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High level process descriptions and ownership of information related to contract structures and billing of demand response and distributed energy resources

Version 1.0

Created:	2012-04-05
By:	Niko Joensuu, Empower Pekka Pietilä, Empower Jan Segerstam, Empower

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1. Preface

This report is part of the results from the second funding period of the Finnish national research project ”Smart Grids and Energy Markets”. The project has been funded by Tekes – the Finnish Funding Agency for Technology and Innovation.

This document is based on work done in the first and second funding periods within work package four of the SGEM-project. The work has been carried out as per the research plan and in conjunction with the SGEM partner consortium.

1.1. Purpose

The purpose of this document is to outline and describe the high level process descriptions related to active customers in a smart grid environment. Specific focus has been taken to enable a toolbox like set of information structures in the future to enable billing and contracting of active customers. This work will be complemented by further research carried out in the third funding period of the SGEM-project.

1.2. Scope

The scope of this work is limited to describing the high level structures involved. It is left to detailed use case modeling work to describe actual information interchanges or device interfaces. This work is not meant to be a technical device interface description.

2. Study case 1 – Demand response process - Supplier

This chapter considers the demand response process from the supplier's point of view. The different types of demand response are introduced and the required information structures for the billing and contracts are considered. High level process description illustrates that what kind of information is required to be handled in the supplier's information systems and what kind of information flows are needed between different modules.

2.1. Introduction

Demand response can be described as a limitation of the power demand during the peak power hours and the peak price hours by shifting the power demand away from those hours. Therefore, demand response is not similar to energy saving as it does not necessarily reduce the required energy but only shift the need for it. Ultimately, the goal of demand response is to reduce the electricity consumption during the peak price hours and to reduce the peak prices by affecting the formation of the market price of electricity.

Reduced peak prices benefit many market actors. An enterprise can achieve savings in power purchase costs by committing itself to the demand response operation. Generally, even a possibility to limit the electricity consumption during a single hour a day could bring benefits.

From the supplier's point of view the demand response process can be described as follows. The supplier predicts how the customers consume electricity and determines a need for demand response. After the need for demand response has been determined, the supplier needs to communicate the need to the consumers. This can be done by sending a demand response request or by using direct load control. These kinds of actions can be regarded as incentive based demand response. Furthermore, demand response can also be price based, which means that demand response actions are customer initiated actions which are implemented based for example on the price signals. To be able to confirm the effects of demand response actions, it should be possible to verify them.

2.2. Contract structure

Demand response process requires a contractual agreement between the supplier and the customer. With the contract the customer commits to adjust the electricity consumption within agreed limits according to the needs of the supplier. The following issues can be agreed between the customer and the supplier in the demand response contract:

- A total amount of load that can be used in demand response purposes (supplier's estimate)
- A load profile or other pre-defined consumption model of the customer loads that could be utilized in demand response (e.g. electric heating). These are utilized to predict the load control potential of the loads.
- Limitations for the amount of load and for the duration of the load control period. Examples:
    - Agreement on how long the load control action can be active for the agreed loads within the agreed time period. For example "load control can be active maximum of six hours during the night-time (10 p.m.-7 a.m.)"
    - Agreement on how long a single load control operation can be active (e.g. one or two hours)
    - Agreement on how often the supplier can utilize the load control (e.g. two times a month)

  - Possible limits for the temperatures (programmed in the equipment, the supplier does not actively monitor this issue)
  - Price limits which define when the load control is allowed to be utilized
- The communication channel and methods from the supplier to the customer must be defined, for example if the demand response is based on the request or critical peak pricing.
- Pricing of the electricity and the compensations based on the demand response. Also, the calculation principles of the compensations.
- All the agreed issues must be delivered to the supplier's system that is used to handle the demand response process. In addition, the issues need to be delivered to the billing module for the invoicing purposes.

2.3. High level process description

The process description is introduced on the below. In the description the information systems of a supplier are divided into modules, which include the required information for the demand response process and for the billing. The process description is based on the supplier centric market model, which means that the supplier invoices also the electricity distribution based on the invoice data from the DSO.

The process description includes the different methods to be used for implementation of desired demand response actions. The demand response can be based on the demand response request that is delivered from the supplier to the end customer. Alternatively, the demand response can be implemented by direct load control. The options are that the supplier have an access to the consumer's load control device and is therefore able to send load control signals or the load control signals are delivered to the local DSO which ultimately implements the load control based on the load control messages that has been sent by the supplier.

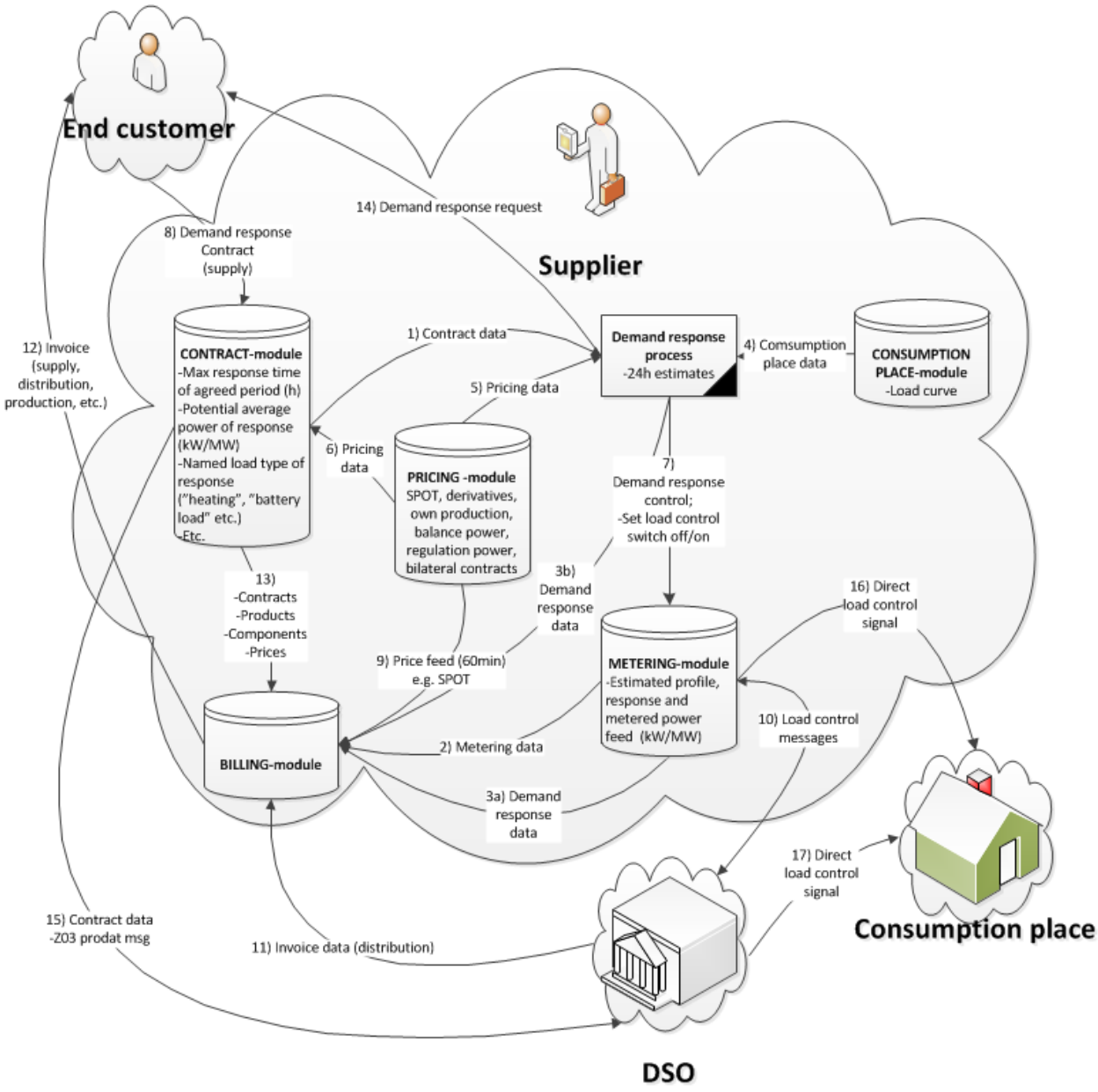

Figure 1. *Demand response process – supplier.*

The descriptions of what kind of information the different information flows contain are introduced in the deliverable 4.6.6 (Study of efficient integration of information related to the demand response processes between information owners and processes).

2.4. Price based demand response

Price based demand response is based on the dynamic pricing of the electricity that enables the consumer to reduce the electricity bill by optimizing the electricity consumption according to the dynamic prices. Therefore, the demand response actions are consumer initiated actions without direct load control signals from the market actors e.g. suppliers. The amount of potential savings for the consumer depends on the fluctuation of the electricity price. Ultimately, it defines the savings that can be achieved by shifting the

electricity consumption away from the hours with high prices. Real-time pricing, critical peak pricing and time-of-use pricing are some examples of dynamic pricing models.

Real-time pricing model

In real-time pricing model, the price of electricity is based on the market price of electricity (spot price). This gives an incentive to reduce the electricity consumption during the high spot prices. This kind of pricing model set requirements for the contract- and billing-modules and for the integration between them. The hourly based price information is needed to be delivered to the billing-module. Additionally, the billing needs to be based on the actual hourly consumption data. The billing would be based on the spot prices added with agreed margin or premium. In this pricing model it could also be required by the consumer that a price cap is agreed for the highest possible price level, which would mean that a limit would be set for the highest possible hourly price. This would reduce the price risk for the consumer and shift it to the supplier. Alternatively, the consumer could agree on a certain amount of electric energy and a fixed price for this certain amount. After the agreed time period the difference between agreed electricity consumption and the realized electricity consumption would be invoiced or compensated according to the spot prices.

Time-of-use pricing model

Time-of-use pricing model means that the price of the electricity is determined according to the time of the day or time of the year when the electricity is consumed. Basically this kind of pricing model does not set additional requirements for the contract- and billing modules or for the integration between them. Time-of-use pricing model is already in use for example with current night-time electricity products.

Critical peak pricing model

The basic idea of the critical peak pricing is that the price of electricity is always fixed excluding some hours when the price is set to be extremely high. This means that the supplier set a high price rate for example for 10 or 100 hours in a year. These are the most potential critical hours from the supplier point of view. These hours are agreed beforehand and the consumer is informed of them in advance for example by e-mails or text messages. Requirement for this pricing model is that in addition to the fixed electricity price, also the hourly price information of the exceptional hours needs to be delivered to the billing-module. Therefore, this type of pricing model requires that the billing is based on actual hourly consumption so that the exceptional hourly prices can be taken into account.

2.5. Incentive based demand response

Incentive based demand response is based on the idea that the end customer agrees about enabling the demand response with the market actor. This kind of agreement enables demand response regardless of the used tariff types. Compensation that is paid to the consumer for the load control possibility and based on the verified demand response actions are agreed in the contract between the end customer and the market actor. Load control can be based on the demand response request from the market actor or it can be based on the direct load control initiated by the market actor for example in a case of strict power balance situation. Generally, a metering or similar reliable method is needed to confirm the adjustment of electricity consumption in order to verify the effects of a demand response operation.

Demand response operation

Basically the demand response operation can be implemented in two possible ways that can be described as follows. The issues that are agreed in the contract between the supplier and the consumer must be taken into consideration when implementing demand response operations.

In a case of direct load control, the supplier executes the demand response operation. Direct load control signal can be delivered directly to the system that controls the customer loads, which is owned by the supplier or consumer. Alternatively, the signal can be delivered to the DSO in a defined message form. In this case, the DSO would own the equipment which can be used for load control.

If there is no equipment in the consumer's premises that can be utilized for load control the demand response operation can be implemented in a form of a request. Basically, this means that the supplier requests the consumer to adjust the electricity consumption. Demand response request is delivered to the consumer and to the billing-module. It could be agreed in the demand response contract that the possible compensations are paid only after the effect of the demand response operation is verified. The information about the demand response operation needs to be delivered to the billing-module because of the potential compensation or customer report.

Fixed pricing

Fixed pricing means that the supplier or the DSO pays a fixed compensation to the consumer for the load steering possibility. This means that the compensation is always paid regardless of whether the load control is actually used. Compensation can be a fixed amount of money or it can be a relative share of the electricity price. In this case the products and contracts can be designed in a way that they include the fixed price information with the possible compensations. Therefore, it would not set additional requirements for the contract-module or for the billing-module.

Examples:

Demand response electricity	*x kWh*	*y c/kWh*

, where x stands for the actual measured consumption (consumption to be invoiced) and y stands for fixed unit price, which already includes the compensation (it is not separated).

Demand response electricity	*x kWh*	*y c/kWh*
Compensation for the demand response	*x kWh*	*-z c/kWh*

, where x stands for the actual measured consumption (consumption to be invoiced), y stands for the unit price without compensation and z stands for the fixed priced compensation.

Demand response electricity	*x kWh*	*y c/kWh*
Compensation for the demand response	*n month*	*-z €/month*

, where x stands for the actual measured consumption (consumption to be invoiced), y stands for the unit price without compensation, n stands for the invoicing period (in months) and z stands for fixed priced time based unit price of the compensation.

Dynamic pricing

Dynamic pricing means that the consumer receives compensation which is depending on the compensation rates that are agreed in the contract and are based on the verified demand response operations. This means that the methods for the calculation of the compensation must be presented in the bill. Some possible compensation units could be the following. The compensation could be based on the amount of electric energy involved in the demand response operation(c/kWh). Alternatively, the compensation could be time-based, which means that compensation would be paid according to the number of hours when demand response operation was activated or the request was in place(€/h). Finally, the compensation could also be based on the number of load control operations(€/pcs).

Parameters for dynamic pricing

The following parameters can be utilized when defining the compensation for demand response (credit line in the bill):

- Regular price of the electricity product (e.g. energy price, basic fee)
- Average agreed demand response potential (kW/MW)
- Realized spot prices
- The prices for the single critical peak price hours
- Agreed cap for the maximum value of the spot price
- The weighted average spot price for the time period (billing module calculates this based on the available hourly consumption data, for example realized measurement)
- Duration of the demand response operation (h) –> can be also a shorter period e.g. 15 minutes.
- Realized number of the demand response actions or load control operations
- Realized energy consumption data of a consumption place (kW/MW)
- Consumption estimate of the consumption place (kW/MW)
    - Factors can be for example the estimate of the annual consumption, load profile of the consumption place and temperature information
- Estimated demand response potential of the consumption place (kW/MW)
    - Factors can be for example average demand response potential and the load profile of the load that is used for demand response
- In addition, the equation which is used to determine the compensation must support regular mathematical expressions and variable processing.

3. Study case 2a – Distributed energy resources – Netting

Netting is based on the idea that the distributed energy resources (energy storages, small power plants, solar panels etc.) are used to level or reduce the consumption in the consumption place. This means that the

possible additional production that is not fully consumed in the consumption place is not delivered to the power grid. The end customer can choose when to use the available energy storages or production capacity.

3.1. Contract structure

The load profile of an end customer who is utilizing netting can differ from the average end customer. Therefore, it is important for the supplier to be informed if an end customer is starting to utilize netting as it would affect the supply forecast. Basically, it would be beneficial to be able to form a load profile for the consumption place that is starting to utilize netting. This could be possible by defining the load profile by utilizing the consumption data that would become available after a while. Therefore, the load profile would be based on the experience of how the load of consumption place has behaved. One option could be to use the consumption information from the preceding twelve months. The contract between the supplier and the consumer must include the agreed method for the production reporting. This would enable the end customer to monitor the effects of the netting on the electricity invoicing.

3.2. Pricing and invoicing

If there is a separate hourly metering for both, consumption and the production, it would be possible for the supplier to offer a service that would include the reporting of the production and the effects of it on the invoicing. This would mean that the end customer would be able to monitor the benefits that have been achieved by netting. The reporting of the production could be delivered with a web based service or by delivering informative bills which include the information of the effects from the customer's own production. Basically, this requires that the billing-module need to include an operation capable of calculating the monetary value of the production based on hourly production values. The value for the production would be based on the unit price of the regular electricity product. The netting operation would be done for the hourly consumption values that would be delivered to the billing-module before the delivery.

3.3. Risk management and customer production report

The process description on the below introduces the information flows that would be required in netting. Basically, most of the issues were already described earlier in this chapter. The production and the consumption of a consumption place would be separately metered. Production can be for example wind power or solar power. This data would be utilized by the supplier in order to determine a "DER" load curve, which could be utilized for example in risk management process. The risk of the end customer who is utilizing netting is that the load profile can differ notably from an average similar end user, which can cause challenges for the supply forecast.

The values of the consumption and the production would be combined in order to deliver the invoicing energy to the billing-module, which produces the invoice. The information on the production would be reported to the end customer as an attachment in the invoice or by offering separate web-portal for the monitoring purposes.

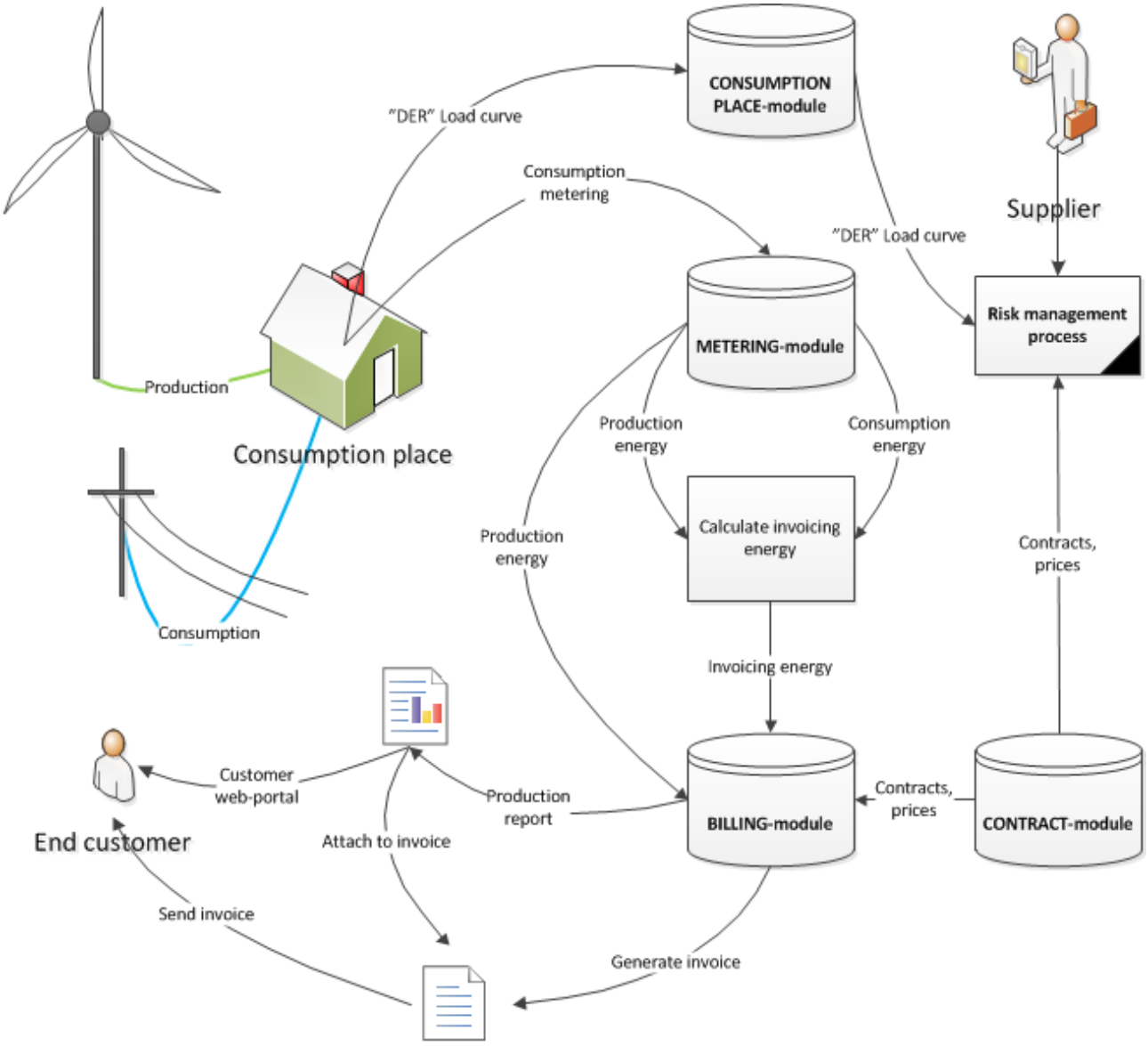

Figure 2. *Risk management and customer production report.*

4. Study case 2b – Distributed energy resources – Producer

The basic idea is that the end customer owns a power plant or a share of it. This means that the power plant could be owned by multiple end customers, which share the potential profits for the produced energy. Production resources are operated in the electricity markets and the end customers can benefit by earning profit for the production. The netting operation is settled in the bill by monetary terms. The end customer's production does not affect the load profile of the consumption place. Therefore, the production resources require a separate consumption place ID.

Furthermore, this sets requirement for the metering as the power plant must be equipped with hourly metering device. This is a requirement for all electricity production that is connected to the distribution network and if the electric energy is delivered to the network. On the other hand, consumption place that has consumption in addition to the production, must be equipped with a metering device which is capable to register the input and output energy separately. In addition, a consumption place with main fuses larger than 3x63 amps must be equipped with a metering system that enables to determine the production that is consumed in the consumption place. It is a producer's responsibility to arrange these systems.

4.1. Contract structure

In this study case, all of the produced electric energy is sold to the electricity market. Therefore, the end customer must have the following contractual agreements with the market actors. In addition to the connection-, distribution- and electricity supply contract the end customer must have a production distribution contract with the DSO and a production supply contract with the supplier. The end user is under the tax responsibility regarding the power production. Electricity tax announcements must be delivered to customs on a monthly basis.

With the production supply contract the supplier commits to purchase the end customer's electricity production. This electricity supplier is not necessarily the same that is delivering the electric energy for the end customer. Even if the supplier is the same, the product and the prices regarding the electricity production that is purchased by the supplier can differ from the values of the electricity supply contract. As the power plant can also be operated by a cooperation of multiple end users, it must be taken into account in the contracts. This means that the consumers have a certain share of the power plant and therefore of the energy production. The consumers can for example have a percentage share of the power plant. It would be beneficial for the supplier and the DSO to acquire the production profile to be used in forecasts.

4.2. The supply fee of a production

There is a separate electricity product in the production supply contract.

An example:

Production electricity *x kWh* *-y c/kWh*

, where x stands for the produced energy, including the possible information about the end customer's share of the power plant and –y stands for the agreed unit price for the production (compensation price gets a negative sign). As a result, the negative billing price is formed (this is the amount of compensation for the production).

When the end customer has a same electricity supplier that delivers the electric energy and purchases the produced electric energy it is possible that the billing module carries out the netting operation.

An example:

General electricity	*x kWh*	*n c/kWh*
Production electricity	*z kWh*	*-y c/kWh*

, where x stands for metered electricity consumption, n stands for the unit price of consumed electricity, z stands for the metered electricity production taking also into consideration the information of the end customer's share of the power plant and y stands for the unit price for the electricity production. The idea is that if the value of the electricity production is higher than the value of the electricity consumption, a compensation bill is formed. In this case the compensation is delivered to the consumer or the compensation will be taken into account in the following bill.

The reporting of the value of the electricity production can be carried out in two ways. The service can be a web-based self-service that allows the end customer to monitor the values or the reporting can be included in to the bill. The end customer should be able to monitor the overall electricity production of a power plant as well as the one's own share of the production.

4.3. The price of the network services of the production

The Electricity Market Act (14 b §) states the following issues concerning the price of the network services of the electricity production:

- The maximum value for the fee that is collected from the production that is connected to the low- or medium voltage networks is 0.07 c/kWh
    - The price of the metering device is included in to the price of the network services
    - Possible additional services can be invoiced separately
- The electricity consumption is charged based on the regular price list of the network services
- The consumption of one's own production is charged based on the fees from the higher grid levels
    - This concerns the production plants higher than 1 MVA

4.4. Production contract and invoicing

The process description on the below illustrates the issues that were described earlier in this chapter. The end customer chooses the suppliers to agree on the production supply and electricity supply. The supplier that has a regular electricity supply contract with the end customer can be regarded as billing responsible party. Ultimately, this supplier invoices the end customer for the electricity supply, distribution and production based on the data that has been delivered by different market actors.

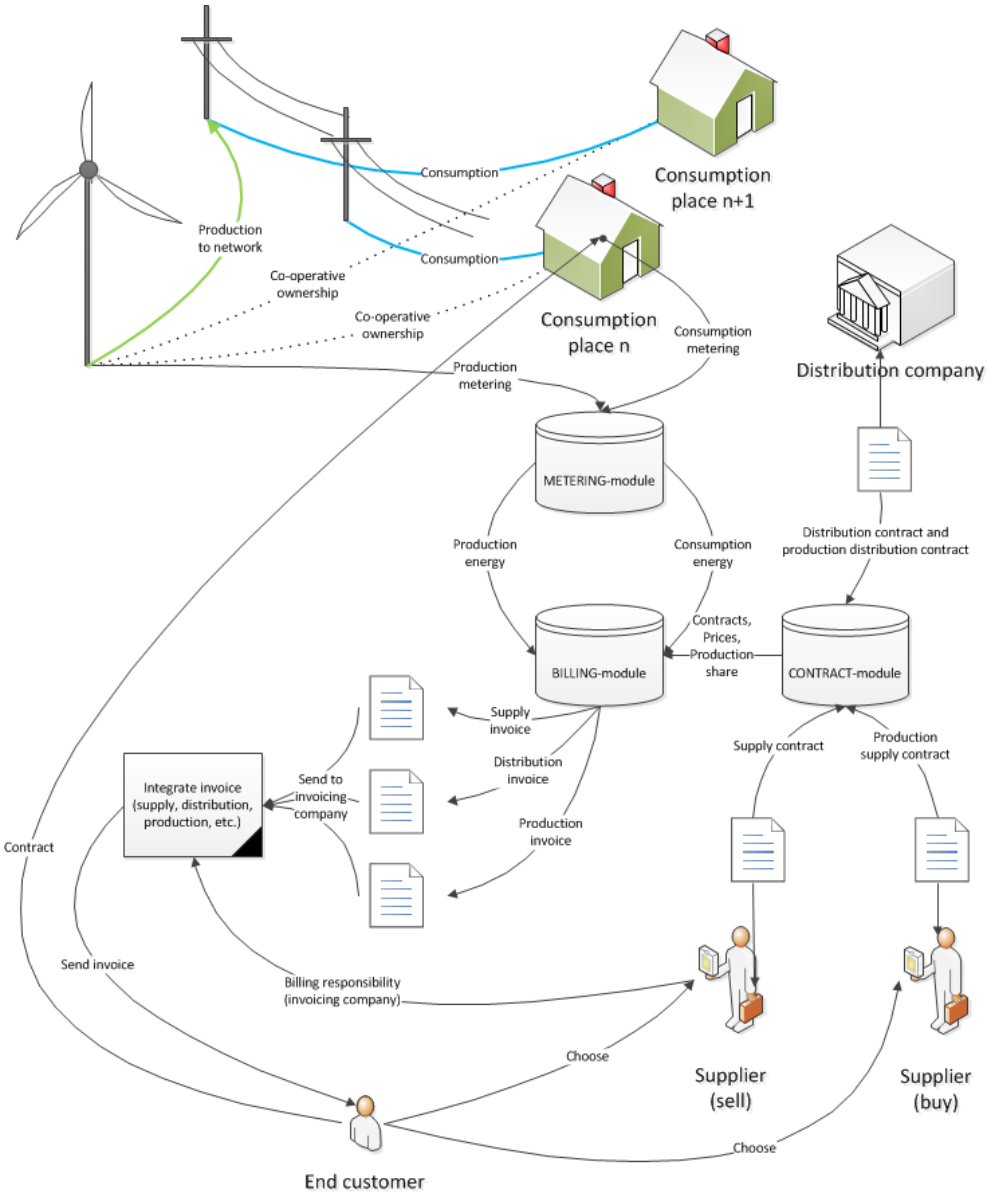

Figure 3. Production contract and invoicing

5. Study case 3 – Demand response process – Distribution system operator

Basically the target for the DSO initiated load control is to level the fluctuation of the power demand in the distribution network. The main goal is to secure the operation of the electricity distribution network. The direct connection to the load control equipment is a prerequisite for the DSO initiated load control. The load control operations can be momentary operations to restore the normal operational status or it can be used for example to limit the power demand during the exceptional events like storms. Therefore the guiding factors for the DSOs are for example the capacity of the distribution network, compensation of the reactive power and the frequency control. The compensation of the reactive power and the frequency control can become more important when the amount of distributed energy production will notably increase.

In addition to these, the decreased fluctuation of the power demand could benefit the DSO by reducing the distribution losses. Also, as the peak power level would be decreased it could allow the optimization of the network investments as the network and the components would not be required to be designed based on the momentary peak power levels. Still, the potential effects of demand response would be different in different parts of the distribution network. This is because the end customer number and the type of end customers as well as the overall load profile vary for example between the feeders. In order to determine the overall effects of the demand response, the whole distribution network must be taken into consideration.

The DSO initiated load control is not under the control of a supplier. Therefore, it can cause additional price risk for the supplier. The DSO could inform the suppliers about the load control operations that have been carried out including the number, volume and duration of the operations. The supplier could utilize this information in order to define the reasons for possible deviation between the estimated and realized consumption. Without this information flow the supplier could not be able to connect the effects of DSO's load control in to the deviation. Basically, the benefits for the end customers can be based on the similar pricing and contract structures as with the electricity supply, which were previously discussed in this document.

5.1. Contract structure

Basically, the price- and contract structures are similar than the ones used with the electricity supply. They enable to take into consideration the effects of DSO initiated load control actions on the distribution pricing. This way the end customers can achieve the benefits by participating in the demand response operations.

The future market model is planned to be based on the supplier centric market model. This means that the supplier would be the main contact point for the end customer on the issues related to the electricity. Basically only the issues that are strictly related to the physical network would be handled between the DSO and the end customer. This would mean that the end customer would make a contract only with the electricity supplier. This is also sometimes the case in the current market. Electricity supplier sends a Z03/14 migration message to the DSO and the DSO can automatically make a distribution contract based on that message. In this case, the end customer does not make contact with the DSO at any time during the process.

Still, in order to be able to offer a contract that includes the demand response agreement, the DSO should be informed about the end customer's demand response potential. Naturally, if the load control would be carried out with the DSO's own equipment the information about the demand response potential could be included to the information concerning the consumption place. Alternatively, if the supplier has agreed on the demand response with the end customer it could inform the DSO about the demand response potential in the Z03/14 message. In practice, the demand response contract between the DSO and the end customer requires a contact between these parties. Either the end customer need to contact the DSO to offer the demand response potential or the DSO would contact the end customer based on the information about the demand response potential that it has acquired.

5.2. High level process description

The process description on the below illustrates the demand response operations that were discussed earlier in this chapter. The information flows are quite similar to the ones that were illustrated in the chapter 2.3. Network module contains the information that DSO utilizes when determining the need for the demand response. The supplier that is regarded as invoicing responsible party invoices the end customer based on the information of the electricity supply, distribution and production.

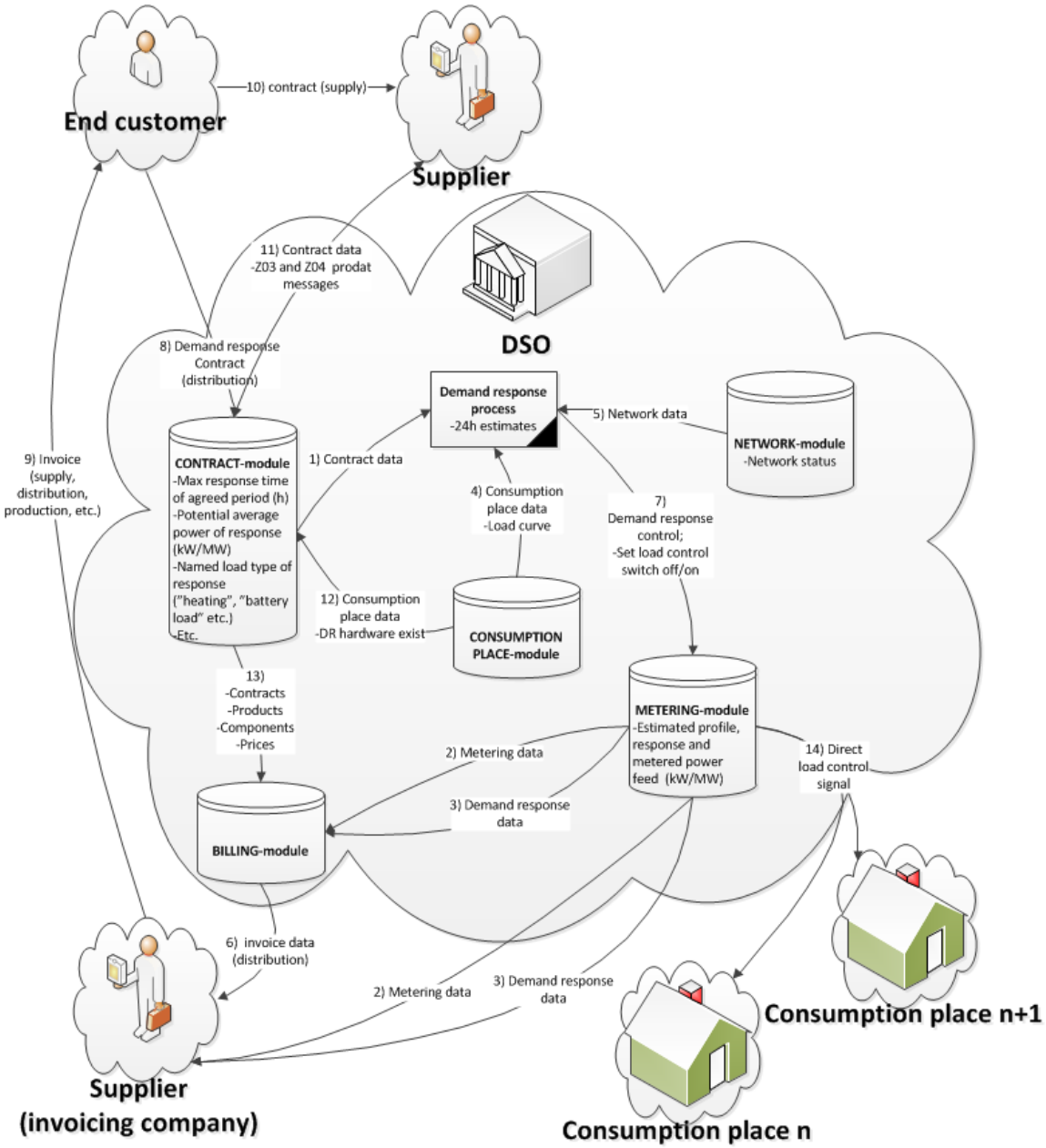

Figure 4. Demand response process – DSO

The descriptions of what kind of information the different information flows contain are introduced in the deliverable 4.6.6 (Study of efficient integration of information related to the demand response processes between information owners and processes).

6. Next steps