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Electricity Sector in Moldova: Evaluation of strategic options

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The German Economic Team Moldova (GET Moldova) advises the Moldovan government and other Moldovan state authorities such as the National Bank on a wide range of economic policy issues. Our analytical work is presented and discussed during regular meetings with high-level decision makers. GET Moldova is financed by the German Federal Office. Our publications are publicly available at our website (www.get-moldova.de).

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Executive Summary

Moldova's electricity system is not yet on a predictable track. It remains unclear by which means electricity demand will be met in the next decade(s), what the cost will be and how the electricity sector will be structured. Consequently, uncertainty prevents investments in electricity intensive industries and generation facilities. Furthermore, politics proposes contradicting plans on investments in networks and power plants. To avoid incoherent investment decisions and resolve the uncertainty a long-term electricity sector strategy is essential. In such a strategy, three interlinked questions need to be answered: Which power plants does Moldova needs? With which countries should Moldova trade electricity? And how should the electricity market be structured?

We propose three long term strategic options. Each of the options has different advantages and disadvantages: (1) East integration will essentially ensure comparatively cheap imports at the cost of continued dependency on Ukraine and Transnistria, slow market development as well as high uncertainty for potential investors. (2) West integration will require expensive investments and imply higher electricity cost but would create the environment for generation capacity extension and the development of a true market. (3) Becoming a trading hub for the region could be an attractive option if Ukrainian generators and Romanian consumer would accept to bear a share of the cost for increased inter-system trading.

We conclude that there is no silver bullet, but that a political choice between different targets (west integration, energy independence, market transparency, low electricity cost) has to be made.

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1. Introduction

The aim of this paper is to describe the main issues facing the Moldovan electricity sector and to introduce the possible choices to resolve these issues.

In the next section we provide a description of the status quo of the Moldovan electricity system. In Section 3 we introduce the main strategic questions faced by the sector. In Section 4 we describe the advantages and disadvantages of three stylised strategic options for the Moldovan electricity system. And in Section 5 we conclude.

2. Description of electricity sector

Moldova's political history left significant traces in its electricity system. The existing infrastructure was mainly built in the Soviet period. At this time the electricity network and the location of power plants in the South-Western Soviet Union, that was split into Russia, Ukraine and Moldova in the 1990s, as well as the neighbouring communist countries (Romania, Hungary, Bulgaria) was laid out as a jointly optimized system. Thus, all countries in this region had to redesign their electricity systems in the last two decades. In this process, Romania, Hungary, Bulgaria decided to get their electricity network synchronized with the Western system (former UCTE, now ENTSO-E) while Ukraine and Moldova joined the Eastern system (IPS). Thus, despite strong existing links between the former Soviet Republics and their Western neighbours, electricity exchange between the two systems is currently only feasible in island mode (ie, a part of one country is desynchronized with the domestic and synchronized with the foreign system) or via expensive back-to-back converter stations. As the smallest and poorest of the regions countries Moldova was hard hit by the disassembly of the regions electricity system. Furthermore, the factual separation of Transnistria deprived Moldova¹ of its main power plant. Consequently, Moldova is left with a non-sustainable domestic electricity system.

2.1 Generation

Currently Moldova covers less than 30% of its demand (2009: 3,200 GWh) by domestic electricity generation (2009: 866 GWh). This is due to a lack of the total available generation capacity and the high generation cost of the existing capacity. Moldova features two non-minor power plants CHP1 with 66 MW installed capacity and CHP2 with 240 MW installed capacity. In addition, CHP-Nord, NHE Costesti, and other domestic producers account for 136 MW.² This total 440 MW is below the base load of Moldova (2009: 366 MW)³ and clearly

¹ Here and in the future we will refer to the right bank of the Dniester when speaking about Moldova and refer to the left bank as Transnistria.

² These numbers refer to a presentation by Ilarion Popa, Deputy Minister, Ministry of Economy, Republic of Moldova. Slightly different numbers are given in the annual report to ENERGO CIS: 74 MW for CHP sugar entreprises; MGRES 2994 MW.

³ Average load is annual consumption (2009: 3,210,500 MWh) divided by 8,760 h = 366 MW.

insufficient to meet the peak load (15.12.2008, 18h: 1106 MW)⁴. Furthermore, the two non-minor power plants that account for 87% of Moldovan generation are combined heat and power plants. Those are fired with natural gas and feature high marginal cost due to poor efficiency. In the summer month, when no heat is needed the fuel efficiency decreases further.⁵ The heat of CHP1 and CHP2 is bought by the state-owned company Termocom⁶ that has been regularly unable to pay for the heat. The corresponding difficulties with cascading debts from Termocom to the CHP's to Moldovagaz and, essentially, to Gazprom are of critical importance for the energy supply in Chisinau. The debts preclude a modernization of CHP1 and CHP2. Thus, the Government asked for assistance from the World Bank to help finding debt-settling mechanism for this issue. In a first step, on June 1, 2010 Termocom, the CHPs, Chisinau-Gaz and Moldovagaz agreed to not allow a for further accumulation of debts. Despite its importance, this particular issue will not be discussed in this policy paper that focuses on long term strategies.⁷

	Installed Capacity	Date of
	(MW)	commissioning
Right bank of the Dniester	440	
CHP-1, Chisinau	66	1951
CHP-2, Chisinau	240	1976
CHP-Nord, Balti	24	1957
HPP Costești	16	1976
CHP sugar entreprises	98	
Left bank of the Dniester	2568	
MGRES	2520	1961-70
HPP Dubasari	48	1955
Total installed capacity	3008	

Table 1: Installed Capacity in Moldovan Power Plants

Source: capacity according to Popa (2010), date of commissioning according to http://www.mepiu.moldnet.md/market.html

⁴ There is some ambiguity on the correct peak load figures that we are unable to resolve. Energo CIS (2009) quotes 1106 MW for both banks of the Dniester. The Ministry of Economy and Trade quotes a peak load of 1200-1300 MW for the right bank of the Dniester only. In both cases, the generation capacity on the right bank is insufficient.

⁵ But as CHPs run according to the heat demand in the warming period, the electricity generation system is inflexible in winter, too.

⁶ Termocom is a joint stock company with minor participation of private capital.

⁷ The situation is inter alia described in the "State of the Country Report 2007", Expert-Group, 2008. According to internet sources (http://www.jurnal.md/ro/news/-termocomfara-datorii-192240/) Termocom fully paid its current debts to CHP2 and Moldova-Gaz, and 69% of debts to CHP1. Historical debts remain however.

According to ANRE 410 mcm of gas were used in CHPs in 2008⁸. This gas was used to produce 809,6 GWh of electricity as well as heat. As 410 mcm correspond to about 4100 GWh of energy, the electricity generation efficiency of the CHPs is about 22%, which is poor even by regional standards. This low efficiency leads to high electricity production cost. Thus, only CHP2 is run in summer and the missing electricity is compensated by imports. Furthermore, natural gas prices in Moldova are higher than in Transnistria leading to a competitive advantage for Transnistrian power generation.

Due to the under-capacity as well as the high generation cost, Moldova has to import the largest share of its electricity consumption. In addition, because of the inflexibility of the Moldovan power plant park (ie, the limited size of quickly responding spare capacities) balancing is provided by Ukraine. Balancing is the compensation of short run deviations in supply and demand. This service is required in all electricity systems as electricity supply and demand in a system need to be equal at any instant while there are various reasons for short run deviations. In Western Europe this service is billed separately, as it causes additional cost (e.g., holding of reserve capacities). In Moldova the responsibilities for this service are not finally settled leading to continuous discussions between Moldelectrica and Union Fenosa. The organisation of the balancing mechanism, thus, is a permanent issue.

	2001	2002	2003	2004	2005	2006	2007	2008	2009
CHP-1	115	115	113	113	129	125	131	121	117
CHP-2	813	678	622	608	725	690	682	641	639
CHP-Nord	32	28	39	45	56	62	55	55	54
NHE Costesti	72	121	63	58	84	76	33	82	54
Other	11	12	5	7	7	6	3	7	2
Total	1043	953	842	831	1000	958	904	905	866

Table 2: Electricity Production (supplied by outgoing electric lines) in GWh

Source: ANRE (2010)

 $^{^{8}}$ 1130.8 mcm of total gas use (p. 19) times 36.3% of gas consumption is used in CHPs = 410 mcm.

2.2 Imports

In recent years, electricity was either imported from Ukraine or Transnistria. In 2007 and 2008, approximately 3000 GWh were imported from Ukraine. In 2009 Moldova switched suppliers and imported about 3000 GWh from Transnistria.

2007					
	GWh	USD/MWh			
Electricity import from Ukraine	2931	29.8			
Cuciurgan (Transnistria)	0.5	-			
	2008				
Electricity import from Ukraine	2958	46.6			
Cuciurgan (Transnistria)	4	41.8			
2009					
Electricity import from Ukraine	7	52.4			
Cuciurgan (Transnistria)	2934	57.7			

Fable 3: Electric	city imports and	d import cost	2007-2009
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Sources: National Bureau of Statistics of Moldova, State Statistical Bureau of Ukraine and Energocom

Import prices were thereby subject to high-level political negotiations. Due to the high stakes involved (3 bn kWh x 5 ct/kWh = USD 150 m) intransparent contracts led to allegations of rent seeking behaviour on the importing and exporting side. Furthermore, price negotiations were regularly mixed with political and legal questions. Low import prices from Ukraine, for example, for some time paid for the Ukrainian right to transmit electricity from Western Ukraine to Odessa. And the dispute over the Ukrainian Novodnestrovsk hydropower plant that occupies 17.35 hectares of Moldovan territory is also included in electricity price negotiations. On the other hand, the tense political situation and the various fields of conflict between Transnistria and Moldova made electricity price discussions not easier. Moldova for example neither recognises the privatisation of MGRES (the biggest power plant in the region, see below) nor the gas arrays accumulated by Transnistria.⁹

Consequently, published import prices from Ukraine and Transnistria have to be interpreted as the outcome of multi-subject discussions, not purely economic electricity purchase negotiations.

In addition, both, Ukraine and Transnistria do not feature well functioning electricity wholesale markets that provides transparent price signals for investment and power plant scheduling. A long planned reform for the Ukrainian wholesale market introducing bilateral contracts is still pending. Whether this reform will deliver on a liquid market and when it will come is also uncertain to date. Thus, the absence of well functioning wholesale markets in the major exporting countries make predictions of import prices very difficult.

⁹ Moldova, however, has been regularly issuing certificates to allow for power exports from Transnistria to the Balkans.

It has to be noted, however, that most countries in the region are net exporters (see Table) and feature prices below Moldovan generation cost.

	2007	2008	2009					
Romania		·						
Net imports (GWh)	-2090	-4248	-2300					
Average wholesale price (USD/MWh)	67.8	64.7	61.4					
Bulgaria								
Net imports (GWh)	-4461	-5344	-3693					
Average wholesale price (USD/MWh)	52.1	102.6	134.6					
Ukraine								
Net imports (GWh)	-9200	-6700	-5100					
Average wholesale price (USD/MWh)	44.3	57.2	47.3					

Table 4.	Flectricity	/ export	s and	nrices	in	the reaior	2
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Sources: National Energy Regulatory Agency of Romania, OPCOM, Eurostat, Electricity System Operator of Bulgaria and State Statistical Bureau of Ukraine

Electricity acquired from Transnistria is mainly generated in the Cuciurgan power plant (MGRES). This plant consists of 12 blocks build with an installed capacity of 2,520 MW. It is, thus, one of the largest power plants in the region. Due to continued operation below installed capacity, the readily available (or quickly restorable) capacity of the plant is unclear. Some blocks have been switched from coal and fuel oil to natural gas. Currently, the plant operates based solely on firing natural gas. Its privatisation to the Russian former monopolist RAO¹⁰ by the Transnistrian administration is formally disputed by Moldova.

2.3 Transmission

As laid out in the introduction, Moldova was well interconnected in the Soviet electricity system. Consequently, significant transmission capacity with Ukraine, Romania and Transnistria are available (see Table 5).¹¹ Also internally, the decrease in electricity demand after the end of the Soviet Union left Moldova with a comfortably overbuilt (although quickly ageing) transmission and distribution system.

¹⁰ The privatisation was carried out through several intermediate steps.

 $^{^{11}}$ In addition to the >300 kV lines, there are 14 110 kV lines to Ukraine and 3 110 kV lines to Romania, with one more 110 kV line Falciu (RO)-Gotesti(MD) planned to be completed by the end of 2010.

Country	Substations		Voltage (kV)	Length (km)	Capacity (MVA)
	MGRES	Usatovo	330	64,37	400
	MGRES	Novoodesskaia	330	45,0	400
Ukraine	MGRES	Kotovskaia	330	145,8	400
	MGRES	Arzis	330	104,4	850
	Balti	Dnestrovskaa GES	330	119,4	400
	Ribnita Nº 1	Kotovskaa	330	36,4	850
	Ribnita № 2	Kotovskaa	330	36,4	850
Romania	Vulkanesti	Isaccea	400	54,7	665

Table 5: International transmission lines (>300 kV)

Source: Energo CIS (2009).

The separation of the Soviet system into two asynchronous zones left Moldova with a transmission system that has to be run different from its intended mode of operation. Instead of enabling electricity exchanges between Bulgaria, Romania, Moldova and Ukraine, the system solely serves for bringing electricity from Western Ukraine to the Odessa region and for importing electricity to Moldova. Only occasionally, the lines to Romania and Bulgaria are activated in island mode to transit electricity from Transnistria and Ukraine.

Due to the desynchronization from the Western neighbours the layout of the network is currently not optimal. Despite the various links with Ukraine the total capacity of the interface between Ukraine and Moldova is only about 1400-1500 MW. As about 1000 MW are used by transits to Odessa, the net import capacity of Moldova is at about 400-500 MW. Thus, the question how to develop the system has been widely discussed. Several proposals have been prepared. The most advanced project is the construction of the so called Suceava (RO) – Balti (MD) –Novodnestrovsk (UKR) connection. This plan consists of three lines:

- 400 kV line "Suceava-Balti", 115 km (55km -Moldovan territory), Cost: 35,1 mln Euro (15,2 mln Euro –Moldovan part)
- 330kV voltage line "Balti-Novodnestrovsk" 121,5 km (88km -Moldovan territory), Cost: 28,5 mln
- 330 kV Balti Chisinau 102 km, Cost: 13,6 mln Euro (including stations'rehabilitation)

The line would allow the export of Ukrainian electricity to Romania through the territory of Moldova and would permit Moldova to increase imports from either Ukraine or Romania. However, the project would only make sense if either both Ukraine and Moldova join ENTSO-E or if a back-to-back converter station would allow linking the two asynchronous systems.

Table 6:	Distribution	system	losses
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Electricity Distribution Companies	Effective Losses (%)					
	2004	2005	2006	2007	2008	2009
RED Nord	16,9	14,39	13,17	11,46	10,97	11,08
RED Nord-Vest	25,4	20,07	15,75	13,81	13,59	13,31
RED Union Fenosa	23,4	21,44	16,92	16,90	15,38	14,01

Source: ANRE

2.4 Demand

According to the IEA (that calculates the consumption for the left and the right bank of the Dniester jointly) electricity demand dropped from about 9,000 GWh in 1990 to bellow 4,000 GWh in 2000. In 2007 a consumption of 4,155 GWh was reported by the IEA. This recent increase in demand is confirmed by Moldovan data. Since 2001 electricity demand increased by about 3 percent per year (2001: 3,195 GWh, 2009: 3800 GWh). This demand increase is mainly fuelled by increasing household and commercial consumption (CAGR: +8% and +13%), while industrial and agricultural consumption declines (-5% and -15%). Due to decreasing population as well as the economic crisis, electricity demand might experience a sluggish development. Thus, Moldova will continue to be a small electricity system. Moldova's final electricity consumption in 2009 was about 3200 GWh and the peak load in 2008 was at about 1100 MW.



Electricity Production and Consumption 1997-2009

Source: ANRE (2010)

Conclusion: Moldova is not big enough to host a fully diversified cost minimizing power plant park. Thus, economies of scale (eg, bigger generator tend to have lower variable cost and lower fixed cost per installed capacity) and scope (eg, more diversified technology portfolios can hedge fuel price and technology risks better) could only be extracted by regional cooperation.

	2006	2007	2008	2009	CAGR
households	1159	1292	1370	1448	8%
Of which: urban	688	738	788	823	7%
Rural	472	553	582	625	11%
Industrial consumers	1064	1101	1040	907	-5%
Agricultural consumers	147	83	76	82	-15%
Commercial consumers	327	356	415	454	13%
Public Institutions	237	280	281	263	4%
Other consumers	53	53	51	56	2%
Total	2987	3165	3232	3211	2%

Table 7: Final electricity consumption in GWh

Source: ANRE (2010)

2.5 Market Structure

By signing the Energy Community treaty in December 2009 Moldova committed to implement the European aquis communitaire into its energy legislation¹². This will inter alia imply stepwise market liberalisation. Up to now, most electricity prices and tariffs are regulated. The National Agency for Energy Regulation (ANRE) sets the price for buying electricity from CHP1 and CHP2 based on generation cost. The electricity has to be purchased by the regional suppliers. That is, they are not allowed to refuse off-take of a certain proportion of electricity from these plants even if cheaper imports are available. The suppliers then sell the electricity at regulated tariffs to their captive customers. Only eligible customers might negotiate prices with different sources (e.g., Lafarge buys power for its cement plant directly from MGRES). As import prices are mainly negotiated by Energocom (for the state owned REDs) or on political level the only means by which the two state owned (RED Nord, RED Nord-Vest) and

¹² By the end of 2009 the Law on electrical energy (implementing Directive 2003/54/EC on common rules for the generation, transmission, distribution and supply of electricity) and Law on natural gas (implementing Directive 2003/55/EC on common rules for the transmission, distribution, supply and storage of natural gas) have been passed. A series of regulations supporting the implementation of these laws as well as harmonization with acquis communitaire in area of cogeneration, environmental protection, energy efficiency and renewable energy development are to be adopted by the end of 2010.

the one private supplier (RED Union Fenosa) could influence their profitability is by increasing the efficiency of electricity distribution.

3. Defining the main questions regarding the future of the electricity sector in Moldova

In this section we identify three major issues that a electricity sector strategy for Moldova should deal with. All three issues: generation capacity, cross-border electricity trade and market model are interrelated.

3.1 Generation capacity

The right bank of the Dniester is short in electricity generation capacity. Furthermore the existing power plants are mainly old, worn out, inefficient and fail to meet European standards.¹³ Finally, state-of-the art IT systems to operate the power system efficiently are missing. Consequently, significant investments in electricity generation are needed to maintain/increase the capacity level, improve efficiency and thus to decrease the cost of electricity generation. Despite ambitious plans, however, no new power plant capacities have been commissioned in recent years.

Furthermore, construction of the new power plant capacities based on the natural gas will not radically solve the issue of supplier diversification. Indeed, both Transnistria's Cuciurgan and Moldova's CHPs use gas which is imported from Russia. Natural gas accounts for almost 44% in total energy consumption. Due to the existing pipeline structure, this dependence on a single supplier for gas imports can only be eased by constructing new pipelines. In this context, the plan of Moldova and Romania to interconnect the countries' gas systems (Ungheni-Iasi project) that was agreed in May of 2010 might prove helpful. This would, however, require that Romania were able to secure sufficient natural gas supplies from non-Russian sources. The corresponding projects (e.g., Nabucco) are subject to substantial uncertainty.

In the context of generation capacity investments, three interlinked question arise:

First, **how much new/modernised capacities** are needed. The answer to this question depends on the price and availability of importing electricity in the short, mid and long term as well as on the development of electricity demand in Moldova. In fact, massive investments in generation capacity - making Moldova quasi electricity independent - could prove a very expensive strategy, if electricity supply from existing power plants in Ukraine and Transnistria would be securely available at low prices.

¹³ According to the Energy Community Treaty Moldova has to implement Directive 200118018C on the limitation of emissions of certain pollutants into the air from large combustion plants by 31 December 2017.

Second, in **which generation technologies** should Moldova invest. Currently, renewable (wind, solar, biomass), natural gas, coal¹⁴ and refurbishment of existing stations¹⁵ are the most discussed options for developing the Moldovan power plant park. The answer to the technology choice question depends on the fixed and variable cost of the technologies, that are partly determined by fuel prices. In addition, the technology choice depends on the price structure of imported electricity. If baseload electricity is imported from Ukraine, peaking units (eg, gas turbines) could be the right choice to minimize cost and to even partially export electricity in peak hours. If peakload electricity is imported from Transnistria, a baseload plant (eg, renewable or coal) might be appropriate to reduce electricity sourcing cost.

Table 8: RES potential in Moldova

Hydropower	Potential is not significant compared to other NIS countries; a few HPS are installed including one of 48 MW and one of 16 MW, generating approximately 0.3 billion kWh/y.
Biomass	The total technical biomass resource potential in Moldova is 0.5 Mtoe/y. In detail: agricultural wastes 0.18 Mtoe, firewood 0.1 Mtoe, wood processing waste 0.1 Mtoe, biogas 0,7 Mtoe and biofuels 0.5 Mtoe.
Wind	Technical potentials assessed at 8 billion kWh/y

Source: Quoted from INOGATE (2008)

Third, **how should the capacity be financed**. Power plants are very capital intensive investments. Therefore, transition countries struggle to find the means for their installation. International financial institutions (EBRD, KfW, World Bank) have, thus, engaged in providing credits for large infrastructure projects in transition countries.

3.2 Cross-border Electricity Exchange

As outlined in the previous section (see, 1.4) establishing an autarkic electricity system in Moldova would not be optimal as the system would be too small to host a well diversified and cost minimizing power plant park. Consequently, interfaces with neighbouring countries could provide diversification and supply security at lower cost. For technical and economic reasons, however, it does not make sense to strengthen uniformly the transmission lines with all neighbouring

¹⁴ "The last major infrastructure project is a proposal of the Czech energy company J&T to construct a 165 MW power station. The estimated cost of the project is EUR 200 mn. The Government of the Republic of Moldova and the Czech company have signed a Memorandum on the project." Innogate (2008). According to Popa (2010): 360 MW.

¹⁵ "Partial modernization of CHP 2 equipment is under consideration, targeted to ... decreased specific consumption by 9,6 g/kWh for production of electricity; ...; annual saving of 534 t.c.c.; additional production of 0,3 mln MWh of electric energy each year;... aprox.1000 MWh increase in electricity supply during summer period." Ilarion Popa, Deputy Minister, Ministry of Economy, Republic of Moldova.

countries. First, Moldova is at the border of the Western (ENTSO-E) and Eastern (IPS) electricity system. Thus, unsynchronized frequencies in the two systems prevent simultaneous alternate current electricity trade with all neighbours. Therefore, the choice of the system is also the choice of the main trade direction.

3.3 Market Model

As Moldova alone cannot host a well balanced power plant portfolio, the country is also too small for an unregulated electricity wholesale market. Due to decreasing average cost domestic generation companies would always be natural monopolies. Therefore, two models for the wholesale market are realistic. Either, Moldova could join a liquid wholesale market. Currently the Romanian OPCOM is the most liquid market in the region while in future the Ukrainian WEM might develop to a reliably functioning marketplace. Alternatively, Moldova could continue to regulate electricity generation prices.

4. Finding the answers: Strategic options for the future

The three described issues are interlinked and could only be properly addressed in a joint strategy. Nevertheless, the key-decision is to be made with respect to the choice of the international electricity system (ENTSO-E vs. IPS) as market structure and generation extension will depend on this discrete decision. Thereby, each strategy choice implies sunk investments. That is, building transmission lines in one direction or another or constructing certain power plants are irreversible decisions. Consequently, a consistent strategy is needed to avoid waste investments. It has, however, to be kept in mind that pure expected cost minimization might not be the optimal strategy in an uncertain world. In fact, investments that increase flexibility (eg, alternative sourcing options) and reduce risk (eq, redundancy of certain assets) might increase welfare. Thus, a comprehensive cost-benefit-risk analysis would be needed to define a proper strategy. But the benefits are often political and hard to quantify. In particular, big politics will play a significant role for the electricity sector strategy as electricity import dependencies are perceived as a sort of political dependency. This is particularly so, as Moldova's main strategic choice is to remain dependent on imports from its Eastern neighbours (IPS) or to switch at high cost to ENTSO-E.

In the following section we will introduce three different strategies. As we are unable to quantitatively assess the costs, benefits, risks and chances, we limit ourselves to describe the advantages and disadvantages of each strategy qualitatively.

4.1 East Integration

The default option for Moldova is to essentially preserve the status quo. This would imply buying electricity from Ukraine and/or Transnistria (depending on the conditions) and to maintain the workability of the existing transmission system.

Cost:

- As the existing infrastructure already corresponds to this scenario no major infrastructure investments will be required, making this scenario rather low-cost in the short run.
- Constructing power plants to counter the adverse effects of import dependency (see below) will be a very expensive option. According to IEA (2010, p.90) The cheapest levelised cost are to be found for a Russian coal fired power plant with about 50 USD/MWh at 5% and about 66 USD/MWh at 10% interest rate.¹⁶ Capital cost in Russia are most likely to exceed 10%. As Moldova has a significantly lower credit rating than Russia¹⁷, capital cost in Moldova will be probably even higher. Thus, the cost of a own power plant is likely to be far above the current wholesale market prices in Ukraine (40-50 USD/MWh) or the current import prices from Ukraine (50-60 USD/MWh).

Benefits:

- The existing overcapacities in Transnistria and Ukraine might allow obtaining import prices that are below the total cost of domestic electricity production. That is, it is cheaper to import electricity then to build own power plants.

Risks:

- Moldova will remain dependent on Ukraine and Transnistria. While dependence on Ukraine might translate into high prices and volatile service quality the dependence on Transnistria might even have adverse political implications.
- Due to the opaque methods in international electricity trade in this region as well as the essential duopoly of electricity suppliers (Transnistria and Ukraine) Moldova will be unlikely to develop a functioning domestic wholesale market. Consequently, the electricity sector will remain highly susceptible of rent seeking behaviour with all its adverse implications on domestic customers and politics.
- The main issues in the electricity trade with Ukraine are the intransparent arrangements that involve (potentially rent seeking) intermediaries, regular renegotiations of the contract conditions, service quality issues

¹⁶ The levelised cost of a new coal unit in in Czech Republic are about 60 USD per MWh if a 5% discount rate is assumed and carbon emissions are for free. At a 10% discount rate the cost increases to about 110 USD per MWh.

¹⁷ Moldova currently has a Moody's rating of B3 while Czech Republic features a A1.

(frequency deviations, black outs) and non-differentiated prices for the different services (balancing, peakload, baseload).

- Moldovas dependence on Ukraine and Transnistrian imports will extend the existing uncertainty about the future of the electricity system of Transnistria for several years. This uncertainty about future electricity prices and supply security is likely to reduce private investment in both the electricity sector and in electricity intensive industries. Thus, investments in generation could only be expected with financial contributions or potentially expensive purchase guarantees from the government. Such generation investments will most likely not be economic from a pure net present value analysis, but might have a value in increasing the bargaining power in electricity import price (and political) negotiations.

Opportunities:

- Ukraine stated its intention to join ENTSO-E several years ago. Even though, a fast switch from IPS to ENTSO-E seems unlikely under the current Ukrainian administration, chances are that Ukraine might join ENTSO-E in the longer-run. In this case, Moldova (that would then join ENTSO-E together with Ukraine) could increase its supply diversification markedly without major investments in its infrastructure.

Box: Power sector in the Baltic's – a long way to ENTSO-E

The Baltic countries and Moldova's electricity system feature striking **similarities**:

For several decades of the Soviet rule all four countries (Lithuania, Latvia, Estonia and Moldova) were fully integrated in the Soviet power system. Currently, the Baltic states and Moldova are **net importers** of electricity. And they import most of the electricity from the East as they are still in the **IPS/UPS** power system and lack significant power connection with the Central European (ENTSO-E) and Nordic (NORDEL) countries. The Baltic countries and Moldova share **fears on political influence** being exercised through its electricity import dependency.

However, there are also significant **differences** between the Baltic countries and Moldova's electricity system:

Lithuania, Latvia and Estonia are in **the European Union** (EU). This brings some cost to these countries as they have to fully implement European legislation that forced these countries to restrict electricity production from shale oil and shut down the only nuclear power plant in the region (NPP Ignalina). This made the countries to electricity importers. On the other hand the EU is also active in funding interconnection projects to decrease the import-dependency of these countries on Russia (eg. The Baltic Energy Market Interconnection Plan). Estonia is able to regularly import some of its electricity need via a **direct current link** from Finland (that, however, also essentially is an importer of Russian electricity). Furthermore, the economic development in the Baltic countries has been, also thanks to the EU membership, much more dynamic and electricity demand also developed stronger.

In conclusion it can be asserted that remaining in the IPS even when joining the EU is possible and convergence towards ENTSO-E from inside the EU provides interesting financing opportunities for infrastructure.

4.2 West Integration¹⁸

A separate (i.e., without Ukraine) accession of Moldova to ENTSO-E is politically and technical difficult but possible. In fact this strategic option would imply desynchronising the Moldovan transmission system from the IPS (and thus Ukraine) and synchronising it with ENTSO-E (and thus Romania). This implies that balancing of the Moldovan system would need to be provided domestically and the operation of the transmission system would need to be changed entirely (all 21 connections with the IPS system would need to be decoupled). The central role of Moldova GRES in the Moldovan transmission system would make a desynchronisation of Transnistria prohibitively expensive. Thus, this option is only meaningful if Transnistria (and RAO the operator of Moldova GRES) could be convinced to join ENTSO-E together with Moldova. Furthermore, a sequential shift from IPS to ENTSO-E has been discussed. This would require that the Moldovan system is split in a part that is synchronised with ENTSO-E and another part that remains within IPS. This would allow to sequentially switch nodes of the network to the Western system and might reduce reliability concerns. Nevertheless, such an option might be challenging when it comes to key-nodes and include the risk of getting stuck in the process and being left with two separate electricity systems. Thus, **switching to ENTSO-E** while Ukraine stays in the IPS would be technically and politically very difficult.

Cost:

- Due to the current East orientation of the transmission system Moldova will need significant investments to meet the reliability criteria if it desynchronizes from Ukraine. For example, meeting the n-1 criterion (the system has to be stable even if any single unit of the system fails) would require new redundant transmission lines. According to Center (2009) the adaption cost of Ukraine to ENTSO-E would be 11 bn UAH. This would represent slightly above 1 percent of the current GDP. The cost in Moldova can be expected to be significantly higher as currently neither balancing nor central dispatch¹⁹ is provided inside Moldova and the small Moldovan system has to be enabled to run in isolated for some time in order to switch from one system to the other.
- Electricity in the Western market is currently more expensive than in Ukraine. Thus, imports from the West might result in higher electricity cost for Moldova. This situation might change when generation capacity in the

¹⁸ It should be mentioned that in March 2006 Moldova's "Moldelectrica" and Ukraine's NEC Ukrenergo made formal application for the synchronous interconnection with UCTE power system. The application was formally accepted and by the end of 2006 working group was established. The process of the interconnection has been designed to take place in three phases. However, so far progress has remained very limited. The interconnection with the ENTSO-E is also seen at the core of Moldova's Energy Community Treaty integration process, and is highlighted in the country's Energy Strategy.

¹⁹ Dispoatching responsabilities are currently shared between Ukraine (overall system reliability), Moldova and Transnistria.

East becomes more scarce and prices in Ukraine have to rise. However, electricity prices in the Western system are also expected to rise, and it is to date unclear, whether the price gap between both systems will narrow (which would make the Western option more attractive) or even widen.

 Political cost of this option is also non-negligible as a desynchronization from the IPS will imply significant cost for Ukraine for re-ensuring reliability inside the Ukrainian system and deprive the Ukraine from an interesting market for electricity exports. For example Ukraine would find it difficult to supply Odessa that is not sufficiently integrated into the Ukrainian electricity system and currently supplied through Moldova.²⁰

Benefits:

- Joining ENTSO-E is a clear strategic choice whose irreversibility will assure investors. As uncertainty is reduced, attracting foreign companies to invest in Moldovan generation and distribution assets will become cheaper.
- The access to one of the biggest electricity markets in the world is also an interesting option for investors in generation capacities in Moldova.
- Thanks to increased investment security and somewhat foreseeable foreign price signals, the market can decide whether imports, domestic generation from new or refurbished conventional plants²¹ or domestic generation from renewable sources²² will be the most economic.

Risks:

- Investing hugely into desynchronisation from Ukraine might prove redundant as soon as Ukraine joins ENTSO-E.
- The central role of Transnistria for the Moldovan electricity system will remain and persuading Transnistria to join ENTSO-E might require political and/or economic concessions.

Opportunities:

- Thanks to the access to one of the biggest electricity wholesale markets in the world, the development of a functioning wholesale market in Moldova (e.g., in cooperation with the Ukrainian OPCOM) becomes possible.
- Joining ENTSO-E is likely to make attracting support from international financial institutions, the EU and bilateral financial and technical assistance

²⁰ The 330 kV transmission line between the Novoodeska and Artsyz substations bypassing the territory of Moldova - is planned to provide a connection between the remote southern part of the Odessa region and Ukraine's joint power grid. Due to environmental concerns financing of the project from either the EBRD or the EIB is not being considered so far. http://www.bankwatch.org/project.shtml?w=162059&s=2226376.

²¹ According to the Energy Community Treaty Moldova has to implement Directive 200118018C on the limitation of emissions of certain pollutants into the air from large combustion plants by 31 December 2017.

²² According to the Energy Community Treaty Moldova has to present a Plan for the implementation of Directive 2001/77/EEC on the promotion of electricity produced from renewable energy sources in the internal electricity market by 31 December 2010.

much easier. In particular the development of own generation capacities (in particular from renewable) could help to decrease import dependency.²³

4.3 East-West electricity trading hub

Trading electricity between systems with different electricity demand and generation cost profiles could provide arbitrage gains. As currently only indirect trade (via load or generation islands) between IPS and ENTSO-E is possible, creating a more direct connection appears an interesting option. Using back-to-back converters it is technically possible to transmit electricity across asynchronous zones. Thus, the idea would be to install a back-to-back converter at the Moldovan-Romanian border to allow electricity exchanges between IPS and ENTSO-E.

Cost:

- Back-to-back converter are very expensive installations that cost up to 125,000 USD per MW of installed capacity.²⁴ In addition back-to-back converter incur efficiency losses. Thus, there operation is only profitable significant price differentials.

Benefits:

- Installing a converter is of dual use for Moldova. On the one hand it allows Moldova to do arbitrage between the IPS and the ENTSO-E electricity system. On the other hand it implicitly increases the supply diversification of Moldova as it allows importing electricity from both systems simultaneously.

Risks:

- The high cost of this installation will not pay off when either (1) Ukraine decides to join ENTSO-E before the facility is fully amortized or (2) the price differential between both systems does converge (e.g., because auf competing projects between Belarus and Poland or Ukraine and Hungary) or (3) market power at the generators side (most likely Ukraine) or the consumer side (most likely Romania) is capturing an over-proportionate share of the arbitrage rent. Especially the last caveat is hard to overcome, as the partial irreversibility of the investment puts the investor (Moldova)

²³ According to the law, suppliers must get green certificates the equivalent of 8.3% of commercialised energy this year, its share increasing to 20% in 2020. One green certificate will be traded at a value between 27 and 55 euro. Investors in Romania expect the law. For the moment, this is a law which cannot be applicable, as there are no norms for its use.

http://www.actmedia.eu/2010/08/19/top+story/wind+energy+%3A+requests+to+be+c onnected+to+the+national+electricity+grid+exceed+four+times+the+transport+capacit y/29043

²⁴ Roberto Rudervall J.P. Charpentier Raghuveer Sharma (2000, p.6) calculate the cost of the two neccesary substations at togther 250 m USD for a 2000 MW connection.

in a hold-up situation so that in the worst case the revenue share would only cover the operation cost of the facility but not its fixed cost.

Opportunities:

- A converter station could smooth the transition to ENTSO-E as it allows access to the EU electricity market without synchronisation, thus, possibly allowing to benefit from the better developed and more liquid Western electricity wholesale markets.
- It is technically and economically possible to sell parts of the converter station at the secondary market, thus, making the investment partly reversible when it becomes redundant after an eventual synchronization.

4.4 Summary

Due to its limited size Moldova will be unable to establish a self-sufficient power sector. Thus, the integration of the Moldovan electricity system in the regions power system is the key strategic decision that will have implications for the development of the market model and the generation capacity. All three outlined options (East-integration, West-integration and trading hub) encompass significant opportunities but also drawbacks. East integration will essentially ensure comparatively cheap imports at the cost of continued (1) dependency on Ukraine and Transnistria, (2) slow market development and (3) high uncertainty for potential investors. West integration will require expensive investments and imply higher electricity cost but would create the environment for generation capacity extension and the development of a true market. Finally, becoming a trading hub for the region could be an attractive option if Ukrainian generators and Romanian consumer would accept to bear a share of the cost for increased inter-system trading.

Thus, there is no easy choice to be made on these options. Due to the significant political uncertainties that influence the advisability of each strategic option as well the far-reaching foreign policy implications of the electricity system choice, the electricity strategy will depend on the general political orientation of the country.²⁵ As hard as it might be, this strategic choice is essential for creating the environment for the development of the Moldovan electricity sector. Such a hard strategic choice implies disregarding some projects that might be advisable under a different option: Building lines to the West, increasing the share of renewable at all cost and establishing a fully fledged wholesale market is a waste of effort when Moldova wants to stay in the IPS for another 10 years while building lines to the East or constructing gas fired power plants does not go well with West integration. Irrespectively of the system choice, however, there is a number of no-regret options that will ultimately foster modernization of the Moldovan energy sector. These options include: the promotion of energy efficiency (here serious steps have already been made on legislative and regulatory levels), debt-restructuring and rehabilitation of the CHPs in Chisinau as well as establishing clear responsibilities for all segments of the electricity value chain (e.g. for balancing).

²⁵ On the political side the tide is towards west-integration of power system.

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