsibility that can guide the bureaucratic steering and establishment of the biofuel complex would then require considerable attention.

The values and goals that can be identified in this bureaucratic direction of R&D for the production of vehicular biofuels in India are threefold. First is a goal of achieving national self-reliance in vehicular fuel production, including through import substitution of crude oil and second is food security in terms of securing the food production system in a way that scarce land and other resources be not diverted from it for the production of fuels. A third broad goal approximates within a notion of sustainability that also seeks to find a workable balance between the earlier two goals.7 At the same time, public deliberation and reflection about the desirability of pursuing the development and deployment of biofuel technologies is nowhere mentioned in policy documents. In addition, a public evaluation comparing the different available technological trajectories for production of biofuels, an evaluation that elicits and engages with the wider public appears absent. Even as it cannot be argued that public engagement (or for that matter employment of any other RRI principle) could have definitely avoided the current situation, the lack of engagement and any explicit institutional reflection merits further attention. No institutional reflection, regarding the process through which prior decisions to develop and deploy attendant technologies were taken, is publicly available; even in spectacular failures like the institution of Jatropha plantations for production of biodiesel, where substantial material and human resources were brought together in a large scale.

The only process that explicitly claimed to have been an outcome of a public engagement was the report of the committee on development of biofuel (constituted by the Planning Commission) in 2003, who had originally proposed the large-scale Jatropha plantations. There was a brief mention in the report that ‘the concept and the project profile of the National Mission on Bio-diesel has been the outcome of an intensive consultation process with the various stake holders, namely the automobile manufacturers, the farming community, NGOs, concerned Central & State Government Departments and research bodies’ (PC, 2003). The enthusiasm exhibited in the report for the plantation is belied by vocal concerns expressed by the civil society, and sobering warnings from experts (Fairless, 2007). Questions about the gaps and failures related to the earlier generation technologies—were they due to the manners in which these technologies were deployed, or were they flawed in its conceptualisation, were there wrong/inaccurate/inadequate factors
attendant to the way technical consideration were evaluated, or were the important attendant social conditions not identified or understood—are conspicuously absent within institutional processes. Engaging with such questions is not only important to understand the reasons for failures of technologies that are developed but are also crucial steps in a process that precedes subsequent bureaucratic direction of technologies, and governmental bodies have a responsibility to ensure such processes. Nevertheless, scant institutional reflection is available about the grand and confident assumptions that led to the bureaucratic direction that preceded failures like the institution of Jatropha plantations, or regarding the fundamental material limitations in the attempts to produce bioethanol in large scale from molasses.

Much apart from the possible engagement with the RRI framework, a certain degree of (legalistic notions of) responsibility for certain kinds of governmental action to be preceded by public consultations and hearings exists in India. Prominent here is a legal expectation to conduct public consultations and/or hearings for impact assessments before regulatory decisions for specific projects are made, say environmental clearances for developmental projects (MoEF, 2006; Thayyil, 2014). There are also examples of public consultation (albeit far and few) before decisions on specific technological trajectories are taken, beyond the aforementioned eliciting of views of the affected communities or general public before the green signal for a specific downstream project is granted. Public consultations ordered by the then Union Environmental Minister Jairam Ramesh in 2010 before a decision on the environmental clearance for the use of Bt Brinjal is a prominent example. Further, Technology Information Forecasting and Assessment Council (TIFAC) claims to have undertaken a wider public engagement process before the preparation of Technology Vision 2035 document (TIFAC, 2015; but see further on this Sekhsaria and Thayyil [2019]).

The bureaucratic direction of research and innovation that preceded development of both first-generation biofuel research and the current synthetic biology-based approaches appears similar in its absence of wider public engagement, reflection and deliberation, and contrary to the spirit (if not the letter) of the aforementioned legalistic notion of responsibility of public consultations. The absence of public evaluations of the failures of prior bureaucratic direction in the development and deployment of earlier technologies raises questions about the process of decision-making in the current promotion and championing of synthetic biology approaches to produce biofuels. The current move in the National Policy on Biofuels 2018 policy to categorise food surplus as a raw material for biofuel, in a country that is at the bottom of world’s nutrition and hunger charts, brings back the concern visible in the fuel vs food security debate. If one were to recognise the hybridity of the construction of next generation biofuels, at the interface of science and policy, different constellation of norms that reside in RRI frameworks—be it anticipation, inclusion, reflexivity and responsiveness (Stilgoe, Owen, & Macnaghten, 2013) or anticipation, reflection, engagement and action (Owen, 2014) are readily identifiable. Whether such arguments for institutionalising an idea of responsibility that is prospective in nature, ‘recognizing profound uncertainties and encouraging
and supporting researchers to join intellectual forces to explore them’ (Stilgoe & Guston, 2017), would be found helpful by policymakers is yet to be seen.

Whether the absence of any serious public process before important decisions like bureaucratic direction of synthetic biology research approaches in the production of biofuels, or invocation of the aforementioned rare instances, can spur moves to institutionalise wider ‘upstream’ engagements to open up innovation process (Stirling, 2008) in India needs a more engaged political analysis. So does the question of realism of such engagement processes becoming part of a cynical legitimating exercise. If we take Winner’s prescient reminder of ‘no innovation without representation’ seriously (Winner, 1993), prospective ways to institutionalise processes of broad public engagement that guides bureaucratic direction of technological trajectory through a mixture of science and policy become crucial. And yet in what ways can the apparent inability of policymakers to reflexively pose questions about their prior decisions lead to institutionalisation of specific forms of public deliberations, including about the desirability and appropriateness of the current turn to synthetic biology in biofuel technologies, would need further attention.

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**NOTES**

1. In colonial India, during World War II, a law mandating 20 per cent power alcohol blending was introduced in the year 1940 by the United Province (today’s state of Uttar Pradesh). The term ‘power alcohol’ denoted ethyl alcohol (ethanol), derived from sugarcane molasses.
2. Biofuels derived from food sources such as corn starch and sugarcane juice or edible oils are classified as first generation biofuel, while second generation biofuel refers to biofuels manufactured from non-food feedstock such as agricultural waste or non-edible oilseeds.
3. Since molasses is not a waste product, requires similar processes that are used in sugarcane or starch based ethanol production, and is not a cellulosic biomass, broadly ethanol produced from molasses is categorised as a first generation biofuel.
4. About half of India’s domestic demand of edible oils is met through imports. Production of first generation biodiesel using traditional feedstock such as soybean or mustard (rapeseed) is thus not considered as a viable option.
5. Biofuels like ethanol are used as blends but not as complete substitutes because that necessarily requires modifications to existing petroleum infrastructure such as pipelines and engines. Thus ethanol use is restricted by blending limits. Whereas advanced drop-in biofuels are equivalent to prevalent petroleum fuels and hence can be used as substitutes without blending limits or infrastructure modifications.

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6. Approximately $1.48 billion.
7. In addition, the recent National Policy on Biofuels 2018, lists expected benefits in biofuels such as health benefits, MSW management, infrastructural investment in rural areas, and employment generation and additional income to farmers.

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