INTRODUCTION

The liberalisation of the electricity market in Slovenia in 2001 has brought many challenges to electric power system. The electricity market after July 2004 is 75% open with only household consumption as non-eligible customers. Design of the market in accordance with EU Directive 96/92 has opened new relations between players. The price of electricity is generally composed by price for energy and use of system charge. Particular attention was paid to network use charges, which essentially determine the overall electricity price. The paper is focused to the method for calculation of transmission and distribution use of network charges and its impacts on overall electricity price in the first regulatory period. In the Slovenian system there are one Transmission system operator and five Distribution regional network operators. Energy Agency as Slovenian Regulator supervises use-of-system charges with the aim to keep transparent electricity market relations and reliable system operation.

SELECTION OF THE METHOD FOR SLOVENIA

Criteria for the method selection

In the early stage of procedure of methodology selection for calculation use of network charges the decision makers set up basic criteria, which chosen method had to carry out. These criteria were as follows:
- Equality for all network users,
- Transparency,
- Simplicity and applicability of method in Slovenian circumstances,
- Effectiveness and reliability of the network,
- Incentives for network investments,
- Competitiveness in accordance with Slovenian legislation and
- Compatibility with Slovenian market model.

Based on initiated criteria and taking into consideration previous experiences in other European countries, Slovenia has selected postage stamp method. In further investigations decisions were made for cost allocation between three voltage levels (HV, MV, LV) and partitioning by gross method [1].

Some specialities of Slovenia system:
- Ownership of network operators is almost 100% of government,
- Existing voltage levels are as follows:
  - High voltage level (HV: 400, 220, 110 kV),
  - Middle voltage level (MV: 35, 20, 10 kV)
  - and low voltage level (LV 0.4 ...1 kV).
- All consumption connected at HV is at 110 kV,
- All distributed resources connected at MV and NN present only 4% of total production.

The methodology defines a regulatory period of three years, which started on 1 Jan 2003. Applying the method of price capping carries out economic regulation. The regulatory framework takes into consideration the operating and maintenance cost of the distribution and transmission networks that the Energy Agency prepared at the end of 2002, and that the government of the Republic of Slovenia approved, after which the Energy Agency published it in the Rules on the Amendments and Supplements to the Rules on Setting the Prices for the Use of Electricity Networks and the Criteria for the Eligibility of Costs.

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APPLICATION OF THE NETWORK USE TARIFF METHODOLOGY

Application Model

For the calculation of the network use tariff a synoptic spreadsheet model was developed [1,2]. The main structure of the model shows Figure 1. The main features of the model
are transparency, plainness and open code. The model use standard consumption, account and network asset data.

### NETWORK USE TARIF MODEL

#### Input Data:
1) **Consumption:**
   - Paccount
   - Waccount

2) **Network Asset Data:**
   - lines (km),
   - substations (Type, Nb),
   - transformers (Nb, kVA),
   - prices (Euro)

3) **Revenue (Required):**
   - Transmission
   - Distribution

#### Calculation
1) **Coincidence factors** ($F_{\text{coincidence}}$):
   - $T$ (operating hours)
   - Peak powers ($P_k$)

2) **Asset Purchase Value**
   - Transmission
   - Distribution
   - HV, MV, LV

3) **Network Tarifs**
   - power charge: $c_p$
   - energy charge: $c_w$

   **Levels**
   - HV, MV, LV (Applied)
   - HV(TR), MV(TR)- New

   **Groups**
   - $T \geq 2500$ h
   - $T < 2500$ h
   - residential

#### Equations (3):
- **Post stamp-brutto method**

### Mathematical model

The classification of the network users to consumer groups up to their connection points at different voltage levels up is the base of the network use tariff methodology (Figure 2). The correct asset data at the different voltage levels is necessary to assign required revenue of transmission and distribution companies as network costs to specific voltage level. The Slovenian case is that 400 kV, 220 kV and 80% of 110 kV system is owned by transmission system operator (TSO) and 20% of 110 kV network by five distribution utilities. Revenue of TSO and smaller part of the required revenue of distribution is assigned to high voltage (level 1) costs. The rest of revenue of distribution is assigned to lower voltage levels (1).

The network cost for each consumer group at a particular voltage level depends upon its average system peak load utilisation factor. The utilisation factor is ratio between consumer group peak load and sum of peak load of other consumer groups. This method is known as gross method for distribution the network costs to consumer groups to different voltage levels. The method is presented on Figure 2 and described in the following formulas (3,4):

$$ P_{k,n} = P_{\text{account},n} \cdot F_{\text{coincidence},n} \cdot T_n $$

$$ F_{\text{coincidence},n} = \left( \frac{8760 - T_n}{8760} \right)^3 $$

$$ T_n = \frac{P_{\text{account},n}}{W_{\text{account},n}} $$

$$ P_{k \text{system}} = \sum_{n=1}^{5} P_{k,n} \cdot F'_n \approx 0.8 $$

The peak load of each consumer group is the most important input data to split costs of the network to different consumer groups (Figure 2). Because of coincidence the peak load is not directly available from the measurements and account data except for the high voltage system load. In the model an approximate empirical formula is used to calculate peak load from account power and energy data and coincidence factor:
The costs attributed to each consumer group \( (C_{u,n}) \) are covered by charging of power \((c_p)\) and energy \((c_e)\):

\[
C_{u,n} = c_p \cdot P_{account,n} + c_e \cdot W_{account,n}.
\]

The costs are calculated from revenue, asset and consumption data \((4)\) the energy charge is usually selected. The only variable that should be calculated is power charge:

\[
\Rightarrow c_p = \frac{C_{u,n} - c_e \cdot W_{account,n}}{P_{account,n}}
\]

For the equity of the costs for the consumer groups below and over 2500 operating hours a special condition should be fulfilled at boundary of T=2500 h:

\[
\begin{align*}
&c_{p,u}(T=2500h) + 2500/12 \cdot c_{w,u}(T=2500h) = \\
&c_{p,u}(T=2500h) + 2500/12 \cdot c_{w,u}(T=2500h)
\end{align*}
\]

For one voltage level only one variable should be defined - energy charge for the consumer group T\(\geq2500\)h ... \(c_{w,u}(T=2500h)\). The power charge is then calculated from the (6) and condition (7):

\[
c_{w,u}(T=2500h) \cdots \text{defined}
\]

\[
\text{Calculation:}
\]

\[
c_{p,u}(T=2500h) = \frac{C_{u,n}(T=2500h) - c_{w,u}(T=2500h) \cdot W_{account,n}(T=2500h)}{P_{account,n}(T=2500h)}
\]

The charges for consumer group T<2500 h are calculated from consumption data, T\(\geq2500\)h charges considering (7):

\[
\begin{align*}
&c_{w,u}(T=2500h) = c_{p,u}(T=2500h) \cdot P_{account,n}(T=2500h) - c_{w,u}(T=2500h) \\
&= \frac{c_{p,u}(T=2500h)}{2500/12} \cdot P_{account,n}(T=2500h) + W_{account,n}(T=2500h)
\end{align*}
\]

\[
\begin{align*}
&c_{p,u}(T=2500h) = c_{w,u}(T=2500h) - W_{account,n}(T=2500h)
\end{align*}
\]

**Intermediate voltage level**

For the intermediate voltage levels \((n=2,4)\) the energy price component for the consumer group is the same as for the previous level. The difference in tariff is reflected only at the power price component \((10)\) at special condition that additional power price for consumer group with low operating hours \((T<2500 \text{h})\) is the same as for the consumer group with high operating hours \((T\geq2500\text{h})\). The average additional power charge of the intermediate voltage level is calculated as difference between actual costs of the intermediate voltage level and hypothetical revenue of intermediate voltage level quantities and prices of previous voltage level divided by sum of power \((11)\).

\[
\begin{align*}
&c_{w,u}(T=2500h) = c_{w,u}(T<2500h) \\
&\Rightarrow c_{p,u}(T=2500h) = c_{p,u}(T<2500h) + \Delta c_{p,u}^{\text{avg}}
\end{align*}
\]

\[
\Delta c_{p,u}^{\text{avg}} = \frac{C_{u,n} - R_{h_{n-1}}}{P_{account,n}(T=2500h) + P_{account,n}(T=2500h)}
\]

\[
\begin{align*}
&R_{h_{n-1}} = c_{w,u}(T<2500h) \cdot W_{account,n}(T=2500h) + \\
&\quad + c_{p,u}(T<2500h) \cdot P_{account,n}(T=2500h) + \\
&\quad + c_{w,n}(T<2500h) \cdot W_{account,n}(T=2500h) + \\
&\quad + c_{p,n}(T<2500h) \cdot P_{account,n}(T=2500h)
\end{align*}
\]

**THE SPECIAL CHARACTERISTICS OF PRACTICAL USE OF SYSTEM CHARGE IN SLOVENIA**

**Distribution Company Revenue Re-arrangement**

The network O&M and existing system costs are quite different for five distribution utilities in Slovenia. Therefore a special adjustment mechanism of Revenue Rearrangment was applied from Energy Agency. A customer pays a bill to Distribution Network Operator (DSO) at tariff for its voltage level connection point. A HV tariff multiplied with correction factor is assigned to Transmission System Operator (TSO) from each DSO. Correction factors diversify from 0.3 to 1.6 for DSO’s and cause Revenue Rearrangements (Figure 3). The result is up to 25% different average net price of distribution between DSO.
Energy Market Liberalization came into force in 2001. On Figure 4. The observed period is from 1995 to 2004, while electricity price comparison, for a typical non-eligible user (household), which yearly consumption is 3,5 MWh is shown.

Consequently Distribution Company’s revenue fails to cover energy purchasing costs and network costs for households. Households are still not eligible costumers in Slovenia and for them use of the system charge is included into the unified tariff for electricity. Yet, these tariffs are still set by the Government (based on the secondary legislation acts and in coordination with a Governments anti-inflation program).

In accordance with current restrictive governmental policy, which aim is to fulfil the ERM 2 criterion, the prices for households has raised less then the inflation rates. In accordance with current restrictive governmental policy, which aim is to fulfil the ERM 2 criterion, the prices for households have raised less than the inflation rates. Consequently Distribution Company’s revenue fails to cover energy purchasing costs and network costs for households. Electricity price comparison, for a typical non-eligible user (household), which yearly consumption is 3,5 MWh is shown on Figure 4. The observed period is from 1995 to 2004, while Energy Market Liberalization came into force in 2001.

The outcome of applied use of the system charges methodology is a tariff that is lower at higher voltage levels. The temporary three-voltage level tariff model induces a huge cascade decreasing of network use costs at higher connection point. The ratio between energy and use of network charge point out to higher degree of market opportunities for high voltage customers as for the middle or low voltage costumers (Figure 5). It is high pressure on cost reduction at companies having higher demand and utilisation factor. Some of them connected to MV network even show interest for investing into high voltage connection point (HV/MV substation). To assure optimal facilities and space usage the Energy Agency decided to apply additional intermediate voltage level connection points (HV or MV including transformation) to enable costs reduction to costumers who had covered major investments for their MV or LV network in the past.

CONCLUSION

The network use charges method applied in Slovenian system is quite similar as in many other European systems but with some specialities for Slovenia. However this calculation method is ongoing process, which will be upgraded for the next regulatory period (2006-2008) taking into consideration impacts of CBT mechanism, cost allocation between generation and load, increasing of connection points levels and structural categories.

REFERENCES