Appendix A. The *ElectTrans* model

C.1. Overview

ElectTrans is an agent-based model, and it is developed on *Eclipse*, an open-source integrated development environment (IDE), using *Repast J* agent modelling toolkit. An instance of the model is composed of two main components; the *model code*, *parameter file* and the *scenario file*. As in the case of *NavalTrans* discussed in Appendix B, the *model code* depicts the actions of the actors, relations between system elements, and general developments in the system. In other words, it depicts the structure of the model. The *parameter file* is a conventional MS Excel file, which contains the initial values of the model parameters that are needed to create an instance of the model. The *scenario file*, as the name implies, includes parameter values, and exogenous time-series data that characterize the scenario context of a simulation.

It its base version *ElectTrans* covers 16 alternative electricity power sources (2 grid-based, and 14 distributed) for the end-users, and 26 alternative electricity generation options that can be used by electricity generation companies to feed the central grid. These technologies can be seen in the parameter files of the base version, which is given in one of the following sections. On the demand-side four types of actors are defined in ElectTrans; industrial users, agricultural users, commercial users, and residential users. The supply-side is represented by agents corresponding to the electricity generation companies.

Although these are the figures related to the base version of the model, which is discussed in Chapter 10, neither number of actor types, nor the number of technologies is hard-coded in *ElectTrans*. *ElectTrans* is designed to offer a highly flexible model structure. In that respect, by simply making related changes in the parameter file, the technology coverage of the model can be extended (e.g. to cover 50 technologies). Or, the actor types to be included in the model, as well as the number of agents from each type can be defined on the parameter file. In short, shifting *ElectTrans* from a very aggregate model (e.g. one supply-side generator, one aggregate end-user) to a very disaggregated model (e.g. 10s of generation companies, 1000s of end-users) can be done just by adding some extra data to parameter file, without any need for changing the model code. This flexibility allows the analyst to shift between different versions of the model quite easily and fast.

In the following section, we will first introduce the *objects* of *ElectTrans.* Following that, the behaviour of the overall model, as well as the *objects* will be discussed mainly using pseudocodes[1] and time-sequence diagrams[2]. When necessary, implemented functional relationships will be introduced in detail.

C.2. Object classes

a. *Controller* class

The *controller class* is the main controller of *ElectTrans*. First of all, the *controller* is responsible for creating an instance of the model. This involves initialization of the agents based on the *parameter file* being used, setting up the simulation context based on the *scenario file*, and setting the simulation run length. Secondly, the *controller* also controls the simulation schedule during a simulation run. The simulation schedule is related to the order in which different agents will be activated to perform their tasks in every simulation step. Finally, the *controller* class is also responsible for collecting data from agents during a simulation run, and displaying this data in the form of display surfaces and time-series plots.

b. *ParamReader* class

This class establishes the link between the *model* and the *parameter file*. While initializing a particular instance of *ElectTrans*, an instance of *ParamReader* class reads the values of the model parameters from the parameter file, and reports these to the *model* object.

This class uses Apache POI HSSF libraries for reading data from MS Excel files.

c. *ScrReader* class

ScrReader is very similar to *ParamReader* in function. *ScrReader* is developed to read data from the *scenario files*. While *ParamReader* reads data just once before a simulation run, *ScrReader* continues reading data even during a simulation run for time-dependent scenario variables, such as fuel prices.

This class also uses Apache POI HSSF libraries for reading data from MS Excel files.

a. *Practitioner* class

The *Practitioner* class depicts the demand-side agents (i.e. end-users of electricity power) of *ElectTrans*. A practitioner is represented by its power demand, preference structure, and the distributed generation capacity it owns. The power demand of a practitioner agent is specified in multiple periods in a year. In other words, rather than a single aggregate level, the demand is represented in the form of a temporal load profile of the agent, which also shows the fluctuations in the demand of the agent during a year.

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[1] *Pseudocode* is a compact and informal high-level description of a computer programming algorithm that uses the structural conventions of a programming language, but is intended for human reading rather than machine reading.
[2] *Time-sequence diagrams* demonstrate the flow of actions that take place during a particular time-step (or an iteration) of the model run.

The basic set of variables of the *Practitioner* class is as follows;

Variable name	Short description
demand[per]	Power demand of the agent in time period p
demandGrowthPerctAvg	Average growth percentage of the agent's power demand
genCapaList	List of distributed generation facilities that is owned by the actor
learningDelay	Average delay for the actor to learn about external developments
objectiveWeight[obj]	Weight of the objective *obj* in the preference structure of the agent
optInfoList	List of power supply options that the actor considers as feasible for its needs
supplyToGrid	Binary variable that indicated whether the agent is allowed to feed electricity back to the grid, or not
type	Type of the agents (industrial, commercial, agricultural, or residential)

The basic set of methods[3] of the *Practitioner* class is as follows;

Method name	Short description
allocateDemand	Allocates the electricity demand of the agent for a particular period to available supply options (e.g. grid, self-generation, etc.) and updates supply figures
calculateCostOfElect	Returns the unit electricity supply cost (Euro/kWh) of an option, based on the information known to the agent
calculateOptUtils	Calculates the expected utility for each electricity supply option feasible/viable to the agent considering multiple objectives of the agent
getFreeDemand	Returns the portion of the electricity demand of the agent that will be 'liquid' (i.e. demand not tied to any generation capacity or supply-contract) in the beginning of the next period.
planCapaForFreeDemand	Plans new supply contracts (for grid) or new generation capacity for the liquid part of the demand (i.e. freeDemand)
updateDemand	Updates the energy demand of the agent for each demand period, and also updates the total yearly demand
updateGenCapa	Updates the capacity of each generation option under the possession of the agent
updateMarketInfo	Updates what is known to the agent regarding the market situation (e.g. self-generation popularity, etc.)
updateOptInfo	Updates the information known to the agent regarding the feasible/considered energy supply options

There are 400 instances of this class in *ElectTrans* corresponding to end-user agents of four different types; i.e. industrial, agricultural, commercial, and residential.

[3] The basic set includes the mechanism related to the behavior of the agents in the socio-technical context. The methods related to the functioning of the program, such as the ones related inter-object communication, data sorting, etc. are not discussed within the set of basic method for the sake of clarity

b. *Provider* class

The *Provider* class represents the supply-side agents, which are the electricity generation companies in the context of *ElectTrans*. Briefly, a provider is characterized by its preference structure, and the park of generation facilities it operates. These agents are mainly responsible operating their generators, and make capacity-related decisions like investing in new generation facilities and decommissioning the old ones.

The basic set of variables of the *Provider* class is as follows;

Variable name	Short description
genList	List of generation facilities owned by the agent
optInfoList	List of power generation options that the actor considers as feasible for investment
planHorizon	Planning horizon of the agent
returnOnInvTHold	Threshold for expected return in investments

The basic set of methods of the *Provider* class is as follows;

Method name	Short description
assessGenPortfolio	Evaluates the profitability of the generators in the portfolio of the provider.
calculateROIExpected	Returns the expected return on investment (ROI) for an investment option being considered based on market expectations for *planHorizon* years ahead, and what is known about the option
makeInvestmentDecision	Returns the investment option that is estimated to provide maximum profit upon completion
updateMarketInfo	Updates what is known to the agent regarding the market situation (e.g. self-generation popularity, etc.)
updateOptInfo	Updates the information known to the agent regarding the feasible/considered energy supply options

There are seven instances of *Provider* class in ElectTrans, which correspond to major utilities in the Dutch context.

c. *Market* class

The *Market* object represents the environment where demand and supply-side information meet and aggregated. Most importantly, the end-users agents' loads that are directed to the grid are aggregated in the *Market*, and the load-duration curve is constructed. Besides, aggregate statistics like total green supply, or consumption are attributes of the *Market* object.

The list of individual variables and methods of the Market object is not very relevant for explaining ElectTrans. Rather, we find the list of issues traced in the Market class regarding the electricity market more informative. The set of issues traced in the *Market* class include the following;

- Active generation capacity by control type (central vs. distributed)
- Active generation capacity by fuel type
- Carbon emissions by source (Central grid, distributed generators)
- Total demand by type (Green vs. gray)
- Generation by source (Central grid, distributed generators)
- Generation by fuel type

Some of the key methods of the *Market* class that are not just related to statistics collections are as follows;

Method name	Short description
calculateCapaBasedExtras	Returns the extra income/expense per kW capacity installed mainly due to subsidy/tax programs.
calculateGenBasedExtras	Returns the generation-based subsidy/support as well as expenses for a given generator in Euro/kWh
collectDemandData	Collects data from *practitioners* and updates demand-side related data, including the load-duration curve
dispatchLoad	Allocates the load to active generators based on merit order by marginal cost (incl. extra subsidy/surcharges), and determines revenue per generator, as well as average market price
setGreenCertPrice	Adjusts certificate process Based on information on the demand for green electricity, and green electricity generations

Every instance of *ElectTrans* has a single instance of the *Market* class

d. *OptPract* class

The class represents the options for the practitioner agents. Mainly these options are grouped under two categories; grid-based and distributed ones. The instances of the *OptPract* class correspond to the state-of-the-art in a particular electricity supply option. For example, small-scale wind turbine is a distributed generation option, and is represented as an instance of this class. The instances of *OptPract* are characterized mainly by their technological (e.g. fuel efficiency, seasonal availability, emission levels) and economical (e.g. investment and operating costs) properties.

The basic set of variables of the *OptPract* class is as follows;

Variable name	Short description
fuelType	The energy source used by the option
efficiency	Average electrical efficiency of the option
efficiencyMax	Maximum electrical efficiency that is likely to be realized by future developments
investmentCost	Investment cost per MW capacity
investmentCostMin	Minimum investment cost per MW capacity that is likely to be realized by future developments
variableCost	Variable cost of generation per MWh
variableCostMin	Minimum Variable cost of generation per MWh that is likely to be realized by future developments
emissionLevel	Carbon emissions per MWh electricity generated
lifeTime	Average lifetime of the option once installed
leadTime	Average lead time for installing the option
ifGreen	Binary variable about whether the option is considered as a green source, or not.
ifCHP	Binary variable about whether the option is a combined heat-power generator, or not.
coFireFrac	The fraction up to which biomass co-firing can be done using the option
techDevFrac	Pace indicator for expected technological developments for the option

The basic set of methods of the *OptPract* class is as follows;

Method name	Short description
updateAttributes	Updates the technological and economical attributes of the option

There are 16 instances of *OptPract* class in ElectTrans, which can be seen in the sample parameter files given below.

e. *OptProv* class

The class represents the electricity generation options for the electricity generation companies who feed the central grid. In other words, the instances of *OptProv* are the investment options for the *provider* agents. The instances of the class correspond to the state-of-the-art in a particular type of electricity generation facility. The instances of *OptProv* are characterized mainly by their technological (e.g. fuel efficiency, minimum load factor, emission levels) and economical (e.g. investment and operating costs) properties.

The basic set of variables of the *OptProv* class is as follows;

Variable name	Short description
fuelType	The energy source used by the option
efficiency	Average electrical efficiency of the option
efficiencyMax	Maximum electrical efficiency that is likely to be realized by future developments
investmentCost	Investment cost per MW capacity
investmentCostMin	Minimum investment cost per MW capacity that is likely to be realized by future developments
variableCost	Variable cost of generation per MWh
variableCostMin	Minimum Variable cost of generation per MWh that is likely to be realized by future developments
emissionLevel	Carbon emissions per MWh electricity generated
lifeTimeLB	Minimum expected lifetime of the option once installed
lifeTimeUB	Maximum expected lifetime of the option once installed
permsDelay	Average time between a provider's investment decision and the start of construction
constDelay	Average construction time of the option
availability	Percentage of the yearly cycle a generator is available for generation
ifGreen	Binary variable about whether the option is considered as a green source, or not.
ifCHP	Binary variable about whether the option is a combined heat-power generator, or not.
coFireFrac	The fraction up to which biomass co-firing can be done using the option
techDevFrac	Pace indicator for expected technological developments for the option

The basic set of methods of the *OptProv* class is as follows;

Method name	Short description
updateAttributes	Updates the technological and economical attributes of the option

There are 26 instances of *OptProv* class in ElectTrans, which can be seen in the sample parameter files given below.

f. *Generator* class

The *Generator* class represents physical electricity generation facilities connected to the central grid. Each instance of this class corresponds to an actual power generator in the Dutch system. In that respect, 76 instances of this class are initialized in the base version of ElectTrans, which represent 76 generators with a capacity more than 15 MW.

Although *Generator* is closely related to the *OptProv* class, the difference should be clear with the following example. A 400-MW combined cycle unit is an investment option for the providers (i.e. an instance of *OptProv*). The conversion efficiency of this option is improving every year. Once a provider decides to invest in one of these, then a physical generation plant is constructed (i.e. an instance of *Generator*). The efficiency of the plant is static and determined by the state of the technology (*OptProv*) at the time of investment. In short, *OptProv* represents technology, whereas *Generator* represents physical installations of this technology at some point in time.

The basic set of variables of the *Generator* class is as follows;

Variable name	Short description
fuelType	The energy source used by the option
efficiency	Average electrical efficiency of the option
variableCost	Variable cost of generation per MWh
emissionLevel	Carbon emissions per MWh electricity generated
lifeTime	Expected lifetime of the option once installed
availability	Percentage of the yearly cycle a generator is available for generation
ifGreen	Binary variable about whether the option is considered as a green source, or not.
ifCHP	Binary variable about whether the option is a combined heat-power generator, or not.
coFireFrac	The fraction up to which biomass co-firing can be done using the option
comStep	Time step when the generator was/will be commissioned
decomStep	Time step when the generator was/will be decommissioned
status	Status of the generator (i.e. retired, active, mothballed, announced, under construction,)
profitHist[year]	Profit of the generator in the year *year*
generationHist[year][per]	Electricity generated in the period *per* of the year *year*

The instances of the *Generator* class are passive objects mainly controlled by the provider agents. Therefore, they do not have methods relevant to understanding the working of *ElectTrans*. All the methods of this class are more related to book-keeping (e.g. updating generation history), or inter-object communication (e.g. report active generation capacity).

g. GenCapaPract class

The class represents the distributed generation capacity of a certain kind owned by a practitioner agent. The correspondence between the *Generator* and *OptProv* classes is identical to the correspondence between the *GenCapaPract* and *OptPract* classes. The major difference of *GenCapaPract* from Generator is that it does not represent a discrete generation unit, but an aggregated generation capacity of the same kind. Every time a *practitioner* installs new wind turbines, the aggregate wind turbine capacity controlled by the practitioner (an instance of the *GenCapaPract* class) is increased, rather than creating new instances of the *GenCapaPract* class.

The basic set of variables of the *GenCapPract* class is as follows;

Variable name	Short description
fuelType	The energy source used by the option
efficiency	Average electrical efficiency of the option
variableCost	Variable cost of generation per MWh
emissionLevel	Carbon emissions per MWh electricity generated
lifeTime	Expected lifetime of the option once installed
availability	Percentage of the yearly cycle a generator is available for generation
ifGreen	Binary variable about whether the option is considered as a green source, or not.
ifCHP	Binary variable about whether the option is a combined heat-power generator, or not.
coFireFrac	The fraction up to which biomass co-firing can be done using the option
capacity	Operational generation capacity
capaPlanned	Planned generation capacity (i.e. under construction)

The instances of the *GenCapaPract* class are passive objects mainly controlled by the *practitioner* agents. Therefore, they do not have methods relevant to understanding the working of *ElectTrans*. All the methods of this class are more related to book-keeping (e.g. updating capacity), or inter-object communication (e.g. report depreciated capacity).

h. *OptionInfoPract* class

This class is the first of three, so called, information classes in *ElectTrans*. This class represents the information a practitioner agent has about an instance of *OptPract*. For example, wind turbine is a *practitioner option*. A practitioner agent's information about the technical and economical properties of this option is registered in an instance of the *OptionInfoPract* class, which corresponds to wind turbine option. In a sense, the instances of this class can be considered as individual files an agent keeps about existing technological options.

Important variables of this class are almost identical to the ones of *OptPract* class.

Since every agent keeps track of available technological options, there are 16 instances of this class for each agent. Considering that the base version of the model includes 400 agents, there are maximum 6400 instances[4] of this class in *ElectTrans*.

[4] This is the maximum number. Since not all options are appropriate for all practitioner agents, some of the agents may keep record of less than 16 options.

i. *OptionInfoProv* class

This information class is related to what provider agents know about central generation options. Similar to the case of *OptInfoPract*, the instances of this class can be considered as files a provider agent keeps about possible capacity investment options.

j. *GeneratorInfo* class

This information class is related to what *provider* agents know about existing and planned generation facilities in the system. The instances of this class can be considered as files a provider agent keeps about generation plants. These information files are used in the feasibility analyses conducted by the *providers*.

The presence of very closely related classes (e.g. *OptProv*, *Generator*, *OptInfoProv*, and *GenInfo*; or *OptPract*, *GenCapaPract*, and *OptInfoPract*) may make the structure of *ElectTrans* difficult to comprehend. A very simple demonstrative example may help to clarify the relationship of these related classes. Figure C.1 demonstrates an example for the provider-related classes. Agent A owns a generator, Facility F, which is an instance of *Generator*. Agent B has some information about Facility F, which need not be precise about the issues like effective capacity, operating costs, or decommissioning date. This information is kept in an information file owned by the Agent B, and this information file is an instance of *GeneratorInfo*. Both agents are aware of the existing options, but what they know about the technical properties of the options need not be neither identical, nor perfect. In other words, both agents keep their own files about the existing options using their private instances of *OptInfoProv*. A very similar situation is valid for the practitioner-side classes; i.e. *OptPract*, *GenCapaPract*, and *OptInfoPract.*

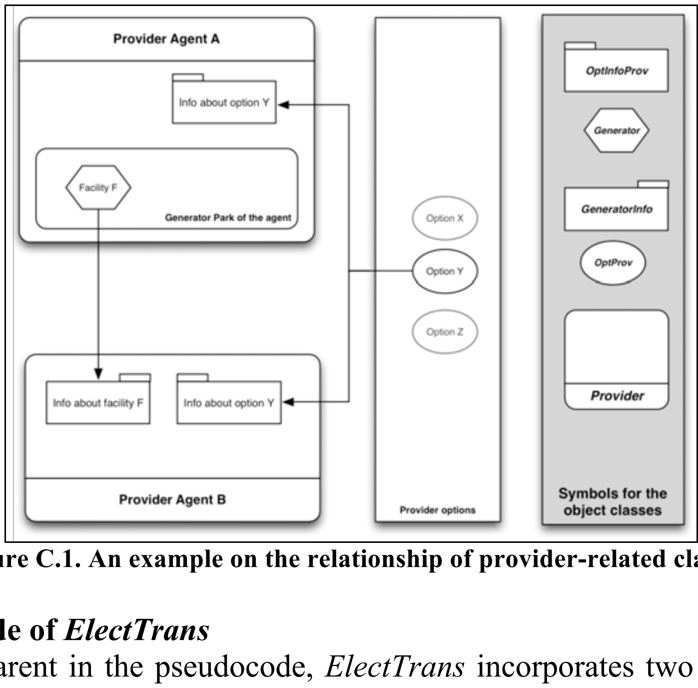

Figure C.1. An example on the relationship of provider-related classes

C.3. Pseudocode of *ElectTrans*

As will be apparent in the pseudocode, *ElectTrans* incorporates two different action cycles. The fast cycle takes place for every time step, which is a quarter-year in the base version of the model, and this cycle is more related to the operational developments related to the agents. The slow cycle is more about slower decisions such as capacity investments, and alike. The slow cycle is activated at the end of each year in *ElectTrans*.

```
Initialize the model instance {
    Link to the parameter file
    Link to the scenario file
    Create the market environment
    Create the options for the provider agents
    Create the provider agents
    Initialize the existing generation facilities, i.e. the generators
    Create the options for the practitioner agents
    Create the practitioner agents
}
Repeat until the time step is equal to the simulation final time {
    Repeat until all practitioners are considered {
        Randomly pick one practitioner agent
        Ask the agent for its demand allocation (allocateDemand)
    }
    Aggregate the demand in the market (collectDemandData)
    Dispatch load in the market to the active generators on the grid (dispathLoad)
    Update market statistics related to generation, emissions, and prices
    Repeat until all generators are considered {
        Pick a generator
        Update its registry regarding generation, revenue, and costs
    }
    If the time-step corresponds to the last period of a year {
        Update green certificate prices in the market (setGreenCertPrice)
        Update fuel prices in the market (updateFuelPrices)
        Update yearly statistics in the market
        Repeat until all providers are considered {
            Randomly pick one provider agent
            Update agent’s information about the options (updateOptInfo)
            Update agent’s information on the market conditions
            (updateMarketInfo)
            Ask the agent to assess the generators in its generator park
            (assessGenPortfolio)
            Ask the agent for its investment decision
            (makeInvestmentDecision)
            If the agent decides for capacity investment {
                Create a new generator
            }
        }
        Repeat until all practitioners are considered {
            Randomly pick one practitioner agent
            Update agent’s information about the options (updateOptInfo)
            Ask the agent to plan for its free-demand
            (planCapaForFreeDemand)
            Update the distributed generation capacity controlled by the agent
            (updateGenCapa)
            Update agent’s demand for electrical power (updateDemand)
        }
        Repeat until all provider options are considered {
            Pick an option
            Update the properties of the option (updateAttributes)
        }
        Repeat until all practitioner options are considered {
            Pick an option
            Update the properties of the option (updateAttributes)
        }
        Repeat until all generators are considered {
```

Pick a *generator*
Update the status of the *generator* (*updateStatus*)
}
}
}
End simulation

C.4. Description of the agent actions

a. Practitioner actions

i. allocateDemand

The amount of electricity supplied from each available source is calculated in this method. Available sources for an agent are grid electricity and distributed generation capacity owned by the agent, if it owns some. The fundamental assumption in the source selection for an agent is that an agent uses distributed generation sources as much as possible before using the grid as a source. For example, assume the energy demand of the agent is 300 kWh in a certain period, and the agent owns wind turbines that can deliver 100 kWh during this demand period. Then the agent uses 100 kWh from turbines, and the rest of the demand is supplied from the central grid.

The method works as follows;

Repeat for each type of generation capacity that is owned by the agent{
Calculate the maximum energy that can be supplied during the current period (considering the seasonality of some distributed generation options, such as wind-based, or solar-based ones)
}
Aggregate the total supply from the actor's distributed generators
Register the remaining demand of the agent to be supplied via central grid

ii. updateOptInfo

The agent updates the information it keeps in the option files (*OptInfoPract*) regarding the options (*OptPract*). The practitioner updates information related to the following properties of distributed generation options; efficiency, investment cost, fixed operating cost, variable operating cost, emission levels, and diffusion level among peers[5]. A first-order information delay formulation is used to represent the way agents' perceptions are updated;

$$Info_{perceived}(step) = Info_{perceived}(step-1) + InfoCorrection(step) \qquad [C.01]$$

$$InfoCorrection(step) = \frac{Info_{actual}(step-1) - Info_{perceived}(step-1)}{learningDelay} \qquad [C.02]$$

iii. planCapaForFreeDemand

The concept of *'free-demand'* is of primary importance in order to understand the functioning of the method. A practitioner agent represent a group of end-users, and this agent owns supply contracts (for grid-based supply) and generation capacity (for supply from distributed generation). At the end of each year, some contracts expire and generation capacity retires. The first component of the free-demand is the demand that was previously supplied from these lost sources. Additionally, the demand of the

[5] 'Peers' of a practitioner agent are the other agents of the same practitioner-type.

agent might have increased. In this case, there is some new demand, and this additional demand is the second component of the free-demand for the agent. This method is related to the agent making a capacity plan related to the sources to be used to satisfy this free-demand in the following time steps. This means making new supply contracts, and/or making new distributed generation capacity installments.

The method works as follows;

```
Calculate the free-demand of the agent
Calculate expected utility for available options as power sources (calculateOptUtils)
For each practitioner option do the following{
        Calculate the share in supplying the free-demand
        Calculate the additional capacity required to satisfy this new demand
        Register the required capacity as planned supply
}
```

The expected utilities for the options are calculated as follows (*calculateOptUtils*);

First the properties (i.e. attributes) of the option are normalized. In normalization, the properties of the gray grid electricity are used as the reference levels. The normalization is conducted as follows;

$$\tilde{a}_{opt,prop} = \frac{a_{opt,prop} - \hat{a}_{prop}}{\hat{a}_{prop}} \qquad [C.03]$$

where $\hat{a}_{prop}$ is the reference level for the property *prop, and* $a_{opt,prop}$ is the level of option opt's property prop according to what is known to the agent. In other words, $a_{opt,prop}$ values come from *OptInfoPract* objects.

Using the normalized properties, the agent calculates a utility for the option;

$$util_{opt} = \prod e^{\alpha_{prop}\tilde{a}_{opt,prop}} \qquad [C.04]$$

where α_{prop} is the priority of the property *prop*[6] for the agent.

The share of an option is supplying the free-demand is calculated as follows;

$$share_{opt} = \frac{util_{opt}}{\sum_{i \in Options} util_i} \qquad [C.05]$$

Capacity required for an option to supply the new energy demand is calculated as follows;

$$capacityExtra_{opt} = \frac{freeDemand \times share_{opt}}{availability_{opt} \times 8760} \qquad [C.06]$$

where availability stands for the yearly average availability of the option. In other words, which fraction of the 8760 hours in a year the option can be used to generate electricity.

[6] To be more precise, it is the priority of the issue that is directly related to that property of the option. For example the issue can be cost minimization, and the property can be cost of generation.

iv. *updateGenCapa*

The method updates the state of distributed generation sources the agent controls. This includes updating the effective capacities of the already possessed ones, and also introducing new distributed generation source if the agent decided to adopt some in the recent decision round.

One important aspect of the method is about property updating. Since the generation capacity represents an aggregated capacity rather than distinct generation facilities, it properties of the generation capacity is actually the average of the properties aggregated into this variable. For example, if the agent adopted a 10 kW wind turbine capacity with operating cost of X, and then another 10 kW with an operating cost of Y, the agent possesses a generation capacity of 20 kW with an operating cost of (X+Y)/2. Therefore, at every time step the properties of this aggregate generation capacity should be updated based on the amount of new capacity installed and the amount of existing old capacity.

For each of the feasible distributed generation options, the agent performs the following;

Calculate the capacity depreciated/retired

$$capaDepr = \frac{capaTotal}{lifeTime} \qquad [C.07]$$

Calculate the capacity from the old time-step that remains operational

$$capaTotalOld = capaTotal - capaDepr \qquad [C.08]$$

Calculate the new capacity that will be installed and become effective in the current time step. This depends on the capacity already planned by the agent in the past, and the installation lead time of the corresponding generation option;

$$capaNew = \frac{capaPlanned}{leadTime} \qquad [C.09]$$

Update the properties of the generation capacity using a weighted average;

$$prop = \frac{propOld \times capaTotalOld + propNew \times capaNew}{capaTotalOld + capaNew} \qquad [C.10]$$

where *capaNew* is the capacity recently installed.

Update the total generation capacity;

$$capaTotal = capaTotalOld + capaNew \qquad [C.11]$$

v. *updateDemand*

Reading the scenario file, the method gets the average demand growth percentages for the agent. Using this percentage, the method updates the power demand of the agent for each period of the following simulation year;

The demand growth percentage for each period of the year is determined using a Gaussian distribution with mean *demandGrowthAvg*, and a standard deviation equal to the 10% of this average.

$$demandGrowthFrac_{period} \sim N(\mu,\sigma) \qquad [C.12]$$

$$\mu = demandGrowthAvg, \quad \sigma = 0.1 \times demandGrowthAvg$$

$$demandGrowth_{period} = demand_{year,period} \times demandGrowthFrac_{period} \qquad [C.13]$$

$$demand_{(year+1),period} = demand_{year,period} + demandGrowth_{period} \qquad [C.14]$$

b. Provider actions

i. updateOptInfo

The agent updates the information it keeps in the option files (*OptInfoProv*) regarding the options (*OptProv*). The practitioner updates information related to the following properties of distributed generation options; efficiency, investment cost, fixed operating cost, variable operating cost, emission levels, and yearly operational availability. A first-order information delay formulation is used to represent the way agents' perceptions are updated. The formulation is identical to the one given in Equations C.01 and C.02.

Besides updating the agent's information regarding already known options, the method also updates the list of options considered by the agent for investment. For example, a new option may be investable at an intermediate stage of the simulation, such as the options with carbon capture and storage. The method checks the scenario file, and reads the activation year[7] for all the provider options. If there is a new option becoming commercially available at that stage of the simulation, the agent creates a new information file (*OptInfoProv*) for this new option, and adds it to the list of considered investment possibilities.

ii. assessGenPortfolio

The agent performs assessment regarding three main issues in this method. The first one is about the fuel mix of the conventional combustion-based generators. The second one is regarding mothballing/reactivation of the existing generators. The last of the three decisions is related to re-evaluation of investment projects planned in the past.

Biomass co-firing has the potential of becoming profitable as function of biomass costs, and the benefits due to carbon emissions avoided by replacing gas or goal with biomass. Following indicator is used to evaluate the ration of benefits (emissions costs avoided by using biomass to generate 1 unit of electrical energy) to costs (extra fuel cost due to using biomass instead of coal to generate 1 unit of electrical energy);

$$BenefitCostRatio = \frac{carbonPermitPriceAvg \times emissionLevel_{option}}{\left(\dfrac{fuelPrice_{biomass} - fuelPrice_{coal}}{efficiency_{option}}\right)} \qquad [C.15]$$

If the ratio is above 1, the agent shifts the generator to the co-firing mode. If the ration is below 1, and the generator is already in the co-firing mode, the agent shifts the generator back to 100% coal-firing mode.

[7] The simulation year beyond which a generation technology becomes commercially available. This parameter is specified as a part of the scenario specification.

Mothballing is an action that an agent can take in case of having generators making losses. The agent checks the profit history of the active generators it owns, and in the case of loss-making one, the agent temporarily deactivates it. Being different from a decommissioned generator, a mothballed generator can be reactivated if the market conditions change. Mothballing can also be used for strategic reasons in order to prevent other agents from making capacity investments.

A decision directly related to mothballing is the reactivation of mothballed generators. For this decision, the agent calculates the expected profit to be made if the generator is activated for the following year. In order to calculate this, the agent runs a simulation of the market (i.e. a sub-simulation, within the main simulation). The agent uses its information about the market (i.e. fuel prices, power demand, other generators connected to the grid, etc) to construct an expected market setup for the following year. In order to do so, the agent first constructs a list of generators that are expected to be active next year. This list involves the currently active generators, since the agent assumes that they will continue to be active. The agent adds new generators to this list, if there are generators that are under-construction to be completed by next year. Then the agent forecasts the expected load and fuel prices. The forecasting is done based on the records that the agent keeps about the historical load and prices, and works as follows (identical for both fuel prices, and load);

$$loadAvgChg = \frac{loadRecent - loadAvg}{trendHorizon} \quad [C.16]$$

where *loadAvg* is the historical average of the load experienced in the previous years.

$$loadTrend = \frac{loadAvgChg}{loadAvg} \quad [C.17]$$

$$loadAvg(step) = loadAvg(step-1) + loadAvgChg \quad [C.18]$$

$$loadForecast = (1 + loadTrend)^{forecastHorizon}\, loadAvg \quad [C.19]$$

Using the forecasted figures, and the generators that are expected to be active, the agent calculates how much load will be dispatched (dispatching algorithm will be discussed below) to the particular generator being considered, and how much profit can be expected. If there is some profit opportunity, the mothballed generator is activated. In other words, the generation unit is committed for the next year. Otherwise, the generator is left as mothballed until the end of the following year.

In some experiments, a generator making loss during the last 3 years is mothballed. However, it was not possible to reach reliable information about the criteria used by the generation companies in their mothballing decisions. Therefore, in the experiments reported in Chapter 10, the agents are not allowed to mothball their generators.

A generator with the status of ‘announced’ actually represents an investment project whose constructions did not start yet. The agents also assess their projects before they proceed into the ‘under-construction’ stage in order to check whether they are still profitable. As in the case of activation of mothballed generators, the agent runs a simulation about the market conditions for a future time point. If an announced project is not profitable anymore, the agent can cancel it.

iii. makeInvestmentDecision

This method calculates the expected return on investment (ROI) for the available investment options, and returns the most profitable one as a result. If the maximum ROI that can be obtained by available investment options is still below the ROI threshold of the agent, the method returns a *'no investment'* decision. In brief the method works as follows;

```
Repeat until all investment options are considered {
        Pick an investment option
        Calculate expected ROI for the option
        If the ROI is greater than the maximum ROI calculated so far {
                Update the maximum ROI
        }
}
If the maximum ROI is higher than the ROI threshold {
        Return the investment option that yields maximum ROI as the investment decision
}
Else the investment decision of the agent is not to make any investment
```

The most important part of the investment decision is the calculation of an expected return on investment. Briefly, the expected ROI is calculated based on annual cost and revenue terms expected *planHorizon* years in the future. The cost terms include investment costs, as well as operating costs. The revenue terms include direct income from the sales of generated electricity, as well as other payments such as subsidies.

The investment cost is converted into annual cost terms spanning the lifetime of the facility. In other words, the total investment cost is converted into levelized annual terms.

$$invCostAnnual = \frac{invCostTotal \times r \times (1+r)^{lifeTime}}{(1+r)^{lifeTime} - 1} \qquad [C.20]$$

where r is the interest rate in the market.

Another cost term is the fixed operating cost of the generation unit, which is dependent mainly on the capacity of the unit, and independent of the generated electricity.

$$fixedCostAnnual = fixedCost_{option} \times capacity_{option} \qquad [C.21]$$

The third cost term is about the variable costs of the generation unit, which is dependent on the amount of electricity the unit will generate in a year. In order to calculate the variable costs, the agent makes a forecast about the expected generation amount when the unit becomes operational.

The forecasting algorithm of the agent works as follows;

```
Forecast the fuel prices
Forecast the generation-based extras
Forecast the load on the central grid
Repeat until all information files on generators are considered {
```

Pick a generator
If the generator is active {
Check the expected decommissioning date
If the generator is expected to be active in the forecasted year, add it to the future generator list (*futureGenList*)
}
If the generator is under-construction {
Add the generator to the future generator list (*futureGenList*)
}
}
Add the currently considered generation unit to the *futureGenList*
Conduct an experimental load dispatching, and calculate the load dispatched to the generation unit being considered for investment.

According to this forecasting procedure, the agent first constructs a sort of mental image of what it expects the market conditions to be by the time the considered new investment will be operational. Then, simulates this mental image to check how competitive this new investment can be by then, and the expected amount of load it can attract to this new facility to be constructed. Based on this expected generation (i.e. *genExp*), the agent calculates other cost and revenue terms;

$$genCostAnnual = (fuelCost + variableCost)genExp \qquad [C.22]$$

$$fuelCost = \frac{fuelPrice}{efficiency_{opt}} \qquad [C.23]$$

The experimental load dispatching conducted by the agent also provides expected revenue from electricity generation (i.e. *genRevExp*). Combining these cost and revenue terms, the agent calculates the yearly profit level;

$$profitAnnualExp = genRevExp - totalCostAnnual \qquad [C.24]$$

where;

$$totalCostAnnual = genCostAnnual + fixedCostAnnual + InvCostAnnual$$

$$roiExp = \frac{profitAnnualExp}{InvCostAnnual} \qquad [C.25]$$

The calculations given in Equations C.20 through C.25 are purely financial, and does not consider the technical feasibility. Depending on the technology that is related to the considered option (e.g. coal incineration in the case of a 500MW conventional coal-based generator), there are some technical considerations such as the expected minimum up time. Independent of the expected profit levels, a base-load generator cannot be implemented if the expected up time of the generator is, for instance, 10%[8]. This is mainly due to the long start-up and stepping-up times required in a generation unit. As a result, using the *genExp* figure, expected up time of the generation unit is also calculated. If this figure is less than the minimum up time of the generation technology, the investment option is considered as an infeasible one.

[8] To be more precise, it can be implemented to serve 10% of the time, but the fact that the generator needs to be ready to supply all the time makes this an inconvenient action. Keeping a coal-based facility ready to supply electricity implies using fuel on continuous basis without generating any electricity, which would change the figures of the profitability analysis, and result in a negative outcome.

c. Market actions

i. collectDemandData

Following the demand allocation of the practitioner agents, the market object collects individual demand figures from the agents for each time period of the year. This way the market object constructs a load-duration curve for each period of the year. In the base version of ElectTrans, every period corresponds to a quarter of the year. This is mainly due to the generation options covered in the model that have some seasonality in their supply patterns (e.g. PV roof, wind turbines, heat-driven cogeneration plants). Due to this seasonality, endogenous developments about the shares of these options in the electricity supply may cause differing dynamics on seasonal demand on the central generation. For example, increase in solar panels on roofs may yield less demand on the central grid in summer (3rd quarter), while not changing much the demand in winter (1st quarter). Hence, load-duration curves of quarters are represented separately in the model.

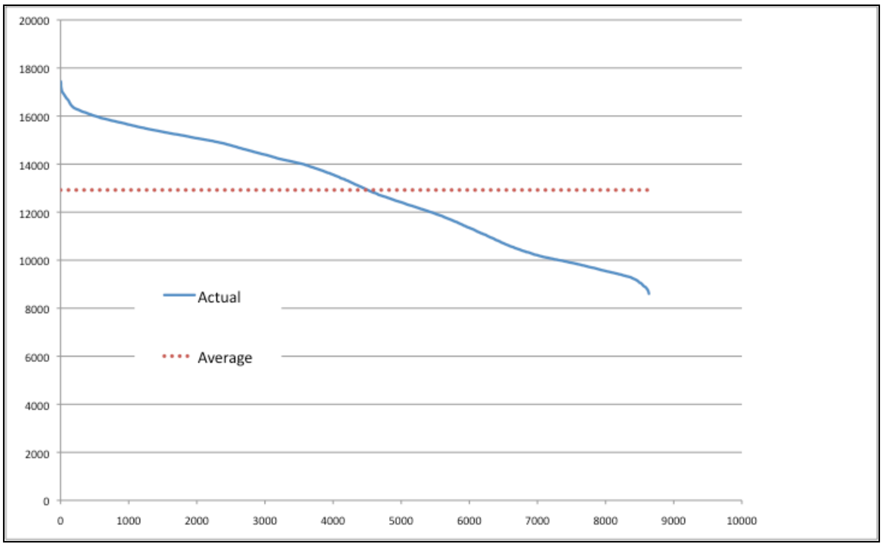

Figure C.2. Averaged vs. actual load pattern

One way to represent a quarterly LDC is to approximate it with a constant average power demand level. This level can easily be obtained by summing up the individual demand levels of the individual practitioner agents. Such a representation flattens out the actual LDC (see Figure C.2), has the potential to distort dispatching (e.g. more generation by base-load plants, no load on peak-load plants). Therefore, another approach is used to represent/construct LDCs in *ElecTrans*; developing LDC templates that resemble the actual LDCs in the Dutch system, and then customize these templates based on the instantaneous average load levels at every step of the simulation. We have constructed quarterly LDCs for 2006, 2007, and 2008 using the load data published by TenneT for 15-min intervals. As can be seen in Figure C.3, the Dutch LDCs do not demonstrate very rapid changes at the edges, and have a very linear character in between. This visual observation is also supported by our regression analyses, in which linear functions have R^2 values above 0.99.

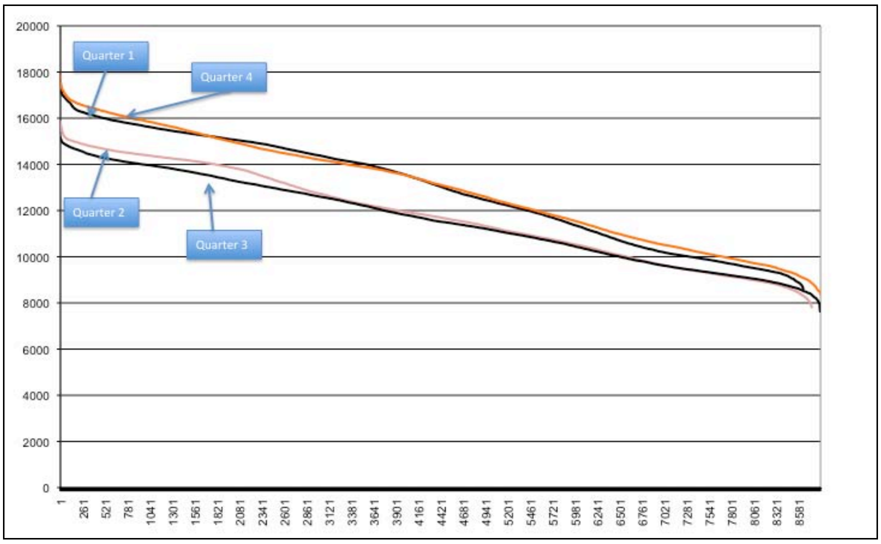

Figure C.3. Actual seasonal LDCs of the Dutch grid (2008)

Each quarter's LDC is represented with a linear function in the following form;

$$f(t) = loadMax - \eta t \qquad [C.26]$$

where η is the slope of the LDC, which is specific to the time period (i.e. quarter)

Going back to how the demand collection method functions, the average load in a period is determined by aggregating the average loads of individual agents. Then this average is used to calculate *loadMax*. Quarter-specific slopes are model parameters specified in the *parameter file.*

$$loadMax = loadAvg + \eta\left(\frac{loadPeriodDuration}{2}\right) \qquad [C.27]$$

ii. dispatchLoad

We assumed that a load dispatching on merit order takes place in the actual system. According to this, generators connected to the central grid are ordered according to their marginal generation costs. Then starting from the lowest cost option, the load is dispatched to the available generators. Before describing the algorithm implemented in order to conduct such a load dispatching process, a simple example is given below to clarify the process better (see Figure C.4).

The negative-sloped dark line in Figure C.4 represents the LDC for a certain time interval (e.g. year, or quarter year). There are 3 active generators, and they are numbered in the order of increasing marginal generation cost (i.e. Generator 1 has the lowest marginal cost). The dispatching starts with Generator 1. During interval 1, the capacity of Generator 1 is enough to supply all demand. Being the most expensive generator that supplies electricity during interval 1, the marginal generation cost of Generator 1 sets the electricity price in this period; the price for interval 1 equals to MC_1. Then Generator 2 is called for supply. Both Generator 1 and Generator 2 supply electricity during Interval 2, and Generator 2 sets the price of the interval; the price in interval 2 equals MC_2. Finally, all three generators supply during interval 3, and the price of this interval equals MC_3.

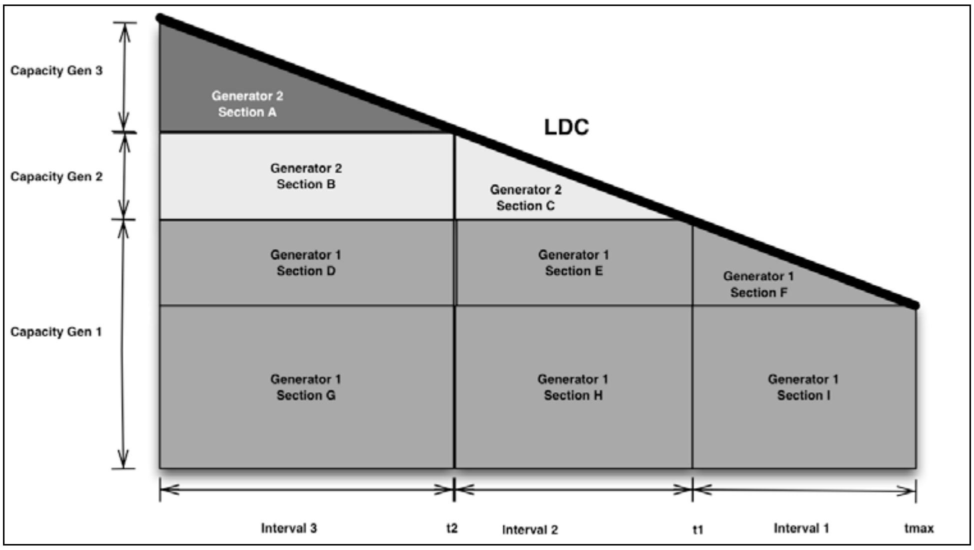

Figure C.4. Load dispatching example

The Y-axis of the figure is power, and the X-axis is time. Therefore, the area under the LDC corresponds to energy. In that respect, when we look at the total electricity energy generated by a specific generator, the amount is equal to the sum of the areas of the sections indicated by the name of the generator. For example, for Generator 2, total energy supply is equal to the sum of areas of section B and C.

The revenue of a generator is calculated by using the price of a certain interval and the amount of energy delivered by the generator during that interval. The total revenue of Generator 1 can be calculated as follows;

$$TotalRevenue = Revenue_{Int1} + Revenue_{Int2} + Revenue_{Int3} \quad [C.28]$$

$$Revenue_{Int1} = MC_1(I+F),\ Revenue_{Int2} = MC_2(H),\ Revenue_{Int3} = MC_3(G) \quad [C.29]$$

As can be seen from Equations C.28 and C.29, determining the boundaries of the time interval is necessary for the calculations about the total generation of plants and the electricity prices. Using Equation C.26, the boundaries of the intervals in the given example can be determined as follows;

Interval 1:

$$UpperBoundary = t_{\max} \quad [C.30]$$

$$LowerBoundary = \frac{LoadMax - Capa_{Gen1}}{\eta} = t_1 \quad [C.31]$$

Interval 2:

$$UpperBoundary = t_1 \quad [C.32]$$

$$LowerBoundary = \frac{LoadMax - (Capa_{Gen1} + Capa_{Gen2})}{\eta} = t_2 \quad [C.33]$$

Interval 3:

$$UpperBoundary = t_2 \quad [C.34]$$

$$LowerBoundary = 0$$
$$\text{since } (\text{Capa}_{\text{Gen1}} + \text{Capa}_{\text{Gen2}} + \text{Capa}_{\text{Gen3}} \geq \text{loadMax}) \quad [C.35]$$

The algorithm used to conduct load dispatching according to this depiction is given below;

```
Repeat until all active generators are considered {
        Get the marginal generation cost (i.e. price bid) of the generator
        Add the generator to the potential generator list (P)
}
Order the set P in increasing marginal generation cost
Initialize interval counter i = 1
Initialize the considered generator list as an empty set (C = {})
Initialize the cumulative capacity variable cumCapa = 0
Initialize the interval upper bound variable t_up = t_max
Repeat until cumCapa > loadMax, or the set P is empty {
        Get the first generator from P as the currently considered generator; gen
        Get the effective capacity of the gen; capa_gen
        Calculate t=(loadMax-(cumCapa+capa_gen))/slope
        If (t>t_up ), do the following {
                Increase cumCapa by capa_gen
                Remove gen from P
                Add gen to C
        }
        Else, do the following {
                Set the duration of the current interval, d_i=t_up-t
                Set the price of the current interval, p_i=margCost_gen
                Update t_up, t_up=t
                Increase cumCapa by capa_gen
                Increase interval counter i by 1
        }
}
```

d. ***OptProv* actions**

i. updateAttributes

The attributes are mostly technical, and updated according to the following formulation according to which the attribute level converges to the expected best levels in the long run. The term in the parenthesis represents the room-for-development for the property.

$$ChangeInProperty = (Property_{Best} - Property_{Current})techDevFrac \quad [C.36]$$

$$Property_{Current}(step) = Property_{Current}(step-1) + ChangeInProperty \quad [C.37]$$

e. ***OptPract* actions**

i. updateAttributes

As already discusses, there are two main classes of practitioner options. The first group contains the grid-based options, and includes conventional gray and green electricity. The properties of these options that are relevant to the practitioners are the cost of electricity and the emissions caused due to grid-based supply. As can be clearly seen, none of these properties is purely technological properties, and they depend on the way whole grid-based system has been functioning. In that respect, these two properties for the grid-based options are calculated as follows;

```
Repeat until all generators are considered {
        Get the total amount of electricity generated by the generator in the previous period,
        and update the cumulative generation of the system
        Get the total revenue of electricity generated by the generator in the previous period,
        and update the cumulative cost of the system
        Get the total emissions from the generator in the previous period, and update the
        cumulative emissions of the system
}
Calculate recent average cost (cumulative cost/cumulative generation)
Calculate recent average emissions (cumulative emissions/cumulative generation)
```

For the distributed generation options, the formulation given above in the Equations C.36 and C.37 are used.

f. *Generator* actions

i. <u>*updateStatus*</u>

This method checks the current simulation step, and the planned commissioning and decommissioning steps of a generator. As a result, changes the status of a generator if necessary.Basic checks, and resulting actions in this method are as follows;

- A generator with ‘under-construction’ status becomes ‘active’ if the *comStep* is equal to the current *step*.
- A generator with ‘active status becomes ‘retired’ if the *decomStep* is equal to the current *step*.
- If the generator is mothballed, its *decom* step is pushed 1 step further.
- If a planned generator is cancelled, its *comStep* is set to infinity.

C.5. Parameter file

Investment Options	OptID-b	Capacity-b (kW)	Fuel Type-b	Eff-b Init	Eff-b Term	Inv Cost-b Init (Euro/kW)	Inv Cost-b Term (Euro/kW)	Fixed Cost-b Init (Euro/kW.yr)	Fixed Cost-b Term (Euro/kW.yr)	VarCost-b Init (Euro/kWh)	VarCost-b Term (Euro/kWh)	Emission Level (gr/kWh)	Life Time-b LB	Life Time-b UB	Perms Delay-b	Const Delay-b	Min Load Factor-b	Green-b	Heat Eff-b Init	Heat Eff-b Terms	Avail-b	Investable Init
No Investment	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Coal Existing	1	800000	1	0.46	0.46	0	0	60	60	0.001	0.001	750	30	35	0	0	0.75	0	0	0	0.9	0
Combined Cycle Existing	2	300000	2	0.55	0.55	0	0	15	13	0.00004	0.00004	350	25	30	0	0	0.2	0	0	0	0.9	0
Gas-fired Existing	3	50000	2	0.36	0.36	0	0	11	11	0.0018	0.0018	500	25	30	0	0	0.5	0	0	0	0.9	0
IGCC Existing	4	300000	1	0.45	0.45	0	0	56	45	0.0009	0.0009	750	30	35	0	0	0.6	0	0	0	0.9	0
Nuclear Existing	5	400000	3	1	1	0	0	52	52	0.0018	0.0018	0	40	60	0	0	0.9	0	0	0	0.95	0
Wind Existing	6	50000	5	1	1	0	0	20	17	0	0	0	30	30	0	0	0	1	0	0	1	0
Peak Load Existing	7	50000	2	0.35	0.35	0	0	11	11	0.0018	0.0018	800	25	30	0	0	0	0	0	0	1	0
Industrial CHP Existing	8	25000	2	0.43	0.43	0	0	10	10	0.00162	0.00162	350	25	30	0	0	0	0	0.29	0.29	0.85	0
strict Heating CHP Existi	9	25000	2	0.33	0.33	0	0	11	11	0.0018	0.0018	500	25	30	0	0	0	0	0.47	0.47	0.85	0
Coal-S	10	400000	1	0.44	0.52	1200	1100	60	55	0.000936	0.000936	750	30	40	0	3	0.75	0	0	0	0.9	1
Coal-L	11	800000	1	0.46	0.52	1200	1100	60	55	0.000936	0.000936	750	30	40	0	3	0.75	0	0	0	0.9	1
Coal CCS	12	800000	1	0.34	0.44	2000	1700	75	60	0.003456	0.00288	130	30	40	0	3	0.75	0	0	0	0.9	0
IGCC	13	300000	1	0.45	0.52	1600	1300	56	45	0.000792	0.00054	750	30	40	0	3	0.75	0	0	0	0.9	1
IGCC CCS	14	300000	1	0.36	0.48	2000	1400	73	55	0.001368	0.00072	80	30	40	0	3	0.75	0	0	0	0.9	0
Gas Turbine	15	50000	2	0.36	0.39	380	380	11	11	0.0018	0.0018	500	25	35	0	2	0	0	0	0	0.9	0
Gas Turbine CHP	16	50000	2	0.33	0.33	760	760	11	11	0.0018	0.0018	500	25	35	0	2	0	0	0.47	0.47	0.9	0
Combined Cycle-S	17	400000	2	0.55	0.63	600	540	15	13	0.000036	0.000036	350	25	35	0	3	0.4	0	0	0	0.9	1
Combined Cycle-L	18	800000	2	0.57	0.63	580	450	15	13	0.000036	0.000036	350	25	35	0	3	0.4	0	0	0	0.9	1
Combined Cycle SOFC	19	400000	2	0.64	0.7	1050	880	27	24	0.00504	0.00504	350	25	35	0	3	0.4	0	0	0	0.9	0
Combined Cycle CCS	20	800000	2	0.47	0.55	900	750	26	17	0.00108	0.00108	60	25	35	0	3	0.4	0	0	0	0.9	0
Combined Cycle CHP	21	200000	2	0.43	0.5	590	590	12.5	12.5	0.00198	0.00198	380	25	35	0	3	0.4	0	0.29	0.29	0.9	0
Nuclear	22	1000000	3	1	1	2100	2100	52	52	0.0018	0.0018	0	40	60	0	6	0.9	0	0	0	0.9	0
Biomass/Waste Fired	23	10000	4	0.35	0.45	1200	1100	60	55	0.000936	0.000936	0	30	40	0	3	0	0	0	0	0.9	0
Coal-S-CoFire	24	400000	7	0.42	0.5	1200	1100	60	55	0.000936	0.000936	750	30	40	0	3	0.75	0	0	0	0.9	1
Coal-L-CoFire	25	800000	7	0.44	0.5	1200	1100	60	55	0.000936	0.000936	750	30	40	0	3	0.75	0	0	0	0.9	1

Figure C.5. Parameters related to provider options

Option Name	Capacity-e (kW)	Eff-e Init	Eff-e Final	Inv. Cost-e Init (Euro/kW)	Inv. Cost-e Final (Euro/kW)	Fixed Cost-e Init (Euro/kW.yr)	Fixed Cost-e Final (Euro/kW.yr)	Var Cost-e Init (Euro/kWh)	Var Cost-e Final (Euro/kWh)	Emission Level-e (gr/kWh)	Life Time-e	Const Delay-e	Perms Delay-e	Min LoadFactor-e	Green-e	Heat Efficiency-e Init	Heat Efficiency-e Final	Avail-e Period1	Avail-e Period2	Avail-e Period3	Avail-e Period4
Grid Gray	1	1	1	0	0	0	0	0.025	0.025	600	10	0	0	0	0	0	0	1	1	1	1
Grid Green	1	1	1	0	0	0	0	0.03	0.03	0	10	0	0	0	0	0	0	1	1	1	1
Micro-CHP	5	0.15	0.2	1250	1000	10	10	0	0	450	20	1	0	0	0	0.7	0.7	0.9	0.9	0.9	0.9
PV Roof	5	1	1	3000	1000	14	7.5	0	0	0	30	1	0	0	1	0	0	0.075	0.12	0.25	0.12
Wind Turbine-InLand-S	5	1	1	950	700	20	17	0	0	0	20	1	0	0	1	0	0	0.24	0.24	0.24	0.24
Wind Turbine-Inland	1000	1	1	850	700	20	17	0	0	0	20	1	0	0	1	0	0	0.24	0.24	0.24	0.24
Gas Engine-CHP	500	0.37	0.39	950	950	24	24	0.00072	0.00072	700	25	1	0	0	0	0.51	0.51	0.4	0.4	0.4	0.4
Gas Turbine-CHP	25000	0.34	0.37	760	760	11	11	0.0018	0.0018	500	25	1	0	0	0	0.45	0.43	0.6	0.6	0.6	0.6
Wind Turbine-InLand-L	10000	1	1	850	700	20	17	0	0	0	20	1	0	0	1	0	0	0.24	0.24	0.24	0.24
Wind Turbine-OnShore-L	10000	1	1	850	700	20	17	0	0	0	20	1	0	0	1	0	0	0.27	0.27	0.27	0.27
Wind Turbine-Nearshore-L	10000	1	1	1510	1200	50	40	0	0	0	20	2	0	0	1	0	0	0.33	0.33	0.33	0.33
Wind Turbine-Offshore-L	50000	1	1	1800	1515	75	68	0	0	0	30	4	0	0	1	0	0	0.365	0.365	0.365	0.365
CCGT CHP	50000	0.45	0.47	590	590	12.5	12.5	0.00198	0.00198	380	30	2	0	0	0	0.28	0.25	0.6	0.6	0.6	0.6
Biomass Combustion	5000	0.25	0.3	3500	2500	0	0	0.076	0.066	0	20	1	0	0	1	0	0	0.6	0.6	0.6	0.6
Biomass Gasification	5000	0.36	0.4	4000	3500	0	0	0.055	0.05	0	20	1	0	0	1	0	0	0.6	0.6	0.6	0.6

Figure C.6. Parameters related to practitioner options

Generator Name	Com. Year-c	Status-c	Capacity-c (kW)
Borssele-1	1973	1	510000
Amer-1	1980	1	645000
Gelderland-1	1981	1	600000
Borssele-2	1987	1	403000
Maasvlakte-1	1988	1	520000
Maasvlakte-2	1988	1	520000
Amer-4	1993	1	600000
Hemweg-1	1994	1	630000
Velsen-1	1974	1	459000
Claus A	1977	1	640000
Claus B	1977	1	640000
Velsen-2	1986	1	361000
Eems-1	1977	1	695000
Bergum-1	1974	1	332000
Bergum-2	1975	1	332000
Harculo-1	1982	1	350000
Hemweg-2	1979	1	599000
Delft-1	1974	1	23000
Delft-2	1974	1	23000
Delft-3	1974	1	23000
Delft-4	1974	1	23000
Borssele-3	1972	1	18000
Amer-2	1972	1	15000
Amer-3	1972	1	15000
Velsen-3	1975	1	25000
Demkolec-1	1993	1	253000
Eems-2	1996	1	341000
Eems-3	1996	1	341000
Eems-4	1996	1	341000
Eems-5	1996	1	341000
Eems-6	1996	1	341000
Donge-1	1976	1	121000
Moerdijk-1	1997	1	339000
Swentibold-1	1999	1	231000
Ijmond-1	1997	1	144000
Temeuzen-1	1998	1	478000
Delesto-1	1987	1	190000
Delesto-2	1999	1	340000
Hengelo-1	1994	1	104000
Yara Suiskil-1	1977	1	105000
Shell-1	1997	1	127000
Almere-1	1987	1	64000
Almere-2	1993	1	54000
Leiden-1	1986	1	81000
Den Haag-1	1982	1	78000
Rotterdam-1	1988	1	209000
RoCa-1	1982	1	24000
RoCa-2	1982	1	24000
RoCa-3	1996	1	221000
Weide-1	1995	1	247000
Merwedekanaal-1	1978	1	96000
Merwedekanaal-2	1984	1	103000
Merwedekanaal-3	1989	1	224000
Diemen-1	1995	1	246000
Purmerend-1	1989	1	69000
Eemshaven-1	2008	1	125000
Eemshaven-2	2011	4	350000
Eemshaven-3	2014	4	1050000
Eemshaven-4	2011	4	800000
Eemshaven-5	2012	4	800000
Eemshaven-6	2012	3	800000
Eemshaven-7	2011	3	0
Bergum-3	2014	3	454000
Delfzijl-1	2014	3	115000
Lelystad-1	2009	4	900000
Maasvlakte-3	2012	4	1050000
Maasvlakte-4	2010	4	419000
Maasvlakte-5	2010	4	840000
Maasvlakte-6	2011	3	0
Maasvlakte-7	2012	4	800000
Geertruidenberg-1	2014	4	800000
Moerdijk-2	2011	3	0
Schoonebeek-1	2011	3	0
Borssele-4	2009	4	870000
Sas van Gent-1	2010	3	0
Maasbracht-2	2011	4	650000

Figure C.7. Initial set of generators in ElectTrans

Pract Group	Weight-d Obj1	Weight-d Obj2	Weight-d Obj3	Weight-d Obj4	Group Size-d	Total Pow Dmd-d (kWh/yr)
Industrial-1	-1.7	-0.05	-0.1	-0.1	100	47671266000
Horticulture-1	-1.2	-0.3	0	-0.5	100	13580098000
Commercial-1	-1.3	-0.2	0	-0.35	100	28725682000
Residential-1	-1	-0.35	0	-0.7	100	26825682000

	PowDmd-d % Perio	PowDmd-d % Perio	PowDmd-d % Perio	PowDmd-d % Period4
Industrial-1	0.25	0.25	0.25	0.25
Horticulture-1	0.26	0.25	0.23	0.26
Commercial-1	0.27	0.24	0.23	0.26
Residential-1	0.26	0.24	0.22	0.28

	CapaOpt-d [0]	CapaOpt-d [1]	CapaOpt-d [2]	CapaOpt-d [3]	CapaOpt-d [4]	CapaOpt-d [5]	CapaOpt-d [6]	CapaOpt-d [7]
Industrial-1	3205342.466	0	0	0	0	0	0	970000
Horticulture-1	631831.0502	0	0	0	0	0	2500000	0
Commercial-1	3179404.206	64885.80011	0	53000	0	0	500000	0
Residential-1	2881000	342465.7534	0	0	0	0	0	0

	CapaOpt-d [8]	CapaOpt-d [9]	CapaOpt-d [10]	CapaOpt-d [11]	CapaOpt-d [12]	CapaOpt-d [13]	CapaOpt-d [14]	SupplyToGrid
Industrial-1	0	1900000	0	0	2380000	0	0	1
Horticulture-1	0	0	0	0	0	0	0	1
Commercial-1	0	0	0	0	0	0	0	0
Residential-1	0	0	0	0	0	0	0	0

Figure C.8. Parameters related to Practitioners

Avg Load-f (kW)	Period1-f	Period2-f	Period3-f	Period4-f
0	9500000	9500000	9500000	9500000
-1	9500000	9500000	9500000	9500000
-2	9500000	9500000	9500000	9500000
-3	9500000	9500000	9500000	9500000
-4	9500000	9500000	9500000	9500000

Avg Price-f (Euro/kWh)				
0	0.02	0.02	0.02	0.02
-1	0.025	0.025	0.025	0.025
-2	0.02	0.02	0.02	0.02
-3	0.02	0.02	0.02	0.02
-4	0.02	0.02	0.02	0.02

Slope-f (kW/t)				
0	3450	3450	3450	3450

Fuel Price-f (Euro/kWh)		Initial
No Fuel	0	0
coal-f	1	0.0065
natural gas-f	2	0.015
uranium-f	3	0.0045
biomass-f	4	0.018
wind-f	5	0
solar-f	6	0
cofiring-f	7	0

GreenCert Price-f	(Euro/kWh)
0	0
-1	0
-2	0
-3	0
-4	0
Base Price	0.04

CarbonPermit Price (Euro/gr)	
0	0.0000001
-1	0.000005
-2	0.000015
-3	0.000025
-4	0.00004
Base Price	0.00002

Figure C.9. Initial parameters for Market

C.6. Scenario files

Fuel Price		Inc Perct	Volatil	Most Likely	Pessimist	Optimist	Gas-killer
no fuel -f	0	0	0	0	0	0	0
coal-f	1	0.015	0	0.015	0.03	0	0.015
natural gas-f	2	0.02	0	0.02	0.04	0	0.04
uranium-f	3	0	0	0	0	0	0
biomass-f	4	0	0	0	0	0	-0.01
wind-f	5	0	0	0	0	0	0
solar-f	6	0	0	0	0	0	0
cofiring-f	7	0	0	0	0	0	0

Blank

Blank2		OptPract TechDevFrac	Efficiency-e Term	InvCost-e Term	Eff-e Likely	Eff-e Possible	Inv-e Likely	Inv-e Possible
Grid Gray	0	0	1	0	1	1	0	0
Grid Green	1	0	1	0	1	1	0	0
Micro-CHP	2	0.12	1	1200	0.2	0.25	1200	1000
PV Roof	3	0.12	1	1200	1	1	1200	1000
Wind Turbine-InLand-S	4	0.12	1	800	1	1	800	700
Wind Turbine-Inland	5	0.12	1	700	1	1	700	650
Gas Engine-CHP	6	0.12	0.39	950	0.39	0.39	950	950
Gas Turbine-CHP	7	0.12	0.37	760	0.37	0.37	760	760
Wind Turbine-InLand-L	8	0.12	1	700	1	1	700	650
Wind Turbine-OnShore-L	9	0.12	1	700	1	1	700	650
Wind Turbine-Nearshore-L	10	0.12	1	1200	1	1	1200	1000
Wind Turbine-Offshore-L	11	0.12	1	1500	1	1	1500	1200
CCGT CHP	12	0.12	0.47	590	0.47	0.47	590	590
Biomass Combustion	13	0.12	0.3	2500	0.3	0.35	2500	1500
Biomass Gasification	14	0.12	0.4	3500	0.4	0.45	3500	2500

Figure C.10. Fuel prices and technological development (Base scenario)

Blank4		OptProv TehcDevFrac	Efficiency-b Term	InvCost-b Term	Eff-b Likely	Eff-b Possible	Inv-b Likely	Inv-b Possible
No Investment	0	0	1	0				
Coal Existing	1	0	0.46	0				
Combined Cycle Existing	2	0	0.55	0				
Gas-fired Existing	3	0	0.36	0				
IGCC Existing	4	0	0.45	0				
Nuclear Existing	5	0	1	0				
Wind Existing	6	0	1	0				
Peak Load Existing	7	0	0.35	0				
Industrial CHP Existing	8	0	0.43	0				
District Heating CHP Existing	9	0	0.33	0				
Coal-S	10	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L	11	0.12	0.5	1100	0.5	0.54	1100	1000
Coal CCS	12	0.12	0.44	1800	0.44	0.47	1800	1500
IGCC	13	0.12	0.52	1400	0.52	0.56	1400	1200
IGCC CCS	14	0.12	0.46	1500	0.46	0.5	1500	1300
Gas Turbine	15	0.12	0.39	380	0.39	0.39	380	380
Gas Turbine CHP	16	0.12	0.33	760	0.33	0.33	760	760
Combined Cycle-S	17	0.12	0.61	500	0.61	0.64	500	450
Combined Cycle-L	18	0.12	0.63	500	0.63	0.66	500	450
Combined Cycle SOFC	19	0.12	0.7	900	0.7	0.7	900	800
Combined Cycle CCS	20	0.12	0.55	700	0.55	0.6	700	600
Combined Cycle CHP	21	0.12	0.5	590	0.5	0.5	590	590
Nuclear	22	0.12	1	2100	1	1	2100	2100
Biomass/Waste Fired	23	0.12	0.42	1100	0.42	0.45	1100	1100
Coal-S-CoFire	24	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L-CoFire	25	0.12	0.49	1100	0.49	0.52	1100	1000

Figure C.11. Technological development for grid-based options (Base scenario)

h	Carbon Permit Price (Euro/gr CO2)	Pract0-W1	Pract0-W2	Pract0-W3	Pract0-W4	Pract1-W1	Pract1-W2	Pract1-W3	Pract1-W4	Pract2-W1	Pract2-W2	Pract2-W3	Pract2-W4	Pract3-W1	Pract3-W2	Pract3-W3	Pract3-W4
2005	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2006	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2007	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2008	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2009	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2010	0.000002	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2011	0.00001	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2012	0.000015	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2013	0.00002	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2014	0.000025	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2015	0.00003	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2016	0.000035	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2017	0.00004	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2018	0.000045	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2019	0.00005	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2020	0.000055	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2021	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2022	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2023	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2024	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2025	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2026	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2027	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2028	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2029	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2030	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2031	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2032	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2033	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2034	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2035	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2036	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2037	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2038	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2039	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2040	0.00006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7

Figure C.12. Priority weights for the practitioner groups (Base case)

Fuel Price		Inc Perct	Volatil	Most Likely	Pessimist	Optimist	Gas-killer
no fuel -f	0	0	0	0	0	0	0
coal-f	1	0.015	0	0.015	0.03	0	0.015
natural gas-f	2	0.02	0	0.02	0.04	0	0.04
uranium-f	3	0	0	0	0	0	0
biomass-f	4	0	0	0	0	0	-0.01
wind-f	5	0	0	0	0	0	0
solar-f	6	0	0	0	0	0	0
cofiring-f	7	0	0	0	0	0	0

Blank

Blank2		OptPract TechDevFrac	Efficiency-e Term	InvCost-e Term	Eff-e Likely	Eff-e Possible	Inv-e Likely	Inv-e Possible
Grid Gray	0	0	1	0	1	1	0	0
Grid Green	1	0	1	0	1	1	0	0
Micro-CHP	2	0.12	1	1200	0.2	0.25	1200	1000
PV Roof	3	0.12	1	1200	1	1	1200	1000
Wind Turbine-InLand-S	4	0.12	1	800	1	1	800	700
Wind Turbine-Inland	5	0.12	1	700	1	1	700	650
Gas Engine-CHP	6	0.12	0.39	950	0.39	0.39	950	950
Gas Turbine-CHP	7	0.12	0.37	760	0.37	0.37	760	760
Wind Turbine-InLand-L	8	0.12	1	700	1	1	700	650
Wind Turbine-OnShore-L	9	0.12	1	700	1	1	700	650
Wind Turbine-Nearshore-L	10	0.12	1	1200	1	1	1200	1000
Wind Turbine-Offshore-L	11	0.12	1	1500	1	1	1500	1200
CCGT CHP	12	0.12	0.47	590	0.47	0.47	590	590
Biomass Combustion	13	0.12	0.3	2500	0.3	0.35	2500	1500
Biomass Gasification	14	0.12	0.4	3500	0.4	0.45	3500	2500

Blank3

Blank4		OptProv TehcDevFrac	Efficiency-b Term	InvCost-b Term	Eff-b Likely	Eff-b Possible	Inv-b Likely	Inv-b Possible
No Investment	0	0	1	0				
Coal Existing	1	0	0.46	0				
Combined Cycle Existing	2	0	0.55	0				
Gas-fired Existing	3	0	0.36	0				
IGCC Existing	4	0	0.45	0				
Nuclear Existing	5	0	1	0				
Wind Existing	6	0	1	0				
Peak Load Existing	7	0	0.35	0				
Industrial CHP Existing	8	0	0.43	0				
District Heating CHP Existing	9	0	0.33	0				
Coal-S	10	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L	11	0.12	0.5	1100	0.5	0.54	1100	1000
Coal CCS	12	0.12	0.44	1800	0.44	0.47	1800	1500
IGCC	13	0.12	0.52	1400	0.52	0.56	1400	1200
IGCC CCS	14	0.12	0.46	1500	0.46	0.5	1500	1300
Gas Turbine	15	0.12	0.39	380	0.39	0.39	380	380
Gas Turbine CHP	16	0.12	0.33	760	0.33	0.33	760	760
Combined Cycle-S	17	0.12	0.61	500	0.61	0.64	500	450
Combined Cycle-L	18	0.12	0.63	500	0.63	0.66	500	450
Combined Cycle SOFC	19	0.12	0.7	900	0.7	0.7	900	800
Combined Cycle CCS	20	0.12	0.55	700	0.55	0.6	700	600
Combined Cycle CHP	21	0.12	0.5	590	0.5	0.5	590	590
Nuclear	22	0.12	1	2100	1	1	2100	2100
Biomass/Waste Fired	23	0.12	0.42	1100	0.42	0.45	1100	1100
Coal-S-CoFire	24	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L-CoFire	25	0.12	0.49	1100	0.49	0.52	1100	1000

Figure C.13. Fuel prices and technological development (Regulatory pressure scenario)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
h	Carbon Permit Price (Euro/gr CO2)	Pract0-W1	Pract0-W2	Pract0-W3	Pract0-W4	Pract1-W1	Pract1-W2	Pract1-W3	Pract1-W4	Pract2-W1	Pract2-W2	Pract2-W3	Pract2-W4	Pract3-W1	Pract3-W2	Pract3-W3	Pract3-W4
2005	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2006	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2007	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2008	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2009	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2010	0.0000002	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2011	0.000001	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2012	0.0000015	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2013	0.000002	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2014	0.0000025	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2015	0.000003	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2016	0.0000035	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2017	0.000004	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2018	0.0000045	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2019	0.000005	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2020	0.0000055	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2021	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2022	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2023	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2024	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2025	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2026	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2027	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2028	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2029	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2030	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2031	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2032	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2033	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2034	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2035	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2036	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2037	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2038	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2039	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2040	0.000006	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7

Figure C.14. Priority weights for the practitioner groups (Regulatory pressure scenario)

Fuel Price		Inc Perct	Volatil	Most Likely	Pessimist	Optimist	Gas-killer
no fuel -f	0	0	0	0	0	0	0
coal-f	1	0.015	1	0.015	0.03	0	0.015
natural gas-f	2	0.02	1	0.02	0.04	0	0.04
uranium-f	3	0	0	0	0	0	0
biomass-f	4	0	0	0	0	0	-0.01
wind-f	5	0	0	0	0	0	0
solar-f	6	0	0	0	0	0	0
cofiring-f	7	0	0	0	0	0	0

Blank

Blank2		OptPract TechDevFrac	Efficiency-e Term	InvCost-e Term	Eff-e Likely	Eff-e Possible	Inv-e Likely	Inv-e Possible
Grid Gray	0	0	1	0	1	1	0	0
Grid Green	1	0	1	0	1	1	0	0
Micro-CHP	2	0.2	1	1000	0.2	0.25	1200	1000
PV Roof	3	0.2	1	1000	1	1	1200	1000
Wind Turbine-InLand-S	4	0.2	1	700	1	1	800	700
Wind Turbine-Inland	5	0.2	1	650	1	1	700	650
Gas Engine-CHP	6	0.2	0.39	950	0.39	0.39	950	950
Gas Turbine-CHP	7	0.2	0.37	760	0.37	0.37	760	760
Wind Turbine-InLand-L	8	0.2	1	650	1	1	700	650
Wind Turbine-OnShore-L	9	0.2	1	650	1	1	700	650
Wind Turbine-Nearshore-L	10	0.2	1	800	1	1	1200	1000
Wind Turbine-Offshore-L	11	0.2	1	1000	1	1	1500	1200
CCGT CHP	12	0.2	0.47	590	0.47	0.47	590	590
Biomass Combustion	13	0.2	0.35	1000	0.3	0.35	2500	1500
Biomass Gasification	14	0.2	0.45	1500	0.4	0.45	3500	2500

Blank3

Blank4		OptProv TehcDevFrac	Efficiency-b Term	InvCost-b Term	Eff-b Likely	Eff-b Possible	Inv-b Likely	Inv-b Possible
No Investment	0	0	1	0				
Coal Existing	1	0	0.46	0				
Combined Cycle Existing	2	0	0.55	0				
Gas-fired Existing	3	0	0.36	0				
IGCC Existing	4	0	0.45	0				
Nuclear Existing	5	0	1	0				
Wind Existing	6	0	1	0				
Peak Load Existing	7	0	0.35	0				
Industrial CHP Existing	8	0	0.43	0				
District Heating CHP Existing	9	0	0.33	0				
Coal-S	10	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L	11	0.12	0.5	1100	0.5	0.54	1100	1000
Coal CCS	12	0.12	0.44	1800	0.44	0.47	1800	1500
IGCC	13	0.12	0.52	1400	0.52	0.56	1400	1200
IGCC CCS	14	0.12	0.46	1500	0.46	0.5	1500	1300
Gas Turbine	15	0.12	0.39	380	0.39	0.39	380	380
Gas Turbine CHP	16	0.12	0.33	760	0.33	0.33	760	760
Combined Cycle-S	17	0.12	0.61	500	0.61	0.64	500	450
Combined Cycle-L	18	0.12	0.63	500	0.63	0.66	500	450
Combined Cycle SOFC	19	0.12	0.7	900	0.7	0.7	900	800
Combined Cycle CCS	20	0.12	0.55	700	0.55	0.6	700	600
Combined Cycle CHP	21	0.12	0.5	590	0.5	0.5	590	590
Nuclear	22	0.12	1	2100	1	1	2100	2100
Biomass/Waste Fired	23	0.12	0.42	1100	0.42	0.45	1100	1100
Coal-S-CoFire	24	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L-CoFire	25	0.12	0.49	1100	0.49	0.52	1100	1000

Figure C.15. Fuel prices and technological development (Optimistic tech. dev. scenario)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
h	Carbon Permit Price (Euro/gr CO2)	Pract0-W1	Pract0-W2	Pract0-W3	Pract0-W4	Pract1-W1	Pract1-W2	Pract1-W3	Pract1-W4	Pract2-W1	Pract2-W2	Pract2-W3	Pract2-W4	Pract3-W1	Pract3-W2	Pract3-W3	Pract3-W4
2005	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2006	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2007	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2008	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2009	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2010	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2011	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2012	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2013	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2014	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2015	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2016	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2017	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2018	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2019	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2020	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2021	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2022	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2023	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2024	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2025	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2026	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2027	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2028	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2029	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2030	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2031	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2032	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2033	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2034	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2035	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2036	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2037	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2038	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2039	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2040	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7

Figure C.15. Priority weights for the practitioner groups (Optimistic tech. dev. scenario)

Fuel Price		Inc Perct	Volatil	Most Likely	Pessimist	Optimist	Gas-killer
no fuel -f	0	0	0	0	0	0	0
coal-f	1	0.015	1	0.015	0.03	0	0.015
natural gas-f	2	0.02	1	0.02	0.04	0	0.04
uranium-f	3	0	0	0	0	0	0
biomass-f	4	0	0	0	0	0	-0.01
wind-f	5	0	0	0	0	0	0
solar-f	6	0	0	0	0	0	0
cofiring-f	7	0	0	0	0	0	0
Blank							

Blank2		OptPract TechDevFrac	Efficiency-e Term	InvCost-e Term	Eff-e Likely	Eff-e Possible	Inv-e Likely	Inv-e Possible
Grid Gray	0	0	1	0	1	1	0	0
Grid Green	1	0	1	0	1	1	0	0
Micro-CHP	2	0.12	1	1200	0.2	0.25	1200	1000
PV Roof	3	0.12	1	1200	1	1	1200	1000
Wind Turbine-InLand-S	4	0.12	1	800	1	1	800	700
Wind Turbine-Inland	5	0.12	1	700	1	1	700	650
Gas Engine-CHP	6	0.12	0.39	950	0.39	0.39	950	950
Gas Turbine-CHP	7	0.12	0.37	760	0.37	0.37	760	760
Wind Turbine-InLand-L	8	0.12	1	700	1	1	700	650
Wind Turbine-OnShore-L	9	0.12	1	700	1	1	700	650
Wind Turbine-Nearshore-L	10	0.12	1	1200	1	1	1200	1000
Wind Turbine-Offshore-L	11	0.12	1	1500	1	1	1500	1200
CCGT CHP	12	0.12	0.47	590	0.47	0.47	590	590
Biomass Combustion	13	0.12	0.3	2500	0.3	0.35	2500	1500
Biomass Gasification	14	0.12	0.4	3500	0.4	0.45	3500	2500
Blank3								

Blank4		OptProv TehcDevFrac	Efficiency-b Term	InvCost-b Term	Eff-b Likely	Eff-b Possible	Inv-b Likely	Inv-b Possible
No Investment	0	0	1	0				
Coal Existing	1	0	0.46	0				
Combined Cycle Existing	2	0	0.55	0				
Gas-fired Existing	3	0	0.36	0				
IGCC Existing	4	0	0.45	0				
Nuclear Existing	5	0	1	0				
Wind Existing	6	0	1	0				
Peak Load Existing	7	0	0.35	0				
Industrial CHP Existing	8	0	0.43	0				
District Heating CHP Existing	9	0	0.33	0				
Coal-S	10	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L	11	0.12	0.5	1100	0.5	0.54	1100	1000
Coal CCS	12	0.12	0.44	1800	0.44	0.47	1800	1500
IGCC	13	0.12	0.52	1400	0.52	0.56	1400	1200
IGCC CCS	14	0.12	0.46	1500	0.46	0.5	1500	1300
Gas Turbine	15	0.12	0.39	380	0.39	0.39	380	380
Gas Turbine CHP	16	0.12	0.33	760	0.33	0.33	760	760
Combined Cycle-S	17	0.12	0.61	500	0.61	0.64	500	450
Combined Cycle-L	18	0.12	0.63	500	0.63	0.66	500	450
Combined Cycle SOFC	19	0.12	0.7	900	0.7	0.7	900	800
Combined Cycle CCS	20	0.12	0.55	700	0.55	0.6	700	600
Combined Cycle CHP	21	0.12	0.5	590	0.5	0.5	590	590
Nuclear	22	0.12	1	2100	1	1	2100	2100
Biomass/Waste Fired	23	0.12	0.42	1100	0.42	0.45	1100	1100
Coal-S-CoFire	24	0.12	0.49	1100	0.49	0.52	1100	1000
Coal-L-CoFire	25	0.12	0.49	1100	0.49	0.52	1100	1000

Figure C.16. Fuel prices and technological development (Greening end-users scenario)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
h	Carbon Permit Price (Euro/gr CO2)	Pract0-W1	Pract0-W2	Pract0-W3	Pract0-W4	Pract1-W1	Pract1-W2	Pract1-W3	Pract1-W4	Pract2-W1	Pract2-W2	Pract2-W3	Pract2-W4	Pract3-W1	Pract3-W2	Pract3-W3	Pract3-W4
2005	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2006	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2007	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2008	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2009	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2010	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2011	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2012	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2013	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2014	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.5	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.7
2015	0	-1.7	-0.05	-0.1	-0.1	-1.2	-0.1	0	-0.49	-1.3	-0.15	0	-0.35	-1	-0.25	0	-0.69
2016	0	-1.7	-0.06	-0.1	-0.1	-1.2	-0.12	0	-0.48	-1.3	-0.17	0	-0.345	-1	-0.28	0	-0.68
2017	0	-1.7	-0.07	-0.1	-0.1	-1.2	-0.14	0	-0.47	-1.3	-0.19	0	-0.34	-1	-0.31	0	-0.67
2018	0	-1.7	-0.08	-0.1	-0.1	-1.2	-0.16	0	-0.46	-1.3	-0.21	0	-0.335	-1	-0.34	0	-0.66
2019	0	-1.7	-0.09	-0.1	-0.1	-1.2	-0.18	0	-0.45	-1.3	-0.23	0	-0.33	-1	-0.37	0	-0.65
2020	0	-1.7	-0.1	-0.1	-0.1	-1.2	-0.2	0	-0.44	-1.3	-0.25	0	-0.325	-1	-0.4	0	-0.64
2021	0	-1.7	-0.11	-0.1	-0.1	-1.2	-0.22	0	-0.43	-1.3	-0.27	0	-0.32	-1	-0.43	0	-0.63
2022	0	-1.7	-0.12	-0.1	-0.1	-1.2	-0.24	0	-0.42	-1.3	-0.29	0	-0.315	-1	-0.46	0	-0.62
2023	0	-1.7	-0.13	-0.1	-0.1	-1.2	-0.26	0	-0.41	-1.3	-0.31	0	-0.31	-1	-0.49	0	-0.61
2024	0	-1.7	-0.14	-0.1	-0.1	-1.2	-0.28	0	-0.4	-1.3	-0.33	0	-0.305	-1	-0.52	0	-0.6
2025	0	-1.7	-0.15	-0.1	-0.1	-1.2	-0.3	0	-0.39	-1.3	-0.35	0	-0.3	-1	-0.55	0	-0.59
2026	0	-1.7	-0.16	-0.1	-0.1	-1.2	-0.32	0	-0.38	-1.3	-0.37	0	-0.295	-1	-0.58	0	-0.58
2027	0	-1.7	-0.17	-0.1	-0.1	-1.2	-0.34	0	-0.37	-1.3	-0.39	0	-0.29	-1	-0.61	0	-0.57
2028	0	-1.7	-0.18	-0.1	-0.1	-1.2	-0.36	0	-0.36	-1.3	-0.41	0	-0.285	-1	-0.64	0	-0.56
2029	0	-1.7	-0.19	-0.1	-0.1	-1.2	-0.38	0	-0.35	-1.3	-0.43	0	-0.28	-1	-0.67	0	-0.55
2030	0	-1.7	-0.2	-0.1	-0.1	-1.2	-0.4	0	-0.34	-1.3	-0.45	0	-0.275	-1	-0.7	0	-0.54
2031	0	-1.7	-0.21	-0.1	-0.1	-1.2	-0.42	0	-0.33	-1.3	-0.47	0	-0.27	-1	-0.73	0	-0.53
2032	0	-1.7	-0.22	-0.1	-0.1	-1.2	-0.44	0	-0.32	-1.3	-0.49	0	-0.265	-1	-0.76	0	-0.52
2033	0	-1.7	-0.23	-0.1	-0.1	-1.2	-0.46	0	-0.31	-1.3	-0.51	0	-0.26	-1	-0.79	0	-0.51
2034	0	-1.7	-0.24	-0.1	-0.1	-1.2	-0.48	0	-0.3	-1.3	-0.53	0	-0.255	-1	-0.82	0	-0.5
2035	0	-1.7	-0.25	-0.1	-0.1	-1.2	-0.5	0	-0.29	-1.3	-0.55	0	-0.25	-1	-0.85	0	-0.49
2036	0	-1.7	-0.26	-0.1	-0.1	-1.2	-0.52	0	-0.28	-1.3	-0.57	0	-0.245	-1	-0.88	0	-0.48
2037	0	-1.7	-0.27	-0.1	-0.1	-1.2	-0.54	0	-0.27	-1.3	-0.59	0	-0.24	-1	-0.91	0	-0.47
2038	0	-1.7	-0.28	-0.1	-0.1	-1.2	-0.56	0	-0.26	-1.3	-0.61	0	-0.235	-1	-0.94	0	-0.46
2039	0	-1.7	-0.29	-0.1	-0.1	-1.2	-0.58	0	-0.25	-1.3	-0.63	0	-0.23	-1	-0.97	0	-0.45
2040	0	-1.7	-0.3	-0.1	-0.1	-1.2	-0.6	0	-0.24	-1.3	-0.65	0	-0.225	-1	-1	0	-0.44

Figure C.15. Priority weights for the practitioner groups (Greening end-users scenario)