



Generation Investment Study

Volume 5: Generation and Transmission Appendices

Appendix 11: GTMax Analyses and Results



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A11.1 Introduction

This appendix provides a description of the GTMax model and major input data. It also presents detailed results of the Reference Case analyzed under Scenario C.

To enhance the representation of each power system, discussions were held with the South East Cooperative Initiative (SECI) group. Over the past several years, the SECI has formed a Regional Transmission System Planning (RTSM) to analyze all power systems in Southeast Europe. This group uses the PSS/E model to analyze load flows, short-circuit, and dynamic analyses under various scenarios.

GTMax results were then used in the PSS/E model. Appendix 12 presents the PSS/E analyses and results, prepared by EKC as a stand alone project.

A11.2 Description of GTMax Model

The Generation and Transmission Maximization Programme (GTMax), allows the simulation of a complex electricity market and operational issues, both for competitive and regulated environments. With GTMax, utility planners can maximize the value of the electric system taking into account not only each utility company's own limited energy and transmission resources but also firm contracts, independent power producer (IPP) agreements, and bulk power transaction opportunities for the group of interconnected systems on the region. GTMax maximizes net revenues of power systems by finding a solution that increases income while keeping expenses at a minimum. The model does this while ensuring that market transactions and system operations are within the physical and institutional limitations of the power system. Figure A11.1 presents the input and output modules of GTMax.

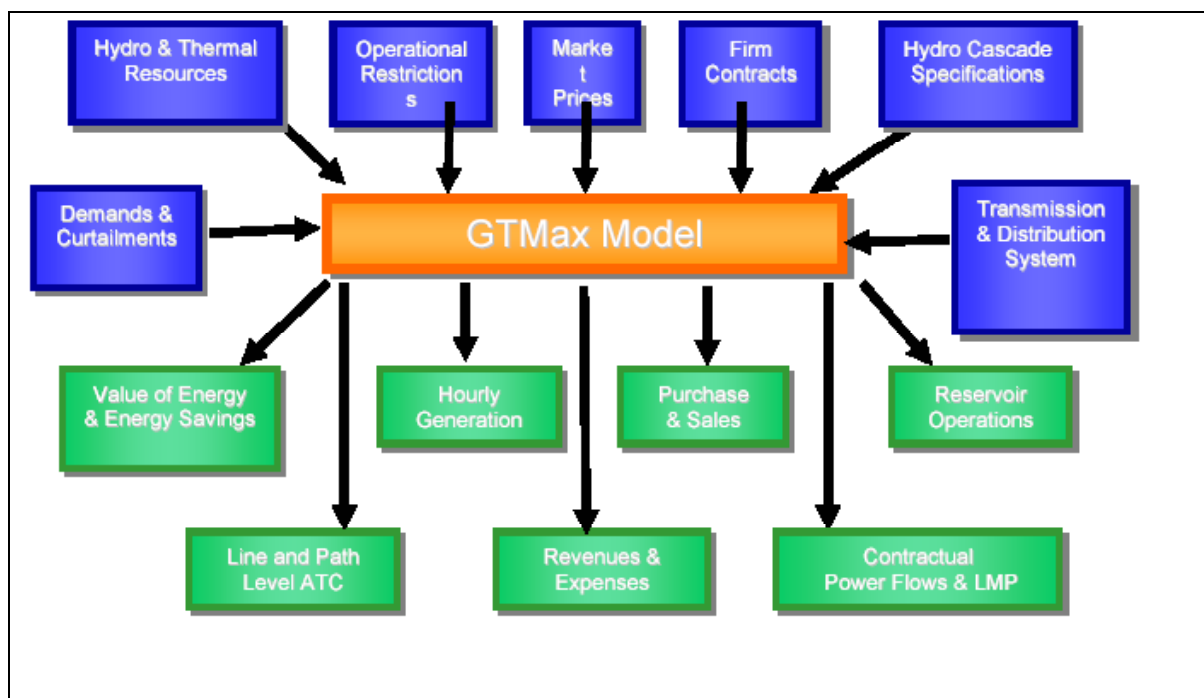


Figure A11.1. GTMax Input Information and Model Results

The GTMax analysis takes into account the topology of the electric power systems, interconnection transfer capabilities, chronological hourly loads, and the differences in the electricity generation costs in each of the utility systems. The programme simulates the



dispatch of electric generating units and the economic trade of energy among utility companies using a network representation of the power grid. Generation and energy transactions serve electricity loads that are located at various locations throughout the simulated region. Transmission links connect generation and energy delivery points to load centres. Electricity loads are satisfied, curtailed via contractual agreements, or not served due to a generator supply shortage or because of transmission limitations.

GTMax calculates market prices for electricity sales/purchases in different regions (market hubs) of the power network based on the capacity constraints of transmission interties. The model simultaneously optimises transactions to minimise overall operating costs in the region. GTMax output includes: the units to be dispatched, how much power should be generated and sold on an hourly basis, when to buy and sell power on the spot market, the cost of alternative power plant operations, the incremental value of water, and the value of demand-side management programmes.

GTMax has a detailed representation of many different components of the power system. Nuclear, baseload thermal, cycling, and peaking power plant can all be characterized in the model. There is also a special representation for Combined Heat and Power (CHP) plant. The types of hydropower plant that can be simulated include storage units, run-of-river power plant, and pumped storage. Hydropower plant can also be specified in a cascade such that reservoir water levels remain within physical and institutional operating levels.

On the demand-side of the power equation, the GTMax model includes an hourly representation of residential, commercial, and industrial electricity demands at user-specified load centres. Demands that are served by the power sector are a function of electricity price. When the locational market price in the network reaches or exceeds a user-specified level, GTMax can simulate a DSM programme for that region to reduce system loads.

The GTMax model is designed to be user-friendly. It operates under a Microsoft Windows environment and employs a Geographical Information System (GIS) interface. The model is very versatile in that the user starts with an empty workspace and builds a power system topology of system components and interconnections using mouse point and click actions. By clicking on a map of utility power plants and transmission lines, input data can be viewed and modified.

The GTMax model requires several different types of data that defines the topology of a power system network and provides detailed information about link and node network components. The regional topology of the region as well as details for each jurisdiction are shown in the following section. An example of a hypothetical power system is shown in Figure A11.2.

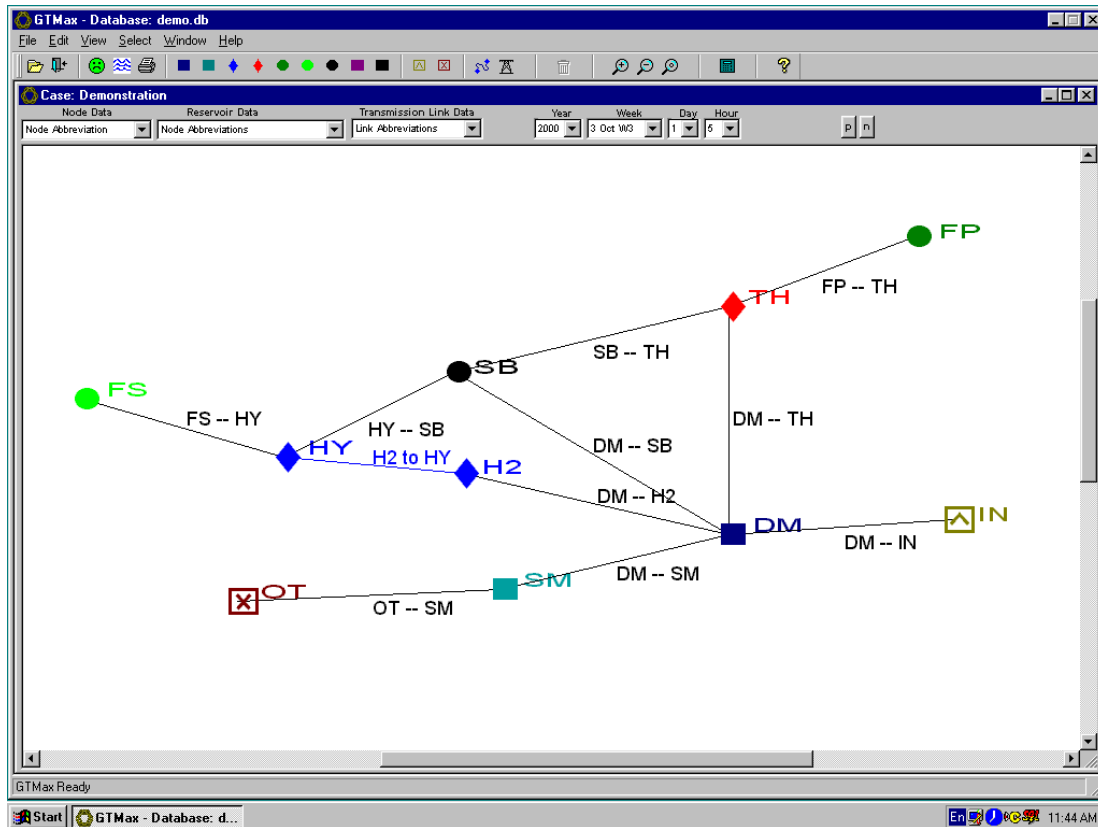


Figure A11.2. Hypothetical GTMax Power System

A summary of the different node types that may be needed to represent an electric power system in the GTMax model include:

Hydro Node ◆ **HY**

The Hydro node represents a hydropower plant. It has numerous inputs including water-to-power conversion efficiencies and maximum and minimum generation levels. See the description of input tables below for more detail.

Thermal Node ◆ **TH**

The Thermal node represents a thermal power plant. It also has numerous inputs including maximum and minimum generation levels and weekly energy limits. See the description of input tables below for more detail.

Demand Node ■ **DM**

The Demand node contains hourly electricity loads.

Purchase Contract Node ● **FP**

The Purchase Contract node data input includes a step-function of purchase prices and quantities. It also has weekly and daily minimum and maximum delivery limits under a contract. A minimum hourly delivery schedule can be specified

Sale Contract Node ● **FS**

This node represents a firm sales contract and has input variables that represent contract sales terms similar to the purchase node.

Spot Market Node ■ **SM**

The main data input for this node are spot market prices.

Substation Node ● **SB**



This node does not have any data input forms. It is only used to connect nodes and is also used to compute regional market energy prices.

There are two types of links that are normally used in GTMax: 1) links that represent transmission lines (black lines in the topology) and links that connect reservoirs in cascade (blue lines in the topology). GTMax uses transmission lines to compute contractual power flows. Inputs include hourly energy transfer capabilities on links and associated line losses. There are also entries for hourly transmission costs or charges.

Cascade links include data inputs for downstream reservoir operations such as minimum and maximum reservoir elevation levels and limits on reservoir elevation changes over time. To make reservoir elevation calculations it is necessary to know how much a reservoir elevation will change when a unit of water is released from it. Typically, an average value between the minimum and maximum allowable elevation level is specified as an input to GTMax.



A11.3 GTMax Topology

The representation or topology for each jurisdiction and the region was discussed with the SECI Transmission group. For each jurisdiction, the total demand was divided one or several load nodes. Each load node is itself associated with a number of generating plants. The names of the representative load centres and generation plants are summarized in Table A11.1.

Figures A11.3 and A11.4 present the GTMax topology used for 2010 and 2015. Details on the new transmission lines and substations are presented in Appendix 12. Figures A11.5 through A11.13 present the topology for each jurisdiction in year 2010.



Table A11.1 GTMax Topology for 2010

Jurisdiction	Name of Load Node	Generation		
		Hydro	Pumped Storage	Thermal
		Plant Name	Plant Name	Plant Name
Albania	V.DEJES	FIERZA		
		KOMANI		
		ULZA - SHKOPETI		
		VAU I DEJES		
	TIRANA-ELBASAN	BISTRICA		BALSH
				FIER 1
				VLORA1
B & H	BANJA LUKA	BOCAC		
	MOSTAR DEMAND	CAPLJINA UPPER	CAPLJINA	
		GRABOVICA		
		JABLANICA		
		JAJCE 1		
		JAJCE 2		
		M.BLATO		
		MOSTAR HYDRO		
		PEC MLINI		
		RAMA		
		SALAKOVAC		
	SARAJEVO			KAKANJ 5
				KAKANJ 6
				KAKANJ 7
	TREBINJE	DUBROVNIK G-2		GACKO
		TREBINJE HYDRO		
	TUZLA	VISEGRAD		TUZLA 3
				TUZLA 4
				TUZLA 5
				TUZLA 6
				UGLJEVIK
BULGARIA	BLAGOEVRAD	BUL SMALL HYDRO		
	CHERVENA MOGILAD			BOBOV DOL
				PERNIK CHP
	KOZLODUI			KOZLODUY 1
				KOZLODUY 2
	MARITSA	IVAILOVGRAD		LUKOIL
		KARDJALY		BRIKEL
		STUDEN KLADENEC		MARITSA 3
				MARITSA EAST 1



Table A11.1 GTMax Topology for 2010

Jurisdiction	Name of Load Node	Generation		
		Hydro	Pumped Storage	Thermal
				MARITSA EAST 2 1
				MARITSA EAST 2 N
				MARITSA EAST 3
	PLOVDIV	ALEKO	ORPHEY	PLOVDIV CHP
		BATAK		
		MOMINA KLISURA		
		PESTERA		
		TESHEL		
		DEVIN		
		KRICHIM		
	SOFIA DEMAND	SESTRIMO	BELMEKEN	SOFIA HEAT
				SOFIA IND P
	VARNA DEMAND			VARNA CHP
				VARNA THERMAL
				RUSE 12
				RUSE 34
				RUSE 56
	VETREN		CHAIRA	
CROATIA	OSIJEK			OSIJEK A
				OSIJEK B
				CC 480 2
	RIJEKA	RIJEKA HPP		PLOMIN 1
		SENJ		PLOMIN 2
		SKLOPE		RIJEKA THERMAL
		VINODOL		
	SPLIT	DJALE	VELEBIT	
		GOLUBIC		
		MILJACKA		
		KRALJEVAC		
		PERUCA		
		ORLOVAC		
		ZAKUCAC		
		DUBROVNIK G-1		
	ZAGREB	CAKOVEC		JERTOVEC
		DUBRAVA		KRSKO
		GOJAK		SISAK
		OZALJ 1		ZAGREB EL TO A
		OZALJ 2		ZAGREB EL TO H
		VARAZDIN		ZAGREB EL TO K
				ZAGREB TE TO A



Table A11.1 GTMax Topology for 2010

Jurisdiction	Name of Load Node	Generation		
		Hydro	Pumped Storage	Thermal
				ZAGREB TE TO C
				CC 288 1
MACEDONIA	BITOLA	GLOBOCICA		BITOLA 1
				BITOLA 2
				BITOLA 3
	DUBROVO	TIKVES		NEGOTINO
	SKOPJE	KOZJAK+MAT		OSLOMEJ
		RAVEN		
		SPIIJE		
		VRBEN		
		VRUTOK		
MONTENEGRO	MONTENEGRO	PERUCICA		PLJEVLJA THERMAL
		SMALL HPPS		
ROMANIA	ARAD			ARAD CHP
	BUCHARESTI SUD	NEHOUI		BRAZI CHP
				BUCURESTI SUD
				BUCURESTI VEST
				DOICESTI
				GROZAVESTI CHP
				GUIRGIU
				OTHER AUTOPRODUC
				PROGRESU CHP
	GUTINAS	BACAU		BACAU THERMAL
		BERESTI		BORZESTI
		CALIMANESTI SIRE		BORZESTI CHP
		GALBENI		IASI I
		RACACIUNI		IASI II
		STEJARU		SUCEAVA
		VADURI		
	ISACCEA			BRAILA 1
				BRAILA 2
				BRAILA 3
				CERNAVODA
				CERNAVODA 2
				GALATI CHP
				PALAS CHP
	PORTILE DE FIER	PORTILE 1		DROBETA
		PORTILE 2		
		RUIENI		

**Table A11.1 GTMax Topology for 2010**

Jurisdiction	Name of Load Node	Generation		
		Hydro	Pumped Storage	Thermal
	ROSIORI	MARISELU		ORADEA
		MUNTENI I		
		REMETI		
		TARNITA		
	SIBIU	BRADISOR		BRASOV THERMAL
		GILCEAG		DEVA 1
		LOTRU CIUNGET		DEVA 2
		SASCIORI		GOVORA THERMAL
		SUGAG		
	TANTARENI	ARCESTI		CRAIOVA
		BABENI		ISALNITA 2
		CALBUCET		PITESTI
		CALIMANESTI OLT		PAROENI
		CORNETU		ROVINARI
		DAESTI		TURCENI 1
		DRAGANESTI		TURCENI 2
		DRAGASANI		
		FRUNZARU		
		GOVORA		
		IONESTI		
		IPOSTESTI		
		IZBICENI		
		MOTRU		
		RETEZAT		
		RIMNICU VILCEA		
		RIURENI		
		RUSANESTI		
		SLATINA HYDRO		
		STREJESTI		
		TISMANA		
		TOTAL UNDER 25		
		TURNU		
		VIDRARU		
		ZAVIDENI		
SERBIA	B. BASTA	BAJINA BASTA	BAJINA	
		BISTRICA KOKIN		
		POTPEC		
		ZVORNIK		
		PIVA		
	DJERDAP	DJER1 AND DJER2		

**Table A11.1 GTMax Topology for 2010**

Jurisdiction	Name of Load Node	Generation		
		Hydro	Pumped Storage	Thermal
	MLADOST			ZRENJANIN CHP
				KOLUBARA B
				KOSTOLAC A 1
				KOSTOLAC A 2
				KOSTOLAC B
				MORAVA
				NOVI SAD CHP
				TENT A 1
				TENT A 2
				TENT B
				KOLUBARA 2
	NIS	PIROT		
		VLASINSKE		
UNMIK	KOSOVO	GAZIVODE		KOSOVO A 3-4
		ZHUR		KOSOVO A5
				KOSOVO C 2X450
				KOSOVO B THERMAL



Figure A11.3 GTMax Representation of Regional Balkan Network in 2010

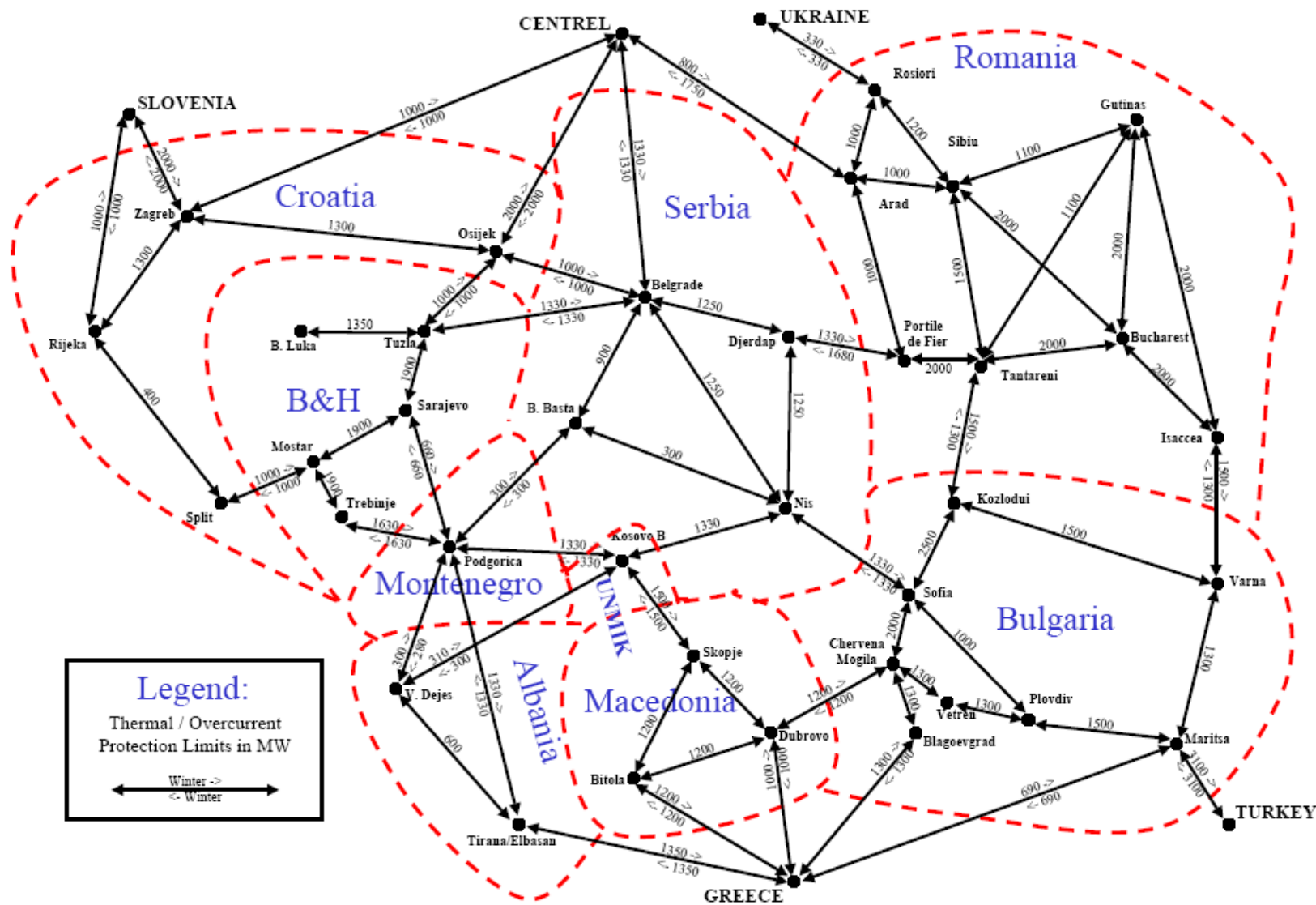




Figure A11.4 GTMax Representation of Regional Balkan Network in 2015

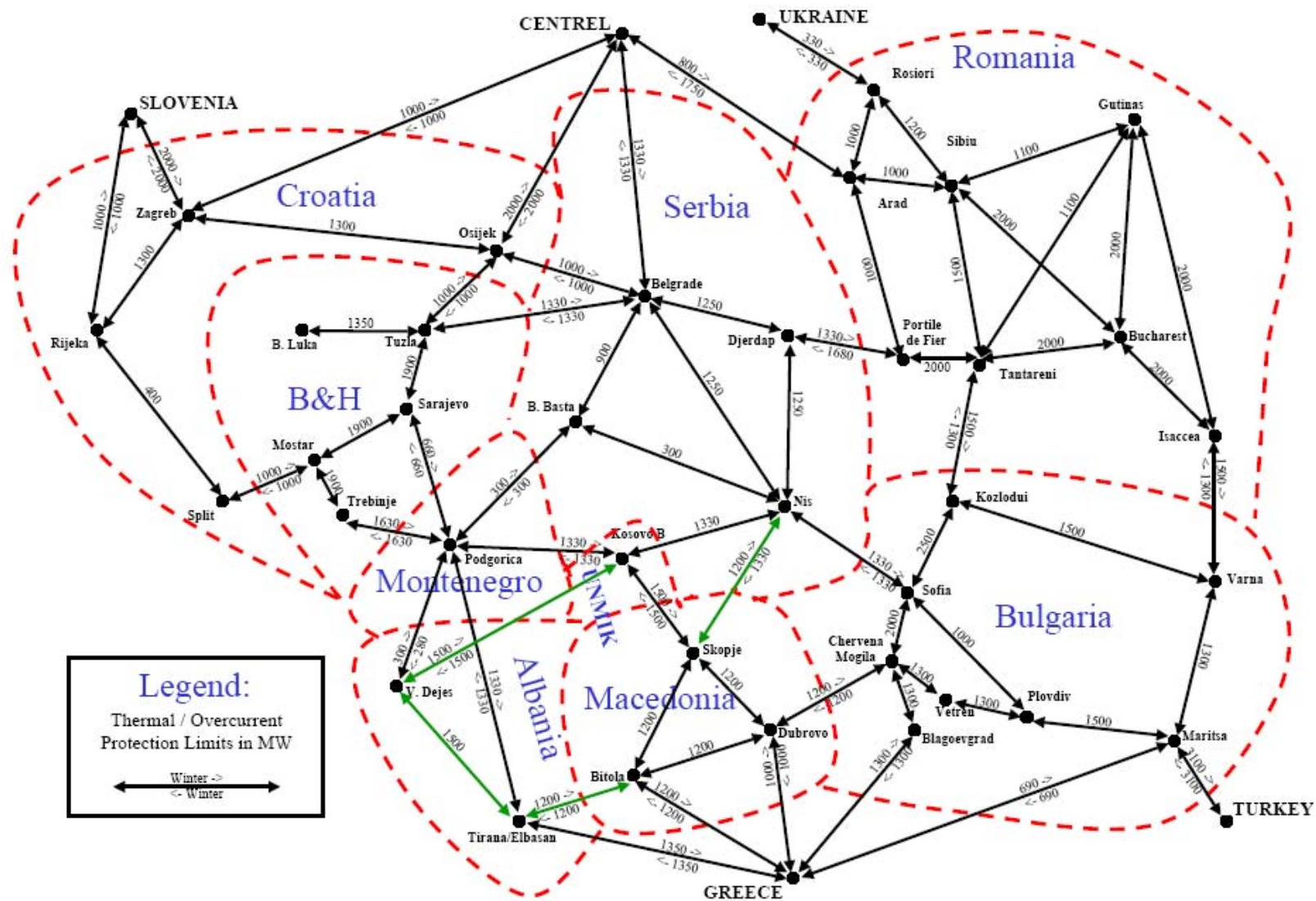




Figure A11.5 GTMAX Representation of Albania in 2010

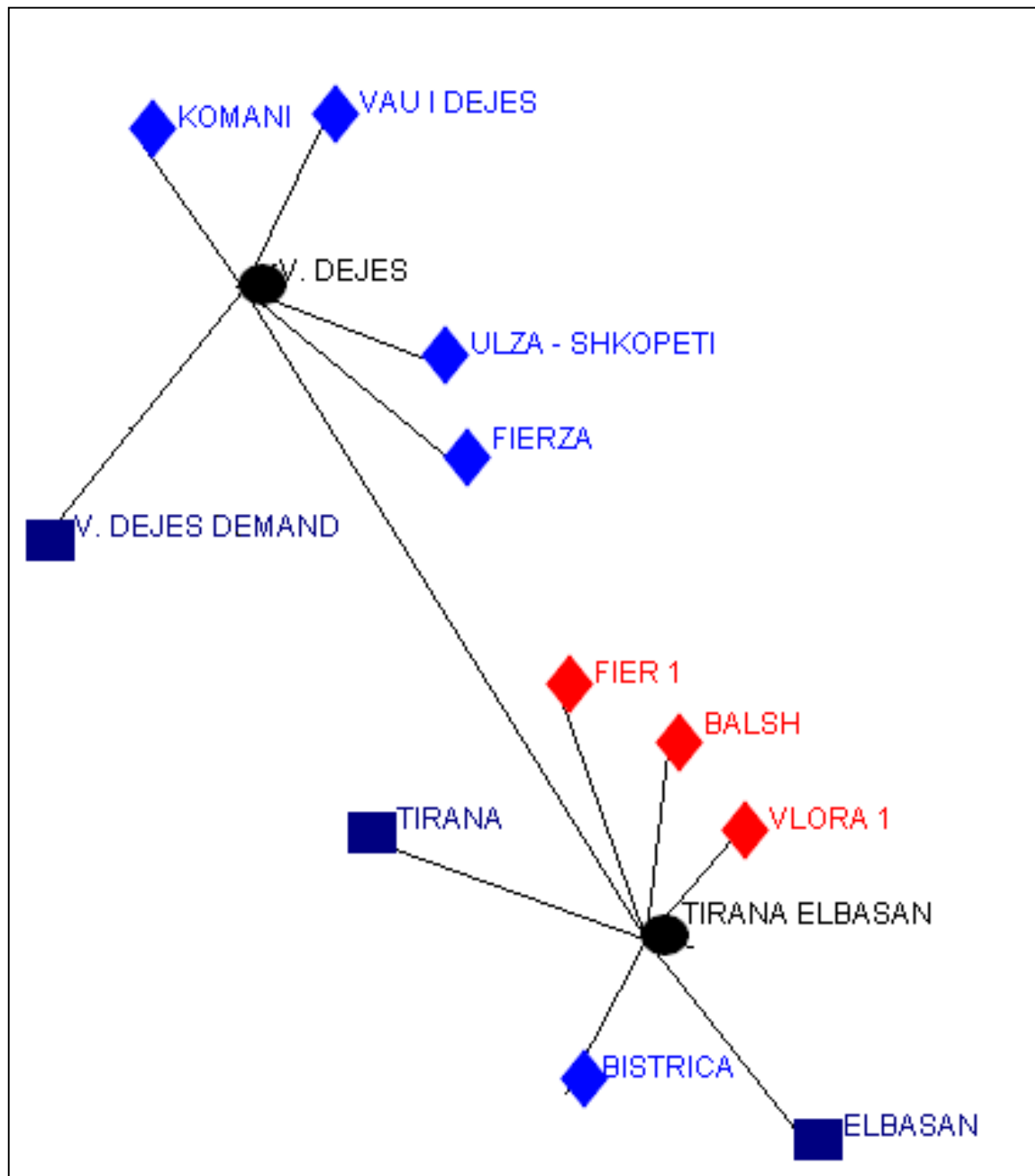




Figure A11.6 GTMAX Representation of Bosnia & Herzegovina in 2010

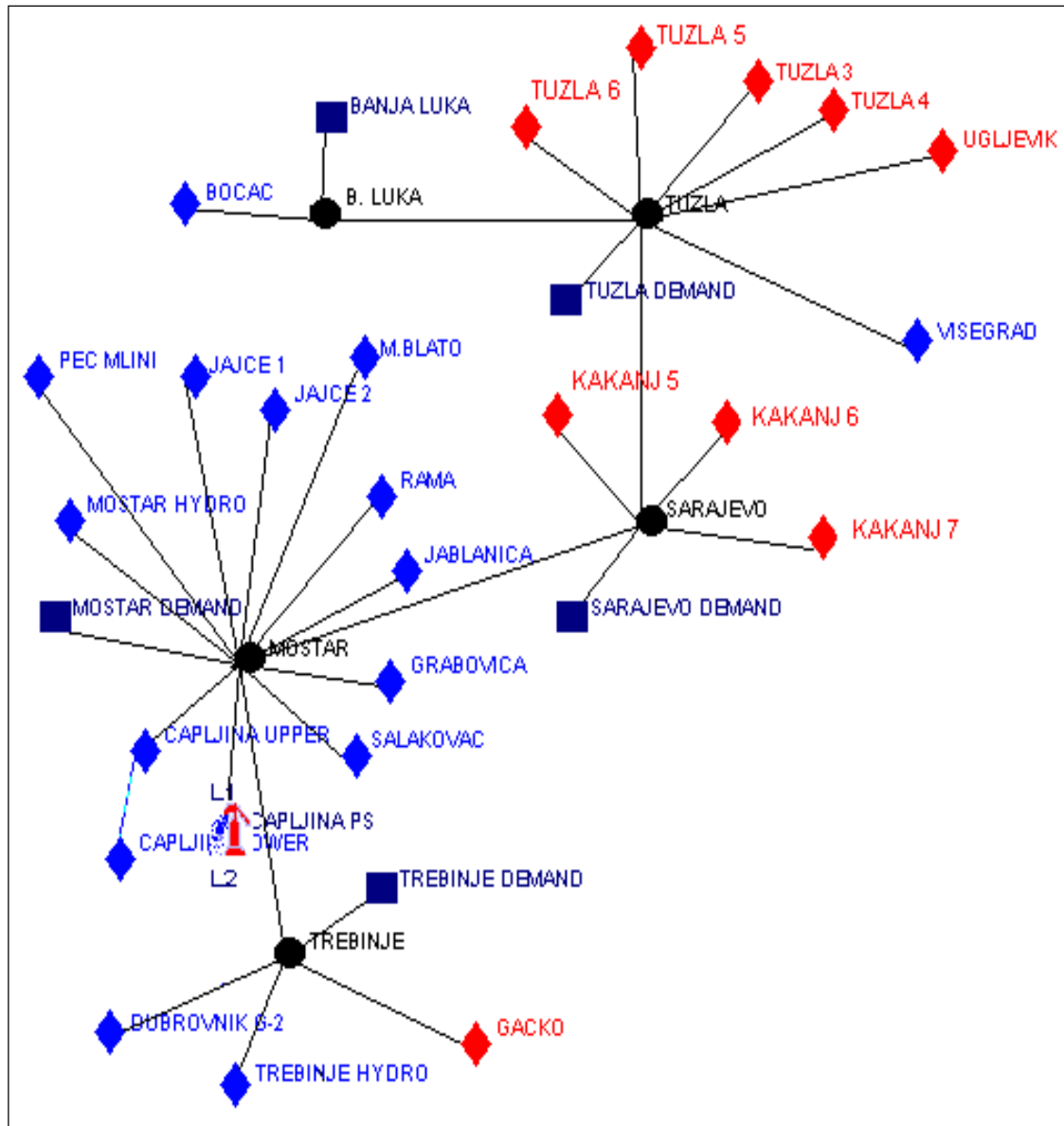




Figure A11.7 GTMAX Representation of Bulgaria in 2010

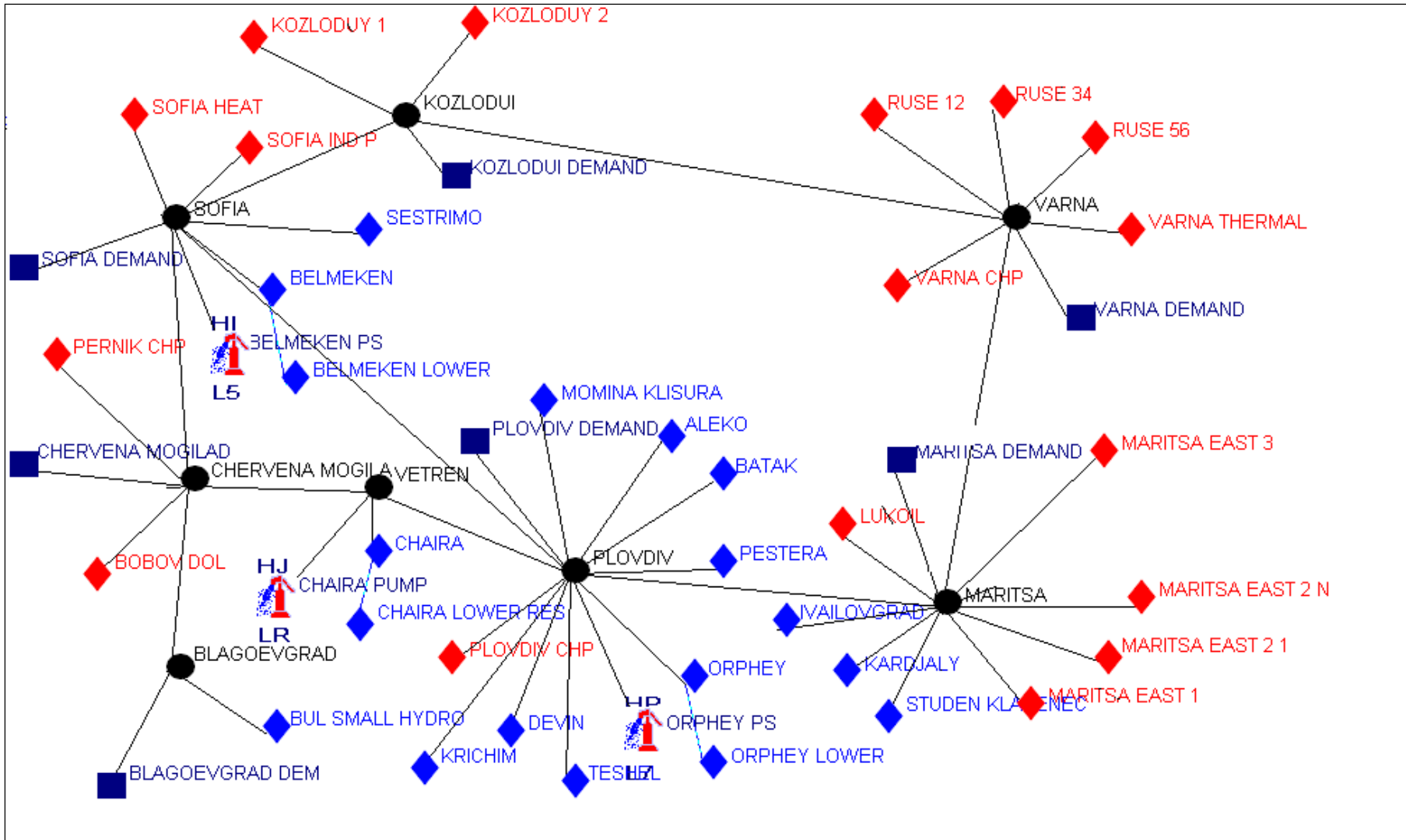




Figure A11.8 GTMAX Representation of Croatia in 2010

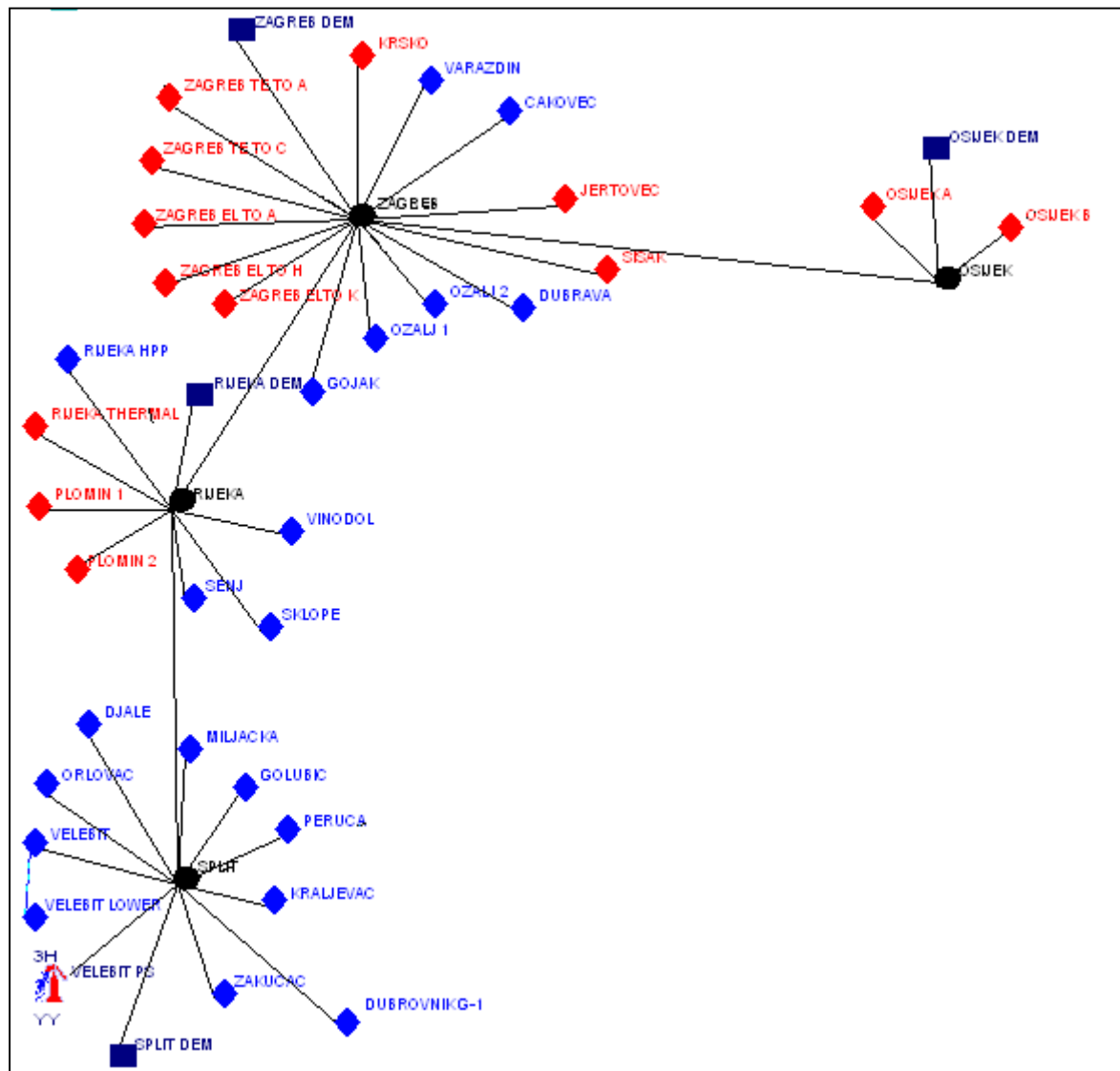




Figure A11.9 GTMAX Representation of Macedonia in 2010

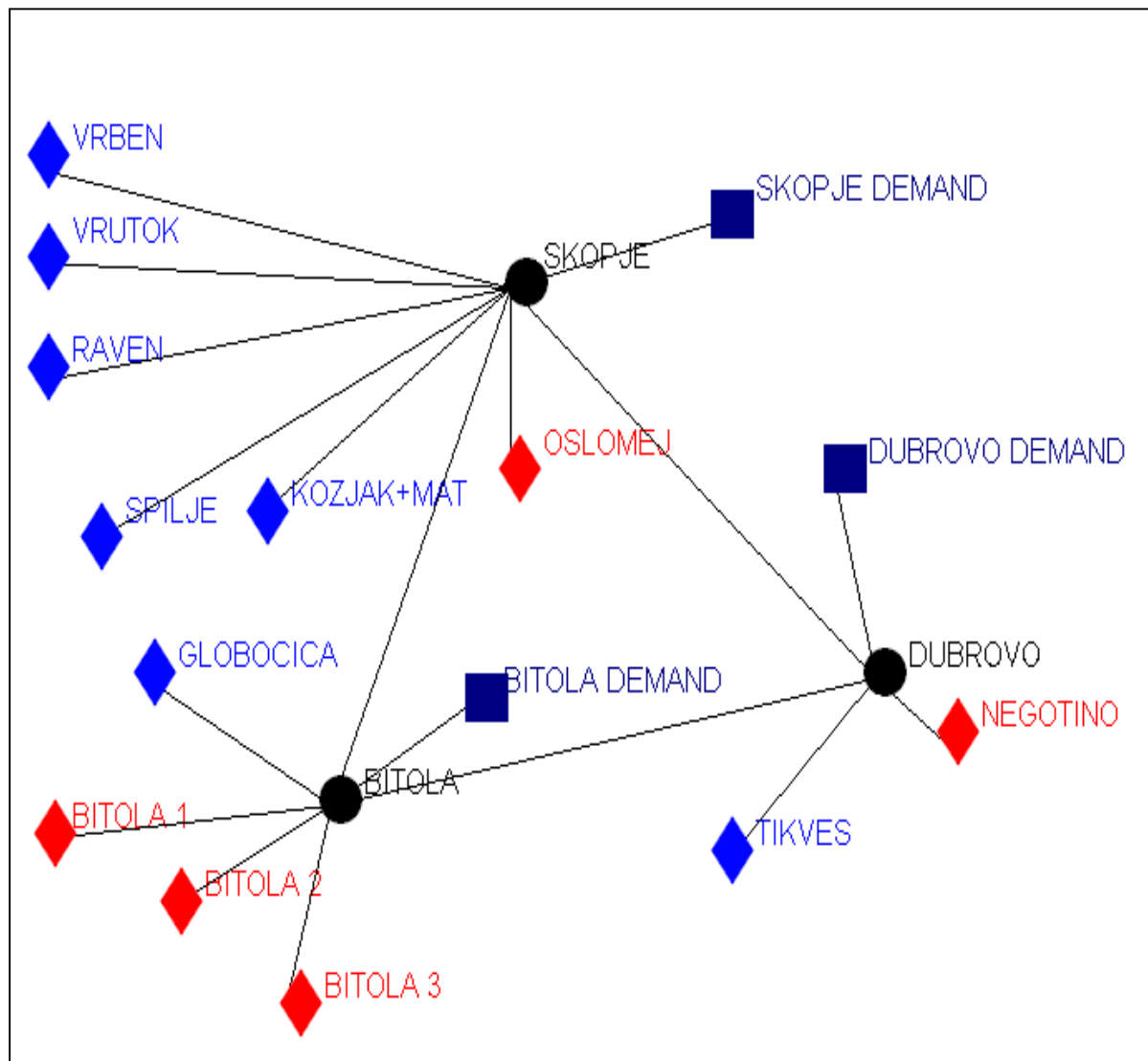




Figure A11.10 GTMAX Representation of Montenegro in 2010

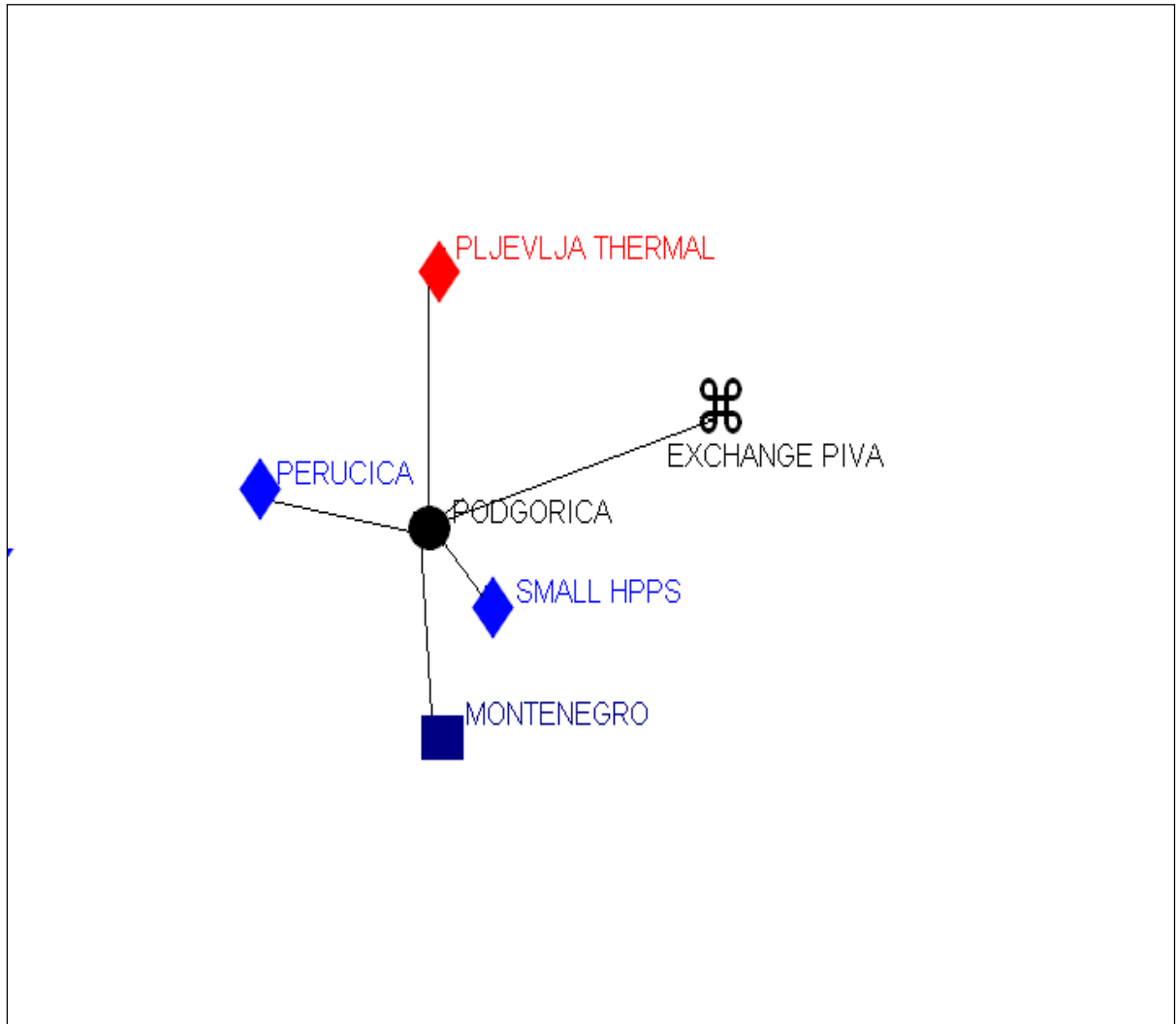




Figure A11.11 GTMAX Representation of Romania in 2010

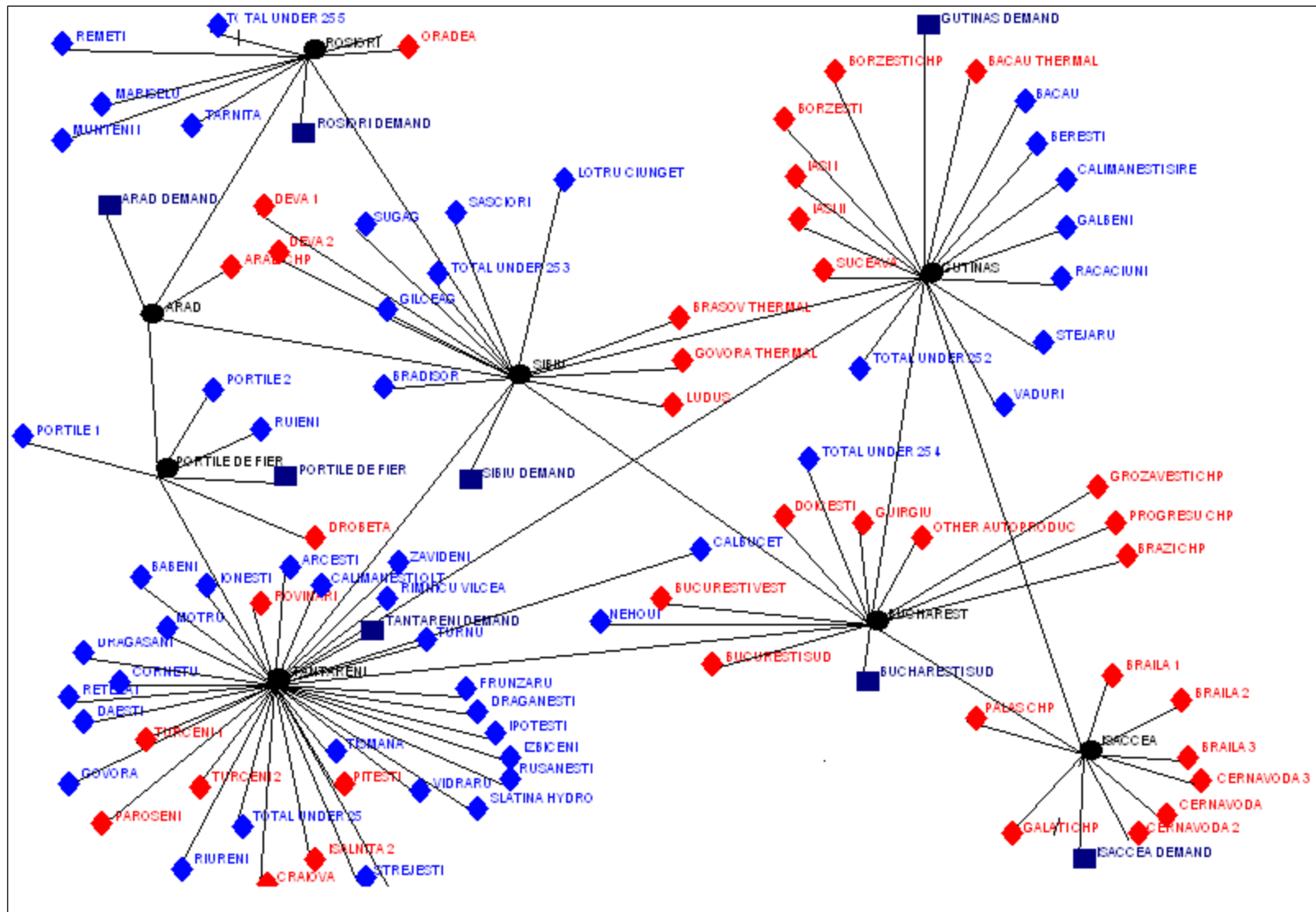




Figure A11.12 GTMAX Representation of Serbia in 2010

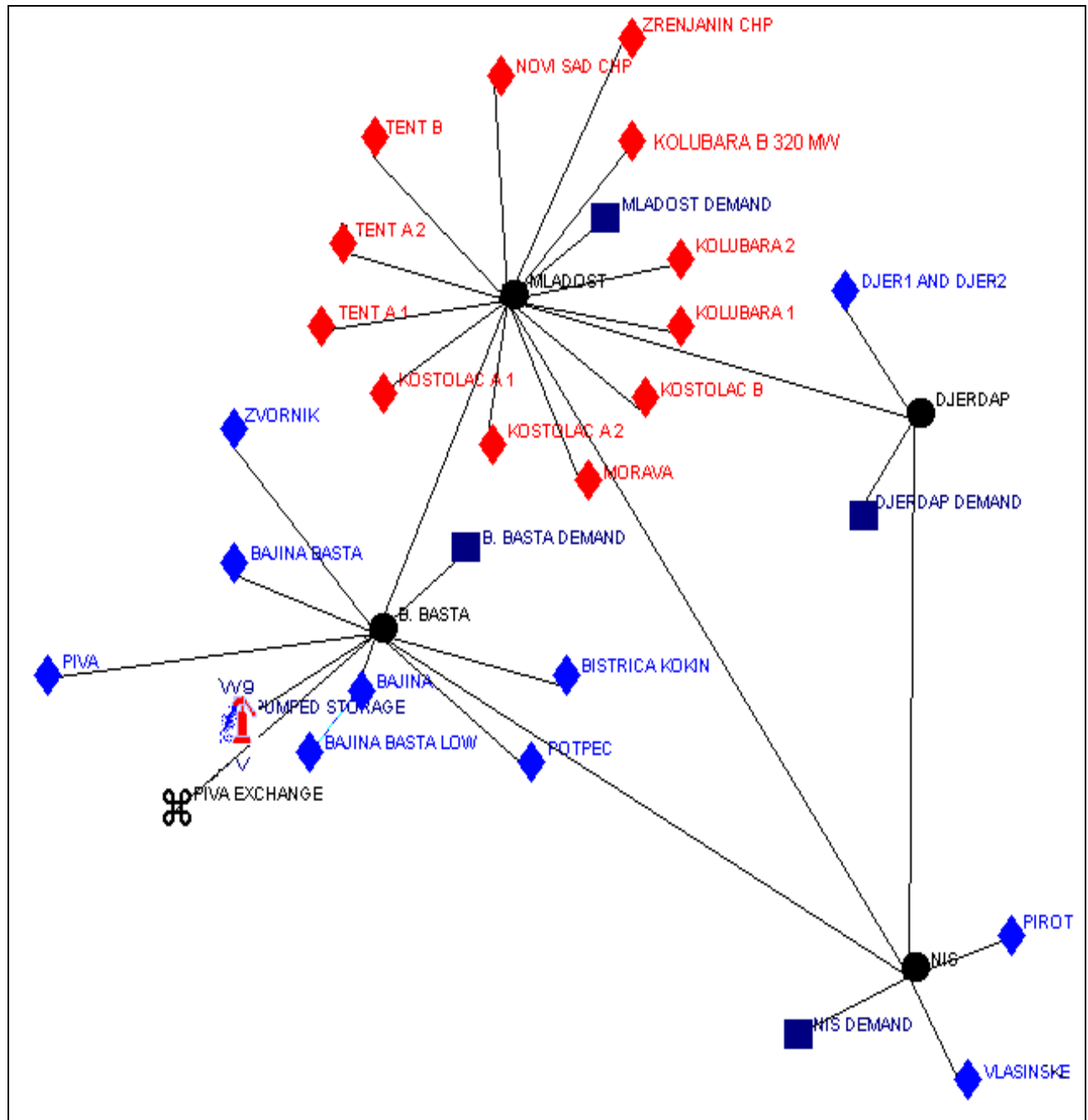
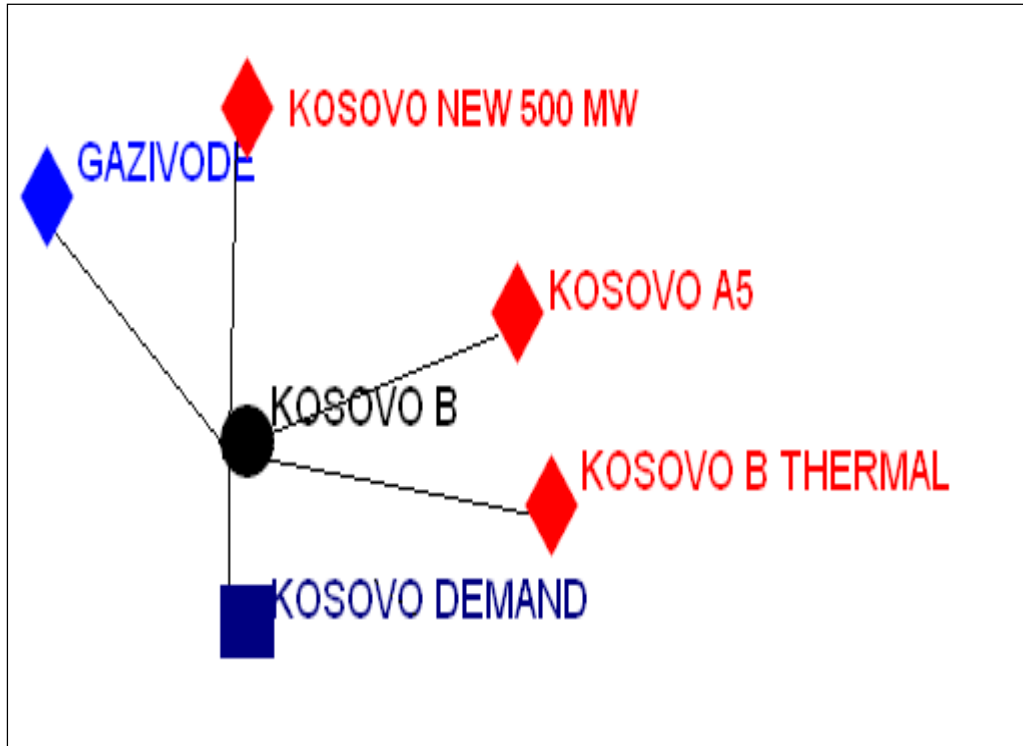




Figure A11.13 GTMAX Representation of Unmik in 2010





A11.4 Load Demand Profiles –

Since the GTMax model operates on a weekly basis, representative seasonal weeks (the third week of January, April, July and October) were selected to simulate the annual demand and supply. The third week of January was selected since it is the peak week for the region.

Tables A11.2 and A11.3 summarize the peak and energy demand for each week.

Table A11.2

Regional Weekly Peak Demand (MW)

	Year 2010	Year 2015
January (Week 3)	29,649	33,151
April (Week 16)	25,271	28,428
July (Week 29)	23,426	26,325
October (Week 42)	25,606	28,769

Table A11.3

Regional Weekly Energy Demand (GWh)

	Year 2010	Year 2015
January (Week 3)	4,157	4,647
April (Week 16)	3,476	3,906
July (Week 29)	3,237	3,640
October (Week 42)	3,445	3,869

For comparison purposes, Table A11.4 summarizes the monthly peak and energy demand for both 2010 and 2015.

Figures A11.14 and A11.15 present typical weekly load demand for January (Week 3), April (Week 16), July (week 29), and October (Week 42) for 2010 and 2015. The graphs also show the thermal and hydro generation under average hydrologic conditions.



Table A11.4
Regional Monthly Peak and Energy Demand

	Year 2010		Year 2015	
	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)
January	29,649	17,524	33,151	19,597
February	29,553	16,807	33,111	18,811
March	27,277	16,656	30,591	18,664
April	27,896	14,788	31,333	16,618
May	21,484	13,041	24,172	14,662
June	23,527	13,679	26,484	15,401
July	23,496	14,408	26,421	16,201
August	22,861	14,071	25,715	15,832
September	23,142	12,987	25,996	14,584
October	27,048	15,015	30,345	16,870
November	26,722	15,650	29,917	17,531
December	28,621	17,605	32,049	19,710



Figure A11.14 2010 Hourly Demand for Weeks 3, 16, 29 and 42

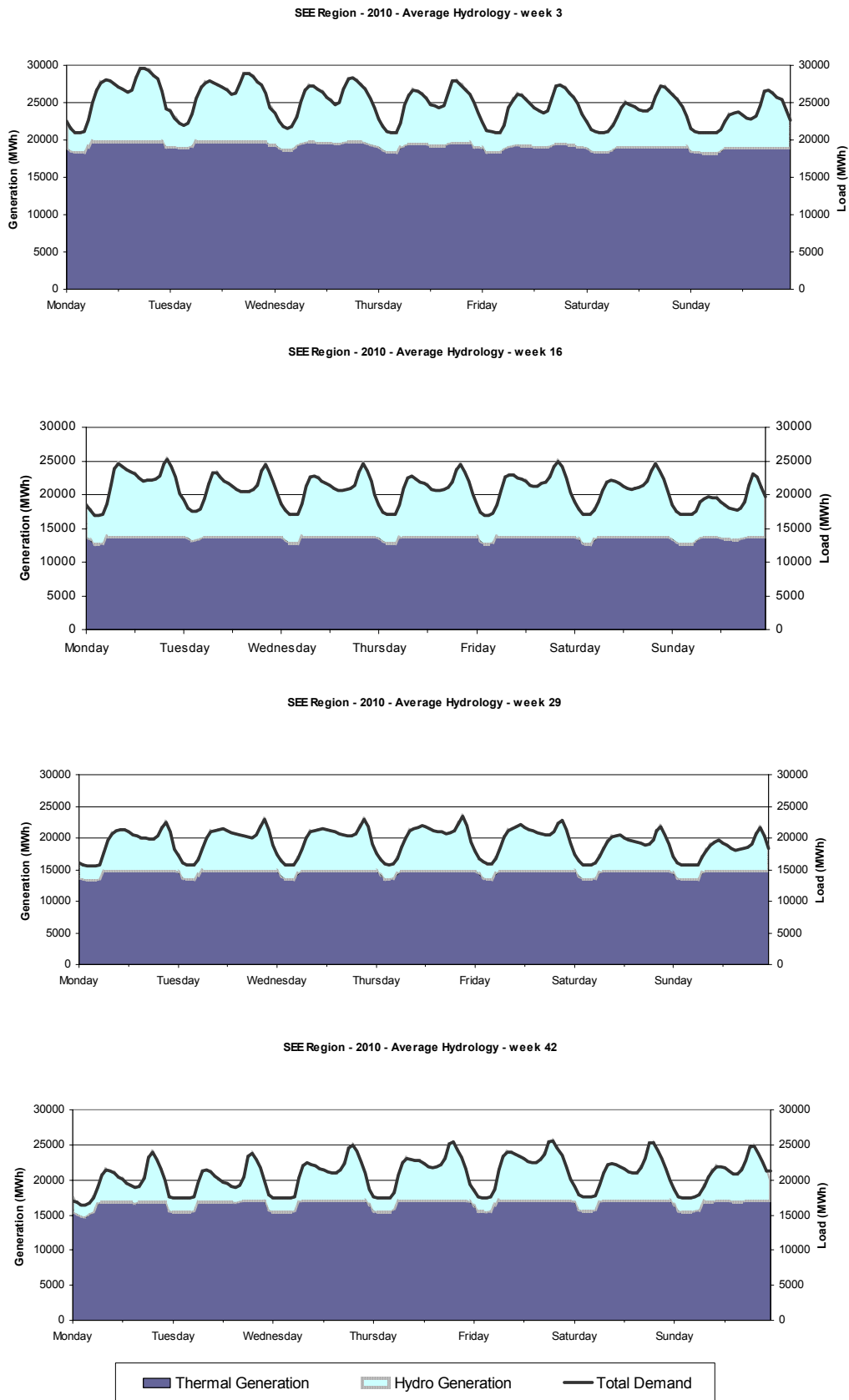
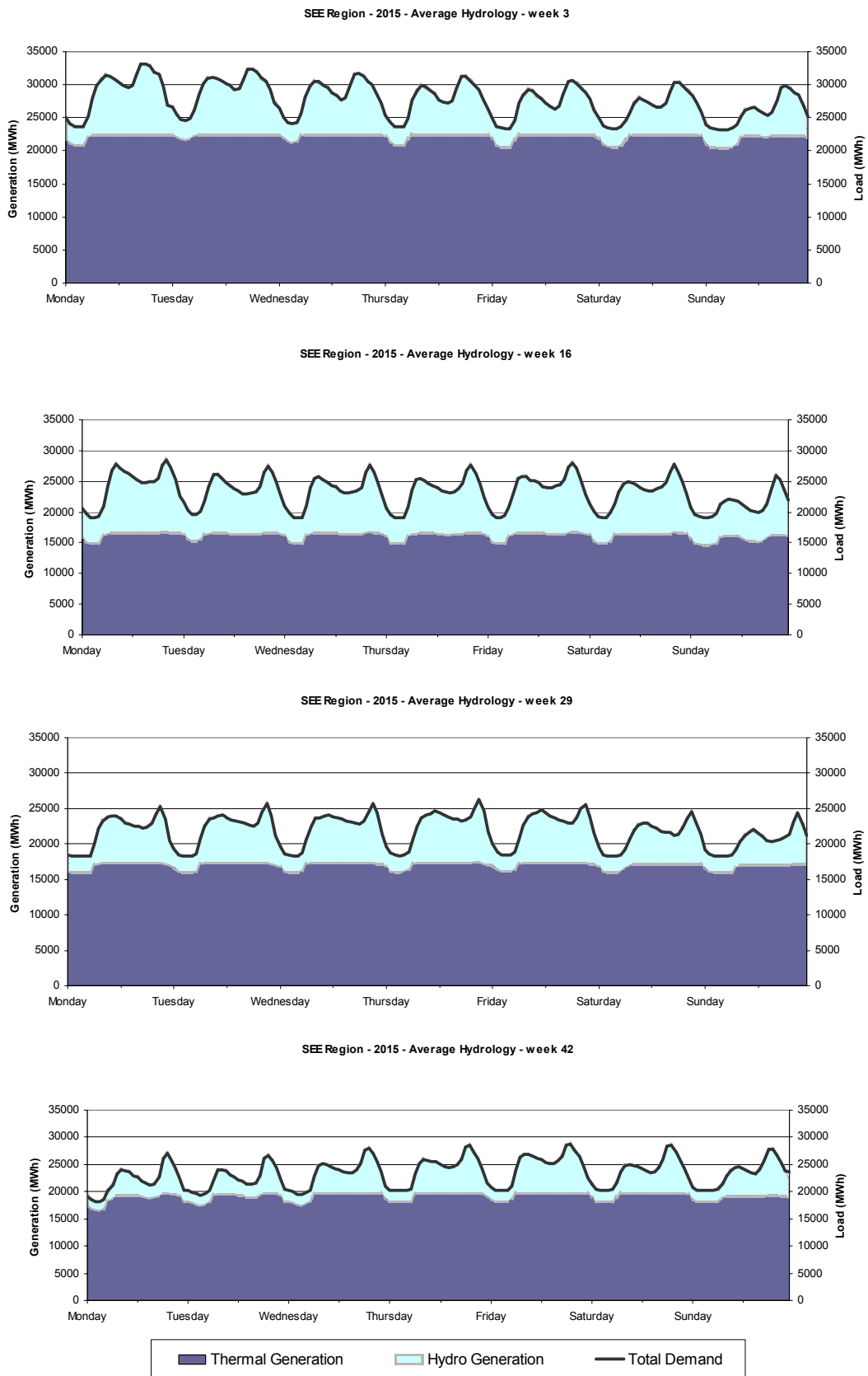




Figure A11.15 2015 Hourly Demand for Weeks 3, 16, 29 and 42





A11.5 Reference Case

Tables A11.5 through A11.8 summarize the GTMax 2010 results for the third week in January, April, July and October, under each of the wet, average and dry hydrologic conditions.

**Table A11.5 Reference Case – Year 2010 – Week 3 (January)**

Regional Market Operation - 2010 - Dry Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	173.8	72.4	31.8	104.1	69.7	0.0	1,079	30.9
B&H	269.2	133.3	217.0	350.3	0.0	81.1	5,559	30.9
Bulgaria	910.6	43.2	1077.6	1120.7	0.0	210.2	16,319	30.9
Croatia	431.5	116.9	239.9	356.8	74.7	0.0	5,363	30.9
Macedonia	172.2	14.4	122.6	137.0	35.2	0.0	1,411	30.9
Montenegro	100.9	37.5	0.0	37.5	66.8	0.0	0	30.9
Romania	1145.3	160.2	941.1	1101.4	43.9	0.0	15,770	30.9
Serbia	817.0	117.6	675.4	793.0	20.7	0.0	11,556	30.9
UNMIK	158.0	1.3	176.4	177.7	0.0	19.7	1,408	30.9
Total	4178.7	696.9	3481.8	4178.6	311.0	311.0	58,466	-

Regional Market Operation - 2010 – Average Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	173.8	86.9	23.5	110.4	63.5	0.0	681	25.9
B&H	269.2	151.7	132.8	284.5	0.0	15.3	3,116	25.9
Bulgaria	899.0	53.6	1074.7	1128.3	0.0	229.3	16,275	25.9
Croatia	431.2	130.0	125.3	255.3	175.9	0.0	1,712	25.9
Macedonia	172.2	18.7	122.6	141.3	30.9	0.0	1,411	25.9
Montenegro	100.9	49.1	0.0	49.1	54.8	0.0	0	25.9
Romania	1145.3	240.1	886.7	1126.9	18.4	0.0	14,158	25.9
Serbia	816.8	218.5	674.2	892.7	0.0	78.8	11,540	25.9
UNMIK	158.0	1.8	176.4	178.2	0.0	20.2	1,408	25.9
Total	4166.6	950.4	3216.2	4166.6	343.5	343.5	50,301	-

Regional Market Operation - 2010 - Wet Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	173.8	98.3	23.5	121.8	52.0	0.0	681	22.8
B&H	269.2	158.1	87.8	245.9	23.4	0.0	2,005	22.8
Bulgaria	896.1	57.3	1060.8	1118.2	0.0	222.0	15,968	22.8
Croatia	431.2	154.8	124.7	279.5	151.7	0.0	1,705	22.8
Macedonia	172.2	36.0	122.5	158.5	13.7	0.0	1,410	22.8
Montenegro	100.9	58.7	0.0	58.7	50.3	0.0	0	22.8
Romania	1145.3	303.0	778.1	1081.1	64.2	0.0	11,110	22.8
Serbia	817.8	247.5	673.3	920.8	0.0	111.0	11,524	22.8
UNMIK	158.0	5.6	174.6	180.3	0.0	22.2	1,394	22.8
Total	4164.7	1119.4	3045.3	4164.7	355.3	355.3	45,797	-



Table A11.6 Reference Case – Year 2010 – Week 16 (April)

Regional Market Operation - 2010 - Dry Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	149.5	66.9	23.9	90.8	58.6	0.0	692	27.7
B&H	219.3	137.4	138.8	276.2	0.0	56.9	3,488	27.7
Bulgaria	745.0	63.8	862.0	925.8	0.0	180.8	13,534	27.7
Croatia	337.8	123.9	133.3	257.2	80.6	0.0	2,172	27.7
Macedonia	144.9	9.0	104.3	113.4	31.5	0.0	1,187	27.7
Montenegro	80.4	43.6	0.0	43.6	38.6	0.0	0	27.7
Romania	1043.0	267.2	601.8	869.0	174.0	0.0	8,388	27.7
Serbia	652.4	209.5	534.2	743.8	0.0	93.1	9,426	27.7
UNMIK	125.1	1.4	176.4	177.8	0.0	52.6	1,408	27.7
Total	3497.4	922.7	2574.7	3497.4	383.4	383.4	40,294	-

Regional Market Operation - 2010 - Average Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	149.5	77.0	23.5	100.5	49.0	0.0	681	17.7
B&H	219.3	166.1	57.1	223.2	0.0	3.9	1,345	17.7
Bulgaria	736.1	66.6	846.5	913.1	0.0	176.9	13,205	17.7
Croatia	337.8	173.8	110.7	284.5	53.3	0.0	1,154	17.7
Macedonia	144.9	30.1	103.8	133.9	11.0	0.0	1,181	17.7
Montenegro	80.4	51.9	0.0	51.9	31.8	0.0	0	17.7
Romania	1043.0	388.8	482.6	871.4	171.5	0.0	5,804	17.7
Serbia	641.6	243.4	479.4	722.8	0.0	84.5	8,423	17.7
UNMIK	125.1	3.4	173.0	176.4	0.0	51.3	1,382	17.7
Total	3477.7	1201.0	2276.7	3477.7	316.7	316.7	33,174	-

Regional Market Operation - 2010 - Wet Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	149.5	110.9	23.5	134.4	15.1	0.0	681	17.1
B&H	219.3	146.8	47.9	194.7	24.6	0.0	1,084	17.1
Bulgaria	736.1	83.9	783.2	867.1	0.0	130.9	11,839	17.1
Croatia	337.8	163.8	107.3	271.1	66.7	0.0	1,426	17.1
Macedonia	144.9	45.2	104.3	149.5	0.0	4.6	1,187	17.1
Montenegro	80.4	64.0	0.0	64.0	13.9	0.0	0	17.1
Romania	1043.0	490.9	434.9	925.8	117.2	0.0	4,915	17.1
Serbia	639.6	238.1	464.3	702.4	0.0	60.2	8,082	17.1
UNMIK	125.1	5.7	161.1	166.8	0.0	41.6	1,290	17.1
Total	3475.7	1349.3	2126.4	3475.7	237.5	237.5	30,502	-



Table A11.7 Reference Case – Year 2010 – Week 29 (July)

Regional Market Operation - 2010 - Dry Hydrology - week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	138.8	51.1	23.9	75.0	63.8	0.0	692	31.9
B&H	217.4	52.4	187.1	239.5	0.0	22.1	4,887	31.9
Bulgaria	669.8	40.6	779.5	820.1	0.0	150.4	11,299	31.9
Croatia	341.2	80.8	233.3	314.0	27.1	0.0	5,442	31.9
Macedonia	142.5	22.3	104.3	126.6	16.0	0.0	1,187	31.9
Montenegro	79.5	9.3	0.0	9.3	60.1	0.0	0	31.9
Romania	968.4	232.6	658.9	891.5	76.9	0.0	10,906	31.9
Serbia	581.3	139.9	509.7	649.6	0.0	58.2	8,907	31.9
UNMIK	114.2	1.4	126.0	127.4	0.0	13.2	991	31.9
Total	3253.1	630.3	2622.7	3253.0	243.8	243.8	44,311	-

Regional Market Operation - 2010 - Average Hydrology – week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	138.8	63.5	23.9	87.4	51.4	0.0	692	28.0
B&H	217.4	56.8	139.3	196.1	21.3	0.0	3,500	28.0
Bulgaria	668.5	64.7	778.4	843.1	0.0	174.6	11,281	28.0
Croatia	341.2	80.2	172.3	252.6	88.6	0.0	3,194	28.0
Macedonia	142.5	26.5	87.9	114.4	28.2	0.0	1,016	28.0
Montenegro	79.5	15.7	0.0	15.7	58.5	0.0	0	28.0
Romania	968.4	309.5	613.5	923.1	45.4	0.0	11,170	28.0
Serbia	573.9	189.9	494.6	684.5	0.0	105.3	8,075	28.0
UNMIK	114.2	1.6	126.0	127.6	0.0	13.4	991	28.0
Total	3244.4	808.4	2435.9	3244.4	293.3	293.3	39,918	-

Regional Market Operation - 2010 - Wet Hydrology - week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	138.8	68.6	23.9	92.5	46.2	0.0	691	27.8
B&H	217.4	66.6	139.2	205.8	11.6	0.0	3,495	27.8
Bulgaria	669.0	72.3	749.6	821.9	0.0	152.9	10,750	27.8
Croatia	341.4	91.2	135.1	226.3	115.1	0.0	2,352	27.8
Macedonia	142.5	26.1	87.9	114.0	28.6	0.0	1,016	27.8
Montenegro	79.5	18.7	0.0	18.7	55.1	0.0	0	27.8
Romania	968.4	373.4	566.2	939.6	28.8	0.0	10,295	27.8
Serbia	576.1	205.6	494.6	700.2	0.0	118.3	8,075	27.8
UNMIK	114.2	2.3	126.0	128.3	0.0	14.1	991	27.8
Total	3247.3	924.8	2322.4	3247.2	285.4	285.4	37,665	-

**Table A11.8 Reference Case – Year 2010 – Week 42 (October)**

Regional Market Operation - 2010 - Dry Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	140.1	57.2	23.9	81.1	59.1	0.0	692	35.0
B&H	226.8	62.6	186.2	248.8	0.0	22.0	4,860	35.0
Bulgaria	712.0	49.4	803.9	853.3	0.0	141.3	11,709	35.0
Croatia	361.0	92.5	226.7	319.2	41.8	0.0	5,245	35.0
Macedonia	147.6	5.2	122.5	127.7	19.9	0.0	1,410	35.0
Montenegro	80.4	13.5	0.0	13.5	61.4	0.0	0	35.0
Romania	1050.3	167.1	912.5	1079.6	0.0	29.2	16,592	35.0
Serbia	666.4	112.0	551.5	663.5	8.3	0.0	9,581	35.0
UNMIK	129.2	1.3	126.0	127.3	1.9	0.0	991	35.0
Total	3513.9	560.7	2953.1	3513.8	192.5	192.5	51,079	-

Regional Market Operation - 2010 - Average Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	140.1	73.5	23.9	97.4	42.8	0.0	691	27.3
B&H	226.8	86.2	166.9	253.1	0.0	26.4	4,326	27.3
Bulgaria	690.0	54.0	798.0	852.0	0.0	162.0	11,617	27.3
Croatia	357.5	85.3	185.3	270.6	86.9	0.0	3,619	27.3
Macedonia	147.6	11.5	122.5	134.0	13.6	0.0	1,410	27.3
Montenegro	80.4	26.0	0.0	26.0	49.0	0.0	0	27.3
Romania	1050.3	247.9	803.9	1051.8	0.0	1.5	12,928	27.3
Serbia	659.2	116.2	552.6	668.8	0.0	4.3	9,049	27.3
UNMIK	129.2	1.8	125.6	127.4	1.8	0.0	988	27.3
Total	3481.2	702.5	2778.7	3481.2	194.1	194.1	44,627	-

Regional Market Operation - 2010 - Wet Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	140.1	83.5	23.9	107.3	32.8	0.0	691	27.2
B&H	226.8	91.7	106.7	198.4	28.4	0.0	2,785	27.2
Bulgaria	688.1	38.1	798.5	836.7	0.0	148.5	11,625	27.2
Croatia	356.2	111.7	115.4	227.1	129.1	0.0	1,665	27.2
Macedonia	147.6	20.2	87.7	108.0	39.6	0.0	1,014	27.2
Montenegro	80.4	31.1	0.0	31.1	43.6	0.0	0	27.2
Romania	1050.3	300.2	795.6	1095.8	0.0	45.5	12,771	27.2
Serbia	657.1	187.0	552.8	739.8	0.0	77.1	9,052	27.2
UNMIK	129.2	5.6	126.0	131.6	0.0	2.4	991	27.2
Total	3475.9	869.3	2606.6	3475.9	273.5	273.5	40,594	-



Tables A11.9 through A11.12 summarize the GTMax 2015 results for the third week in January, April, July and October, under each of the wet, average and dry hydrologic conditions.

**Table A11.9 Reference Case – Year 2015 – Week 3 (January)**

Regional Market Operation – 2015 - Dry Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	209.8	72.4	23.8	96.2	113.6	0.0	690	27.2
B&H	312.5	133.3	232.6	366.0	0.0	53.5	6,084	27.2
Bulgaria	986.4	46.1	1144.2	1190.3	0.0	203.9	17,676	27.2
Croatia	507.9	120.1	283.2	403.3	104.6	0.0	5,084	27.2
Macedonia	201.5	14.4	120.3	134.7	66.9	0.0	1,734	27.2
Montenegro	101.9	37.5	32.1	69.6	35.7	0.0	884	27.2
Romania	1330.3	160.2	1074.8	1235.1	95.2	0.0	16,693	27.2
Serbia	878.6	123.1	691.9	815.0	60.2	0.0	11,569	27.2
UNMIK	156.3	1.4	373.6	375.0	0.0	218.7	3,122	27.2
Total	4685.1	708.6	3976.5	4685.1	476.1	476.1	63,536	-

Regional Market Operation – 2015 – Average Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	209.8	86.9	23.5	110.4	99.4	0.0	681	22.6
B&H	312.5	151.7	128.3	279.9	32.6	0.0	3,020	22.6
Bulgaria	970.8	53.8	1145.5	1199.3	0.0	228.5	17,695	22.6
Croatia	502.9	130.0	252.8	382.8	120.1	0.0	4,271	22.6
Macedonia	201.5	18.7	117.1	135.7	65.8	0.0	1,675	22.6
Montenegro	101.9	49.1	32.1	81.2	23.7	0.0	884	22.6
Romania	1330.3	240.1	942.3	1182.4	147.8	0.0	12,938	22.6
Serbia	871.8	219.2	692.5	911.6	0.0	42.7	11,577	22.6
UNMIK	156.3	1.8	372.6	374.4	0.0	218.2	3,114	22.6
Total	4657.7	951.2	3706.6	4657.8	489.4	489.4	55,856	-

Regional Market Operation – 2015 - Wet Hydrology - week 3								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	209.8	98.3	23.5	121.8	88.0	0.0	681	22.6
B&H	312.5	158.1	89.0	247.1	65.4	0.0	2,036	22.6
Bulgaria	968.8	58.1	1126.3	1184.3	0.0	215.6	17,274	22.6
Croatia	502.9	154.8	252.0	406.7	96.2	0.0	4,254	22.6
Macedonia	201.5	36.0	87.6	123.6	78.0	0.0	1,013	22.6
Montenegro	101.9	58.7	32.1	90.8	19.2	0.0	884	22.6
Romania	1330.3	303.0	909.7	1212.7	117.6	0.0	12,274	22.6
Serbia	874.9	249.8	644.2	894.0	0.0	27.1	10,711	22.6
UNMIK	156.3	5.6	372.2	377.8	0.0	221.6	3,111	22.6
Total	4658.8	1122.3	3536.5	4658.8	464.3	464.3	52,238	-

**Table A11.10 Reference Case – Year 2015 – Week 16 (April)**

Regional Market Operation – 2015 - Dry Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	180.6	66.9	23.5	90.4	90.2	0.0	681	25.0
B&H	255.2	137.4	99.8	237.2	18.0	0.0	2,362	25.0
Bulgaria	810.7	65.7	917.7	983.4	0.0	172.7	14,690	25.0
Croatia	394.4	124.2	208.1	332.3	62.1	0.0	3,361	25.0
Macedonia	169.9	9.0	120.5	129.5	40.4	0.0	1,740	25.0
Montenegro	81.2	43.6	32.1	75.7	7.3	0.0	884	25.0
Romania	1211.4	267.2	727.6	994.7	216.7	0.0	11,391	25.0
Serbia	699.3	212.6	554.2	766.8	0.0	69.3	9,489	25.0
UNMIK	131.8	1.4	323.2	324.6	0.0	192.7	2,705	25.0
Total	3934.6	927.9	3006.7	3934.6	434.8	434.8	47,304	-

Regional Market Operation – 2015 - Average Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	180.6	77.0	23.5	100.5	80.1	0.0	681	17.8
B&H	255.2	166.1	50.9	217.0	38.3	0.0	1,276	17.8
Bulgaria	799.1	66.6	899.6	966.2	0.0	167.1	14,287	17.8
Croatia	394.0	173.8	156.1	329.9	64.1	0.0	2,170	17.8
Macedonia	169.9	30.1	87.2	117.3	52.6	0.0	1,008	17.8
Montenegro	81.2	51.9	32.1	84.0	0.5	0.0	884	17.8
Romania	1211.4	388.8	593.6	982.4	229.1	0.0	8,113	17.8
Serbia	686.3	245.0	543.9	788.9	0.0	105.8	9,316	17.8
UNMIK	131.8	3.4	320.2	323.6	0.0	191.7	2,682	17.8
Total	3909.6	1202.5	2707.1	3909.7	464.6	464.6	40,417	-

Regional Market Operation – 2015 - Wet Hydrology - week 16								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	180.6	110.9	23.5	134.4	46.2	0.0	681	16.9
B&H	255.2	146.8	47.9	194.7	60.5	0.0	1,084	16.9
Bulgaria	799.1	83.9	901.8	985.7	0.0	186.7	14,321	16.9
Croatia	394.0	163.8	115.2	279.0	115.0	0.0	1,333	16.9
Macedonia	169.9	45.2	87.7	133.0	37.0	0.0	1,014	16.9
Montenegro	81.2	64.0	32.1	96.0	0.0	17.4	884	16.9
Romania	1211.4	490.9	512.9	1003.8	207.6	0.0	6,686	16.9
Serbia	682.7	238.4	522.2	760.5	0.0	75.3	8,919	16.9
UNMIK	131.8	5.7	313.2	318.8	0.0	187.0	2,627	16.9
Total	3906.0	1349.5	2556.4	3905.9	466.3	466.3	37,550	-

**Table A11.11 Reference Case – Year 2015 – Week 29 (July)**

Regional Market Operation – 2015 - Dry Hydrology - week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	167.0	51.1	23.9	75.0	92.0	0.0	691	28.2
B&H	251.4	52.4	208.2	260.5	0.0	9.1	5,562	28.2
Bulgaria	727.3	46.2	902.4	948.7	0.0	221.5	13,272	28.2
Croatia	401.9	83.7	247.5	331.3	70.7	0.0	4,477	28.2
Macedonia	166.7	22.3	86.2	108.4	58.2	0.0	1,350	28.2
Montenegro	80.3	9.3	32.1	41.4	28.7	0.0	884	28.2
Romania	1124.8	232.6	716.3	948.9	176.0	0.0	11,788	28.2
Serbia	623.7	143.3	514.6	657.9	0.0	24.1	8,138	28.2
UNMIK	129.2	1.3	298.8	300.1	0.0	171.0	2,554	28.2
Total	3672.3	642.3	3030.0	3672.2	425.6	425.6	48,717	-

Regional Market Operation – 2015 - Average Hydrology – week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	167.0	63.5	23.5	87.0	80.0	0.0	681	25.5
B&H	251.4	56.8	100.3	157.1	94.3	0.0	2,420	25.5
Bulgaria	723.3	68.5	902.6	971.1	0.0	247.8	13,273	25.5
Croatia	399.8	81.6	208.6	290.2	109.6	0.0	3,375	25.5
Macedonia	166.7	26.5	85.5	112.0	54.6	0.0	1,343	25.5
Montenegro	80.3	15.7	32.1	47.8	27.2	0.0	884	25.5
Romania	1124.8	309.5	677.4	986.9	137.9	0.0	10,719	25.5
Serbia	622.4	197.7	514.6	712.3	0.0	84.6	8,138	25.5
UNMIK	129.2	1.6	298.8	300.4	0.0	171.2	2,554	25.5
Total	3664.9	821.4	2843.4	3664.8	503.6	503.6	43,386	-

Regional Market Operation – 2015 - Wet Hydrology - week 29								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	167.0	68.6	23.5	92.2	74.8	0.0	681	25.3
B&H	251.4	66.6	101.3	167.9	83.5	0.0	2,397	25.3
Bulgaria	729.0	79.7	836.3	915.9	0.0	187.0	12,469	25.3
Croatia	402.3	94.2	208.2	302.4	99.9	0.0	3,362	25.3
Macedonia	166.7	26.1	84.9	111.0	55.6	0.0	1,333	25.3
Montenegro	80.3	18.7	32.1	50.8	23.8	0.0	884	25.3
Romania	1124.8	373.4	633.5	1006.9	118.0	0.0	9,525	25.3
Serbia	625.4	214.1	514.6	728.7	0.0	97.5	8,138	25.3
UNMIK	129.2	2.3	298.0	300.3	0.0	171.1	2,548	25.3
Total	3676.1	943.7	2732.4	3676.0	455.6	455.6	41,338	-

**Table A11.12 Reference Case – Year 2015 – Week 42 (October)**

Regional Market Operation – 2015 - Dry Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	168.6	57.2	23.9	81.0	87.6	0.0	690	29.2
B&H	262.1	62.6	218.7	281.3	0.0	19.1	5,864	29.2
Bulgaria	771.5	50.0	900.5	950.4	0.0	178.9	13,687	29.2
Croatia	423.1	94.7	274.0	368.7	54.4	0.0	5,445	29.2
Macedonia	171.9	5.2	100.3	105.5	66.5	0.0	1,483	29.2
Montenegro	81.2	13.5	32.0	45.5	30.2	0.0	884	29.2
Romania	1220.0	167.1	960.5	1127.6	92.3	0.0	14,399	29.2
Serbia	707.8	111.0	570.3	681.4	31.9	0.0	8,871	29.2
UNMIK	134.8	1.4	298.2	299.6	0.0	164.8	2,550	29.2
Total	3940.9	562.5	3378.4	3940.9	362.9	362.9	53,872	-

Regional Market Operation – 2015 - Average Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	168.6	73.5	23.5	97.0	71.6	0.0	681	24.8
B&H	262.1	86.2	153.7	239.9	22.2	0.0	3,957	24.8
Bulgaria	759.3	61.5	900.7	962.2	0.0	202.8	13,686	24.8
Croatia	420.9	88.5	205.6	294.1	126.8	0.0	3,321	24.8
Macedonia	171.9	11.5	99.5	111.0	60.9	0.0	1,474	24.8
Montenegro	81.2	26.0	32.0	58.1	17.8	0.0	884	24.8
Romania	1220.0	247.9	933.7	1181.7	38.3	0.0	13,853	24.8
Serbia	705.4	118.7	561.6	680.3	30.4	0.0	9,557	24.9
UNMIK	134.8	1.8	298.1	299.9	0.0	165.1	2,549	24.8
Total	3924.1	715.6	3208.6	3924.2	368.0	368.0	49,960	-

Regional Market Operation – 2015 - Wet Hydrology - week 42								
System	Total Demand (GWh)	Hydro Generation (GWh)	Thermal Generation (GWh)	Total Generation (GWh)	Import (GWh)	Export (GWh)	Generation Costs (€1000)	Average LMP (€/MWh)
Albania	168.6	83.5	23.5	107.0	61.6	0.0	681	25.0
B&H	262.1	91.7	100.8	192.5	69.6	0.0	2,385	25.0
Bulgaria	756.9	45.2	901.0	946.2	0.0	189.3	13,690	25.0
Croatia	420.3	115.3	206.1	321.4	98.8	0.0	3,328	25.0
Macedonia	171.9	20.2	99.8	120.0	51.9	0.0	1,478	25.0
Montenegro	81.2	31.1	32.0	63.2	12.4	0.0	884	25.0
Romania	1220.0	300.2	821.8	1122.0	98.0	0.0	13,017	25.0
Serbia	706.1	191.5	555.0	746.5	0.0	34.8	8,585	25.0
UNMIK	134.8	5.6	297.3	302.9	0.0	168.1	2,542	25.0
Total	3921.8	884.4	3037.3	3921.7	392.2	392.2	46,590	-



Figure A11.16 summarizes the expected 2010 and 2015 annual hydro and thermal generation in each jurisdiction.

The following Figures (A11.17 through A11.34) shows the weekly hydro and thermal generation for each of the selected weeks (third week of January, April, July and October) under each hydrologic conditions (wet, average, and dry). For each jurisdiction, the first graph is for 2010 and the second graph is for 2015.



Figure A11.16 Annual Hydro and Thermal Generation for Years 2010 and 2015

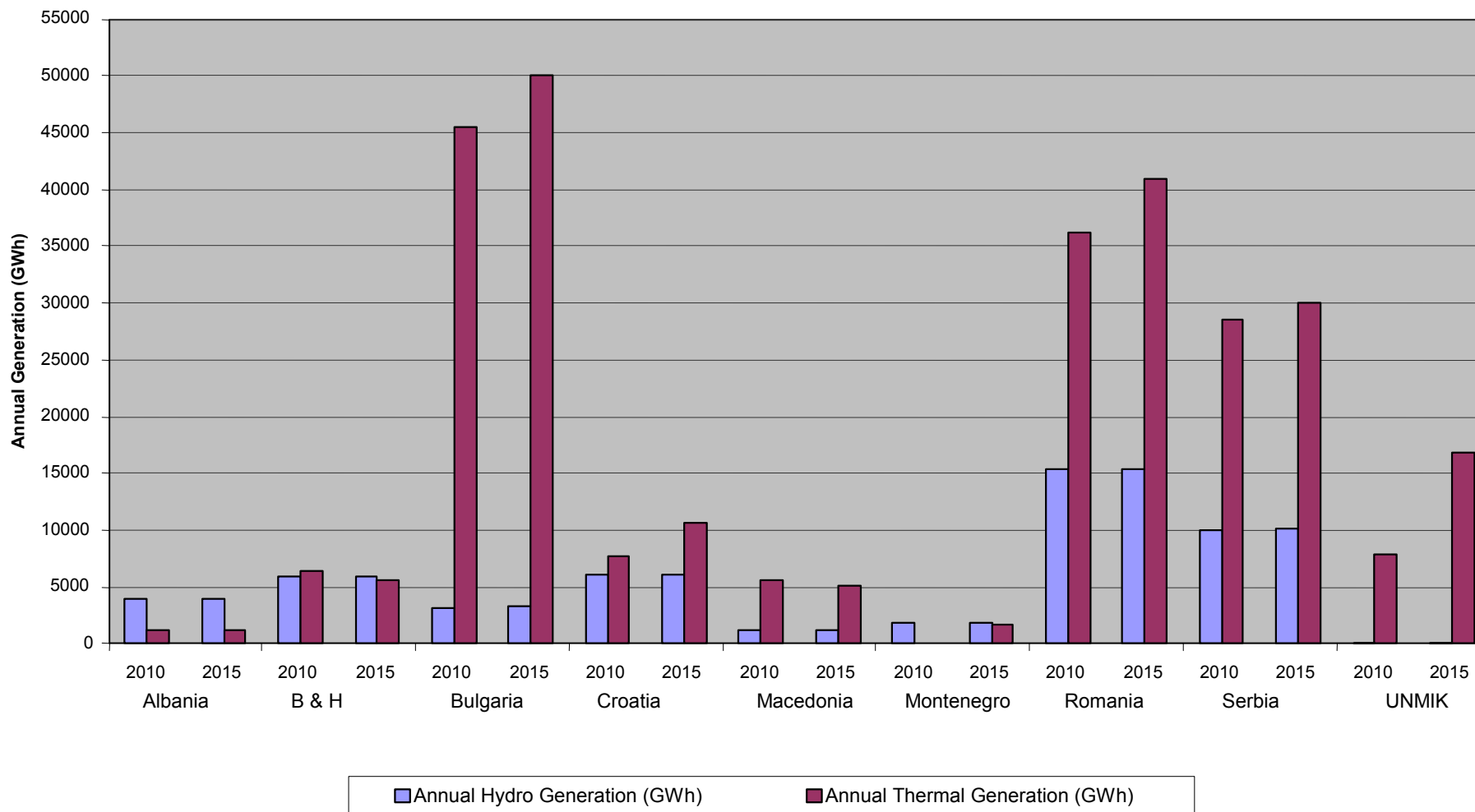




Figure A11.17 Weekly Hydro and Thermal Generation in Albania for Year 2010

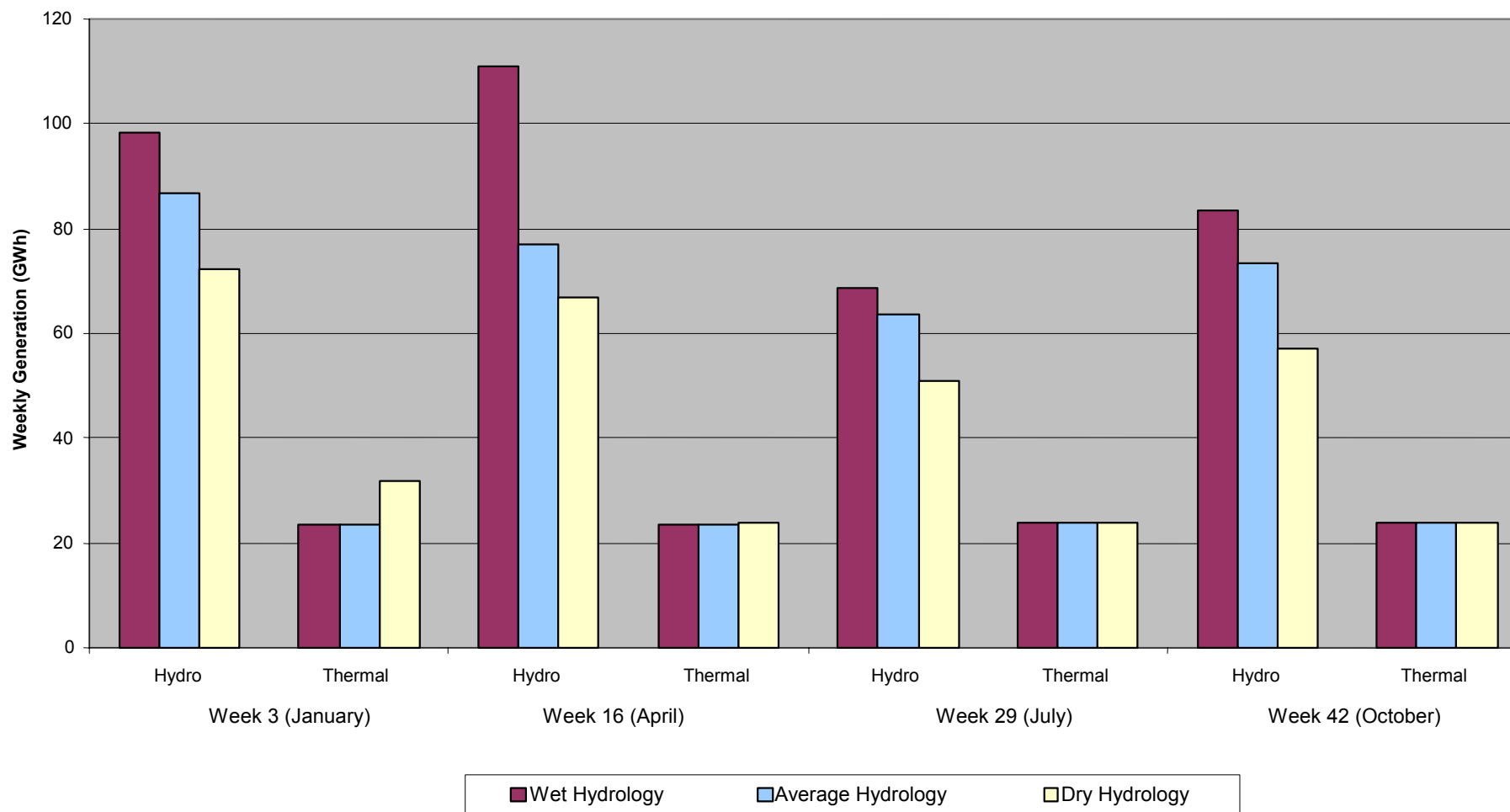




Figure A11.18 Weekly Hydro and Thermal Generation in Albania for Year 2015

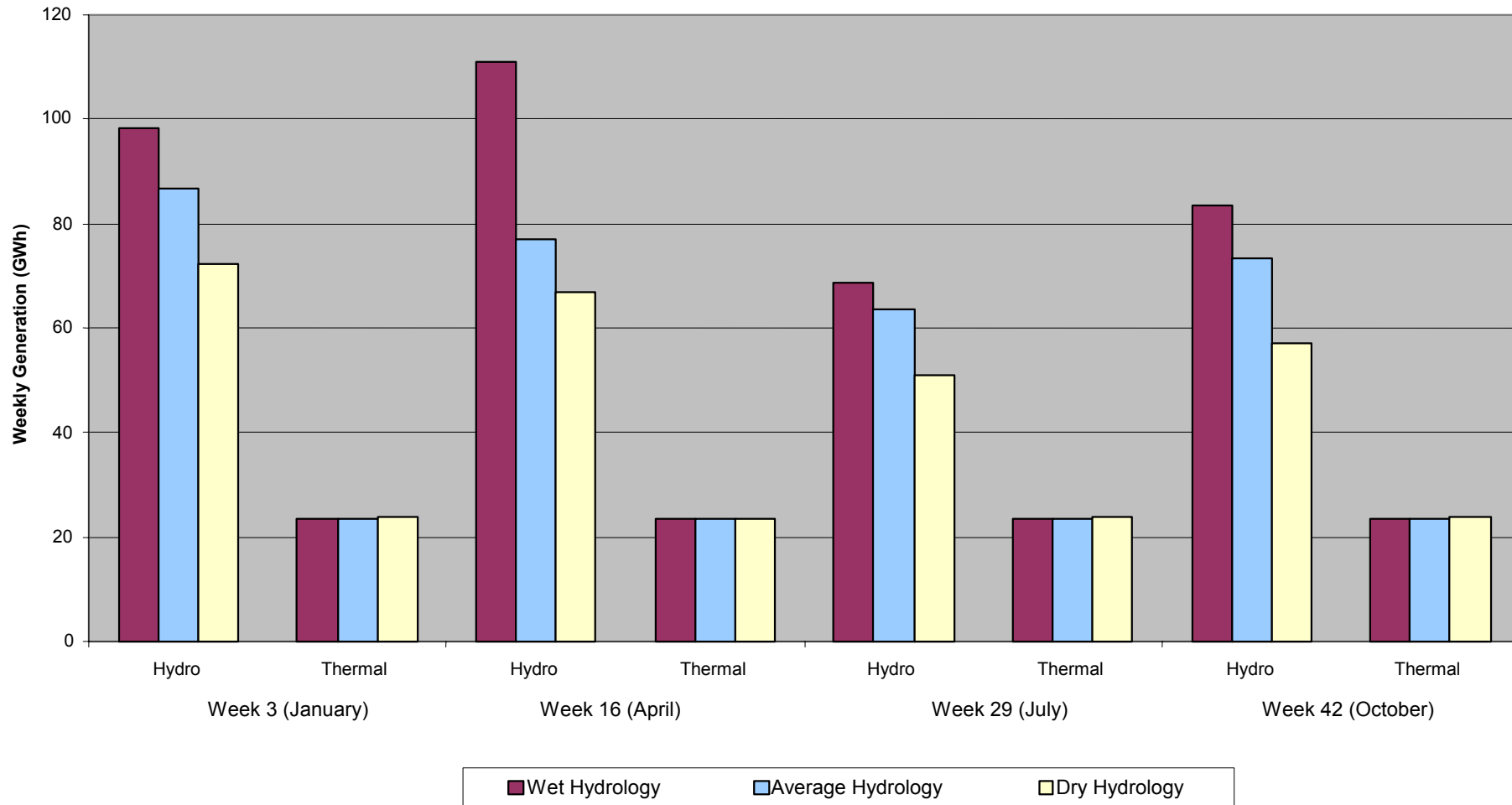




Figure A11.19 Weekly Hydro and Thermal Generation in B&H for Year 2010

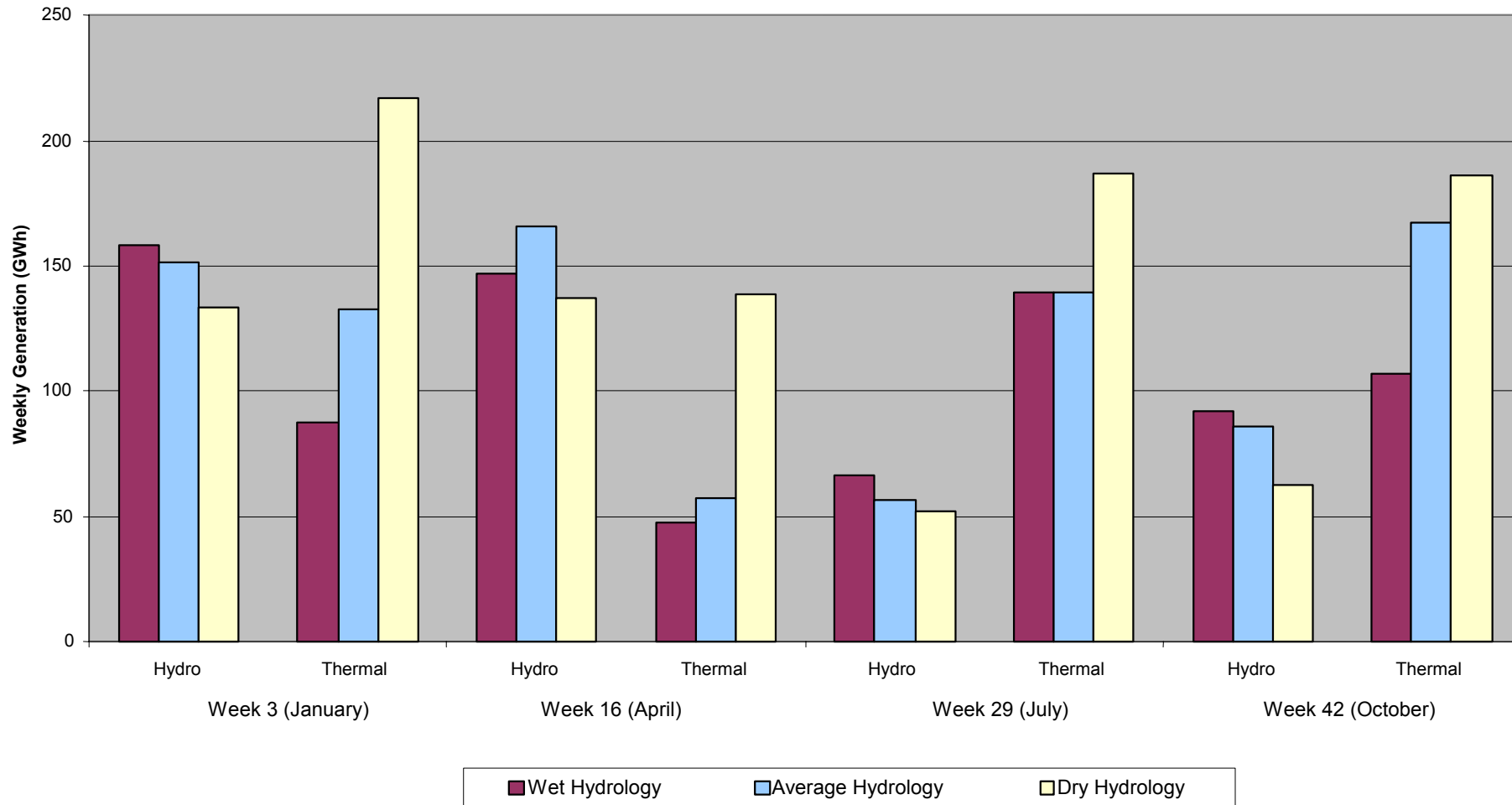




Figure A11.20 Weekly Hydro and Thermal Generation in B&H for Year 2015

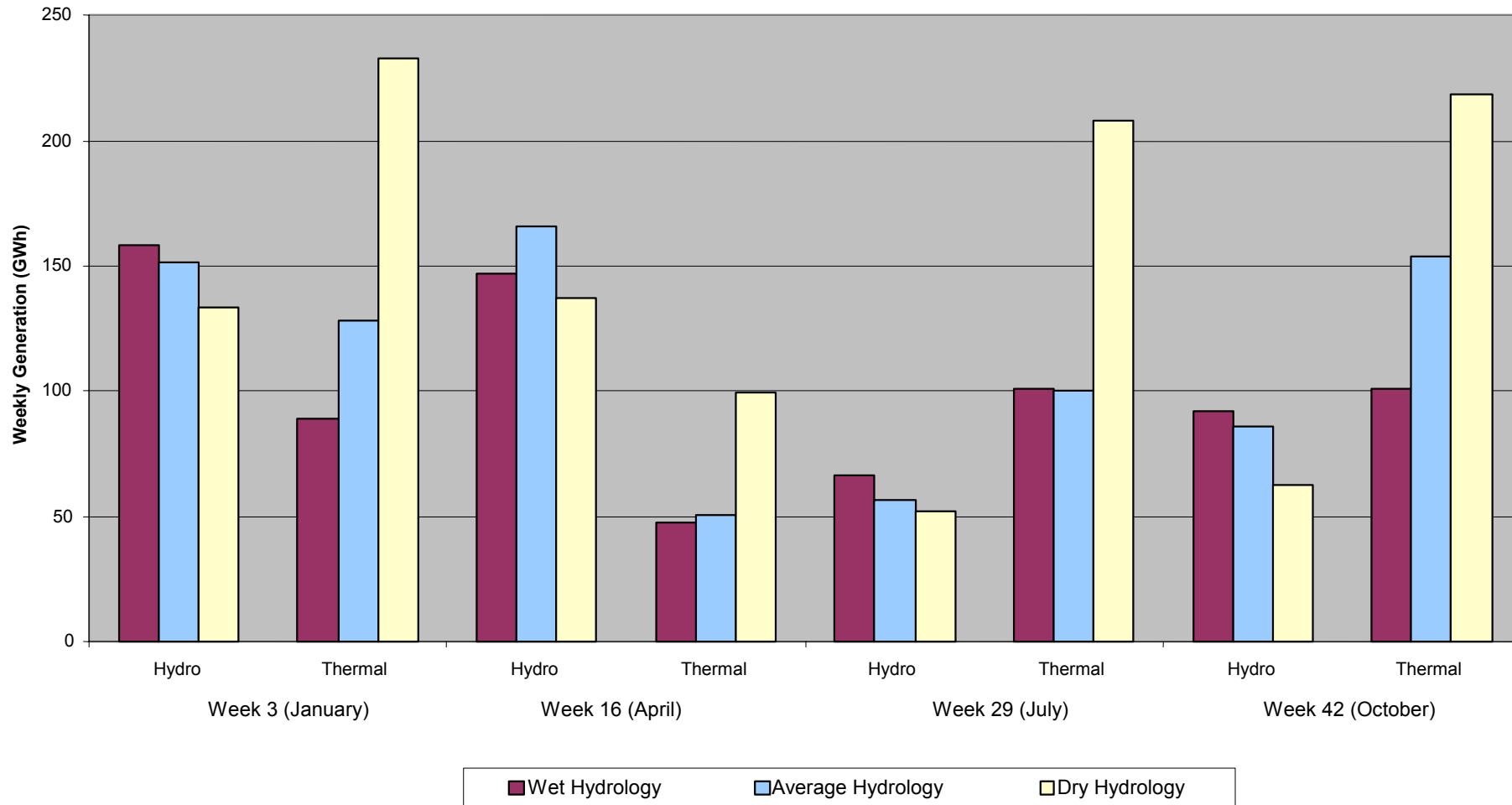




Figure A11.21 Weekly Hydro and Thermal Generation in Bulgaria for Year 2010

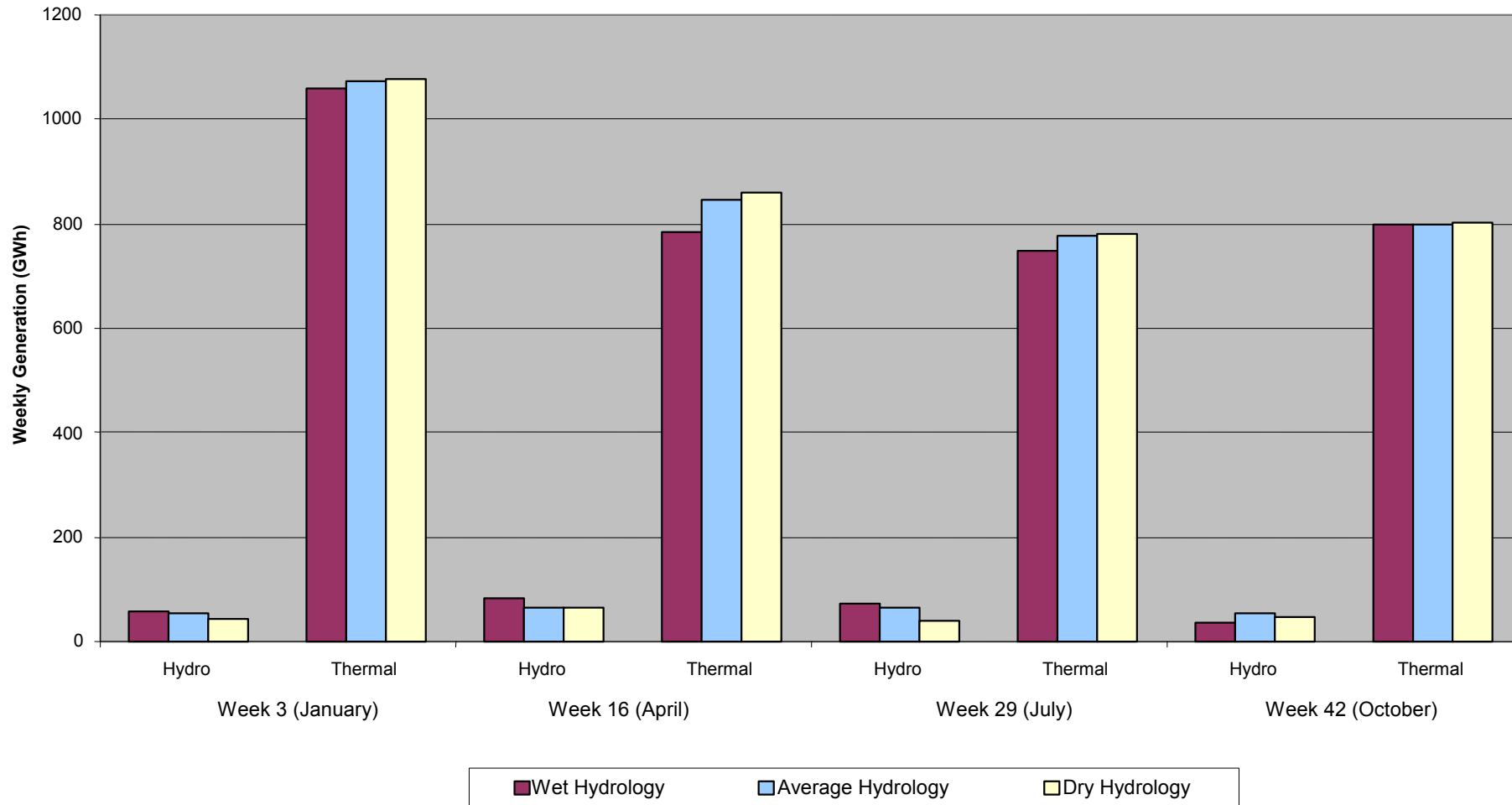




Figure A11.22 Weekly Hydro and Thermal Generation in Bulgaria for Year 2015

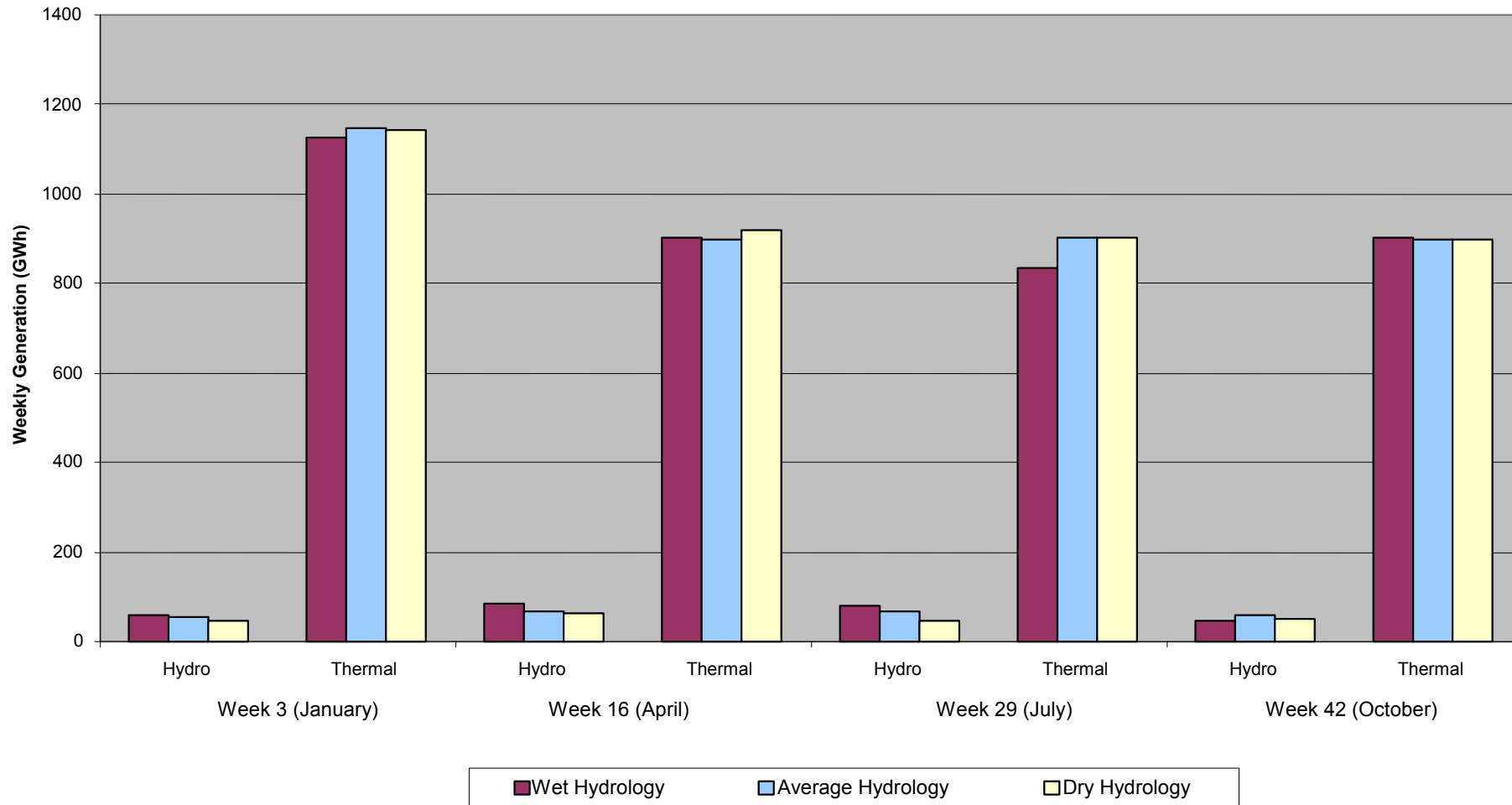




Figure A11.23 Weekly Hydro and Thermal Generation in Croatia for Year 2010

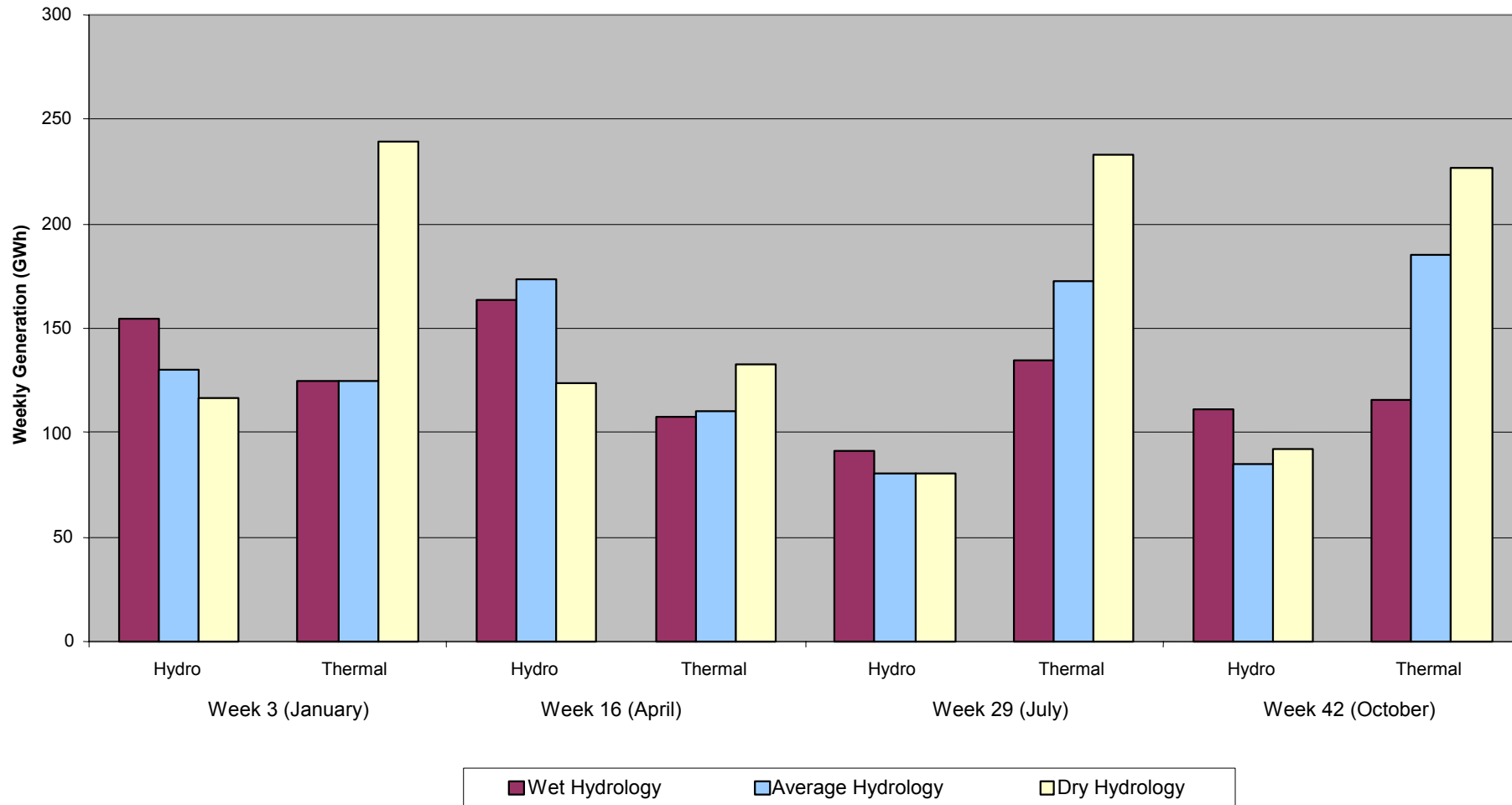




Figure A11.24 Weekly Hydro and Thermal Generation in Croatia for Year 2015

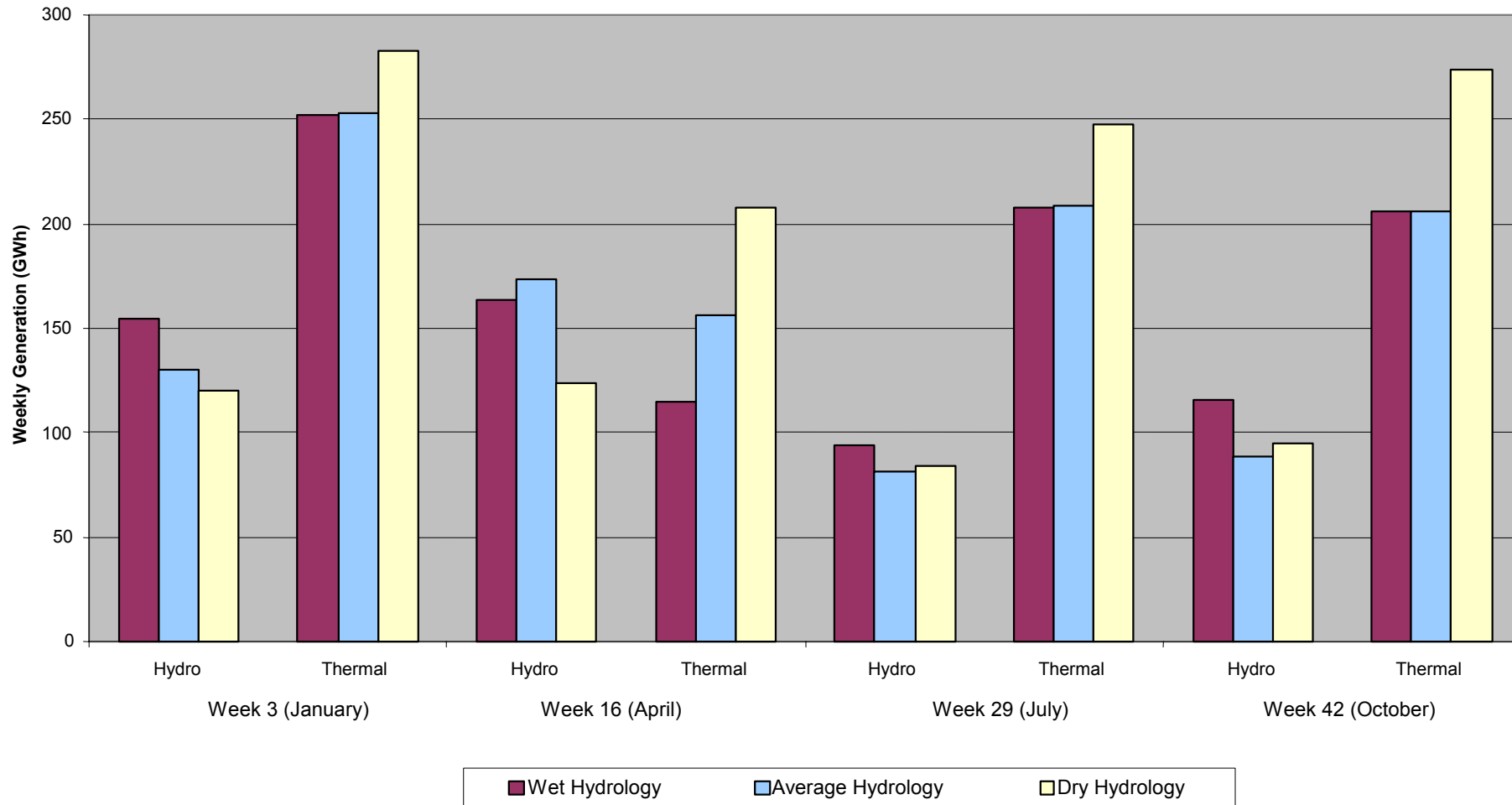




Figure A11.25 Weekly Hydro and Thermal Generation in Macedonia for Year 2010

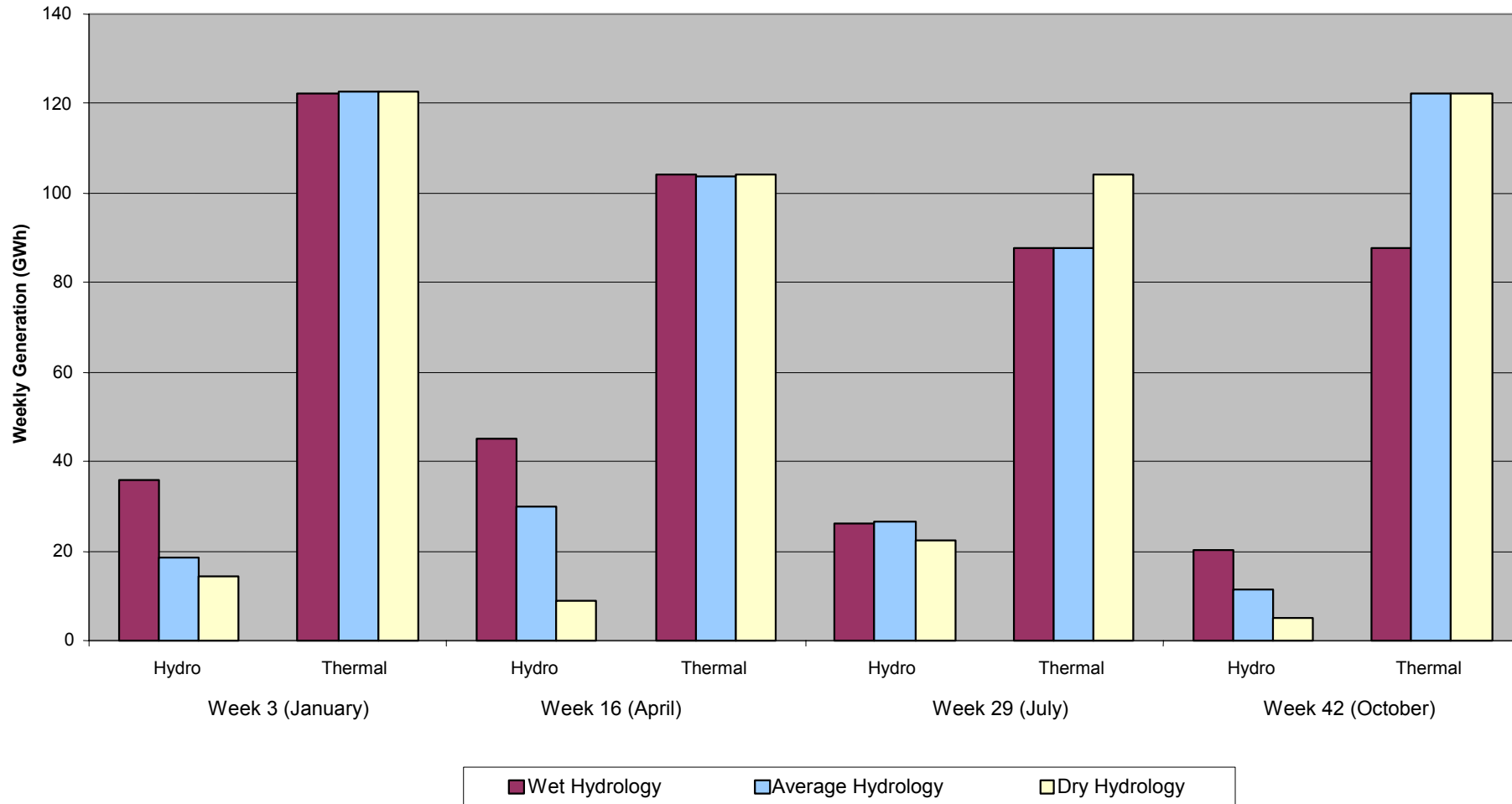




Figure A11.26 Weekly Hydro and Thermal Generation in Macedonia for Year 2015

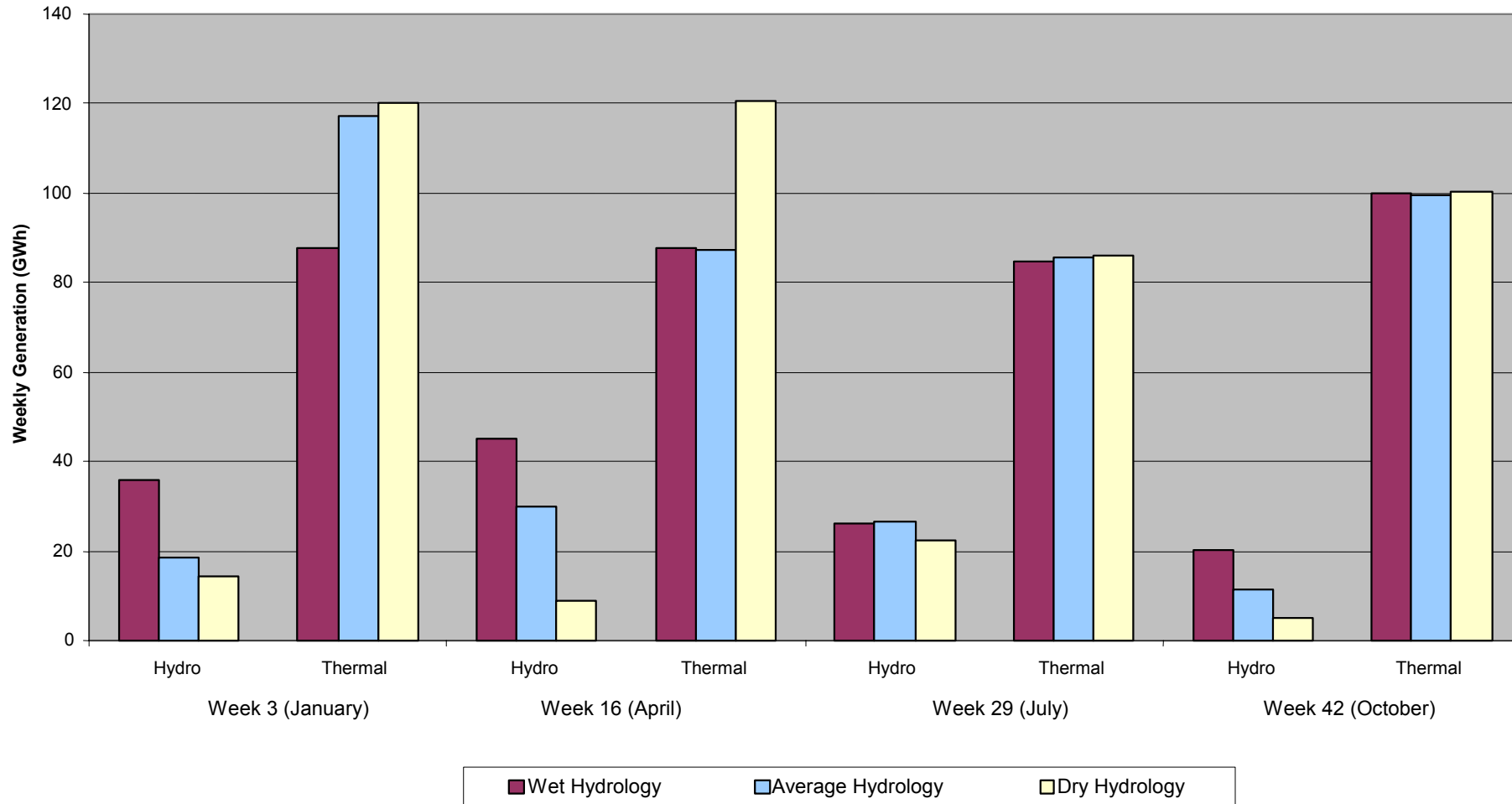




Figure A11.27 Weekly Hydro and Thermal Generation in Montenegro for Year 2010

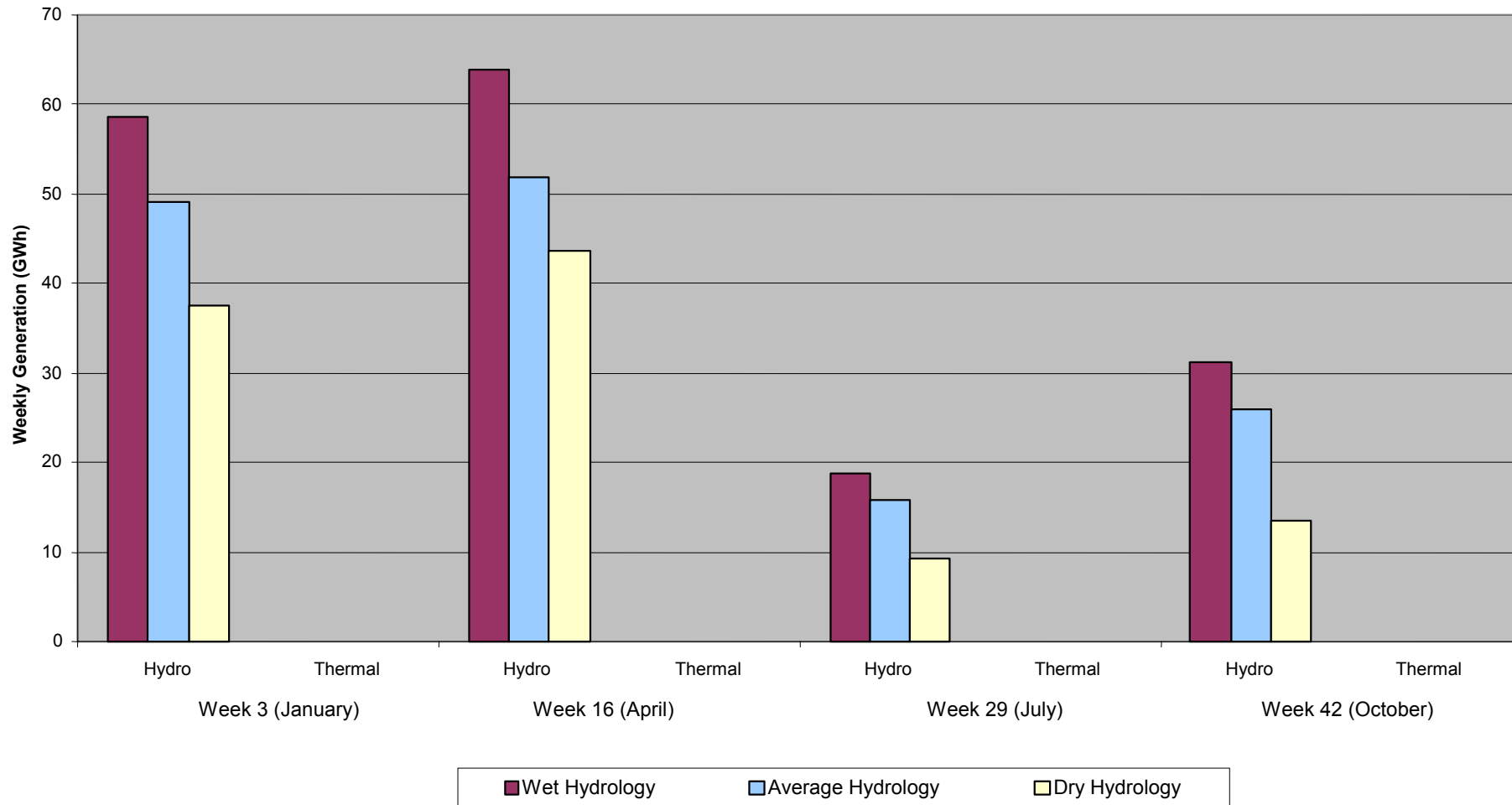




Figure A11.28 Weekly Hydro and Thermal Generation in Montenegro for Year 2015

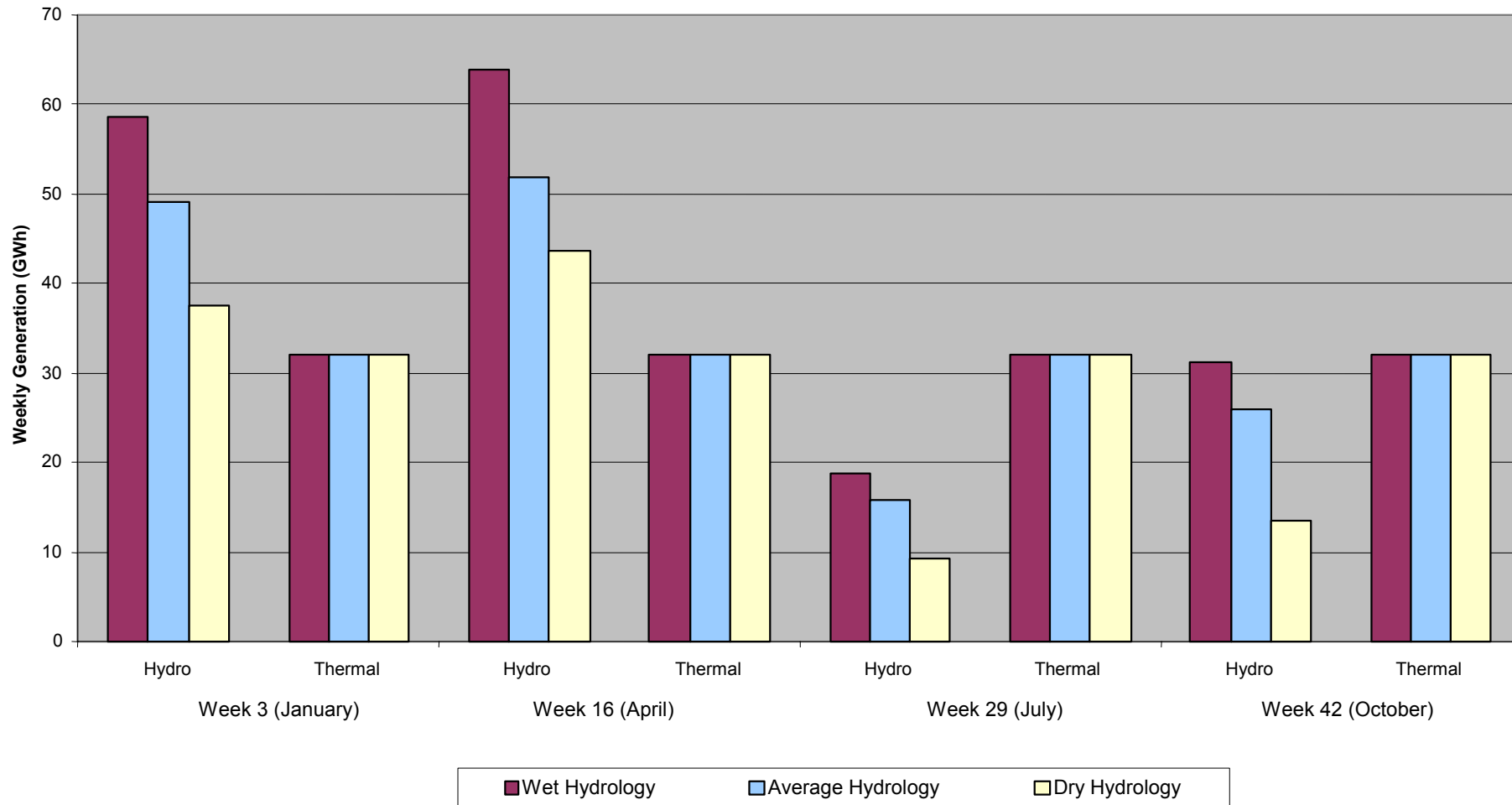




Figure A11.29 Weekly Hydro and Thermal Generation in Romania for Year 2010

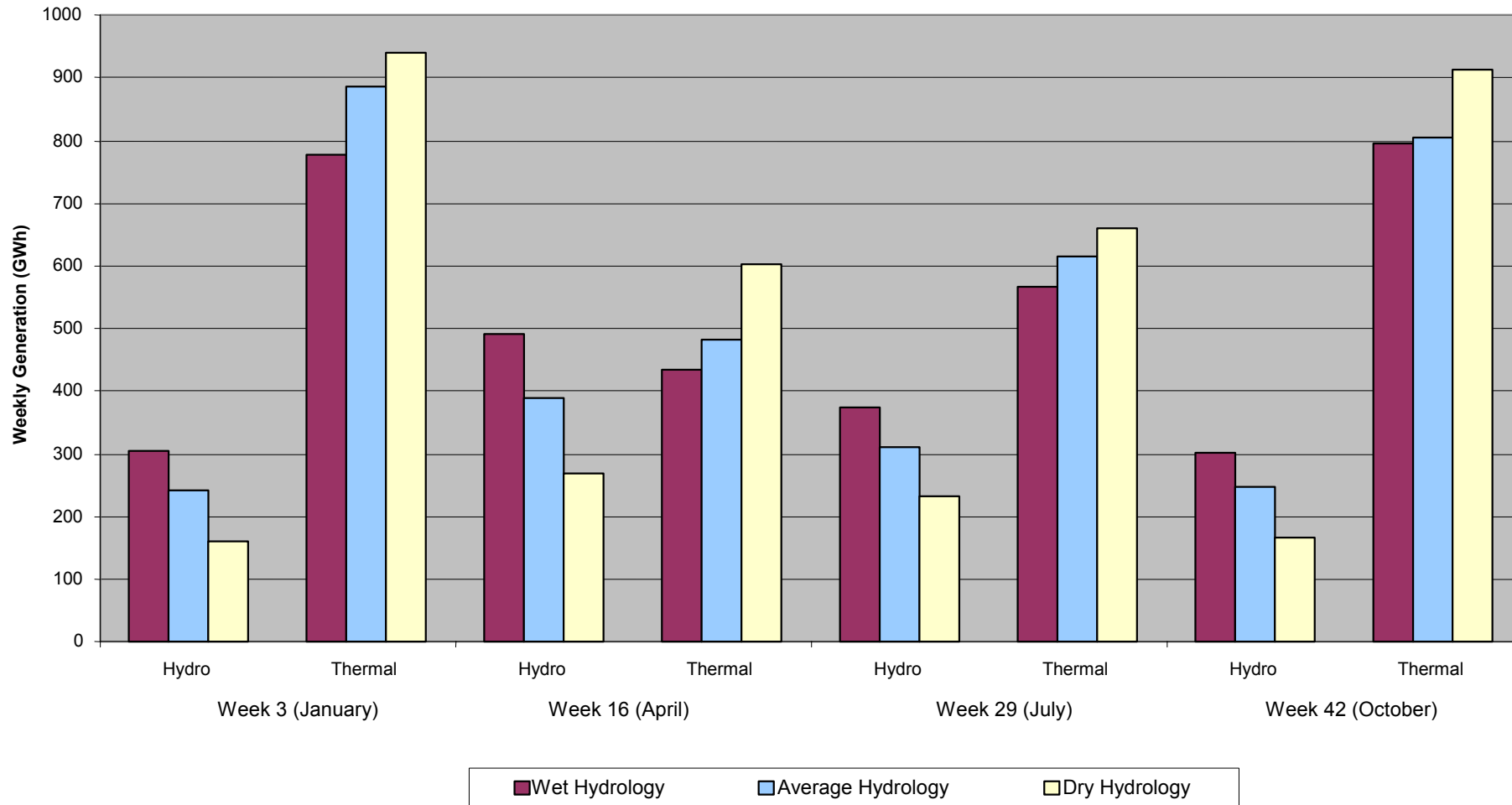




Figure A11.30 Weekly Hydro and Thermal Generation in Romania for Year 2015

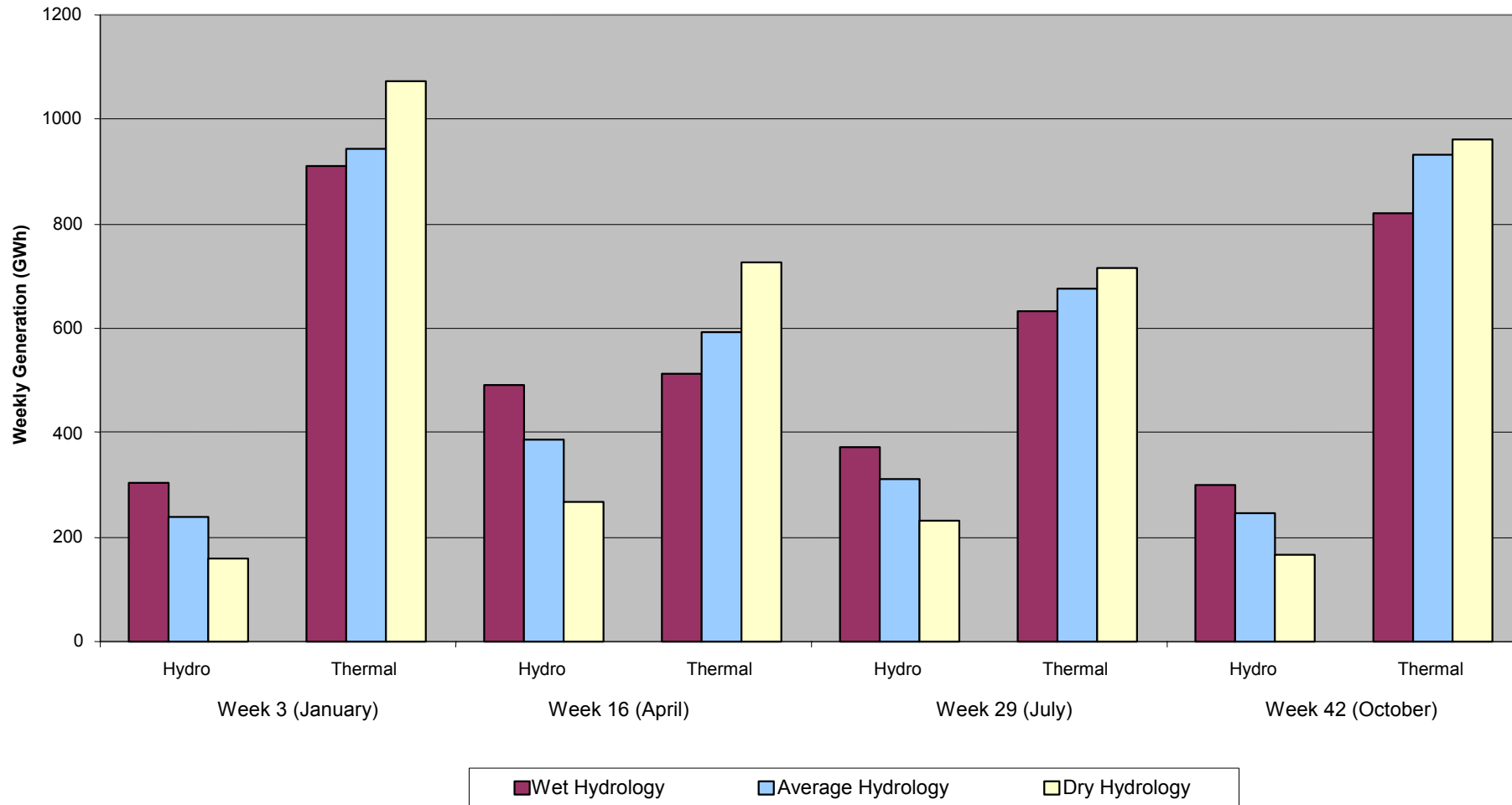




Figure A11.31 Weekly Hydro and Thermal Generation in Serbia for Year 2010

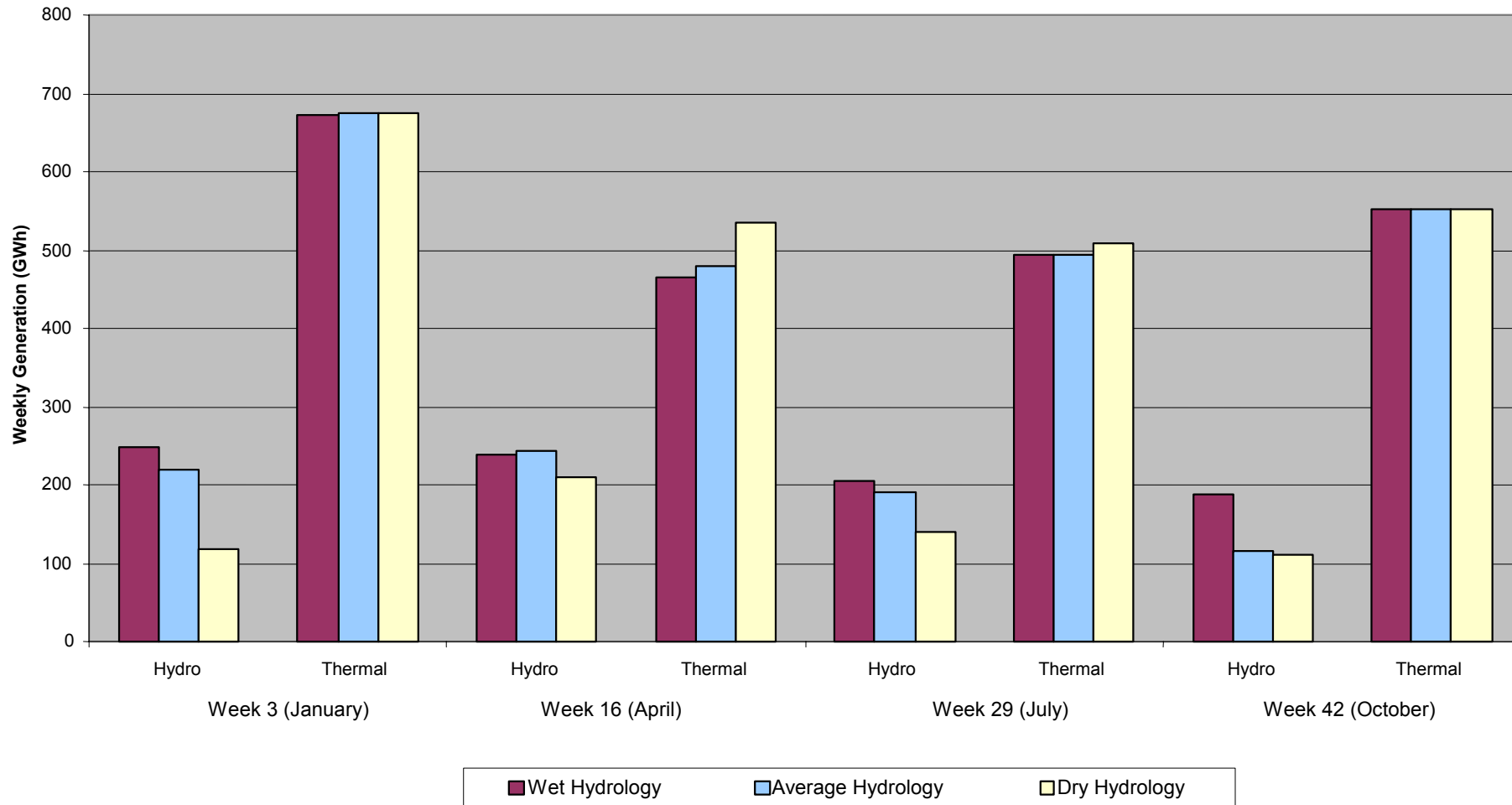




Figure A11.32 Weekly Hydro and Thermal Generation in Serbia for Year 2015

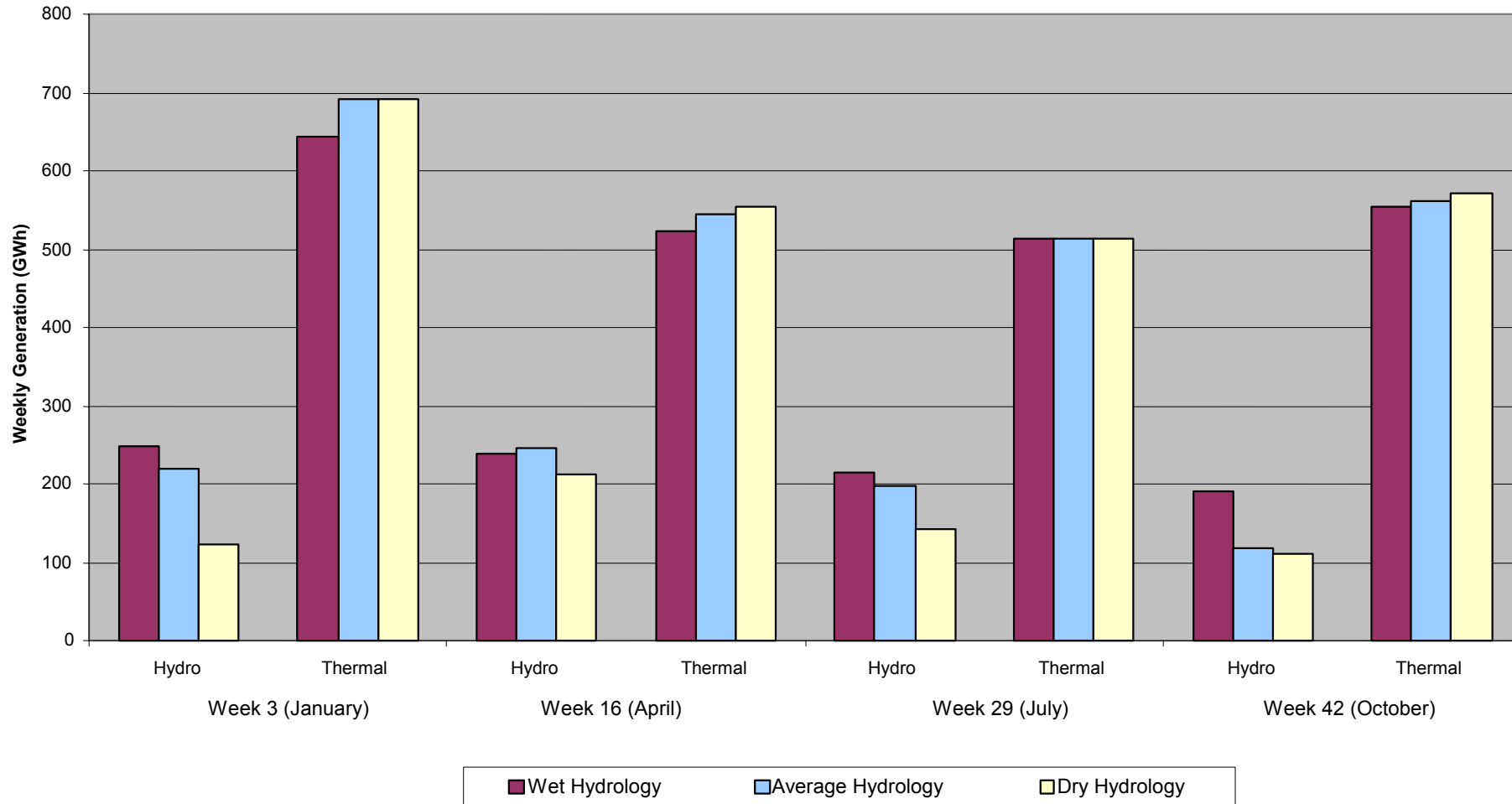




Figure A11.33 Weekly Hydro and Thermal Generation in UNMIK for Year 2010

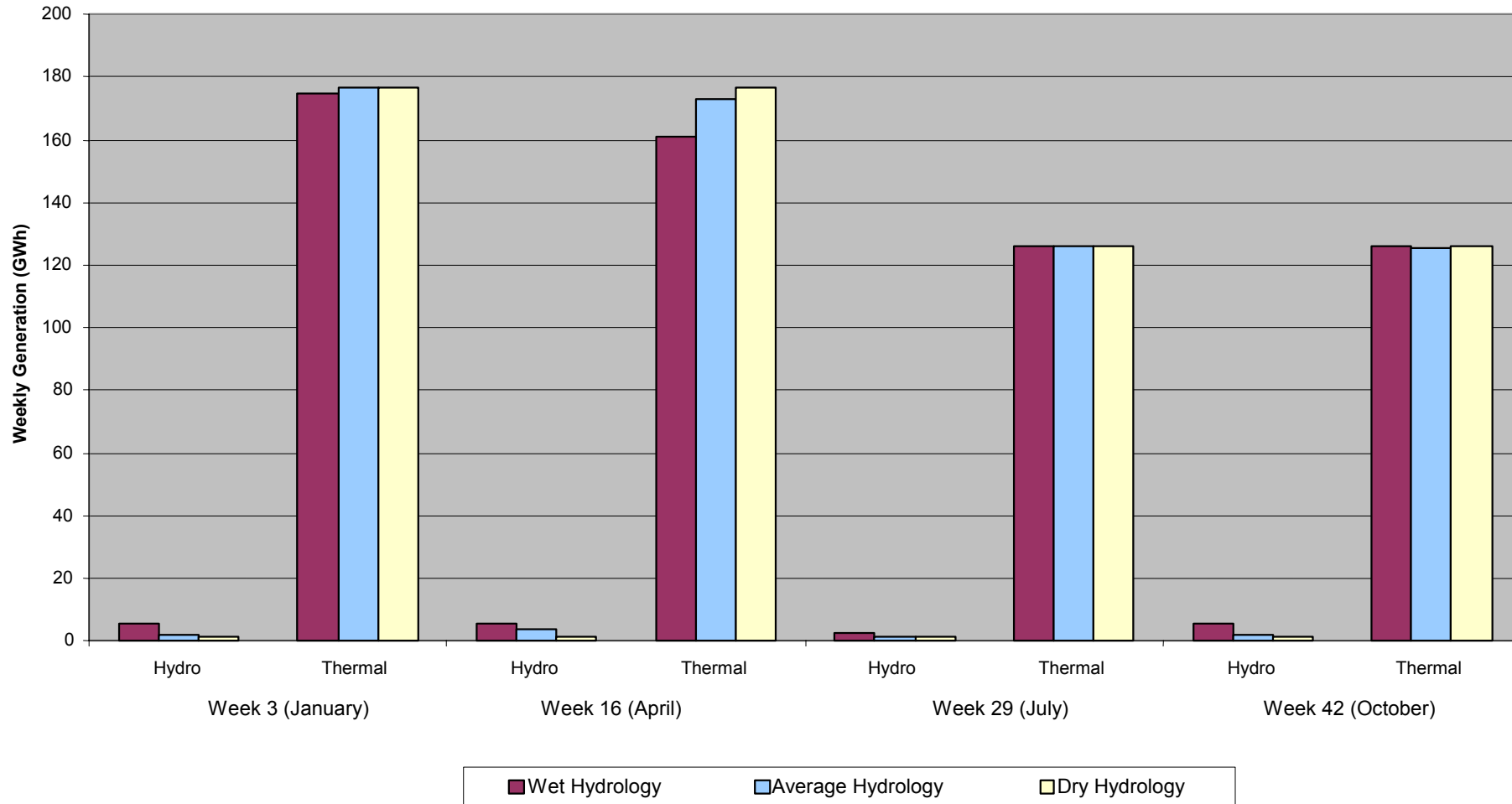




Figure A11.34 Weekly Hydro and Thermal Generation in UNMIK for Year 2015

