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The benefit of regional diversification of cogeneration investments in Europe: A mean-variance portfolio analysis

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ABSTRACT

The EU Directive 2004/8/EC, concerning the promotion of cogeneration, established principles on how EU member states can support combined heat and power generation (CHP). Up to now, the implementation of these principles into national law has not been uniform, and has led to the adoption of different promotion schemes for CHP across the EU member states. In this paper, we first give an overview of the promotion schemes for CHP in various European countries. In a next step, we take two standard CHP technologies, combined-cycle gas turbines (CCGT-CHP) and engine-CHP, and apply exemplarily four selected support mechanisms used in the four largest European energy markets: feed-in tariffs in Germany; energy efficiency certificates in Italy; benefits through tax reduction in the UK; and purchase obligations for power from CHP generation in France. For contracting companies, it could be of interest to diversify their investment in new CHP facilities regionally over several countries in order to reduce country and regulatory risk. By applying the Mean-Variance Portfolio (MVP) theory, we derive characteristic return-risk profiles of the selected CHP technologies in different countries. The results show that the returns on CHP investments differ significantly depending on the country, the support scheme, and the selected technology studied. While a regional diversification of investments in CCGT-CHP does not contribute to reducing portfolio risks, a diversification of investments in engine-CHP can decrease the risk exposure.

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1. Introduction

Combined heat and power (CHP) technologies bear a substantial potential for increasing energy efficiency and reducing environmental impacts compared to separate heat and power production. To encourage its member states to promote the CHP generation, and to provide an attractive framework for highly efficient cogeneration, the European Commission launched the EU CHP Directive 2004/8/EC in February 2004. The implementation of the directive has progressed more slowly than originally expected, but after more than five years, a number of EU member states have introduced support mechanisms to promote CHP technologies. The national promotion schemes are based on different principles, and vary considerably between the member states. In this paper, we first provide an overview of the different CHP promotion schemes used within the European Union. In a next step, we investigate the economic attractiveness of CHP investments in selected countries. In the applied model, we pay particular attention to the typical operational characteristics of CHP generation and to the promotion schemes implemented in different countries. Our intention is to compare CHP investments and to create robust CHP portfolios that are diversified from a regional as well as from a technological perspective. Under "robustness," we understand in this context the ability to generate stable revenues for an investor, irrespective of changes in external effects, such as the impact of fuel and electricity price variation, changes in regulation, or technical change.

The benefits of regional diversification could be of particular interest for international contracting companies that invest in CHP applications in different countries. "Contracting" means the delegation of energy supply-related tasks to a specialized company. Especially in the case of CHP generation for smaller utilities or industrial companies, contracting models have gained attractiveness over the last few years (Helle, 1997). The deeper know-how of contractors in energy-related topics leads in many cases to win–win situations for both parties involved. The technical basic design of the CHP assets is hereby quite similar, but the energy economics conditions, such as the level of commodity prices and the type of promotion scheme, are significantly different in various countries. The findings of this

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paper give an indication of internationally acting contracting companies regarding countries that provide economically attractive conditions for CHP investments, and to what extent commodity price risks as well as country and regulatory risks can be reduced by a regional diversification of the asset base.

2. Status of CHP implementation in Europe

Combined heat and power generation has been an energy policy focus of the EU for more than twenty years now. Despite of this, the share of electricity from CHP only in Europe has increased very slowly (EEA, 2008). In the 1990s, there was a steady development of new CHP capacity; for instance, between 1994 and 1998, the share of CHP power generation rose significantly from 9% to 11%. However, since then, the contribution of CHP across Europe has stalled, and the indicative 18% target set by the community in 1997 for the year 2010 for the EU-15 (European Commission, 1997) will not be achieved, mostly due to the liberalization of the electricity and gas markets, and less favorable CHP economics caused by rising fossil fuel prices and falling electricity prices. As illustrated in Fig. 1, on an average, around 11% of electricity supply across Europe is generated by CHP plants. The share of CHP power generation varies considerably across the EU member states, ranging from 42.8% in Denmark to 0% in Malta. The big differences concerning CHP implementation are a response to differences in climate, availability of domestic fuels, industry demands, and variations in building and energy policies. The recently published IEA report "Cogeneration and District Energy" (IEA, 2009) states that there are signs that conditions for CHP across Europe have improved again over the last few years. According to the report, policy makers in various countries have realized the benefits of CHP, and promote its further uptake to achieve policy goals, such as cost savings and carbon reduction targets.

3. Support mechanisms for the CHP generation

In most liberalized energy markets, political support is essential to increase the share of CHP generation. Within the EU, each member state has a unique approach concerning the CHP promotion. In this section, we first introduce the most important support mechanisms for CHP within the EU-27 states, after which we provide an overview of which mechanisms are applied in each of the different countries. Finally, we take a more detailed look at the specific promotion schemes applied in the four EU member states with the largest power demand: Germany, France, Italy, and the UK.

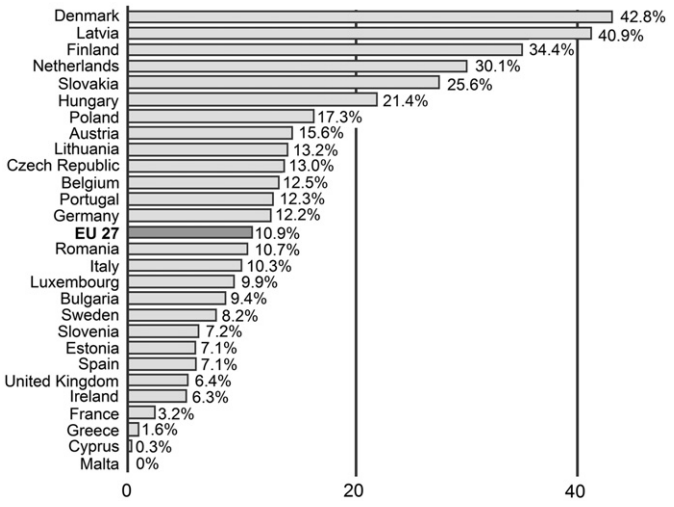

Fig. 1. CHP share in power generation in the EU-27 (2007 data).
Source: Eurostat (2009).

3.1. Survey of support mechanisms for CHP

3.1.1. Feed-in tariffs

Feed-in tariffs (FITs) are an energy output-based mechanism designed to provide direct support for CHP applications. CHP plant operators receive a bonus for each kWh of electricity generated or fed into the grid. In general, the bonus can be fixed, be defined as a share of the electricity price, or be indexed against fuel prices. FITs are mostly combined with a purchase obligation that forces the power grid operator to buy CHP-generated electricity on the basis of the current market price. The costs of FITs are usually passed onto the final energy consumers (for the mechanism in Germany, see Gesetz zur Förderung der Kraft-Wärme-Kopplung, 2008), and depend on the duration of the promotion for CHP technologies and the level of the tariffs. FITs improve the competitive position of CHP in the market, and encourage investment. The investment incentives also contribute to accelerate the commercialization of emerging CHP technologies. In this way, FITs promote energy efficiency, and can help to achieve cost-effective CO_2 emission savings. From an investor's point of view, FITs increase the economic performance and guarantee a secure and predictable cash flow over a determined time period. This contributes to reducing risks and improving returns. More detailed and recent discussions about FITs can be found in Klein et al. (2008), Lesser and Su (2008), or Uran and Krajcar (2009), among others.

3.1.2. Certificate schemes

Certificate schemes for CHP or energy savings are market-based mechanisms that provide additional revenues to the operators of CHP facilities. In its basic form, a state authority places an obligation on electricity suppliers to deliver a certain amount of primary energy savings. In many of the existing certificate schemes, CHP is an acknowledged standard measure to save primary energy. The government can adjust the primary energy-saving obligations for electricity supplies on a yearly basis. Realized energy savings are certified by an independent certifying body. The certificates issued confirm the achieved energy savings, and can be traded on a certificate market. This means that each certificate is a unique and traceable commodity that carries a property right over a defined amount of savings. Electricity suppliers that need to meet the saving obligation can either invest in new primary energy-saving measures, or they can purchase the required number of certificates from third parties that have introduced energy efficiency measures. Supply of, and demand for, certificates determine their price. The advantage of certificate schemes is that the actors are given an incentive to find the most efficient and least cost way of achieving the energy-saving obligations. The EU has considered certificate schemes as a possible market approach to increase energy efficiency (European Commission, 2006a). More detailed and recent discussions on energy efficiency certificate mechanisms can be found, for instance, in Bertoldi and Huld (2006), Bertoldi and Rezessy (2006), or Lees (2007).

3.1.3. Investment support

Some EU member states promote CHP generation by granting investment support in the form of allowances for new CHP installations, or the refurbishment of existing CHP plants. The political goal behind this is to reduce the barrier of high up-front investments, and to encourage capital-constrained organizations

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