Energy Technology and Governance Program:

# South East European Distribution System Operators Disaster Response: Lessons Learned from Recent Climate Related Emergencies

February 4, 2016

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# Energy Technology and Governance Program

# South East European Distribution System Operators Disaster Response: Lessons Learned from Recent Climate Related Emergencies

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# 1. TERMS OF REFERENCE

Southeast Europe has been plagued with an increasing number of extreme climate related events the past few years which has jeopardized the security of supply of electricity. Catastrophic flooding, record breaking cold periods and severe icing have affected millions of electricity customers. As a result, the electric distribution system operators (DSOs) in the region have been faced with unprecedented power outages and damage to their distribution network infrastructure.

This study will review the recent catastrophic climate related events in Southeast Europe and analyze how the affected USAID / USEA DSO Security of Supply Working Group member DSOs responded to these extreme situations. The report will be based upon a combination of surveys and in-depth case studies which will identify which disaster response measures were utilized and their effectiveness.

The Consultant will identify the key emergency response and mutual assistance parameters to analyze in the report including existence and suitability of emergency and disaster response plans, the availability and deployment of human resources, inventory, repair equipment, use of weather forecasting tools, mutual assistance arrangements both within and outside of the company etc.). Questionnaires will be distributed to the Working Group DSOs to collect information on what emergency preparedness plans they have in place and what measures they utilized during recent climate related emergencies.

A minimum of two of the affected DSOs will then be utilized for case studies for this study. The consultants will travel to the select DSOs to conduct in-person interviews with key personnel who were responsible for responding to these emergencies. Post mortem analyses will be performed reviewing in-depth the specific disaster response and mutual assistance efforts that were utilized including the sharing of personnel, equipment, and spare parts both within different units of the same company and between other DSOs in the region, if applicable; the logistics to coordinate the responses, and the communication among the various parties.

The consultant will then perform a critical analysis of what disaster response measures were implemented, which ones worked and which didn't, and provide recommendations for improvements. The consultant will also review a select U.S. electric distribution utility's disaster response and mutual assistance best practices and determine their applicability in Southeast Europe.

The final report will include a recommended set of best practices for Working Group member DSOs on disaster response and mutual assistance programs. The structure of the report will include the following sections:

- Overview of the recent extreme climate related events in Southeast Europe including the extensive flooding in Bosnia and Herzegovina, Croatia and Serbia in spring 2014; the severe ice storms in Croatia (winter 2013/2014) and in Macedonia (winter 2014/2015).

- Based on surveys, review of the emergency response and mutual assistance measures undertaken by each of the affected Working Group member DSOs including details of any special technical solutions that were utilized.

- Case study analysis of a minimum of two Southeast Europe DSOs affected by recent climate related emergencies to perform a critical post mortem analysis of what disaster response measures were implemented, which ones worked, which didn't and provide recommendations for improvements.

- Review of a select U.S. DSO's emergency response best practices and an examination of their applicability to the DSOs in Southeast Europe

- A set of recommended guidelines for disaster response and mutual assistance programs

The project deadlines are given as follows, starting from the contract date:

- 2 weeks for preparation and distribution of the questionnaire,
- 3 weeks minimum for collecting the answers,
- 3 weeks for clarifications, amendments of the data and preparation of the overview.

**TASK 1: Survey the emergency response and mutual assistance measures undertaken by each of the affected Working Group member DSOs**

- Identify the key emergency response and mutual assistance parameters to analyze in the report (human resource management, inventory management, repair equipment, weather forecasting tools, mutual assistance arrangements both within and outside of the company)
- Prepare and distribute questionnaires to the Working Group DSOs to collect information on what emergency preparedness plans they have in place and what measures they utilized during recent climate related emergencies

| **Action** | **Date** | **Scope percentage** |
|---|---|---|
| Summary overview and presentation for each working group member DSO on their disaster response plans | 3 weeks after questionnaire responses collection (expected on June 1, 2015) | 20% |

**TASK 2: Case study analysis of a minimum of two DSO Working Group member utilities affected by recent climate related emergencies**

- Identify a minimum of two Working Group member DSOs for case study analyses
- Travel to the select DSOs and conduct in-person interviews with key personnel responsible for responding to recent emergencies
- Utilize the key emergency response and mutual assistance parameters identified in Task 1 to perform a critical post mortem analysis of what disaster response measures were implemented, which ones worked, which didn't and provide recommendations for improvements.

| Action | Date | Scope percentage |
|---|---|---|
| Case Studies of a minimum of two DSO Working Group Member Utilities Affected by Recent Climate Related Emergencies | 8 weeks after the preliminary presentation and input data collection (expected on July 30 | 30% |

**TASK 3: Select a U.S. Distribution System Operator and Provide an Overview of their Emergency Response Programs and their Applicability in Southeast Europe**

| Action | Date | |
|---|---|---|
| Overview of a U.S. Distribution System Operator's Emergency Response Programs and their Applicability in Southeast Europe | September 30, 2015 | Milestone |

**TASK 4: Preparation of Final Report**

| Action | Date | Scope percentage |
|---|---|---|
| Final Report | 4 weeks after US DSO data collection (expected on October 30, 2015) | 50% |

# 2. INTRODUCTION

On May 13-18 2014 a low-pressure cyclone designated *Tamara* and *Yvette* (Figure 3.1) affected a large area of South East and Central Europe, namely 10 countries: Poland, Austria, Czech Republic, Slovakia, Hungary, Croatia, Serbia, Bosnia - Herzegovina, Bulgaria and Macedonia, causing huge flooding and landslides, especially around Sava river (Figure 3.2).

Serbia, Bosnia - Herzegovina and Croatia suffered the greatest damage (Figure 3.3), as the rain was the heaviest in 120 years of recorded weather measurements. 83 people had died in SEE (57 in Serbia, 24 in BiH and 2 in Croatia) as a result of the flooding, and hundreds of thousands were forced out from their homes. Larger towns like Obrenovac (Serbia) and Doboj (BiH) account for most victims, after being inundated by waters several meters high from nearby rivers. The largest total damage estimated by European Commission was in BiH, around 2 bil.€, while in Serbia it was around 1.7 bil.€.

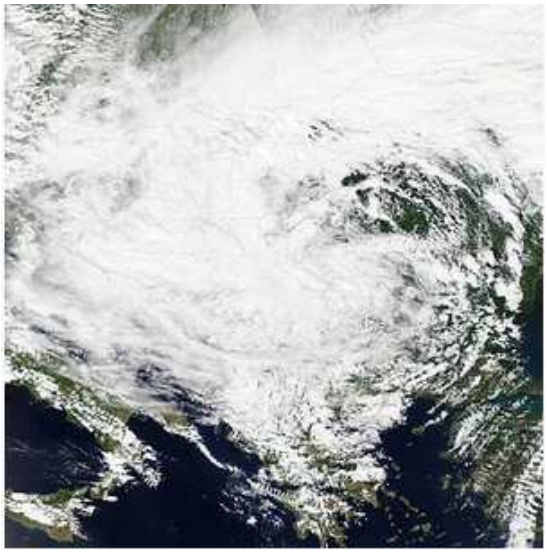

*Figure 2.1 Meteorological perspective of Tamara and Yvette storm in SEE in 2014, May 15*


*Figure 2.2 Satellite image on Sava river flooding (source: Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite, 19 May 2014)*

Floodwaters caused over 2,000 landslides across the region. The rains activated torrents and mudslides, and subsequently several rivers in watersheds of Sava and Morava rose and flooded surrounding valleys. Official counts over 1.6 million people affected only in Serbia and BiH, after a week of flooding. Total damage assessment was up to several billion €. Recovery process took a long time and effort, while several areas will never recover and remain inhabited.

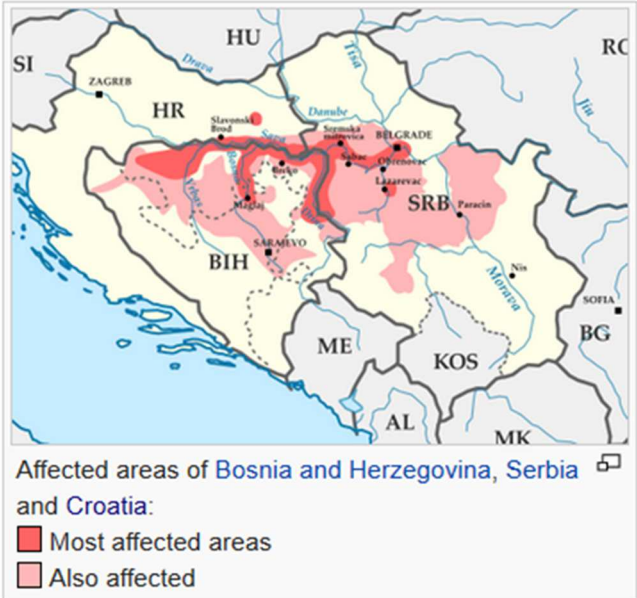


*Figure 2.3 Flooded areas in SEE (source: Wikipedia)*

Heavy storms and other climate change issues have different perspectives and consequences in many different areas: health, financial, social, technological etc. This report is focused on the South East European countries only and its power system damage and power supply consequences due to heavy weather conditions in 2014 and 2015. Other important aspects of the climate change will remain to be analyzed in some other analyses and reports.

# 3. TASK 1: SURVEY THE EMERGENCY RESPONSE AND MUTUAL ASSISTANCE MEASURES UNDERTAKEN BY EACH OF THE AFFECTED DSO

The basic set of input data for this report was collected through the survey/questionnaire distributed to all 9 DSOs in the region on April 25, 2015, including HEP ODS (Croatia), EPBiH (BiH), EPHZHB (BiH), ERS (BiH), EDB (BiH), EPS (Serbia), EVN (Macedonia), OSHEE (Albania) and KEDS (Kosovo). The questionnaire was consisting of 5 groups of topics, with 30 questions in total, related to power supply interruption issues due to heavy weather conditions in the period 2014 - 2015. Copy of the questionnaire is given in the Appendix. Responses were collected till May 22, 2015 and all 9 DSOs responded to the questionnaire. The responses are not given in the Appendix since most of the answers were in local language. Accordingly, collected data are analyzed and shown graphically in this Chapter.

Altogether 12 relevant events were reported (one event per each of 9 DSOs plus in Croatia there were 2 events reported and in Macedonia 3 events). More than 300 inputs were collected. Finally, 92% responses were collected, while remaining 8% of the data were not available, as shown in the following Table.

*Table 3.1 Input data availability per each DSO*

| Q/DSO | Albania | BiH (EPHZHB) | BiH (EPBiH) | BiH (EDB) | BiH (ERS) | Croatia | Serbia | Macedonia | Kosovo |
|---|---|---|---|---|---|---|---|---|---|
| 1a | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 1b | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 1c | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2a | √ | √ | √ | √ | √ | √ | X | X | √ |
| 2b | √ | √ | √ | √ | √ | √ | X | X | √ |
| 2c | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2d | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2e | √ | √ | √ | √ | √ | √ | √ | √ | X |
| 2f | √ | √ | √ | √ | √ | √ | √ | √ | X |
| 2g | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2h | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2i | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2j | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3a | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3b | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3c | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3d | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3e | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 3f | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 4a | √ | √ | √ | √ | X | √ | X | √ | √ |
| 4b | √ | √ | √ | √ | X | √ | X | X | √ |
| 4c | √ | √ | √ | √ | √ | √ | X | X | √ |
| 4d | X | √ | √ | √ | √ | √ | √ | X | √ |
| 4e | √ | √ | √ | √ | √ | √ | √ | X | √ |
| 4f | X | √ | √ | √ | √ | √ | X | X | X |
| 4g | √ | √ | √ | √ | √ | √ | √ | √ | X |
| 5a | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 5b | X | √ | √ | √ | √ | √ | √ | √ | √ |
| 5c | X | √ | √ | √ | √ | √ | √ | √ | √ |
| 5d | X | √ | √ | √ | √ | √ | √ | √ | X |

Generally, quality of collected input dana can be described as follows:

- lot of input data are descriptive
- part of data not available
- part of data not comparable
- might be necessary to spent some more time (meeting) on discussion and inputs clarification

Besides above mentioned flooding there were another 4 less intensive but still heavy weather events reported in the region in 2014-2015 that also affected power system operation, as shown on the following Figure. In total more than 1.5 million consumers were disconnected for the power system in given time frame 2014-2015.

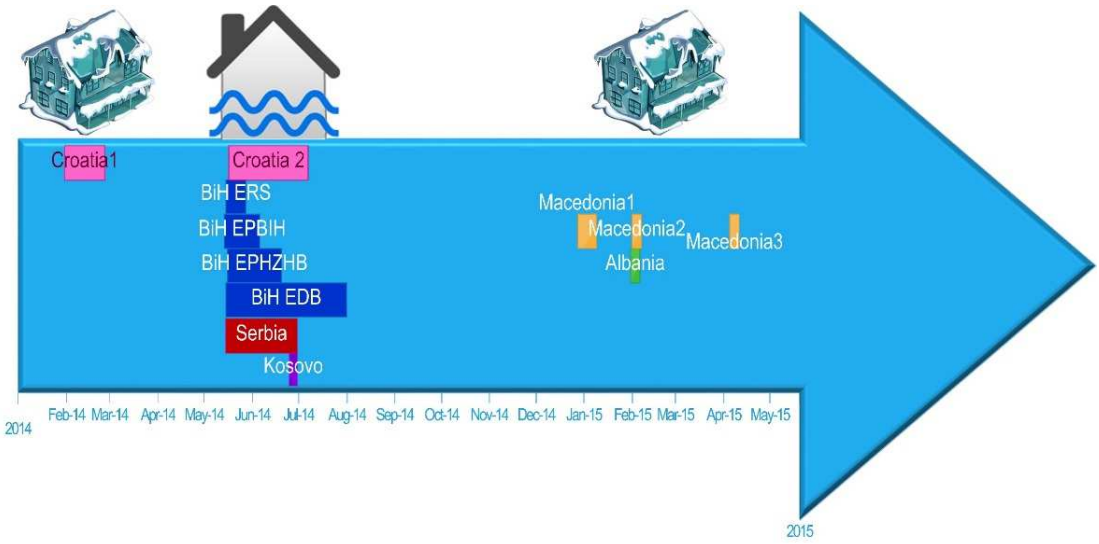


*Figure 3.1 Time scale of heavy weather events in SEE in 2014 - 2015*

The following heavy weather events have jeopardized SEE power system operation in 2014-2015:

1. Ice storm in Croatia (February 2014, untitled on the Figure 3.1 as “Croatia 1”)
2. Flooding in Croatia (untitled as “Croatia 2”), BiH, Serbia and Kosovo (May 2014)
3. Snow storm in Macedonia (January 2015, untitled as “Macedonia 1”)
4. Snow storm in Macedonia (February 2015, untitled as “Macedonia 2”) and Albania (February 2015)
5. Flooding in Macedonia (May 2015, untitled as “Macedonia 3”)

The largest power system direct damage was reported in Serbia (119 mil.€) and BiH (97 mil.€), mainly in power distribution and generation.

## 3.1. Experience with flooding

Natural disaster such as May 2014 flooding practically has never happened in this region. At least not in the last 120 years with recorded meteorological measurements. 7 out of 9 DSOs responded that

they've never had any comparable experience (EPHZHB (BiH), EDB (BiH), ERS (BiH), EPBiH (BiH), HEP ODS (Croatia), EVN (Macedonia), EPS (Serbia), while in Albania there were comparable snow storms on the northern part of the country (Shkodra region), but never on the South. Also, in Kosovo there were flooding comparable to the one from 2014, the latest one in 2015 followed by the heavy snow.

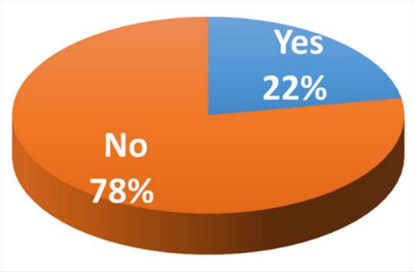


*Figure 3.2 Nine DSOs questionnaire responses: "Any comparable event in the recent history ?"*

## 3.2. Affected area and customers

In analyzed time horizon 2014-2015 and during all these emergency events there were around 1.5 mil. customers reported as disconnected, which is 16% of total number of customers in this region (9.2 mil.). The largest number of disconnected customers is reported in Macedonia, during the snow storm in January 2015 - more than 366 thousands and in the other event a month later in February - more than 290 thousands.

It is interesting that during the flooding in May 2014 that heavily hit mainly Serbia, BiH and Croatia there was a very different number of reported disconnected customers: in BiH 247 291, in Serbia 127019 and in Croatia significantly less – 2 983. This means that flooding affected urban areas in BiH and Serbia, while in Croatia it was mainly rural area.

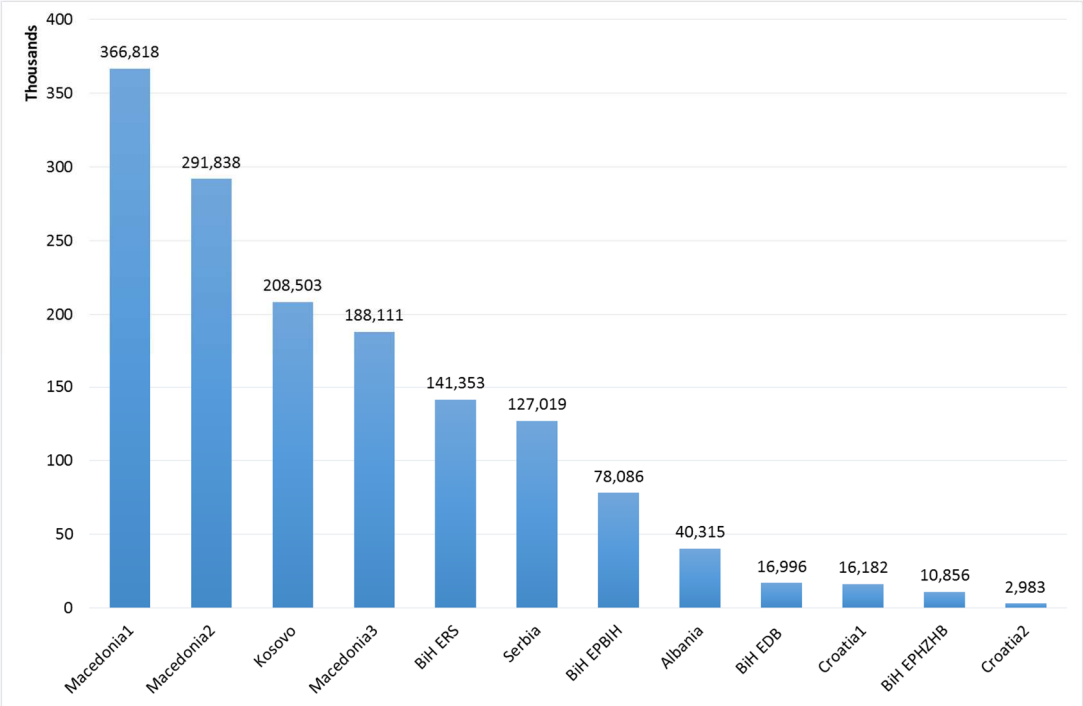


*Figure 3.3 Total number of disconnected customers per each reported event*

Looking cumulatively, from January to May 2014 there were about 30 000 disconnected customers reported altogether. In May it grew up to about 300 000 and in December up to about 700 000. Due to large number of disconnected customers in Macedonian emergency events in January, February and April 2015 total number of disconnected customers reached cumulative level of about 1.5 million till June 2015, as shown on the following Figure.

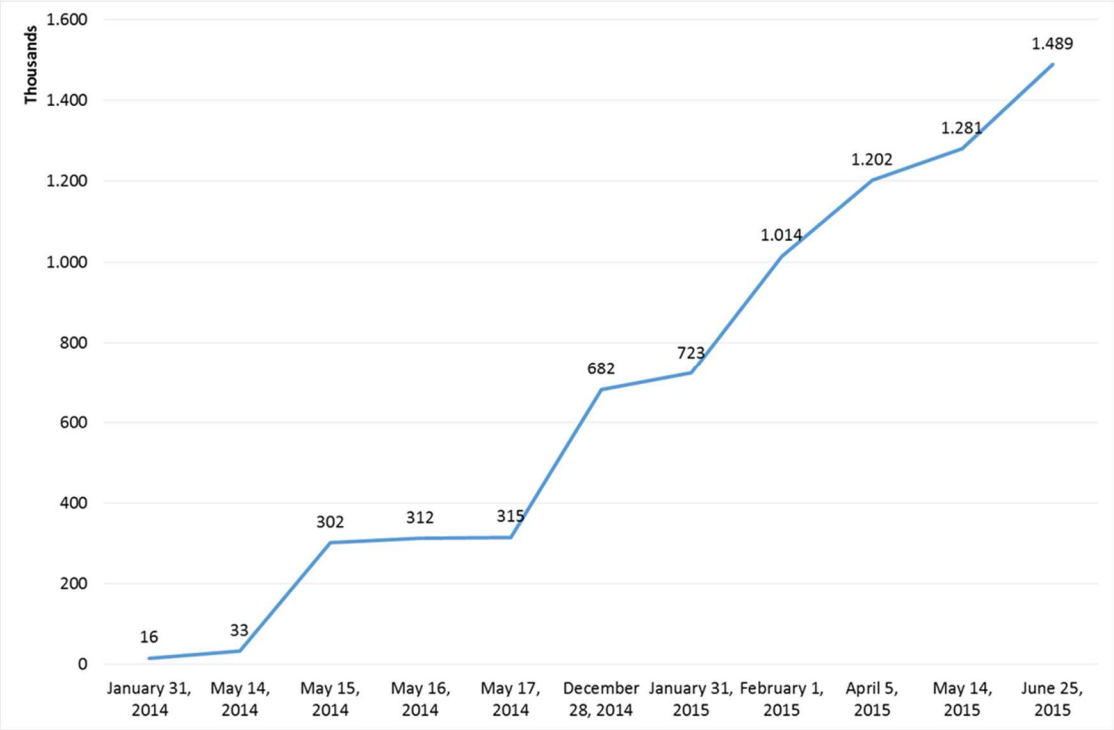


*Figure 3.4 Cumulative number of disconnected customers in SEE*

As given above, flooding in May 2014 mostly hit Serbia, BiH and Croatia. The largest number of disconnected customers was reported in BiH, about twice more than in Serbia while in Croatia it was much lower, even though the largest affected area was in Serbia (about 15000 km$^2$), in BiH 13,200 km$^2$ and in Croatia just 130 km$^2$ (see Figure 4.5).

In total, area affected by all analyzed events in the region was about 40500 km$^2$ . About half of it was in Serbia and BiH.

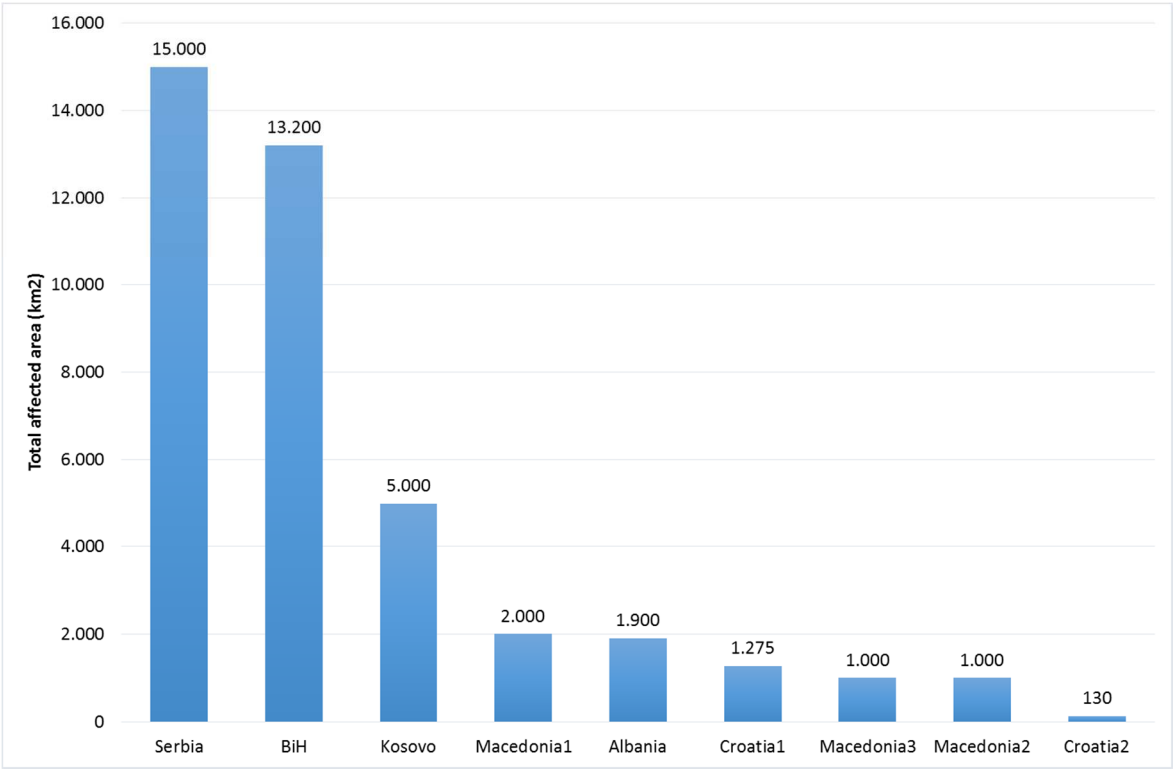


*Figure 3.5 Total area affected by the heavy weather events in 2014 and 2015*

Most of the this area was affected during the flooding in May 2014, as shown on the following Figure.

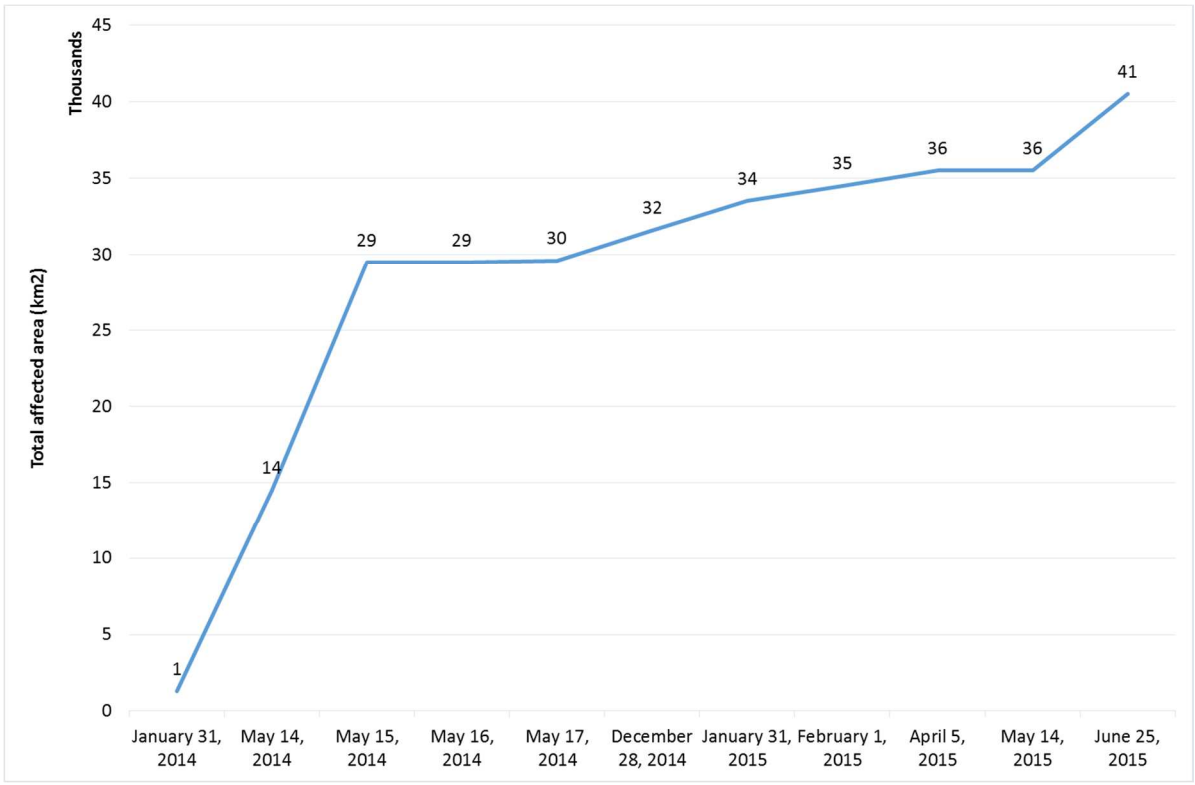


*Figure 3.6 Cumulative area affected by the heavy weather events in 2014 and 2015*

## 3.3. Electricity not delivered

One of the most important indicators of the impact of the heavy weather conditions to the power system operation is the amount of electricity not delivered. Unfortunately, for 6 out 12 events this value was not available, so total reported amount of 37 GWh electricity not delivered in 2014 – 2015 due to weather conditions is definitely not realistic value. Practically, only EPBiH reported full amount of undelivered electricity – 30,6 GWh. Total amount of electricity not delivered is much higher than 37 GWh. Moreover, there are no any more detailed specifics on the affected type of consumers (industry, households, services, public lighting etc.), so it is impossible to estimate the value of electricity not delivered.

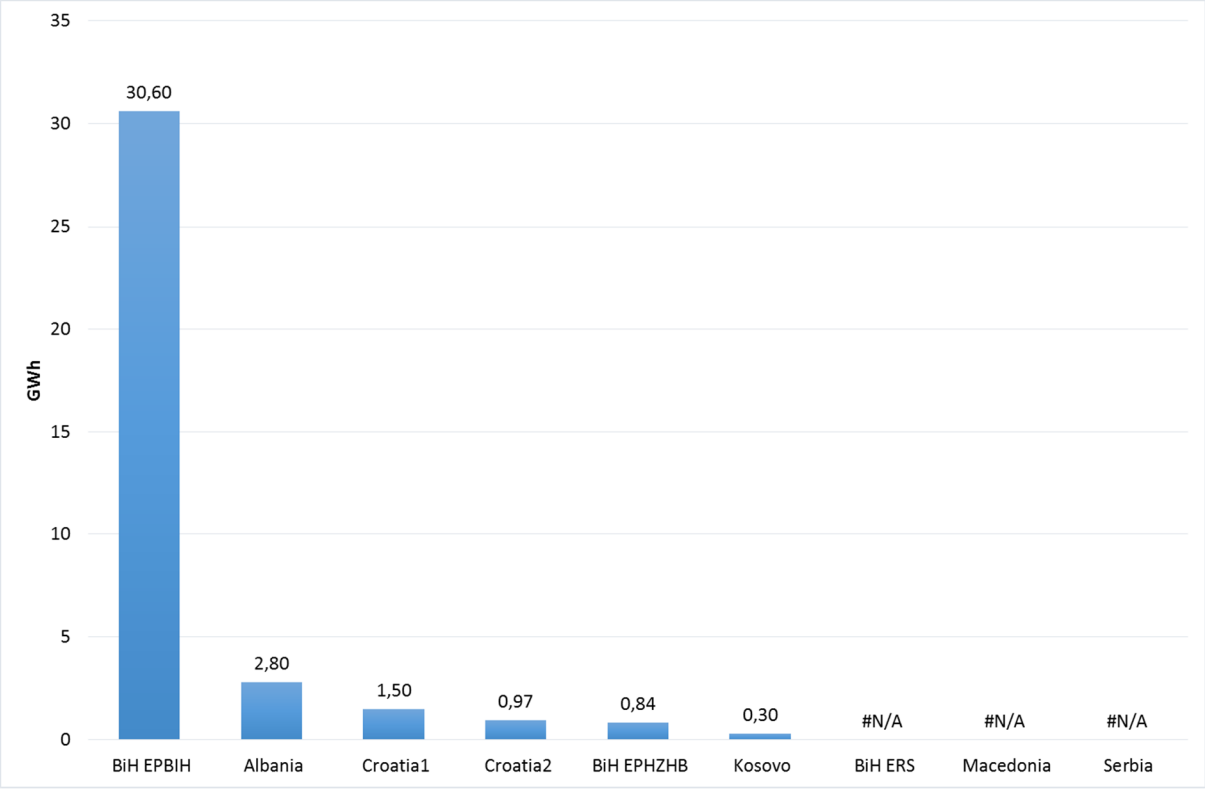


*Figure 3.7 Electricity not delivered during heavy weather events in 2014 and 2015 per each DSO*

## 3.4. DSO equipment damage assessment

Total reported damage in distribution network equipment due to heavy weather conditions in time frame Jan 2014 - June 2015 is 46 mil.€, as shown on the following Figure. But again, input data for three events in Macedonia were not available, so total damage in the region is certainly much larger. Also, it has to be kept in mind that these values represents estimated value of new equipment needed to replace damaged one. DSOs are obliged to follow public tendering procedure, so it is possible that final value of needed new equipment is slightly different than the estimated value.

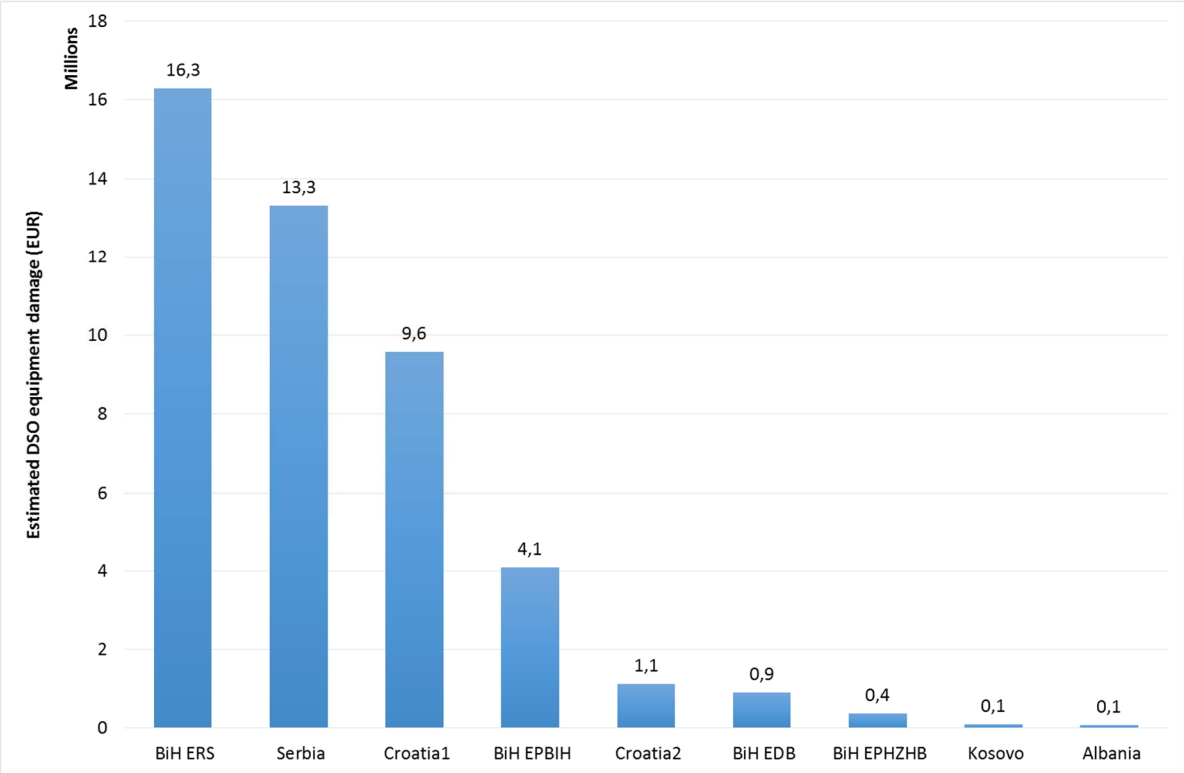


*Figure 3.8 DSO equipment damage assessment caused by heavy weather events in 2014 and 2015*

Total length of all reported damaged distribution lines is 2014 km (Figure 3.9). Data for Macedonia were not available. The largest share is in Serbia - 37%, 32% in BiH and 25% in Croatia. Remaining 6% was found in Albania.

Most of damaged lines was found on the low voltage level (0,4 kV) – 59% or 1194 km (Figure 3.10). 420 km or 21% of damaged lines was on 10 (6) kV voltage level, 269 km or 13% was on 20 kV and remaining 132 km or 7% on 35 kV voltage level.

Besides damaged lines there were much more disconnected lines that remained undamaged, as shown on the Figure 4.11. Data for Serbia, Kosovo and Macedonia were not available here.

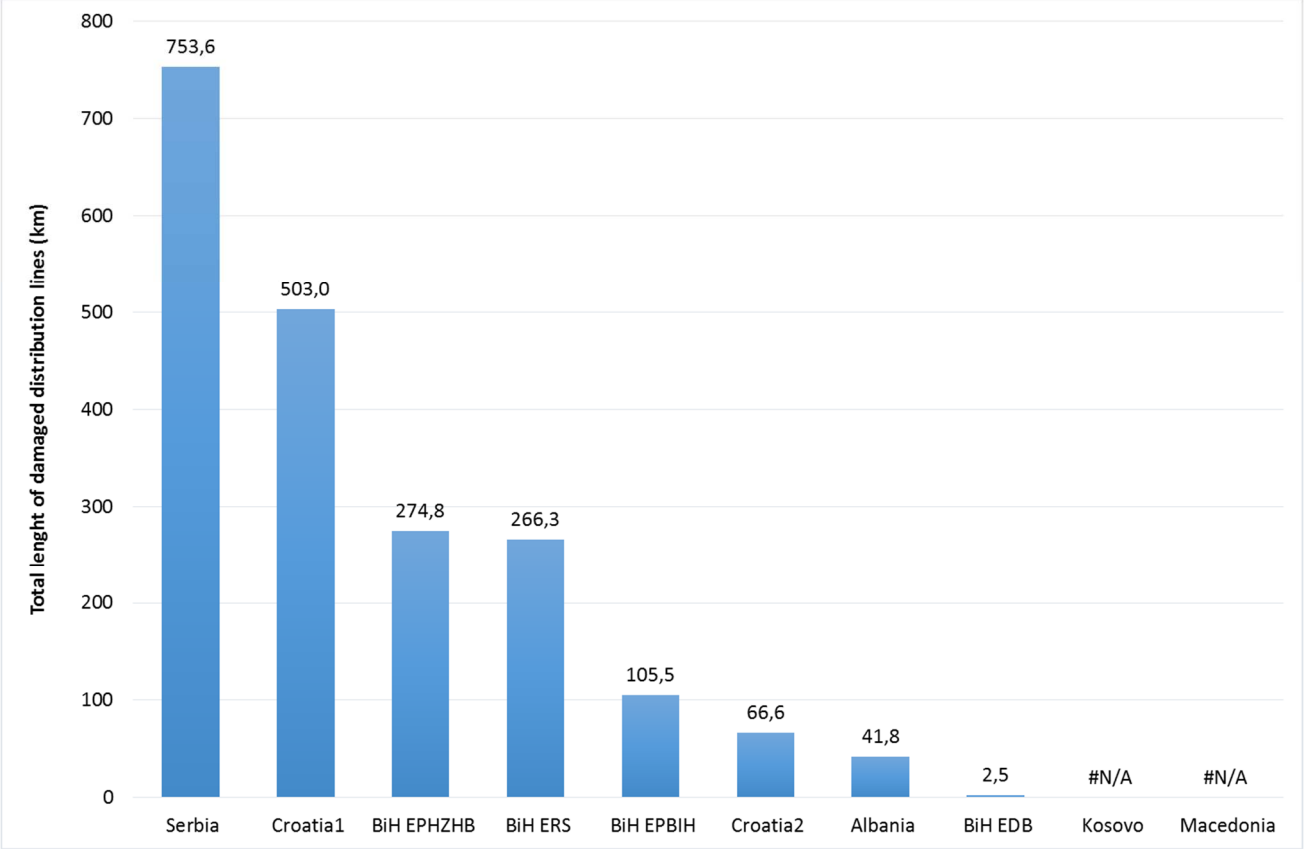


*Figure 3.9 Total length of damaged distribution lines (km)*

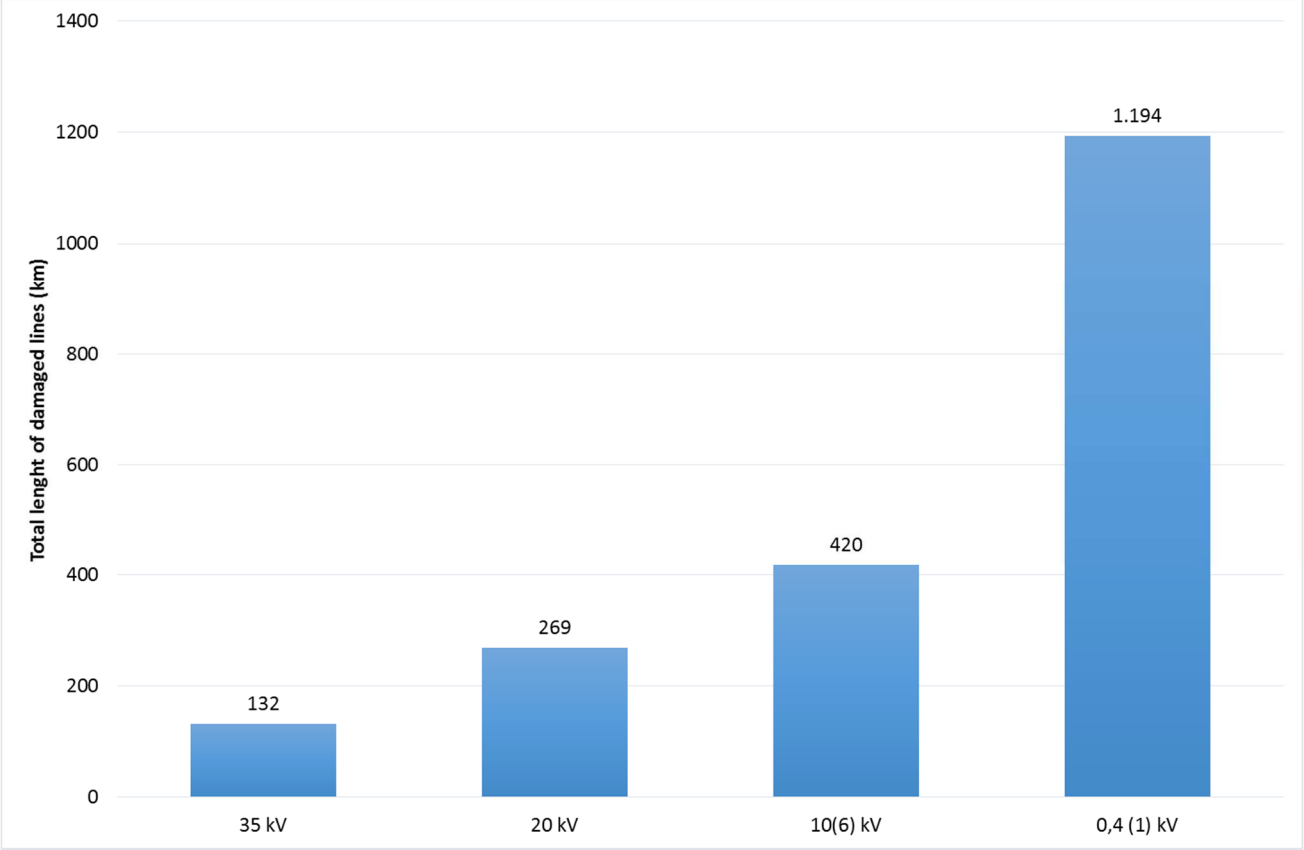


*Figure 3.10 Total length of damaged distribution lines per voltage level (km)*

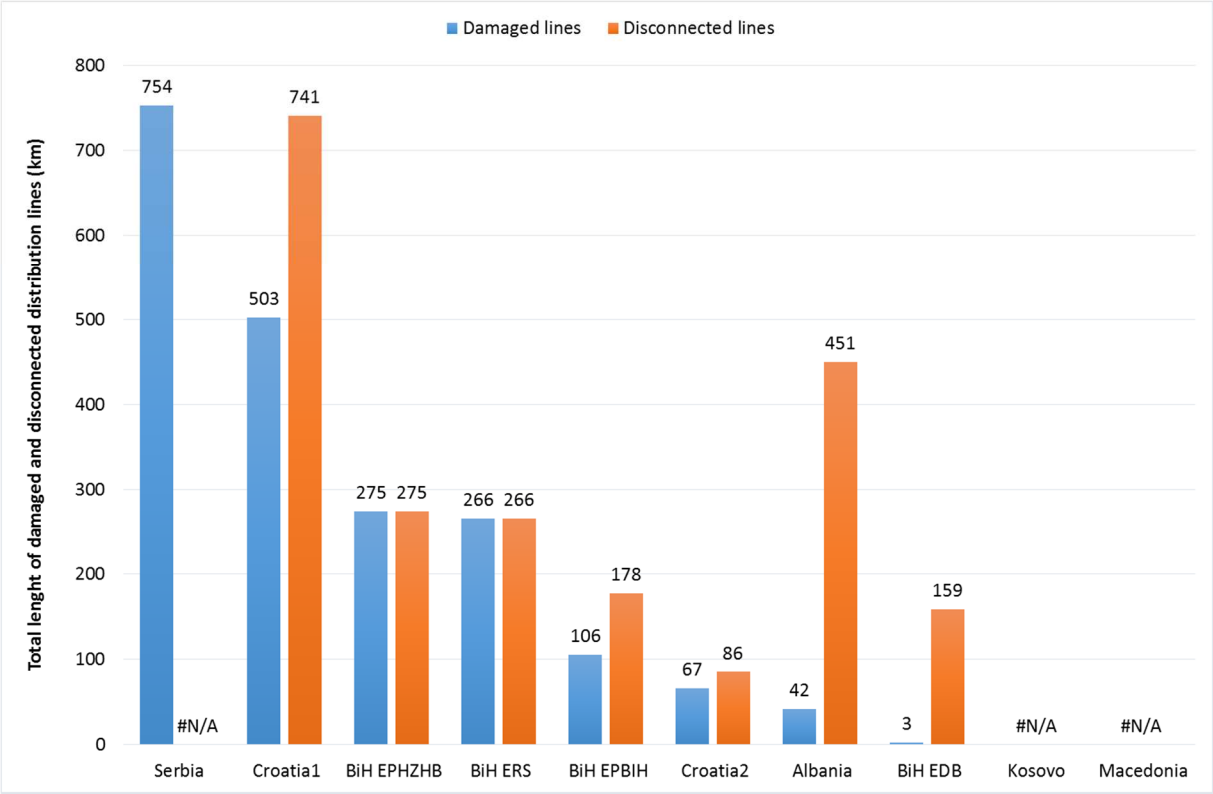


*Figure 3.11 Total length of damaged and disconnected distribution lines (km)*

As given above, total length of reported damaged 35 kV lines was 132 km, 93 km in Croatia, 28,6 km in BiH and 9,3 km in Albania. There were no input data for other countries.

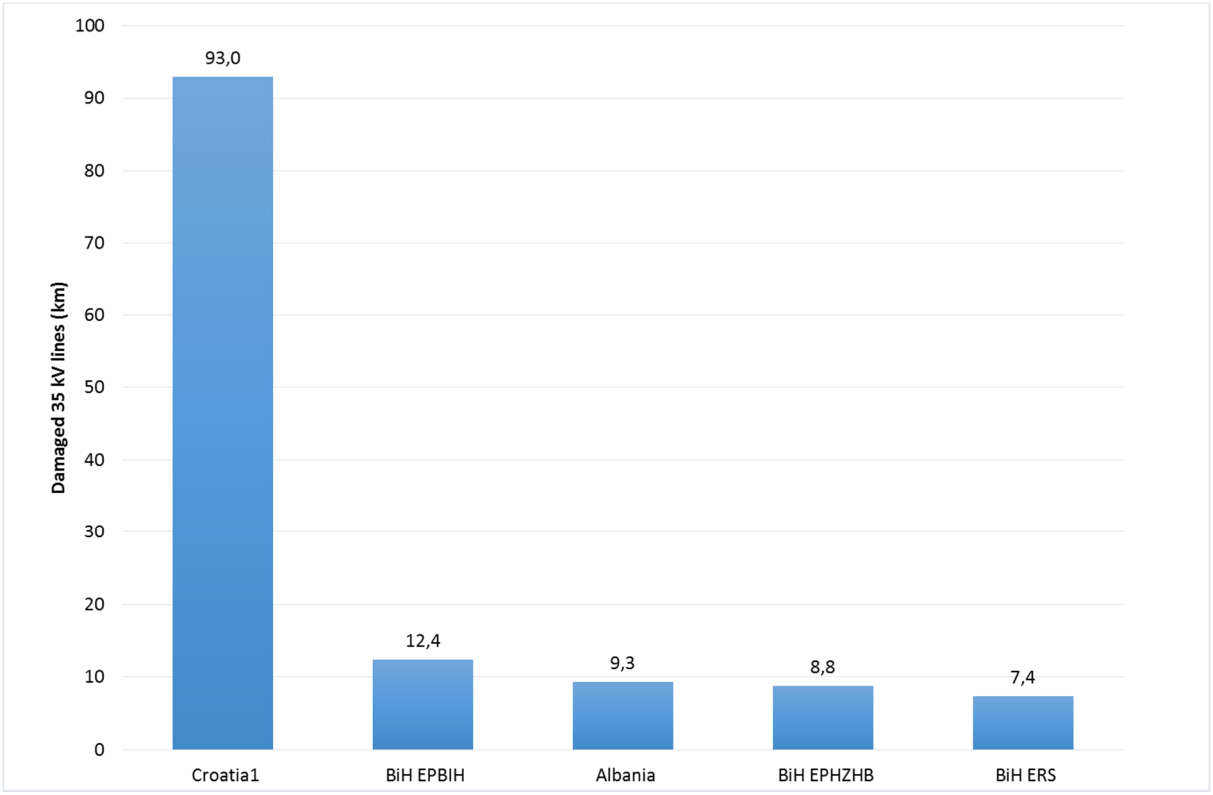


*Figure 3.12 Total length of damaged 35 kV distribution lines (km)*

On 20 kV voltage level there were input data available only for Croatia, Serbia and one DSO from BiH (ERS). They reported 269 km of damaged 20 kV lines. Other DSOs reported no damage on 20 kV lines or have no 20 kV network in its jurisdiction.

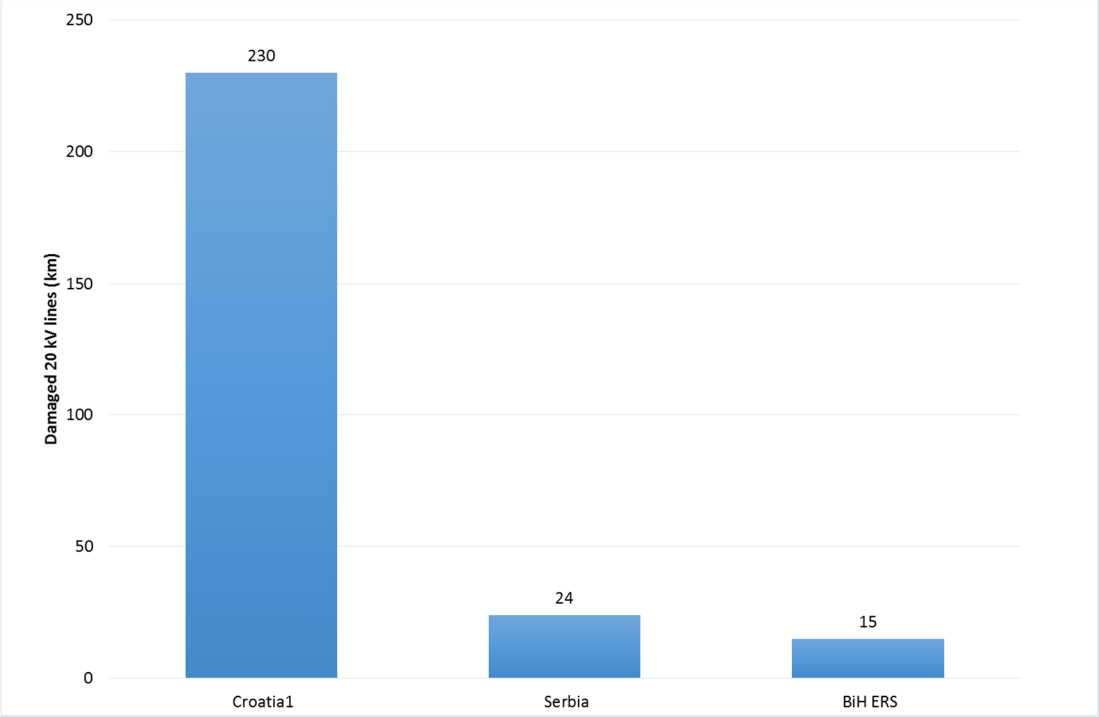


*Figure 3.13 Total length of damaged 20 kV distribution lines (km)*

On 10 kV voltage level all DSOs reported total length of damaged lines, except Kosovo and Macedonia, as given on the following Figure. In total it is 420 km of damaged 10 kV lines, mainly in BiH (196 km or 46 %) and Serbia (141 km or 34%).

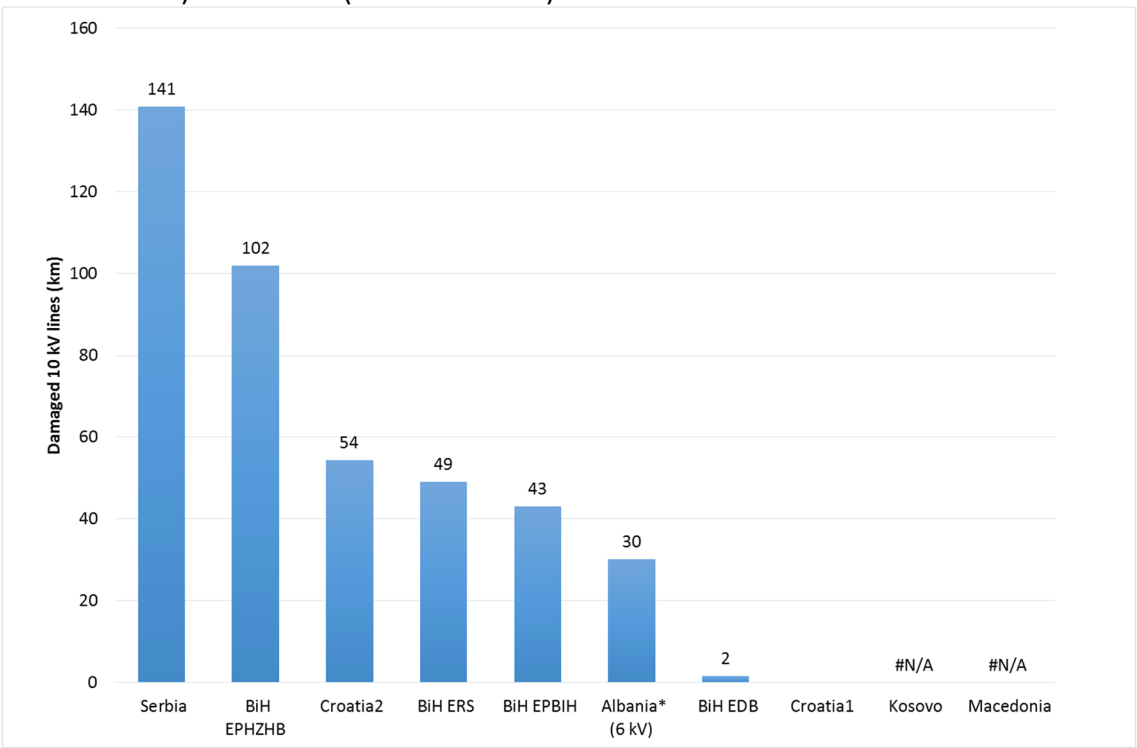


*Figure 3.14 Total length of damaged 10 kV distribution lines (km)*

On low voltage level there was 1 194 km of reported damaged lines in total (data missing for Kosovo and Macedonia), again mainly in Serbia (589 km or 49%) and BiH (410 km or 34%).

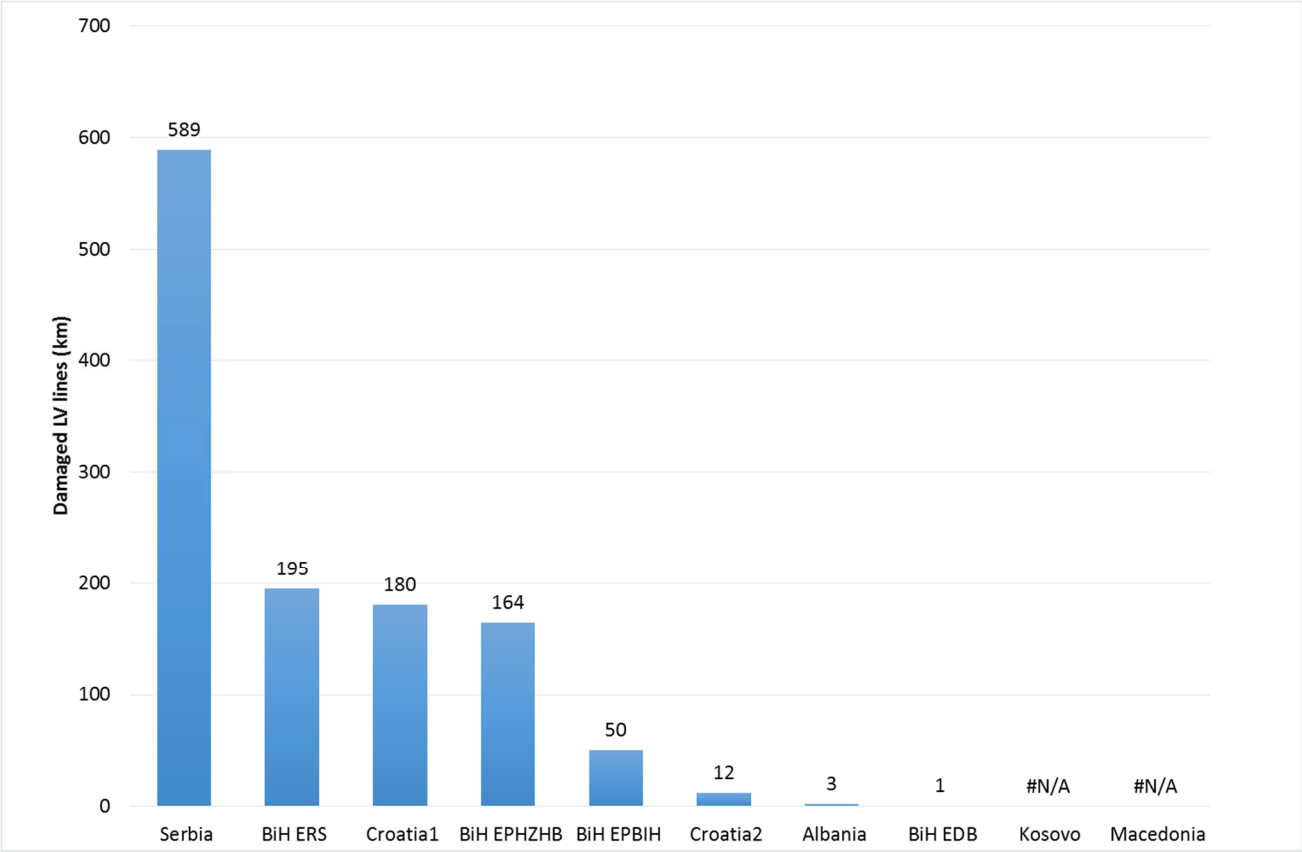


*Figure 3.15 Total length of damaged low voltage distribution lines (km)*

Regarding power substations, there were 498 substations in regional distribution network declared as “damaged” in given timeframe, mainly in Serbia (235 or 47%) and in BiH (227 or 45%). In Kosovo and Macedonia there were no reported damaged substations at all.

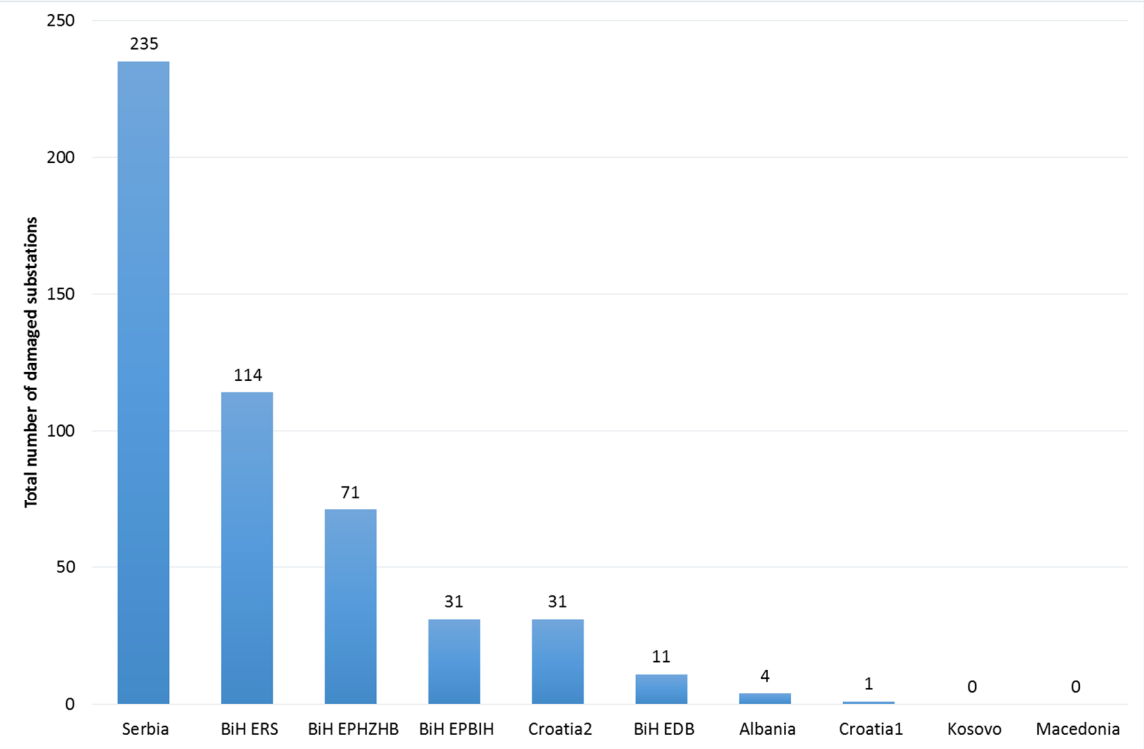


*Figure 3.16 Total number of damaged substations in the distribution network*

Similar to the lines, besides damaged substations there were 8 times more disconnected substations, in total 4 116, mainly in Serbia (1 934 or 47%) and BiH (1 725 or 42%), as shown on the following Figure. Data for Macedonia were not available.

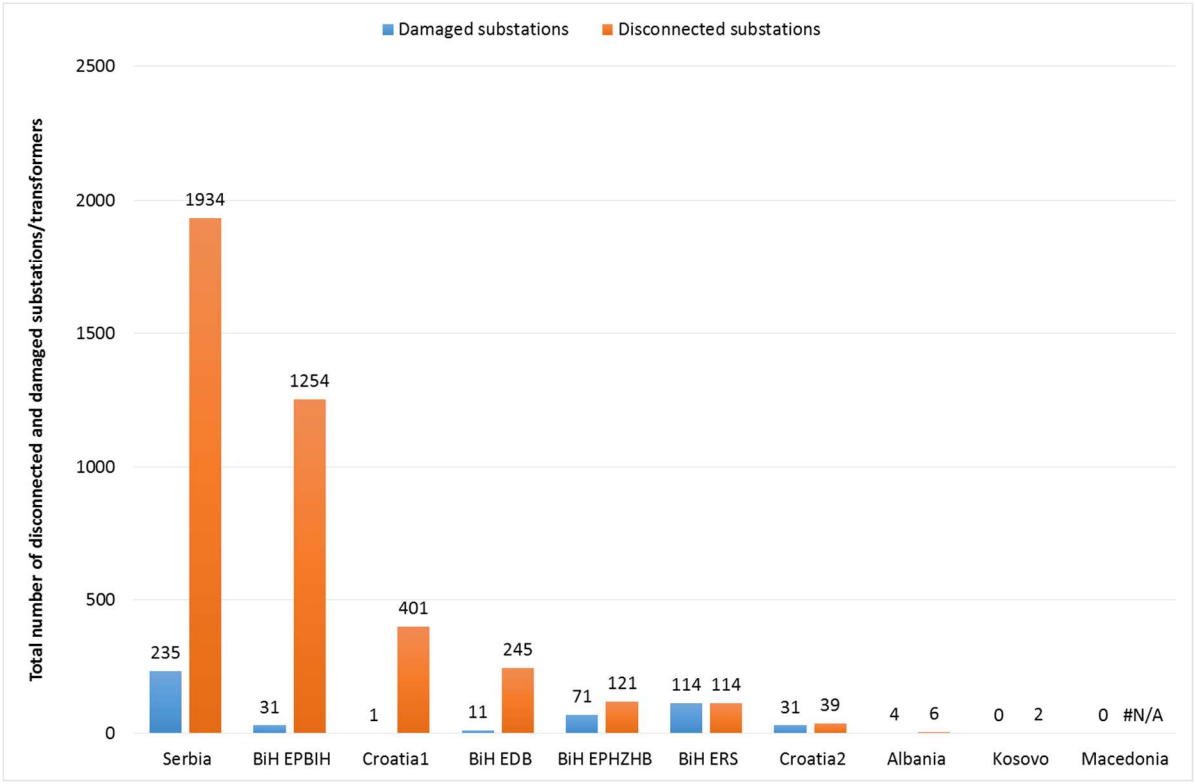


*Figure 3.17 Total number of damaged and disconnected substations in the distribution network*

Substations 110/35(20) kV were reported as damaged only in Serbia. There were 4 damaged SS 110/35(20) kV. In most of other countries substations 110/x kV are under jurisdiction of the TSO.

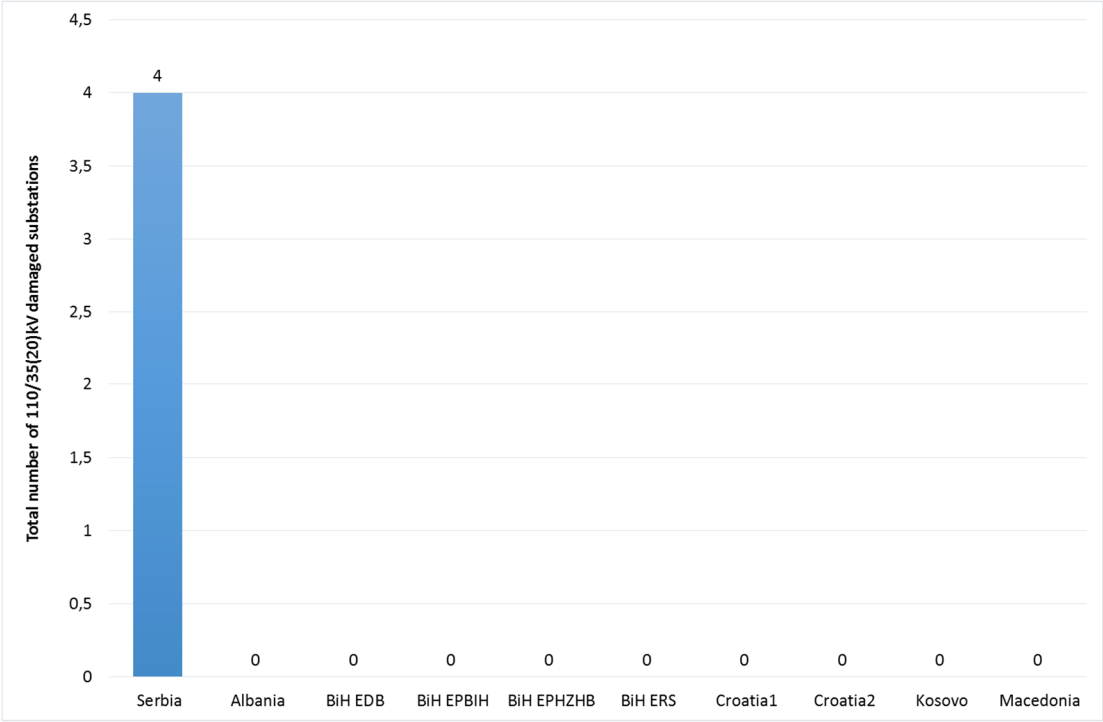


*Figure 3.18 Total number of damaged 110/35 kV substations in the distribution network*

14 substations 35/10(20) kV were reported as damaged, 7 in BiH, 6 in Serbia and 1 in Albania.

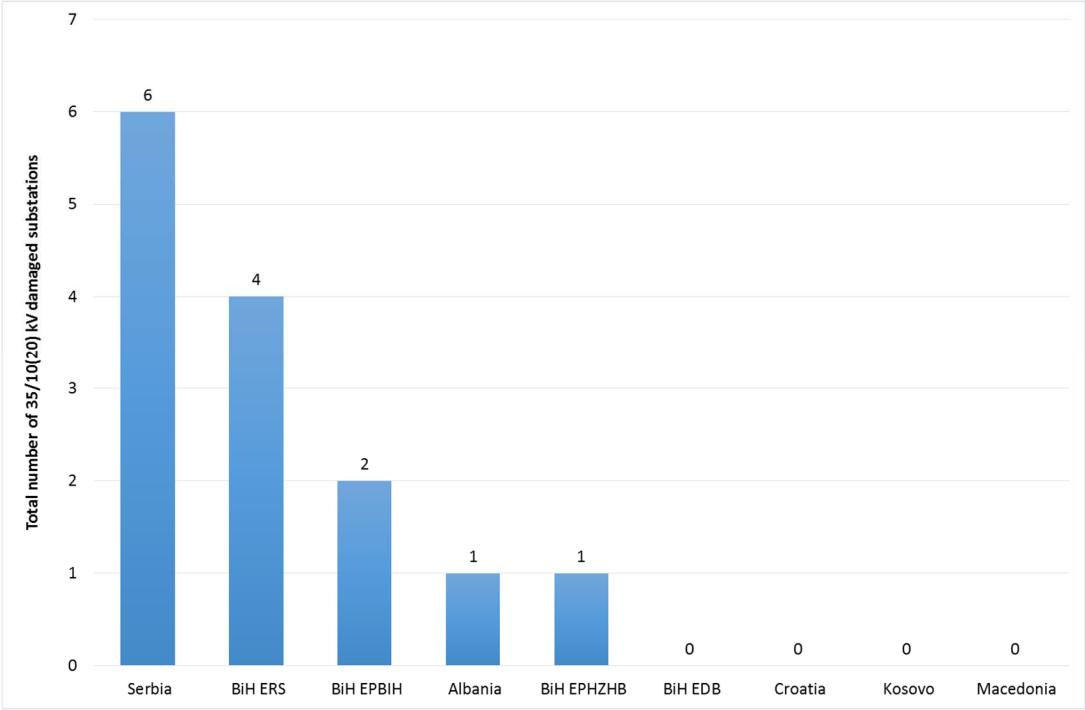


*Figure 3.19 Total number of damaged 35/10 (20) kV substations in the distribution network*

As expected, the largest number of damaged SS was on the level 10(20)/0,4 kV. In total there were 480, 225 in Serbia, 220 in BiH etc.

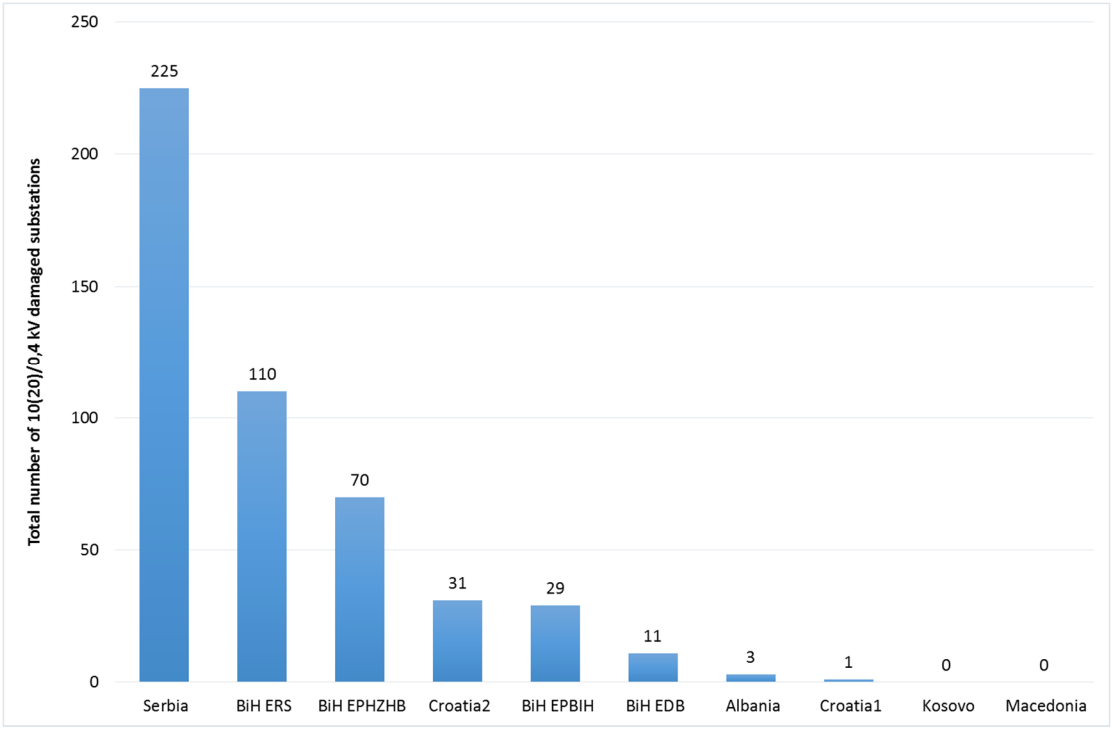


*Figure 3.20 Total number of damaged 10/0,4 kV substations in the distribution network*

Very important consequence of these weather conditions was damage of the metering devices. In total there were more than 43 150 completely damaged meters in the region, the largest portion in ERS (BiH): 26 048 or 60% (Figure 4.21). Data for Kosovo were not available.

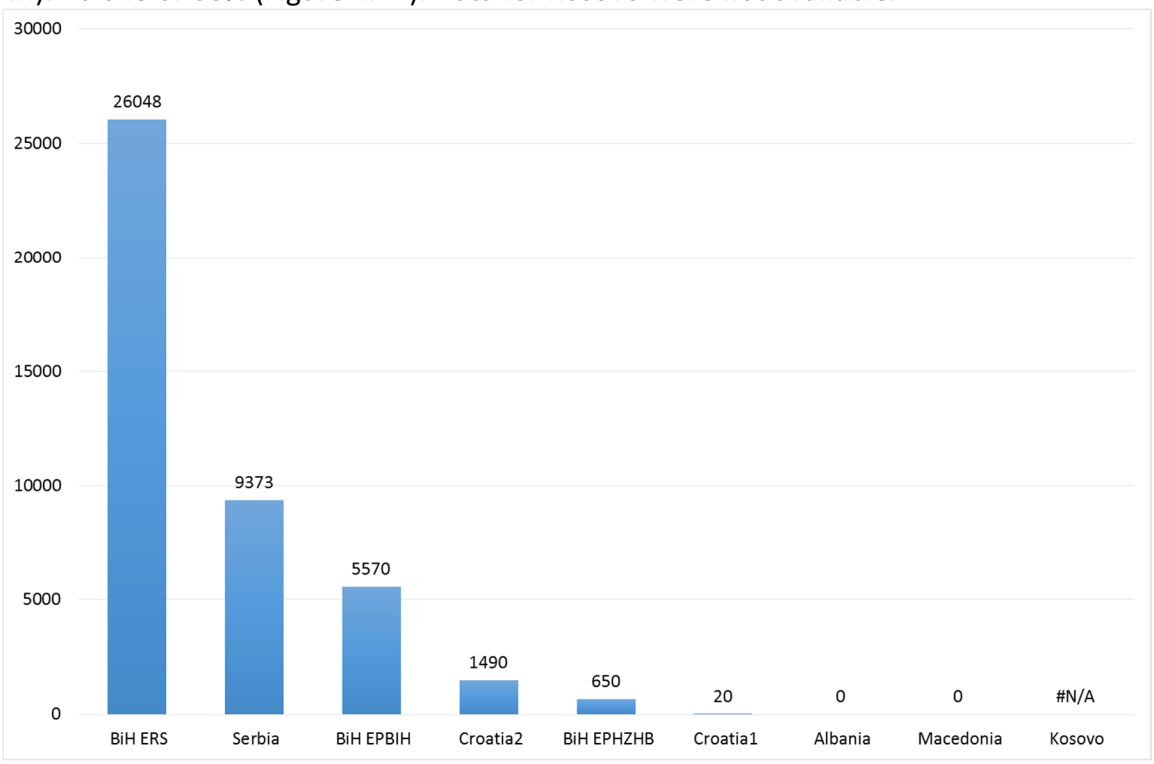


*Figure 3.21 Total number of destroyed metering devices in the distribution network*

Besides 43 150 completely damaged metering devices, there were additional 325 metering devices reported as “partly damaged”, as shown on the following Figure.

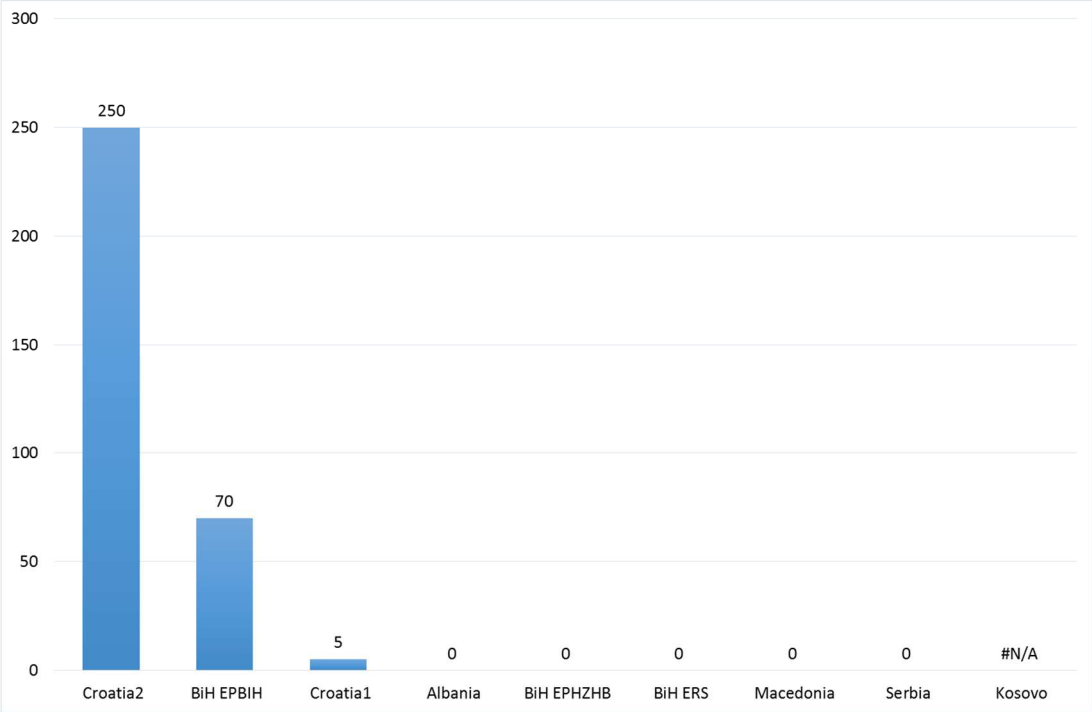


*Figure 3.22 Total number of partly damaged metering devices in the distribution network*

With this we fulfilled the first part of the report: consistent overview of the recent extreme climate related events in SEE including the extensive flooding in Bosnia and Herzegovina, Croatia and Serbia in spring 2014; the severe ice storms in Croatia (winter 2013/2014) and in Macedonia (winter 2014/2015). Clearly, not all data were collected in consistent way in all DSOs, so it is not possible to compare all consequences and measures taken by the DSO to minimize the damage.

The second part of this report assumes the most critical issues and lessons learned with these emergency operation conditions and it is related to the legal framework and emergency measures.

## 3.5. Legal framework

Most of the DSOs (7 out of 9) have primary legal framework relevant for system operation under emergency, but the problem are missing implementation acts for the most extreme cases as we had in 2014 – 2015.

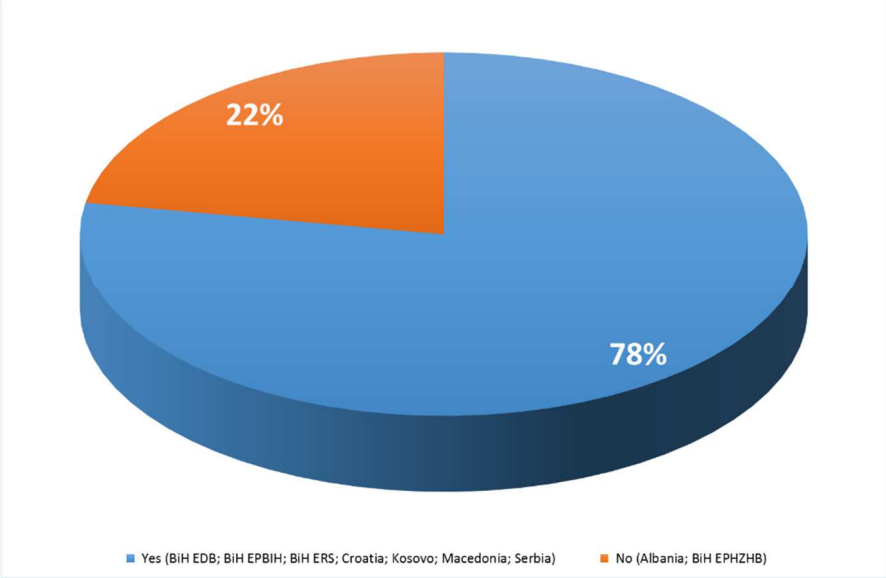


*Figure 3.23 DSO responses to the question about existence of the legal framework to operate under emergency conditions*

In general it can be concluded that incomplete legal framework for DSO emergency response is one of the major obstacles for SEE DSO operation in extreme situations like during the storms in 2014 – 2015.

Based on the current practice and experience, most of the DSOs (7 out of 9) expect to cover total damage from its internal sources. EPHZHB (BiH) and EVN (Macedonia) are hoping to get additional funding approved by the regulator to cover recovery costs caused by extreme weather.

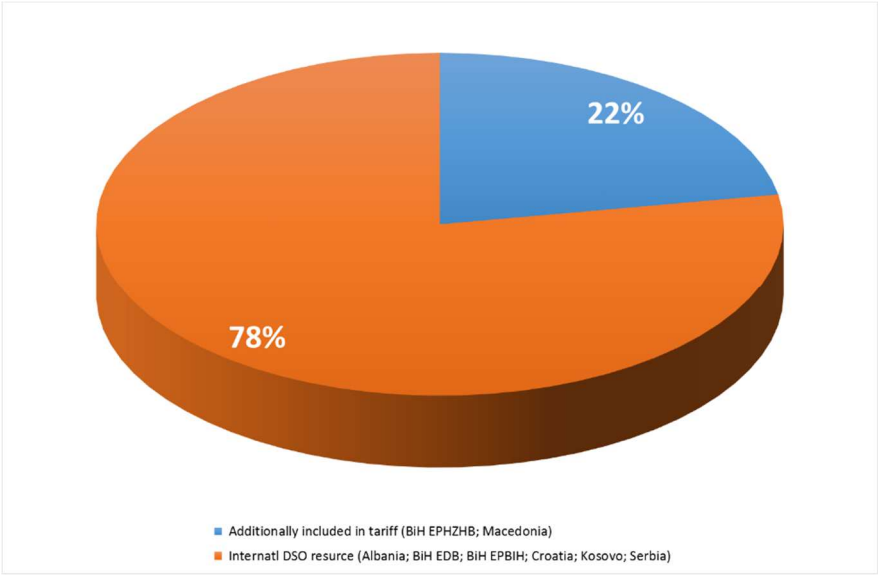


*Figure 3.24 DSO responses to the question about funding of the network reparation costs*

## 3.6. Emergency measures

Among many other input data collected here, one of the most important is set of emergency measures taken by each DSO. Every DSO specified one or more main emergency measures they found effective and crucial for the supply restoration and damage minimization:

### 3.6.1. Albania (OSHEE)

- Command Team established
- Expert teams sent to the area
- Dispatching Center reported hourly to the Controlling Team and every ½ hr about the line that go to "Hidrovor" (pumping water into the sea)

### 3.6.2. Croatia (HEP ODS)

- Expert teams sent to the area
- The most important equipment parts removed (i.e. circuit breakers from TS 35/10 kV)
- Military forces included
- Mutual assistance from other distribution areas
- Detailed daily reports sent to DSO headquarter and other institutions.

### 3.6.3. Bosnia and Herzegovina (EPHZHB)

- The most important equipment parts removed from one to another SS
- After water drop immediate checking of the installations and re-energizing

### 3.6.4. Bosnia and Herzegovina (EDB)

- Improvised temporary re-energizing wherever possible

### 3.6.5. Bosnia and Herzegovina (EPBiH)

- Improvised temporary re-energizing wherever possible

### 3.6.6. Bosnia and Herzegovina (ERS)

- Improvised temporary re-energizing wherever possible
- Target: to re-energize all customers within 48 hrs after water withdrawal.

### 3.6.7. Kosovo (KEDS)

- Establishment of the emergency working group
- All departments were engaged to establish needed teams to re-energize the system, mostly MV and LV
- Target: to re-energize 80% of the MV network within 24 hours

### 3.6.8. Macedonia (EVN)

- Engagement of all generating units connected to the network

- Temporary solutions for re-energizing (i.e. wooden poles)

### 3.6.9. Serbia (EPS)

- Establishment of the emergency working group
- Decision for reconnection was fully on dispatchers, based on the prior testing of each network element.

With respect to the customers' disconnection and reconnection there were different approaches and principles. For example:

- Croatia: full evacuation of the population, disconnection and systematic and safer workers' activities
- BiH (EPHZHB): no full evacuation, maximum prolongation of disconnection, especially of water pump stations
- Croatia: reconnection of all customers with no formal reconnection request
- BiH (EPHZHB): customers formally request for supply restoration, educational leaflet

For the future working group discussion it is recommended to clarify these details, specific reasons and to conclude which approach was more appropriate.

## 3.7. Mutual assistance

Even though these extreme weather conditions and consequent large damage have practically never been experienced in this region, there was no any DSO – to - DSO mutual assistance. Not in equipment, nor in services or workforce. There were offers for mutual assistance especially among neighboring DSOs in BiH, but at the end all problems were resolved with internal DSO resources.

On the other hand, there was large cross-border civil protection assistance and humanitarian aid in which countries/entities were assisting, supporting and helping each other.

# 4. TASK 2: CASE STUDY ANALYSIS OF THREE DSO AFFECTED BY THE CLIMATE RELATED EMERGENCIES

As defined in the Terms of Reference three DSOs were selected for the case study analyses – ERS (BiH), EPHZHB (BiH) and EPS (Serbia), as the DSOs with the heaviest consequences and damage of the extreme weather conditions in given time frame, namely flooding in May 2014 (Figure 4.1).


*Figure 4.1 Flooded area in May 2014*

Moreover, the most specific "distribution areas" within each of these three DSOs were selected instead of analyzing the whole DSO. In ERS (BiH) Distribution Area Doboj was selected, in EPHZHB (BiH) Distribution Area North, while in EPS (Serbia) Distribution Area of Belgrade is analyzed.

The authors traveled to the selected DSOs in BiH and Serbia in May 2015 and conducted in-person interviews with key personnel responsible for responding to recent emergencies. Also, certain amount of documents and information were collected and analyzed as follows.

## 4.1. Case 1: EPHZHB (BiH) – Distribution Area North

Distribution Area North is chosen here since it reported more than 90% of total damage due to flooding in the area supplied by EPHZHB (BiH). Extreme flooding conditions in EPHZHB (BiH) – Distribution Area North can be divided in three phases as follows:

| | |
|---|---|
| PHASE 1: Flooding and customer disconnections | 16.-24.5.2014. |
| PHASE 2: Flooding stagnation and customer reconnection | 24.5.-15.6.2014. |
| PHASE 3: Recovery and basic replacements | 15.6.-31.12.2014. |

Problems with flooding started on May 15, 2014, while customer disconnections started a day after – on May 16, 2014. Three days later there was the heaviest damage in the distribution system, with the consequences shown on the following Figure.

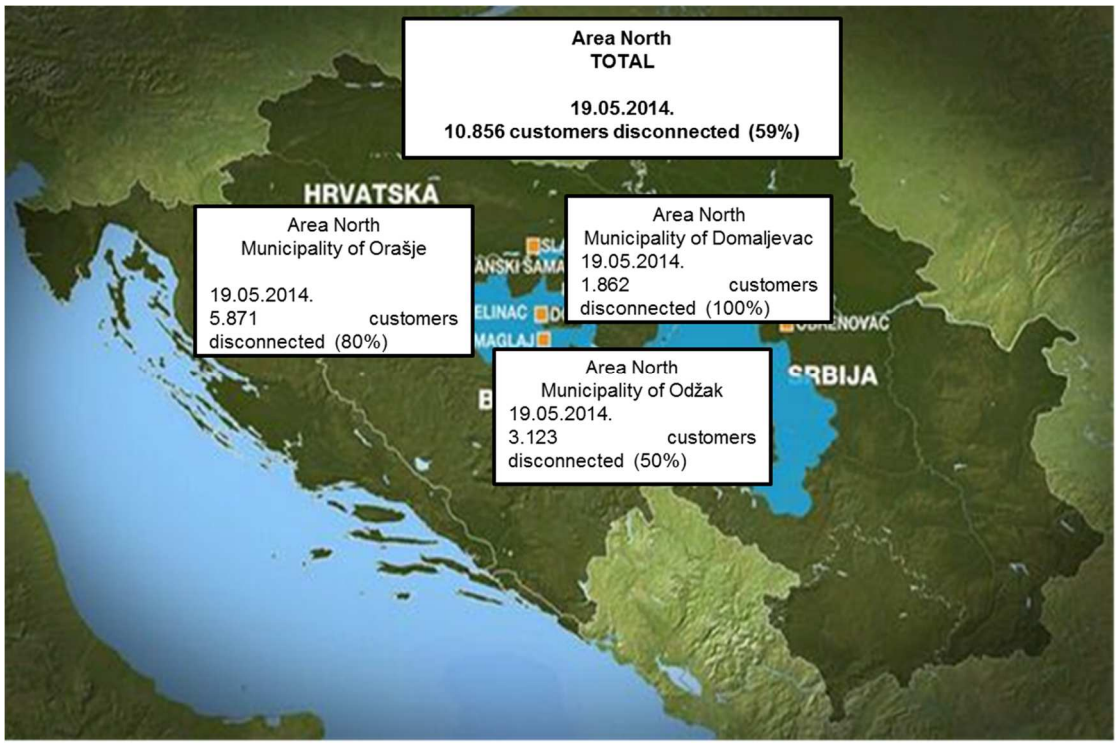


*Figure 4.2 Customer disconnections in three municipalities of Distribution Area North in EPHZHB (BiH) on May 19, 2014*

Chronology of activities taken by the local DSO and state authorities are as follows:

- Daily reports sent to the EPHZHB Management Board 16.5. – 3.6.
- Flooding reports sent to the State Regulator 20.5., 22.5.
- Crisis staff management established 23.5.
- Reconnection procedures started 27.5.
- Instructions for the electricity usage after flooding 27.5.
- Equipment and staff (urgent) requirements 28.5., 10.6.
- Local authority official statement of the Natural disaster 16.5.
- Flooding reports to the Ministry 6.6., 12.6.
- Report for the World Bank 6.6.
- Power system damage estimation 11.6.

After all, the following lessons are learned:

- The whole workforce was engaged to build dams around substations (90% of SS totally flooded, somewhere whole tower was flooded - more than 10 m deep water)
- Disconnection were done in very last moment, especially public lighting – to avoid panics
- Strong coordination with Civil Protection Forces
- All customers reconnected in about 1 month

- 30% of customers (connection points) did not requested reconnection (old houses, weekend houses, permanent emigration etc.)
- Gradual reconnection depending on conditions on each site
- Every single house was checked by the DSO worker before reconnection
- Rulebook on emergency cases is not existing (draft prepared, related to steps in supply restoration, but not covering extreme conditions like flooding). It is strongly recommended to prepare and implement Rulebook with main steps and responsibilities in the case of emergency
- Responsibilities were not clear – full responsibility for public safety taken by the workers (24 h) – keeping in line with the Law would significantly delay supply restoration
- Leaflet was distributed to the citizens - educating the public about the danger of coming into contact with live electrical equipment
- Lot of emergency measures and activities were not harmonized with the relevant „business as usual" legislation
- „fortunately" low network loading due to total damage of home appliances helped to restore the system quickly

The most important (missing) aspects are procedures:

1. before emergency appears
2. on system operation during emergency
3. for damage control and reconstruction prioritization

The most important conclusions of the workers:

- This experience and approach assumes huge risk for the workers and citizens – it is strongly recommended to avoid improvisation in the future and to establish clear principles and responsibilities !

After all, the most important conclusion is that **nobody was hurt due to power system problems !**

## 4.2. Case 2: ERS (BiH) – Distribution Area Doboj

Distribution Area Doboj is chosen here since it reported the largest level of destruction in whole ERS. Extreme flooding conditions in ERS (BiH) – Distribution Area Doboj started on May 15, 2014. The following input data were collected here:

- Flooding chronology report
- Detailed assessment on damaged equipment
- Report on damaged equipment prepared for the Stock Exchange
- GIS report on SS 35 and 10 kV

Few days later there was the heaviest damage in the ERS distribution system, with the consequences shown on the following Figure.


*Figure 4.3 Customer disconnections in three Distribution Areas of ERS (BiH) on May 17 and 18, 2014*

*Figure 4.4 Flooding in Doboj downtown in just 10 minutes on May 15, 2014*

After all, the following lessons are learned:

- damaged equipment was fully replaced by local reserves, meaning that maintenance strategy was appropriate

- design criteria should be upgraded, such as:
  - install cables instead of OHL (it is already done - 100 km in the last 2 years)
  - Substations should be located on higher terrain
- 3 days after terrible flooding most of the customers reconnected.
- all customers reconnected after 30 days
- Needed customer's formal request for reconnection
- full mobilization of all resources
- employers strong motivation
- delivering necessary materials and equipment from all distribution companies warehouses (transformers, poles, cables, switchboards, meters etc.)
- emergency procurement of materials and equipment
  - ✓ DC power supply for SS 35/10 kV
  - ✓ diesel generators
  - ✓ driers
  - ✓ air compressors ...

The most important conclusions of the workers:

- This experience and approach assumes huge risk for the workers and citizens – it is strongly recommended to avoid it in the future and to establish clear principles and responsibilities !

After all, the most important conclusion is that **nobody was hurt due to power system problems !**

### 4.3. Case 3: EPS (Serbia) – Distribution Area Belgrade

Distribution Area of Belgrade is chosen here since it reported the largest level of damage in the period of flooding in the territory of Serbian DSO. Extreme flooding conditions in EPS (Serbia) – Distribution Area of Belgrade started on May 15, 2014. In total there were around 153 000 customers disconnected. But, as the wave was moving forward new disconnections were done. Coincident disconnection was done for about 127 000 customers, as shown on the following figure. It is estimated that total of more than 300 000 citizens were out of electricity.


*Figure 4.5 Customer disconnections in Distribution Areas of Belgrade in EPS (Serbia) on May 18, 2014*

It is important to point out that the largest damage in Serbian power system was in generation company, namely in the coal mines where the water was up to 65 m deep. It took more than a year to recover. In the distribution network the following lessons are learned:

- Disconnections are done in very last moment
- DSO was reporting to the Civil Protection Center and directly to the Government every 2 hours
- Dispatcher was responsible for all actions and conditions needed for reconnection
- The largest number of customers was reconnected in a day or two, while all customers were reconnected till the end of June 2014, after water withdrawal in the heavily damaged city of Obrenovac
- Disconnection of the whole feeder 10(20) kV, not like in EPHZHB (BiH) on the level of SS 10/0,4 kV. This approach is more safe for DSO workers

The most important conclusions of the EPS workers is the same as in the previous two cases:

- This experience and approach assumes huge risk for the workers and citizens – it is strongly recommended to avoid it in the future and to establish clear principles and responsibilities !

After all, the most important conclusion is that **nobody was hurt due to power system problems !**

# 5. TASK 3: US DSO EXPERIENCE AND OVERVIEW OF THEIR EMERGENCY RESPONSE PROGRAMS AND MUTUAL ASSISTANCE

## 5.1. US DSO EXPERIENCE WITH NATURAL DISASTER

In long US history of large and destructive storms for the purpose of this study we selected June 2012 Mid-Atlantic and Midwest Super Derecho storm. It was one of the most destructive and deadly fast-moving severe thunderstorm complexes in North American history. It is selected not only because it was the heaviest storm in history, but because it is very good example of mutual assistance.

The progressive derecho tracked across a large section of the Midwestern US and across the central Appalachians into the mid-Atlantic states on the afternoon and evening of June 29, 2012, and into the early morning of June 30, 2012. It resulted in 24 deaths, widespread damage and millions of power outages across the entire affected region. The storm prompted the issuance of four separate severe thunderstorm watches by the Storm Prediction Center. A second storm in the late afternoon caused another watch to be issued across Iowa and Illinois. This storm came with very little warning. Severe wind gusts caused extensive damage to all American Electric Power Company (AEP) east operating companies. More than 1.4 million AEP customers were disconnected at the peak load.

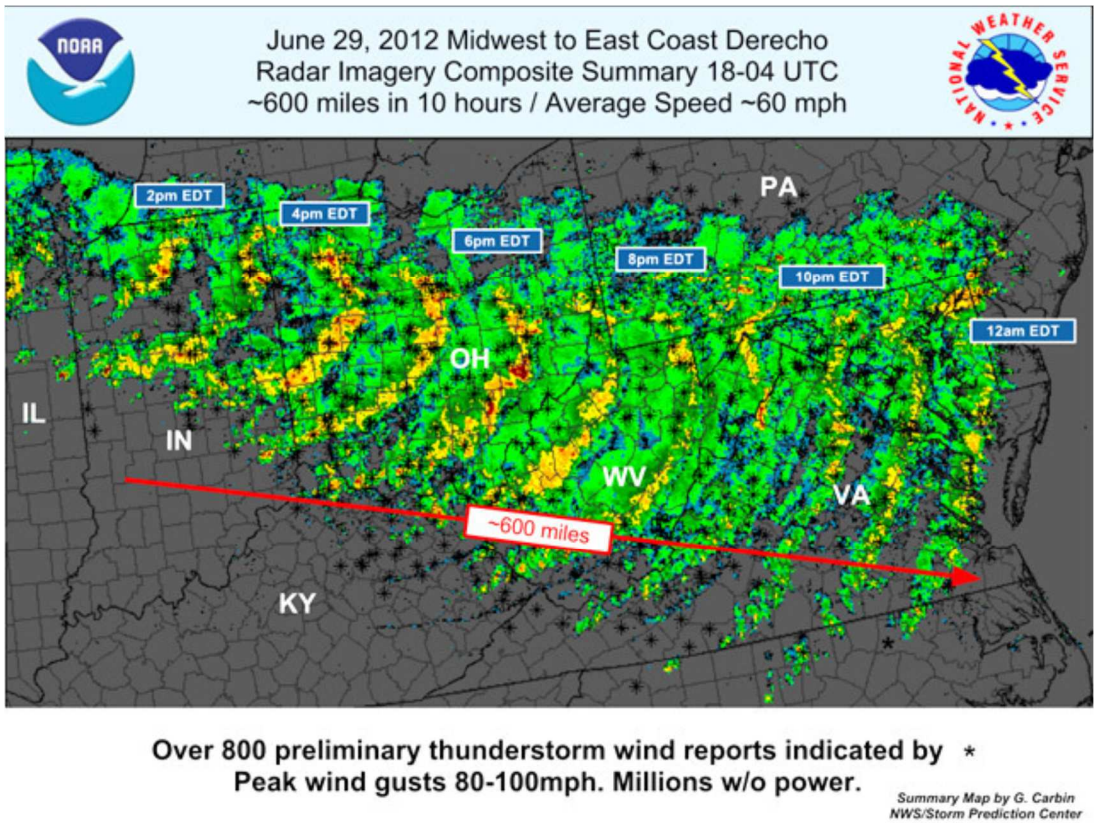


*Figure 5.1 Meteo report on June 29, 2014 (source: AEP)*

Super Derecho is unlike any other storm seen in 100-year history of AEP. The following Figure shows outages by State on June 30, 2012.

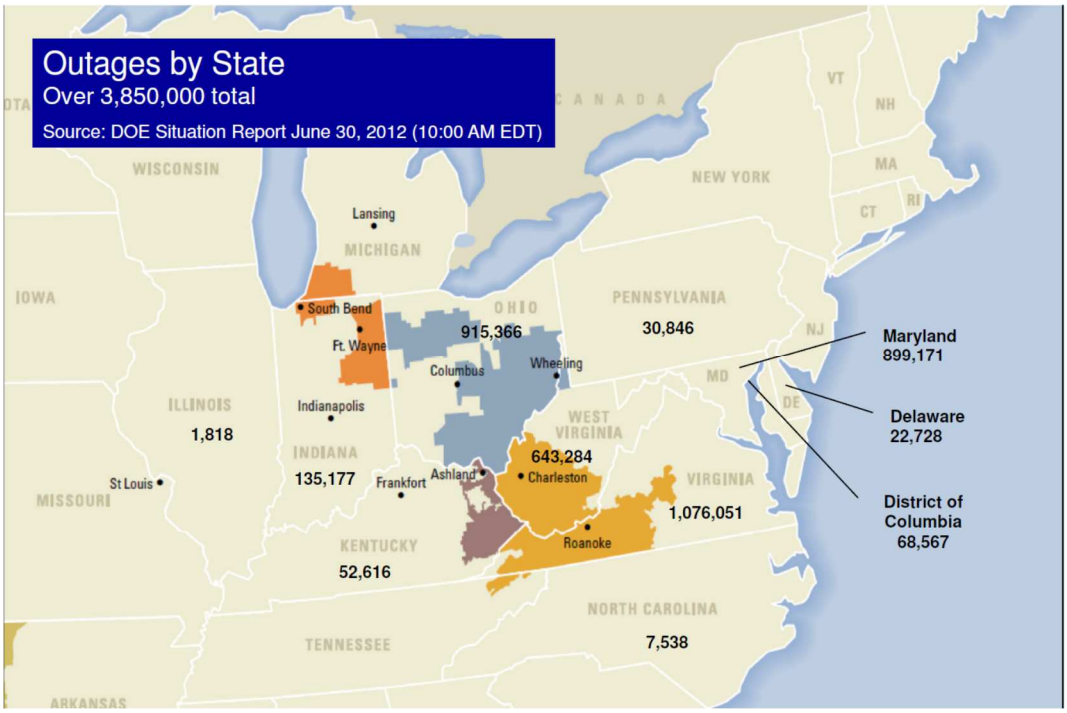


*Figure 5.2 Outages by State on June 30, 2012*

Other notable storms are given in the following Table along with number of disconnected customers.

*Table 5.1 Other notable storms in AEP with number of affected customers (source: AEP)*

| Date | Event | Territory | Customers Affected |
|---|---|---|---|
| 9/2008 | Hurricane Ike | SWEPCO, AEP Ohio | >887,000 |
| 12/2004 | Ice | AEP Ohio | 350,000 |
| 1/2009 | Ice | AEP Ohio, APCo, KYPCo, SWEPCO | > 300,000 |
| 12/2009 | Snow | APCo, KYPCo | 300,000 |
| 2/2009 | Winter storms | AEP Ohio, APCo, I&M, KYPCo, SWEPCO | 296,000 |
| 12/2007 | Ice | PSO | 256,000 |
| 12/2000 | Ice | SWEPCO | 234,000 |
| 7/2008 | Hurricane Dolly | AEP Texas | 205,000 |
| 9/2005 | Hurricane Rita | SWEPCO | 186,000 |
| 2/2011 | Ice | AEP Ohio | >181,000 |

Total number of customers affected by Super Derecho was about 1.4 million and its distribution per company and per day is shown on the following Figure.

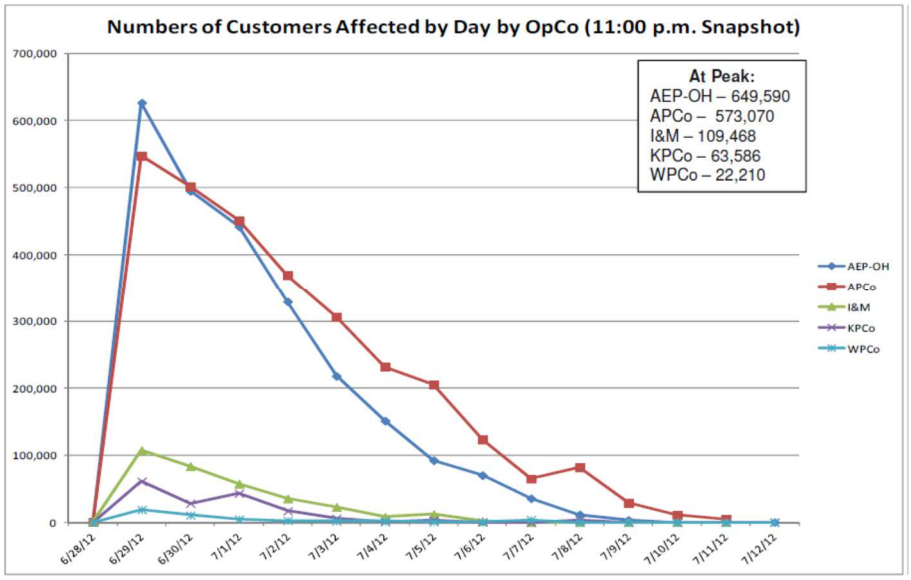


*Figure 5.3 Number of disconnected customers in the period June 28 – July 12 2012 (source: AEP)*

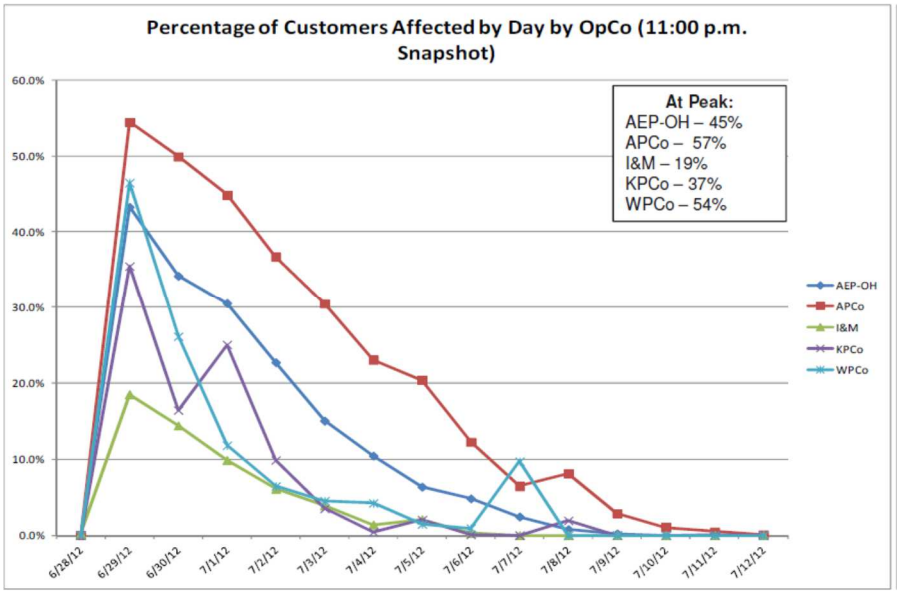


*Figure 5.4 Percentage of disconnected customers in the period June 28 – July 12 2012 (source: AEP)*

In local distribution network Super Derecho 2012 was having the following damage consequences:

- number of distribution feeders affected: 2,445
- number of feeders locked out: 928
- total number of AEP System active outage tickets (at peak): 186,000
- poles replaced: > 3,200
- transformers replaced: > 2,000

In local transmission network Super Derecho 2012 was having the following damage consequences:

- Miles replaced: 23
- Towers damaged: >500
- Stations affected: 424
- Transmission circuits/line sections affected: 261

The following Table shows number of internal (AEP) employees engaged to restore the system on the most critical day of June 29/30, 2012. In addition to its front line workers, there were 938 employees from other distribution companies, 121 from non-distribution companies and 595 other workers. Altogether there were about 3,000 internal workers engaged.

*Table 5.2 Number of workers engaged in the system restoration on June 29/30 2012 (source: AEP)*

| OpCo | D Front Line | Other OpCo Distribution | Other OpCo Non-Distribution | C&DS Employees | Total |
|---|---|---|---|---|---|
| AEP-OH | 608 | 370 | 44 | | **1,022** |
| APCo | 407 | 360 | 14 | | **781** |
| I&M | 201 | 111 | 58 | | **370** |
| KPCo | 94 | 97 | 5 | | **196** |
| **Total** | **1,310** | **938** | **121** | **595** | **2,964** |

The following Table shows number of external (non-AEP) employees engaged to help to restore the system. In addition to its 2,964 internal employees, there were 8,899 external employees from other companies: 5,924 line contractors and 2,947 forestry contractors. So, 75% of total workforce was external.

*Table 5.3 Number of workers engaged in the system restoration on June 29/30 2012 (source: AEP)*

| OpCo | D-Line Contractors | D-Forestry Contractors | Total |
|---|---|---|---|
| AEP-OH | 1,588 | 1066 | **2,654** |
| APCo | 3,251 | 1365 | **4,616** |
| I&M | 457 | 173 | **630** |
| KPCo | 655 | 344 | **999** |
| **Total** | **5,924** | **2,947** | **8,899** |

The following Figure shows geographical dispersion of 19 US states (and Canada) that send their workers to critical area.

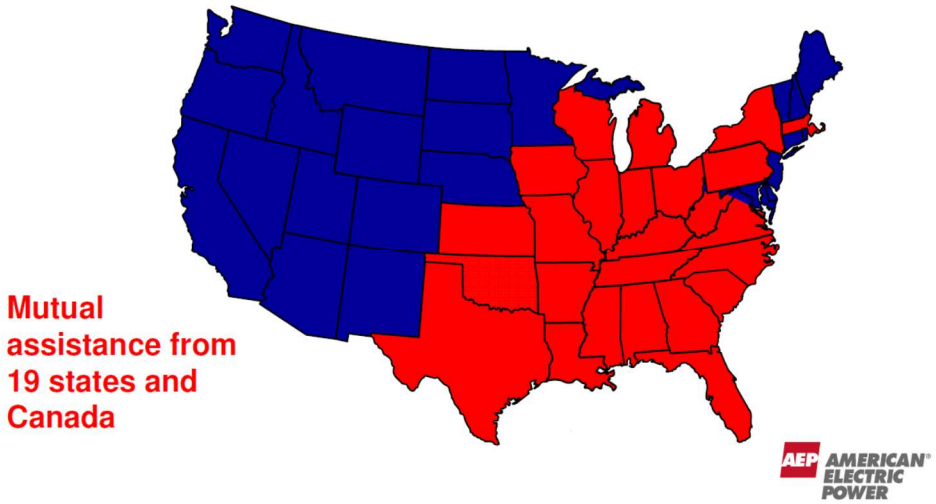


*Figure 5.5 Geographical dispersion of workers sent to critical area as a part of mutual assistance program (source: AEP)*

Not all external workers were sent the same day, as it is shown on the following Figure.

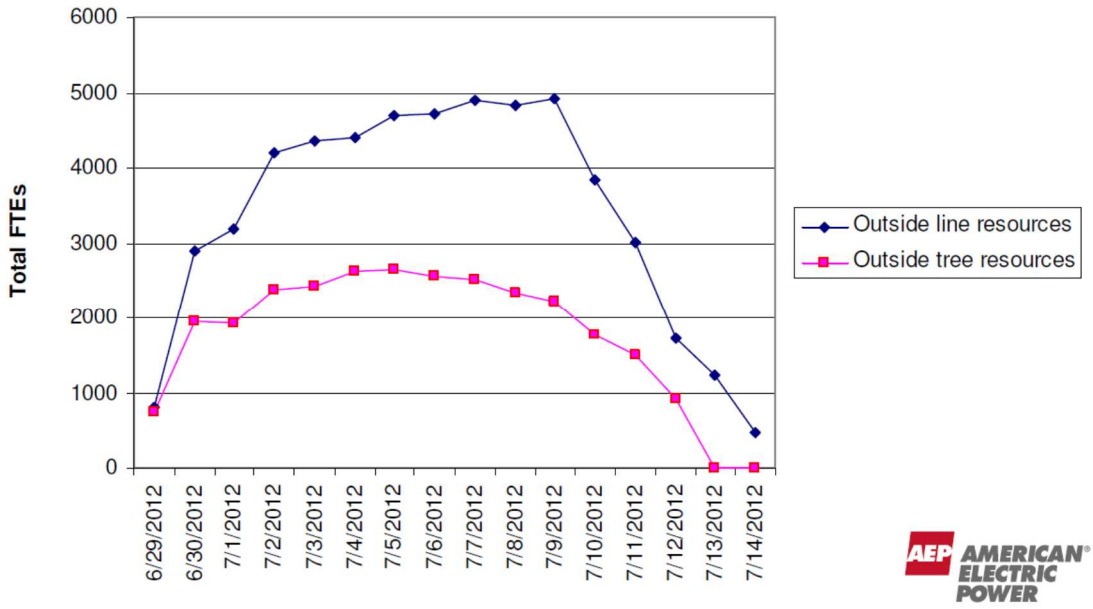


*Figure 5.6 External resources by day (source: AEP)*

Significant logistics was needed for the mutual assistance of almost 9,000 external workers in about 10-day period of time, such as:

- 8,400 hotel rooms
- 72 bunk trailers with 2,550 beds
- 400,000 meals
- 16,000 cases of water/sports drinks
- 79,644 gallons of gasoline
- 172,049 gallons of diesel

Also, very important part of the whole situation was to keep customers (citizens) well informed.

- new record of 70,000 calls per hour for overflow outage system
- Customer Operations Department incurred more than 15,000 hours overtime
- outsourcers provided additional 1,044 hours of overtime
- initiated 123 outbound campaigns targeting > 51,000 customers

Importance of adequate information and warning system is clearly shown in the following Table with comparison of the number of website and mobile visits before and during the storm.

*Table 5.4 Increase of website and mobile visits before and during the storm (source: AEP)*

Website visits

| OpCo | Before Storm (June 16-28) | During Storm (June 29-July 11) | % Change |
|---|---|---|---|
| AEP-OH | 171,741 | 1,122,654 | +554 |
| APCo | 88,135 | 791,804 | +798 |
| I&M | 62,592 | 172,749 | +176 |
| KPCo | 14,733 | 51,135 | +247 |

Mobile visits

| OpCo | Before Storm (June 16-28) | During Storm (June 29-July 11) | % Change |
|---|---|---|---|
| AEP-OH | 20,626 | 223,839 | +985 |
| APCo | 10,417 | 116,507 | +1,018 |
| I&M | 8,001 | 39,602 | +395 |
| KPCo | 1,793 | 7,173 | +300 |

For these purposes European Commission launched survey in 2012 in order to understand European citizens' awareness of and attitudes towards activities in the area of emergency response (general, not only power outage). Among the most important findings regarding emergency preparedness and strategic planning there are:

- The majority of European citizens are concerned about the following types of disaster occurring in their country: man - made disasters (75%), natural disasters (67%), terrorist attacks (64%) and armed conflicts (59%)
- a clear majority of European citizens (84%) agree that European countries should be obliged by law to prepare and publish disaster management plans
- there is strong agreement that emergency response activities should be coordinated across Europe
- 19% of European citizens says they feel very or fairly well informed about the civil protection activities. However, 28% say they are not at all well informed.

Both US experience and European survey shows the importance of mutual assistance in the emergency response. In order to have clear and effective rules and procedures there need to be appropriate organizational structure and legal framework established in advance between all stakeholders. It is given in the following Chapter.

## 5.2. US EXPERIENCE WITH MUTUAL ASSISTANCE AND APPLICABILITY IN SEE

One of the major drivers for this report in SEE was to evaluate DSO disaster responses in 2014 and to recommend mutual assistance arrangements based on the US experience. US experience is chosen for two reasons:

1) On the global level US has the most organized emergency management system
2) Vast practical experience with electric companies mutual assistance in emergencies.

The first given reason is based on the long experience of the Federal Emergency Management Agency (FEMA). It is an agency of the United States Department of Homeland Security, initially created in 1979. The agency's primary purpose is to coordinate the response to a disaster that has occurred in the US and that overwhelms the resources of local and state authorities. Even though it is not directly involved in power system operation in emergency cases (it is solely responsibility of power companies), it has significant role in emergency preparedness and assistance in the large power system outages and emergencies. The governor of the state in which the disaster occurs must declare a state of emergency and formally request from the president that FEMA and the federal government respond to the disaster. The only exception to the state's gubernatorial declaration requirement occurs when an emergency and/or disaster takes place on federal property or to a federal asset, for example; the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma, or the Space Shuttle Columbia in the 2003 return-flight disaster.

While on-the-ground support of disaster recovery efforts is a major part of FEMA's charter, the agency provides state and local governments with experts in specialized fields and funding for rebuilding efforts and relief funds for infrastructure by directing individuals to access low interest loans, in conjunction with the Small Business Administration. In addition to this, FEMA provides funds for training of response personnel throughout the US as part of the agency's preparedness effort.

The second given reason for choosing US experience is based on the work of the Edison Electric Institute (EEI), the association that represents all US investor-owned electric companies. Its members provide electricity for 220 million Americans, operate in 49 states and the District of Columbia and directly employ more than 500,000 workers. EEI has 70 international electric companies as Affiliate Members and 250 industry suppliers and related organizations as Associate Members. Organized in 1933, EEI provides public policy leadership, strategic business intelligence, and essential conferences and forums. In October 2014 EEI published “Governing Principles Covering Emergency Assistance Arrangements Between Edison Electric Institute Member Companies”. The main principles are given in this Chapter.

### 5.2.1. The Emergency Management Institute (EMI)

The Emergency Management Institute (EMI) of the US Federal Emergency Management Agency (FEMA) serves as the national focal point for the development and delivery of emergency management training to enhance the capabilities of state, territorial, local, and tribal government officials; volunteer organizations, FEMA's disaster workforce, other Federal agencies and the public and private sectors to minimize the impact of disasters and emergencies on the American public. EMI curricula are structured to meet the needs of this diverse audience with an emphasis on separate organizations working together in all-hazards emergencies to save lives and protect property. Particular emphasis is placed on governing doctrine such as the National Response Framework, National Incident Management System, and the National Preparedness Guidelines. Based in Emmitsburg, Maryland, EMI is fully accredited by the International Association for Continuing Education and Training (IACET) and the American Council on Education (ACE).

The independent study program at EMI consists of free courses offered to US citizens in Comprehensive Emergency Management techniques. In short, EMI provides leadership in developing and delivering training to ensure that individuals and groups having key emergency management responsibilities at all levels of government, possess the requisite competencies to perform their jobs effectively. In addition to its resident training program, EMI disseminates centrally developed training materials through a comprehensive national training program in the US. EMI has responsibility for training FEMA staff to perform their disaster response functions. EMI students do not have to be employed by FEMA or be a federal employee for some of the programs.

The EMI Independent Study (IS) Program, a Web-based distance learning program open to the public, delivered extensive online training with approximately 200 courses and trained more than 2.8 million individuals. The EMI IS Web site receives 2.5 to 3 million visitors a day. Some other countries are having similar organizations. The UK counterpart of the Emergency Management Institute is the Emergency Planning College in Easingwold.

On the other side, emergency coordination and mutual assistance in European Union is not having long history. The Emergency Response Coordination Centre (ERCC) was established few years ago, based on the Treaty of Lisbon that was signed by the EU member states in 2007 and entered into in late 2009. ERCC is operating within the European Commission's Humanitarian Aid and Civil Protection department (ECHO) and it was set up to support a coordinated and quicker response to disasters both inside and outside Europe using resources from the countries participating in the European Union Civil Protection Mechanism. The ERCC replaces and upgrades the functions of the previous Monitoring and Information Centre (MIC).

The ERCC is a coordination hub facilitating a coherent European response during emergencies helping to cut unnecessary and expensive duplication of efforts. It collects and analyses real-time information on disasters, monitors hazards, prepares plans for the deployment of experts, teams and equipment, and works with Member States to map available assets and coordinate the EU's disaster response efforts by matching offers of assistance to the needs of the disaster-stricken country. The ERCC also supports a wide range of prevention and preparedness activities, from awareness-raising to field exercises simulating emergency response.

Finally, it is obvious that experience with organization of mutual coordination and assistance is much shorter in Europe in the US. Moreover, most of the SEE countries are not EU member states, having no direct access to EU organizational structure. Also, cases of natural disasters in the US are much more often than in Europe. So, it is clear that US experience in organization and practice is more than welcome in SEE while analyzing large natural disasters with power system outages.

### 5.2.2. Emergency Assistance Arrangements Between Edison Electric Institute Member Companies

In addition to the above mentioned organizational structures for emergency response, the most critical part for SEE DSO responses in emergency cases is lack of emergency assistance agreements. One of the best international practices can be found in the US, such as “Emergency Assistance Arrangements Between Edison Electric Institute Member Companies”. Based on this agreement electric companies have occasion to call upon other companies for emergency assistance in the form of personnel or equipment to aid in maintaining or restoring electric utility service when such service has been disrupted by acts of the elements, equipment malfunctions, accidents, sabotage or any other occurrences where the parties deem emergency assistance to be necessary or advisable. While it is acknowledged that a company is not under any obligation to furnish such emergency assistance, experience indicates that companies are willing to furnish such assistance when personnel or equipment are available.

In the absence of a continuing formal contract between a company requesting emergency assistance ("Requesting Company") and a company willing to furnish such assistance ("Responding Company"), the following principles are suggested as the basis for a contract governing emergency assistance to be established at the time such assistance is requested:

1. The emergency assistance period will commence when personnel and/or equipment expenses are initially incurred by the Responding Company in response to the Requesting Company’s needs. This would include any request for the Responding Company to prepare its employees and/or equipment for transport to the Requesting Company’s location but to await further instructions before departing. The emergency assistance period will terminate when such employees and/or equipment have returned to the Responding Company, and shall include any mandated rest time resulting from the assistance provided and reasonable time required to prepare the equipment for return to normal activities (e.g. cleaning off trucks, restocking minor materials, etc.).

2. To the extent possible, the companies should reach a mutual understanding and agreement in advance on the anticipated length – in general – of the emergency assistance period. For extended assistance periods, the companies should agree on the process for replacing or providing extra rest for the Responding Company’s employees. It is understood and agreed that if; in the Responding Company’s judgment such action becomes necessary the decision to terminate the assistance and recall employees, contractors, and equipment lies solely with the Responding Company. The Requesting Company will take the necessary action to return such employees, contractors, and equipment promptly.

3. Employees of Responding Company shall at all times during the emergency assistance period continue to be employees of Responding Company and shall not be deemed employees of Requesting Company for any purpose. Responding Company shall be an independent Contractor of Requesting Company and wages, hours and other terms and conditions of employment of Responding Company shall remain applicable to its employees during the emergency assistance period.

4. Responding Company shall make available upon request supervision in addition to crew leads. All instructions for work to be done by Responding Company's crews shall be given by Requesting Company to Responding Company's supervision; or, when Responding Company's crews are to work in widely separate areas, to such of Responding Company's crew lead as may be designated for the purpose by Responding Company's supervision.

5. Unless otherwise agreed by the companies, Requesting Company shall be responsible for supplying and/or coordinating support functions such as lodging, meals, materials, etc. As an exception to this, the Responding Company shall normally be responsible for arranging lodging and meals on route to the Requesting Company and for the return trip home. The cost for these in transit expenses will be covered by the Requesting Company.

6. Responding Company’s safety rules shall apply to all work done by their employees. Unless mutually agreed otherwise, the Requesting Company’s switching and tagging rules should be followed to ensure consistent and safe operation. Any questions or concerns arising about any safety rules and/or procedures should be brought to the proper level of management for prompt resolution between management of the Requesting and Responding Companies.

7. All time sheets and work records pertaining to Responding Company's employees furnishing emergency assistance shall be kept by Responding Company.

8. Requesting Company shall indicate to Responding Company the type and size of trucks and other equipment desired as well as the number of job function of employees requested but the extent to which Responding Company makes available such equipment and employees shall be at responding Company's sole discretion.

9. Requesting Company shall reimburse Responding Company for all costs and expenses incurred by Responding Company as a result of furnishing emergency assistance. Responding Company shall furnish documentation of expenses to Requesting Company. Such costs and expenses shall include, but not be limited to, the following:

    a. Employees' wages and salaries for paid time spent in Requesting Company's service area and paid time during travel to and from such service area, plus Responding Company's standard payable additives to cover all employee benefits and allowances for vacation, sick leave and holiday pay and social and retirement benefits, all payroll taxes, workmen's compensation, employer's liability insurance and other contingencies and benefits imposed by applicable law or regulation.

b. Employee travel and living expenses (meals, lodging and reasonable incidentals).

c. Replacement cost of materials and supplies expended or furnished.

d. Repair or replacement cost of equipment damaged or lost.

e. Charges, at rates internally used by Responding Company, for the use of transportation equipment and other equipment requested.

f. Administrative and general costs, which are properly allocable to the emergency assistance to the extent such costs, are not chargeable pursuant to the foregoing subsections.

10. Requesting Company shall pay all costs and expenses of Responding Company within 60 days after receiving a final invoice therefor.

11. Requesting Company shall indemnify, hold harmless and defend the Responding Company from and against any and all liability for loss, damage, cost or expense which Responding Company may incur by reason of bodily injury, including death, to any person or persons or by reason of damage to or destruction of any property, including the loss of use thereof, which result from furnishing emergency assistance and whether or not due in whole or in part to any act, omission, or negligence of Responding Company except to the extent that such death or injury to person, or damage to property, is caused by the willful or wanton misconduct and / or gross negligence of the Responding Company. Where payments are made by the Responding Company under a workmen's compensation or disability benefits law or any similar law for bodily injury or death resulting from furnishing emergency assistance, Requesting Company shall reimburse the Responding Company for such payments, except to the extent that such bodily injury or death is caused by the willful or wanton misconduct and / or gross negligence of the Responding Company.

12. In the event any claim or demand is made or suit or action is filed against Responding Company alleging liability for which Requesting Company shall indemnify and hold harmless Responding Company under paragraph (11) above, Responding Company shall promptly notify Requesting Company thereof, and Requesting Company, at its sole cost and expense, shall settle, compromise or defend the same in such manner as it in its sole discretion deems necessary or prudent. Responding Company shall cooperate with Requesting Company's reasonable efforts to investigate, defend and settle the claim or lawsuit.

13. Non-affected companies should consider the release of contractors during restoration activities. The non-affected company shall supply the requesting companies with contact information of the contactors (this may be simply supplying the contractors name). The contractors will negotiate directly with requesting companies.

# 6. RECOMMENDATIONS

SEE DSO working group launched this study in order to analyze consequences of the 2014 storm in consistent way, to identify the most critical aspects in SEE DSO emergency response needs and to introduce mutual assistance benefits and needs.

Natural disasters in SEE in 2014 were among the largest ones in the last 120 years. More than 1.4 mil. customers were disconnected from the power system in different periods in 2014-2015 as a consequence of natural disasters. Total area of more than 40 000 $km^2$ was affected (size of Virginia (US) or Holland). Total direct damage in the power systems of SEE was estimated to 230 mil.€. Indirect damage is much higher. SEE DSOs prepared different reports for the international financing institutions, claiming for help, but there was no any financial support, except for Croatia (~8 mil.€ received from EU funds).

There were several activities on the regional level launched to analyze natural disaster impact on the power network business (such as OSCE Expert Workshop "Sharing Best Practices to Protect Electricity Networks from Natural Disasters", Vienna on July 2, 2014). But, this USAID financed report is the first one collecting systematic, comparable and verified dataset from the regional DSOs perspective. It is focused on SEE DSO disaster responses and operational experiences in the period 2014 - 2015. The basic set of input data for this report was collected through the survey/questionnaire distributed to all 9 SEE DSOs. Altogether 12 relevant events were reported in 5 timeframes:

1. February 2014: ice storm in Croatia
2. May 2014: flooding in Croatia, BiH, Serbia and Kosovo
3. January 2015: snow storm in Macedonia
4. February 2015: snow storm in Macedonia and Albania
5. May 2015: flooding in Macedonia

There were 3 events reported in Macedonia (2 snow storms and 1 flooding) and 2 events reported in Croatia (ice storm and flooding).

More than 300 inputs were collected. Some of the required data were simply not available, so finally 92% responses were collected, while remaining 8% of the data were not available.

After input data collected and analyses, presented US experience as well as discussions at the working group meeting held in Athens in June 2015, the recommendations for the improvement of DSO disaster response can be divided in two groups:

1. Operational recommendations – related to short term measures and operational activities that can be taken to minimize negative consequences to DSO operation in emergency cases. These recommendations are based on the DSOs experience in 2014 and 2015 and it can be implemented immediatelly.

2. Strategic recommendations – related to mid to long-term measures. These recommendations are based on the US experience and it assumes larger timeframe to prepare it, adopt and implement in SEE.

Operational recommendations are given as follows:

1. The most important equipment parts replaced prior to total flooding
    - This practice was used in the most organized way by Croatian and BiH DSOs (HEP ODS and EPHZHB), for example removing circuit breakers from one to another TS 35/10 kV. It saved important part of equipment from total damage and it is recommended to be included in formal DSO procedures in emergency cases of this kind.
2. Engagement of all generating units connected to the network
    - This practice was used in Macedonia. It enabled significantly larger dispatching maneuver and increased security of supply.
3. Temporary solutions for re-energizing (i.e. wooden poles, improvised cable back-up connections)
    - This practice was also used in Macedonia and Croatia. The implementation of this measure takes some time, but it is useful not only for the emergency response, but also for recovery period till normal system operation is fully re-established.
4. Internal reorganization
    - All DSOs were internally ad-hoc reorganized during emergency period. Practically, all departments were engaged to establish needed teams to re-energize MV and LV system. Most of them were having clear targets, i.e. to re-energize 80% of the MV network within 24 hrs (Kosovo) or to re-energize all customers within 48 hrs after water withdrawal (ERS, BiH). These were mainly ad-hoc decisions, so it is recommended to have it clearly defined in advance, in DSO rulebooks for emergency cases.
5. After water withrawal immediate checking of the installations and re-energizing
    - There were different approaches to the re-energizing in the region. Some of the DSO were checking every single installation (within each house) before re-energizing in terms of its moisture and readiness for normal operation without danger for final consumers, while other DSOs were checking only the most relevant (indicative) parts of the installations. Also, in some cases individual customers were reconnected one by one, while in other areas group of customers was reconnected after their feeder and all its users were fully prepared. So, it is important to clarify re-energizing criteria, to minimize time needed for re-energizing and at the same time to keep final users fully safe. EPHZHB prepared and distributed safeguard leaflet to all customers to inform them on potential danger of electricity installation after flooding and relevant procedures and measures.

6. Detailed and consistent information and reports to be sent to High Level Command Team, DSO headquater and other relevant institutions
    - This was done by all DSOs, but with different institutions included (DSO Management Board, Government, Civil Service, Regulators, media etc.). It is very important to have information, reporting and decision making hierarchy established in advance.
7. Mutual assistance from other distribution areas wherever possible
    - There was no such a case in SEE. There were offers for mutual assistance especially within BiH, but at the end all problems were solved with internal DSO resources. There was large cross-border civil protection assistance and humanitarian aid. It is strongly recommended to sign and implement mutual assistance agreement in SEE, since relativelly small regional DSOs simply can not be enough prepared and equiped for large disturbances like the ones happened in 2014 and 2015. The US example clearly prove large benefits of mutual cooperation in emergency cases that are now happening much more often than few decades ago.

Strategic recommendations are given as follows:

1. To establish clear procedures and responsibilities in emergency cases
    - 7 out of 9 SEE DSOs have no emergency response formal procedures, AEP has it in details. This project offers possibility to implement AEP experience and practice in SEE
2. To organize better communication and internal DSO procedures in emergency cases
    - inter-DSO and DSO-DSO information and data exchange protocols in emergency cases are not existing in SEE, AEP has it developed in details. This is another possibility for improvements in SEE based on US experience.
3. To clearly define supply costs in emergency cases
    - in SEE it is fully covered by the internal DSO funds, not recognized as a part of regulated income (tariff). This could be large regulatory and financial problem in the case of large scale emergencies. National regulatory agencies should develop procedures and methodologies for inclusion of these costs in network tariff.
4. To properly use and maintain meteo-alarm
    - most of DSOs had information about natural disaster, but it couldn’t be applied on time and used accordingly. It should be part of automatic internal DSO procedures and acions in emergency cases.

5. To establish new operational and development standards (to upgrade existing standards, methodologies and criteria in emergency situations) such as:
    - to build SS on the locations higher than flooding level
    - to build SS out of potential landsliding areas
    - to establish alternative supply routes for all risky areas (double fed SS)
    - to constantly have network equipment reserves and emergency funds
    - to use isolated conductors in specific areas
    - to establish higher level of automation of MV network
    - to ensure special vehicles for transport of material and staff in emergency cases
    - etc…
6. To use lessons learned from the TSOs' experiences
    - Usage of generic models to enable exchange of information and collaboration frameworks for mutual assistance in emergency cases (i.e. ENTSO-e Operational Handbook requirements)
7. To use best practices to address in risk management and restoration phases
    - to define "Defense" and "Restoration" plans as well as special security packages for all emergency conditions

This report was not supposed to cover all aspects of the DSO operation in emergency conditions. Future work that goes beyond scope of the work in this document could cover the following areas:

- streamline the analysis (i.e. protection system issues, maintenance and revitalization criteria and methodology, relevant regulatory framework etc.)
- implementation of the selected lessons learned from the US experience
- preparation of the changes in the local legal and procedural framework
- preparation of mutual assistance rulebooks
- analysis of the governance, social, economic, technological and human factors relevant for the power networks protection.
- lessons learned from the TSOs' experiences such as generic models to enable exchange of information and collaboration frameworks for mutual assistance;

- best practices to address in risk management and restoration phases such as “Defense” and “Restoration” plans as well as special security packages
- good practices from other sectors such as “near-misses”, relevant in the aviation industry.

Finally, future activities of this working group on this topic could be divided in three steps:

1. **Internal DSO** legal and procedural improvements
2. **Periodic update** on internal DSO legislative changes and emergency response experience
3. **Mutual assistance** agreement based on US experience in three steps:
    1) Inter-DSO
    2) Inter-state (i.e. BiH)
    3) Regional

Having in mind that from one side this is the first document covering regional DSOs emergency response, along with collection of systematic, comparable and verified dataset, while from the other side emergency conditions are nowadays much more often and severe than before, it seems that there will be a constant need to further develop this topic in the future.

# 7. APPENDIX: QUESTIONNAIRE

1. **Scope and scale of the event:**
    a. **Dates (period):** When did it happen, from the first problem in your power system till its normal operation and reconnection of all customers?

    _____

    b. **Total population affected:** How many people / consumers were affected by this event in terms of power supply interruption or power quality reduction?

    _____

    c. **Total affected area ($km^2$)**: What is the size of the area affected by this event?

    _____

2. **Impact on critical infrastructure - distribution system in affected areas**
    **a. Damaged lines:** What is the number and length of damaged lines and feeders (by voltage levels)?

    _____

    **b. Disconnected lines:** What is the number and length of disconnected lines and feeders (by voltage levels)?

    _____

    **c. Damaged substations:** What is the number and installed capacity of damaged substations (by voltage levels)?

    _____

d. **Disconnected substations:** What is the number and installed capacity of disconnected substations (by voltage levels)?

_____

e. **Destroyed metering devices:** What is the number of destroyed metering devices (by types)?

_____

f. **Damaged metering devices:** What is the number of damaged and later repaired metering devices (by types)?

_____

g. **Any other data on damaged equipment (warehouses, primary, secondary equipment etc.):**

_____

h. **Please give a short description of conditions in which catastrophic event occurred (**disaster outlook, aggravating factors, precipitation, how many days of rain you had, mudslides, generating units outage etc.)

_____

i. **Did you have any other comparable event in your power system in the recent history?**

_____

j. **How often in average such events (of similar or smaller scale) occur in your power system?**

_____

3. **Emergency measures**

   a. **Legal framework for operation under emergency conditions** (Emergency strategy):

      i. Yes (if "Yes", please shortly describe)

      _____
      _____
      _____
      _____

      ii. No

   b. **Re-energizing areas – realized actions**: What were the actions taken and timeframes needed to re-energize the system?

      _____
      _____
      _____
      _____
      _____

   c. **Reconnecting key customers/public services**: What was your operational plan and procedure for prioritization of reconnection of key customers/institutions/public services?

      _____
      _____
      _____
      _____
      _____

   d. **Cooperation/Mutual assistance from other DSOs (excluding those connected by common ownership)**: Were there any mutual assistance and help from other DSOs in terms of material and equipment, staff exchange and/or coordination? Please provide estimated numbers for 1) material and equipment, 2) staff, 3) working hours and/or 4) coordination for a) DSO own resources and b) assistance from other DSOs.

      _____
      _____
      _____

   e. **Cooperation/Mutual assistance from other distribution areas/companies connected with the affected DSO by common ownership**: Were there any mutual assistance and

help from other distribution areas/companies connected with the affected DSO by common ownership, in terms of material and equipment, staff exchange and/or coordination? Please provide estimated numbers for 1) material and equipment, 2) staff, 3) working hours and/or 4) coordination for a) DSO own resources and b) assistance from other distribution areas/companies connected with the affected DSO by common ownership.

_____

_____

_____

f. **Material/Equipment needed, Staff involved**: How many staff and equipment/material was involved/spent in system recovery (in addition to regular DSO activities in normal operational conditions)?

_____

_____

_____

## 4. Consequences (damage assessment)

a. **Duration of supply interruption:** How many disconnected consumers (and estimated electricity non-delivered, if available) did you have in the following timeframes: up to 1 hour, 1 to 3 hours, 3 to 8 hours, 8 hours to 1 day, 1 to 3 days, 3 to 5 days, 5 to 7 days, over 7 days)?

_____

_____

**b. What was total electricity non-delivered?**

_____

c. **What is the total set of equipment replaced due to this event** (not included in regular replacement/maintenance)? Please provide the quantities (km, #) for removed equipment due to 1) permanent damage and 2) sent for repair.

Lines (by types and voltage _____

Transformers (by voltage levels):_____

Meters by types:_____

Switching devices by types and voltage levels:_____

Other by types:_____

d. **What is the total set of equipment installed due to this event** (not included in regular replacement/maintenance)? Please provide the quantities (km, #) and costs (EUR) including material and work of 1) new and 2) repaired equipment.

i. Lines (by types and voltage levels)
ii. Transformers (by voltage levels)
iii. Meters by types
iv. Switching devices by types and voltage levels
v. Other by types

| Asset | Type | Replacement (new) assets | | Repaired assets | |
|---|---|---|---|---|---|
| | | Quantity (#, km) | Cost (EUR) | Quantity (#, km) | Cost (EUR) |
| Line | type, voltage | | | | |
| Line | type, voltage | | | | |
| … | … | | | | |
| Transformer | voltages | | | | |
| … | … | | | | |
| Meter | type | | | | |
| … | … | | | | |
| Switching device | type, voltage | | | | |
| … | … | | | | |
| Other | type | | | | |
| … | … | | | | |

e. **What is the estimated total cost of:**

i. Replacement (new) assets:_____
ii. Repair of the existing assets_____
iii. Work:_____

iv. Other:_____

**f. What are the estimated losses for DSO:**

**i. Increase in operational losses (**during flood periods and in the coming months**): _____**

**ii. Loss in revenues:_____**

**g. Do you plan/expect to request revision of the network tariffs by the regulator or you will cover these expenses from your own cashflow/loan only?**

_____

**5. Observations/Lessons learned/Recommendations**

a. **Drawbacks observed in the following areas: safety, network operation, network technical design, impact on network operation in unaffected areas, impact on customers and most frequent complaints, impact on suppliers, impact on other entities in power supply line (specify which)**:

_____

_____

_____

_____

_____

_____

b. **Short description of special technical solutions you eventually used**:

_____

_____

_____

_____

_____

_____

**c. Recommendations derived from the experience gained (lessons learned)**

_____

_____

d. **Plans for improving performance under emergency events**:

_____

_____

_____

_____

_____

_____