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# Do national-level policies to promote low-carbon technology deployment pay off for the investor countries?

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## HIGHLIGHTS

- Study long-term benefits of low-carbon deployment in climate mitigation context.
- Focus on reduced long-term abatement costs and early-mover advantage benefits .
- Benefits depend on interactions among country, sector and technology factors.
- Reduced long-term costs may not sufficiently incentivize expensive investments.
- Early-mover advantages may incentivize such investments if strong and persistent.

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## ABSTRACT

National-level policies to promote deployment of low-carbon technologies have been suggested and used as a means to reduce greenhouse gas emissions in the context of international climate change mitigation. The long-term benefits of such policies in the context of international climate change mitigation depend on their effects on near-term emissions abatement and resultant long-term technological change that will reduce abatement costs of achieving global mitigation goals. There is also an argument that these policies might foster early-mover advantages in international low-carbon technology markets. We first review the factors that could influence such benefits and use a global integrated assessment model to present an illustrative example to understand the potential magnitude of these benefits. We find that reductions in long-term abatement costs might not provide sufficient incentives to justify policies to promote the deployment of low-carbon technologies, in particular, the emerging, higher-risk, and currently expensive alternatives. We also find that early-mover advantages can potentially provide substantial benefits, but only if these advantages are both strong and persistent. Our results suggest a role for international cooperation in low-carbon technology deployment to address the existence of free-riding opportunities in the context of global climate change mitigation.



## 1. Introduction

In the recent years, a number of countries have proposed or implemented deployment policies such as renewable portfolio standards, feed-in-tariffs, subsidies and tax incentives to promote the deployment of low-carbon technologies at the national level (IEA, 2009; OECD, 2011). An important justification for these policies has often been their contribution to national strategies to reduce greenhouse gas (GHG) emissions. For example, China's intended nationally determined contribution (INDC) outlining greenhouse gas mitigation action for the near-term includes a commitment to increase the share of non-fossil energy sources in primary energy to 20% by 2030 (UNFCCC, 2015). Likewise, India has committed to ramp up the share of non-fossil-based power capacity from 30% currently to about 40% by 2030. These proposals are natural extensions of continuing investments in low-carbon technologies motivated by a diverse set of policy goals including energy security, air pollution reduction, domestic industry, and climate mitigation. For example, in the U.S.A., clean energy was the focus of more than $90 billion in government investment and tax incentives in the American Recovery and Reinvestment Act (ARRA) of 2009, which is an economic stimulus package in response to the global financial crisis of 2008–2009 (Council of Economic Advisers,

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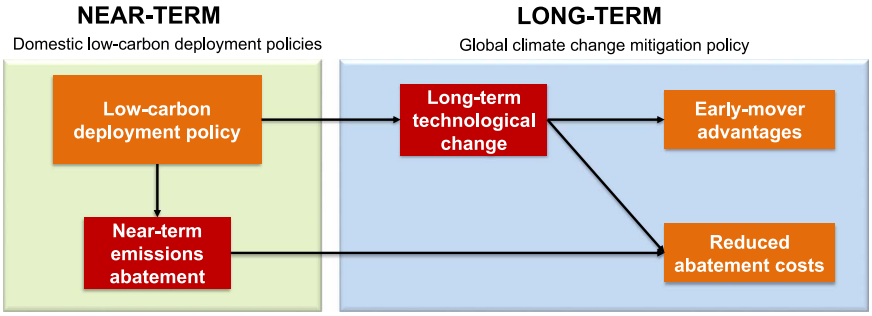


**Fig. 1.** Examples of long-term benefits of near-term low-carbon deployment policies in the context of climate change mitigation (Iyer et al., 2015b).

2014). Likewise, China's 12th Five-year Plan announced investments of US$ 468 billion in "greening" key economic sectors, with a focus on waste recycling, clean technologies and renewable energy (UNEP, 2015).

A key question for public policy is whether investments in national-level policies to promote the deployment of low-carbon technologies might pay off in the long-term for the investor countries. In this paper, we focus on the benefits of such investments in the context of global climate change mitigation. In particular, we assess two long-term domestic benefits (Fig. 1).[1] First, because these policies lead to emissions abatement in the near-term, they can ease the future burden of emissions abatement associated with meeting any fixed climate goal, such as a $CO_2$e concentration goal or a cumulative emissions budget of achieving a stringent long-term climate goal such as limiting temperature change to 2 °C this century (IPCC et al., 2014; Iyer et al., 2015d). Additionally, promoting the deployment of low-carbon technologies could induce technological change in the long-term in the targeted technologies. Thus, long-term emissions abatement can be achieved at lower costs (Goulder and Mathai, 2000; Schneider and Goulder, 1997). We refer to this as "*reduced long-term abatement costs*".

Second, investing in policies to promote the deployment of low-carbon technologies could give rise to comparative advantages and increased competitiveness for domestic industries in international markets, leading to an expansion of export industries and international leadership in low-carbon technology markets. International mitigation has an important role to play in this context, because it will increase the international market size for low-carbon technologies as emissions are reduced over time. We refer to this as "*early-mover advantages*" (Bowen and Fankhauser, 2011; Fankhauser et al., 2013; Karp and Stevenson, 2012; Lieberman and Montgomery, 1988).

We answer our question by first reviewing the literature on the reduced abatement cost and the early-mover advantage benefits of near-term policies to promote the deployment of low-carbon technologies (referred to as low-carbon deployment policies or simply, deployment policies in the rest of the paper). We then discuss the factors that could influence the magnitudes of these benefits. Following this, we use a global integrated assessment model (Global Change Assessment Model; GCAM) to present an illustrative example to understand the long-term benefits of near-term low-carbon deployment policies. Our example builds off Iyer et al. (2015b) that analyzed the long-term benefits of near-term low-carbon deployment policies in the context of climate change mitigation from a global perspective. Iyer et al. (2015b) demonstrated the divergence in domestic and global outcomes when countries promote the deployment of low-carbon technologies in the near-term based on domestic benefits alone. The current study differs from Iyer et al. (2015b) in that we focus on *domestic* long-term benefits.

[1] An emerging literature on "co-benefits" discusses a variety of other benefits of such investments such as energy security, improved air quality and improved health (von Stechow et al., 2015). A detailed examination of such benefits is beyond the scope of this paper.

## 2. Overview of the long-term benefits of near-term low-carbon deployment policies

### 2.1. Reduced long-term abatement costs

Promoting the deployment of low-carbon technologies could lead to reduced costs of emissions abatement in the long-term through two effects. First, these policies will lead to near-term emissions abatement by avoiding lock-in into carbon intensive fossil fuel technologies. The policies would displace fossil fuel technologies and add low-carbon energy to the energy system, leading to emissions abatement. Thus, if, in the long-term, there is global action against climate change to achieve a climate target such as a $CO_2$e concentration goal or a cumulative emissions budget to limit global warming to 2 °C (IPCC et al., 2014), abatement in the near-term would result in lower abatement in the long-term, resulting in reduced long-term abatement costs.

Second, promoting the deployment of low-carbon technologies could induce technological change in the targeted technologies in the long-term. Accumulating experience with a technology is known to lead to technological improvements, for example via experience-driven refinements in the production process, which can also be supported by a number of forces such as increases in labor efficiency, new processes and changes in production methods (Arrow, 1962). Such improvements could also be facilitated by users' experience feeding back as sources of learning and further R&D and tacit learning through exchange of information between various stakeholders (Kahouli-Brahmi, 2008). Thus, promoting the deployment of low-carbon technologies could generate cheaper technological options and future emissions abatement can be achieved at reduced costs (Goulder and Mathai, 2000; Grubb, 1997; Grübler and Messner, 1998; Schneider and Goulder, 1997).

### 2.2. Early-mover advantages

A commonly cited benefit of low-carbon deployment policies is that the improvements in technology due to these policies could lead to increases in productivity resulting in comparative advantages and increased international competitiveness of domestic firms. This could create "early-mover advantages" in what is being suggested as a global "green race" similar to the "space race" of the 1950's (Eisen, 2011; Fankhauser et al., 2013; Galiana