Arthur D Little

Energy & Utilities

“Keeping the Lights on”

A Much Tougher Challenge Than Before

Content

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Executive summary

In recent years, energy markets have experienced a “greening wave” through the ramp-up of more sustainable electricity sources. This has transformed the energy value chain, with fundamental changes on the Generation mix as well as on the customer-facing Sales & Marketing strategies and processes. A much less recognized impact is the effect on the high-voltage electricity network: Transmission System Operators (TSO) need to deploy fundamentally new mechanisms to manage their networks, triggered by substantially higher volatility in both supply and demand.

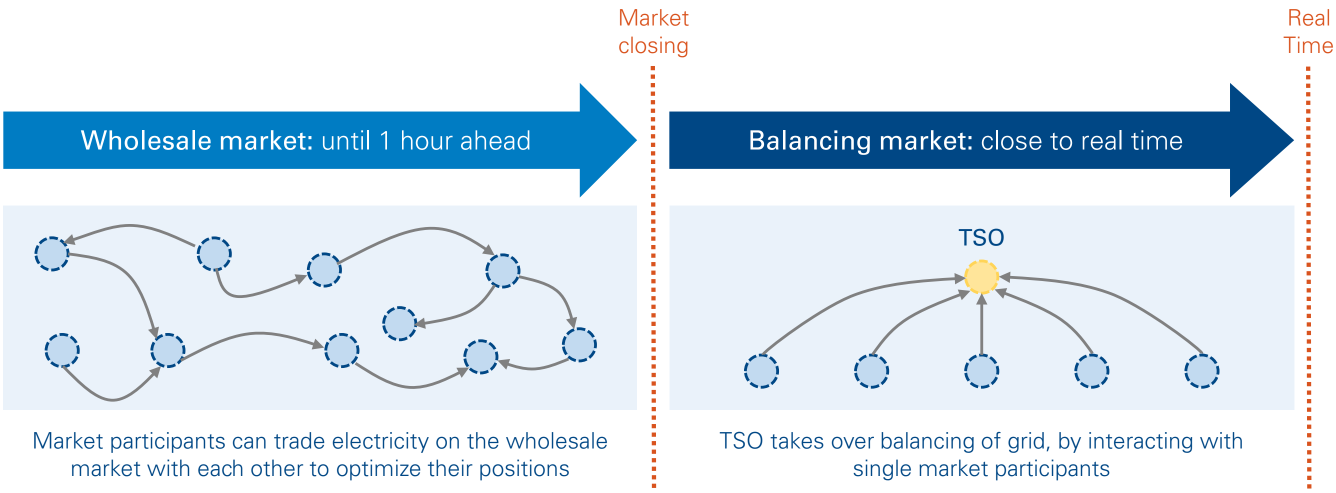
Expanding and strengthening the physical infrastructure network through additional capacity is one core ingredient of the answer, but is costly and slow in implementation. TSOs therefore need to deploy additional balancing mechanisms. These come from national and international peaking plants, controlling energy demand, and alternative storage systems. Managing this portfolio effectively is a key requirement to keep the lights on, and has transformed the profession of the network operator.

Simultaneously, the balancing challenge creates interesting opportunities for the other stakeholders along the value chain. Provided that they are willing to think out of the box, they can tap into new business models which arise through this new complexity. Moreover, additional new entrants may be tempted to play along in the balancing market, which was in the past served almost exclusively by the traditional energy players. The increased stress on the system may create room for new value propositions with interesting business cases. Is this industry about to see another wave of new entrants?

1. Balancing supply and demand: An imminent & growing challenge

"Greening" the energy market calls for fundamentally new mechanisms to manage electricity networks, with interesting opportunities for stakeholders along the value chain that are willing to think out of the box

Figure 1: Wholesale market vs. balancing market



Source: Arthur D. Little

1.1 Matching supply and demand using balancing services

Unlike most other energy sources, currently electricity cannot be stored on a large industrial scale in an economically viable way[1]. Therefore electricity generated by producers (supply) needs to be balanced with electricity used by consumers (demand) at all times. Large electricity market participants must continuously balance their portfolio and correct any differences between forecast usage and reality by trading their surpluses or deficits on the wholesale market. This is particularly important given the difficulty of predicting energy usage.

The Transmission System Operator (TSO) is accountable for balancing supply and demand over the entire electricity grid, and is the only actor with a real-time overview of all components in the system. Therefore, close to real-time, market participants have to hand over the (residual) balancing of the electricity system to the TSO, who balances the grid by giving the necessary instructions to generation (power plant) or load (user).

This set of instructions – "ancillary services" – is the key mechanism for the TSO to ensure balance in the network, and is similar in nature across different power networks. In order to guarantee the availability of these ancillary services, the TSO negotiates and contracts reserve capacity with market players (e.g. power generators or large industrial consumers). In other words, capacity is put aside as a form of insurance for the TSO in case of imbalance[2].

1 Except for pumped storage hydro, which require specific geographical conditions

2 EURELECTRIC Position Paper: Towards Market Integration of Reserves & Balancing Markets, July 2008

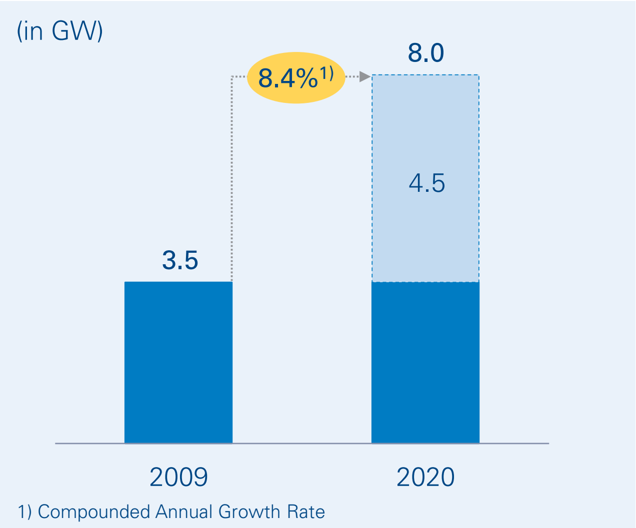
1.2 Growth for balancing services

The capacity required for balancing services will most certainly increase over time. Country specifics will differ, as this growth depends on many factors such as the power mix and its geographical footprint, the current portfolio of balancing services, cross border connections, the overall grid capacity and legislation.

One example is the UK. The National Grid predicts a strong increase in the requirement for balancing services in the coming years. In 2009, the volume of balancing services procured by National Grid amounted to ~3.5 GW. This TSO expects an additional volume requirement of 4.5 GW of Balancing Services by 2020 to meet reserve requirements – more than double the current volume[3].

Double digit growth for balancing services in certain countries during the period 2010-2020 is foreseeable. These projections are a promising sign for suppliers of balancing services, as well as an imminent challenge for the TSOs requiring them.

Figure 2: Annual volume balancing services procured by UK's National Grid



Source: Arthur D. Little

3 Operating the Electricity Transmission Networks in 2020, Initial Consultation, UK National Grid, June 2009

Double digit growth for balancing services in certain countries is imaginable, and poses an imminent challenge

1.3 Growth drivers for balancing services

The growing need for balancing services is driven by increased volatility in both supply and demand. Four key drivers are generating this growth[4].

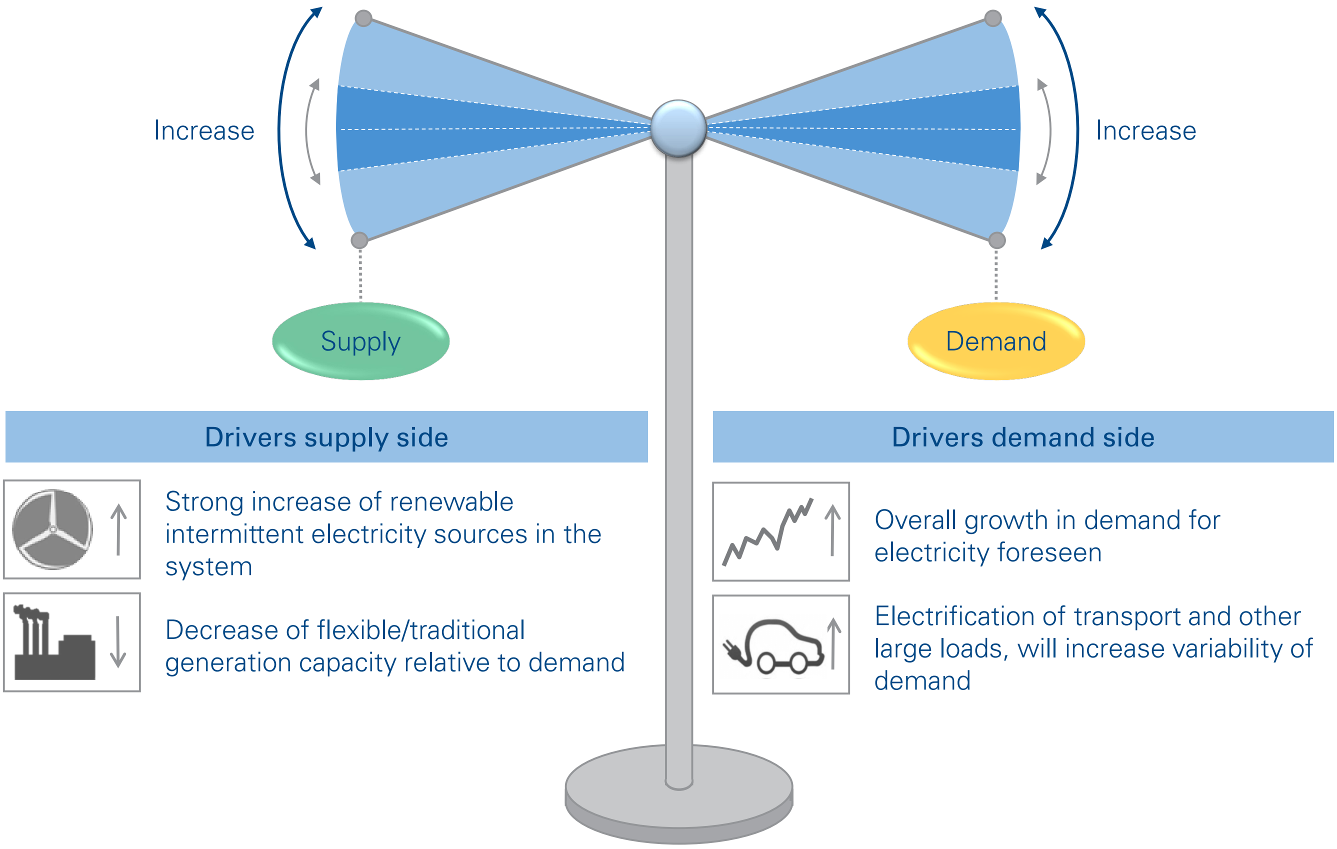
1.3.1 Growth drivers on the supply side

Throughout mature and emerging markets, governments are setting ambitious growth targets for renewable generation[5]. These energy sources, such as wind and solar parks, generate electricity as a function of specific weather conditions. This logically creates volatility in electricity production and causes fluctuations in the electricity grid, triggering the need for additional balancing services. As the use of renewables increases, so too does the need for balancing services as the system becomes more volatile.

Renewal and construction of additional traditional flexible generation sources such as gas powered plants are being delayed because of their lagging or uncertain returns on investment, while others like nuclear and coal are gradually being phased out in some markets. Market participants are hesitant to invest in traditional generation capacity given the reduced run-time of conventional plants due to penetration of renewables, uncertain regulation (among others the rush in the nuclear phase out, unpredictable subsidies for renewables), and uncertain clean spark spreads . These elements weaken the business case for the construction of continual generation sources. For this reason, back-up capacity for renewable intermittent sources of electricity is shrinking , which results in the ancillary services calling upon a gradually narrower generation asset base. Some European countries (like the UK, France and Germany) recognize the risks, and put capacity mechanisms in place to make investments in specific types of generation more attractive.

4 The Fourth Carbon Budget, Committee on Climate Change, 2010
5 Flexible generation: Backing up renewables, Eurelectric, Oct 2011

Figure 3: Growth drivers for balancing services



Source: Arthur D. Little

1.3.2 Growth drivers on the demand side

Global electricity demand is expected to continue to minor GDP patterns, following stagnation in 2008 and 2009 as a result of the global recession[6]. The IEA[7] projects an increase of electricity demand until 2035, by around one third of current volume. Primary drivers are population growth, economic growth and electrification of specific loads (e.g. transport: e-vehicles). Increased energy efficiency causes the rate of electricity demand growth to slow down. Therefore, in the OECD countries, annual growth is expected to decline from 0.9% over the period 2008-2020 to 0.8% over the period 2020-2035.

Nevertheless, the net effect on power demand is expected to be positive, which increases in absolute terms the need for balancing services.

Next to this overall demand volume growth, variability will most likely increase due to the electrification in some high consumption sectors (e.g. transport, IT). Large loads such as electric vehicles will potentially further enlarge demand volatility given their seasonality and fluctuating nature. This will in turn require additional balancing services.

6 Eurelectric, Power Statistics & Trends 2012
7 IEA, World Energy Outlook 2010

2. What tools exist to balance the network?

Given the challenges for electricity systems, several tools exist to address this growing demand for balancing services (see figure 4). These present business opportunities for those that use and provide the service. Next to this toolbox, TSOs should continue their efforts in improving their networks (by eliminating bottlenecks and by making the grid smarter), as well as expanding the wholesale market, allowing players to trade closer to real-time (by using improved planning tools).

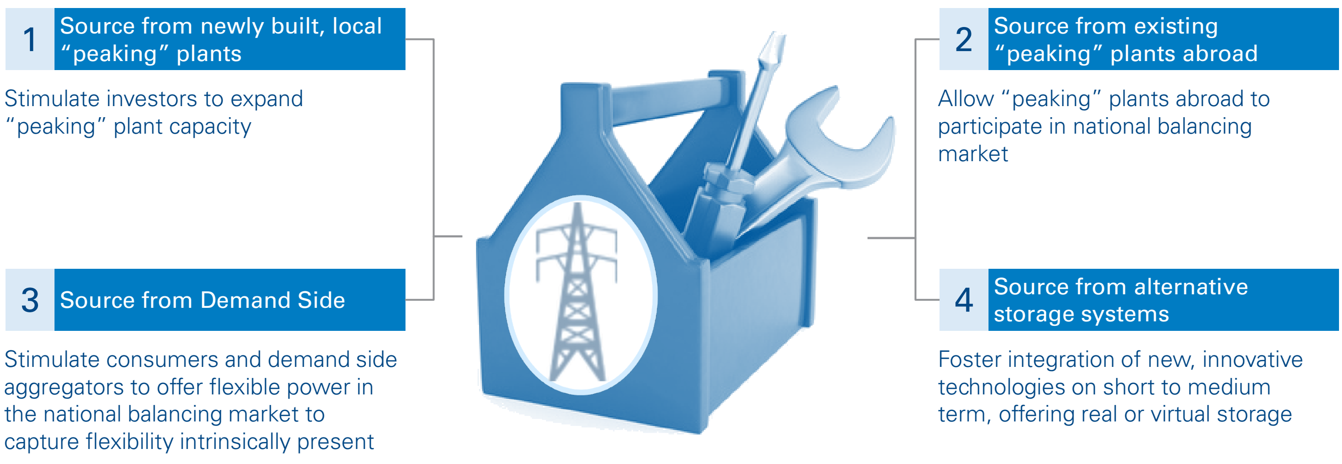
2.1 Source from newly built, local "peaking" plants

Peaking plants are electricity generation installations that are designed to be used as flexible capacity in a transmission network which needs to be kept in balance. OCGT (open cycle gas turbines) are best placed to deliver balancing services, due to their flexible ramp up/down capabilities. An emerging trend is for diesel generators to be used for Stor ("Short Term Operating Reserve"). Other types of power plants, such as coal or nuclear, have much less flexibility. OCGT power plants can provide reliable and rapid back-up capacity in case renewable plants face unfavorable weather conditions. These gas turbines have been built since the 1980s, which classifies the technology as mature and reliable.

Some challenges:

- **Long throughput time** to build such power plants (2 to 5 years), due to common time-consuming hurdles such as obtaining local permits and grid connection
- **CO2 emissions** are significant, since an OCGT produces power through the combustion of gas.
- **Unfavorable market conditions** on the wholesale market do not sufficiently incentivize investors to build new peaking plants. Alongside balancing services, peaking plants rely on regular electricity sales on the wholesale market for revenue. Investors shy away from building plants that will only be online for limited periods of time per year to provide backup capacity in a balancing services contract.
- **TSOs are not allowed to invest in building peaking plants themselves.** The EU 1st, 2nd & 3rd package for electricity and gas markets clearly state that TSOs need to source balancing services from market parties, and cannot construct or manage generation assets themselves.

Figure 4: Toolbox



Source: Arthur D. Little

- **Inefficient regulatory conditions.** Some balancing markets do not incentivize the replacement of old and inefficient power plants with new ones. They use bid price mechanisms which lead suppliers to apply "strategic bidding" based on marginal costs of old plants.

2.2 Source from "peaking" plants abroad

If "peaking" plants and other balancing sources abroad were allowed to participate in the national balancing market, these cross-border power exchanges could become part of the solution. Ahead of real time, TSOs could secure capacity on the trans-border interconnectors in order to guarantee access to power. Close to real-time, balancing services would be exchanged cross-border. Such exchanges involve unused surpluses of balancing energy that are not required in the neighboring geography. Cross-border exchanges of balancing electricity can make use of either previously reserved transfer capacity by the TSO or make use of transfer capacity left unused by intraday markets. These cross-border balancing schemes would increase competition for balancing services, by making the balancing market more liquid.

Some challenges :

- **A standard model for cross-border balancing** should be used by all parties, in order for this cross-border balancing trade to take place in a real "market model". This harmonization would require time and effort from all TSOs. In several parts of Europe, TSOs are already working to develop cross border balancing schemes and several examples already exist today.
- **Relying on foreign sources of balancing services** is not a failsafe scenario. If neighboring countries do not have a surplus of balancing services to transfer, or if their own network suffers from instability due to high proportions of renewables, the TSO would need to fall back on the balancing services providers in their own grid area. Therefore these solutions should only be considered as "additional", not the core balancing source.
- Exchanged balancing services must have the **same characteristics as the source** of the electricity (e.g. a peaking plant)[8]

2.3 Source from Demand Side (Aggregators)

Unlike the other solutions, this route covers demand as well as supply. Demand side aggregators offer balancing services by combining and steering electricity demand (so-called "demand side response ", or "negawatts"). Aggregators manage electricity consumption of their customers in response to balancing conditions. They reduce or increase the consumption of electricity, following a preplanned load prioritization scheme. Demand response is an environmentally friendly way of balancing the grid by switching loads on/off, as opposed to putting additional capacity (and assets) such as "peaking" plants in place.

Demand response has been present for some time, since TSOs can control large loads on the transmission grid within preplanned limits. For example, TSOs can have arrangements with large chemical plants in order to adjust their electricity consuming processes. But these options offer slow response time and require that the load is connected to the transmission grid, limiting their effectiveness.

Some challenges:

- **The technology is relatively new** and will require some time before it can be deployed on a large scale (demand response has been around for some 10 years in the USA)
- **Legislation needs to be further developed,** since currently the legislation in some countries does not allow the sourcing of balancing services from the demand side
- **The business model for Demand Side Aggregation** is not yet fully established within the electricity sector. Not every market player is able to handle and leverage it.

8 Position paper on cross-border balancing, ENTSO-E, July 2011

2.4 Source from alternative storage systems

Large scale storage of electricity only used to be possible in the form of hydro pumped storage plants. Currently, other technology solutions are emerging as credible alternative storage systems. Some examples of these technologies are based on batteries (Li-ion, NiMh, Zinc Air, NaS), flow batteries, compressed air storage, flywheels, thermal storage, and ultra-capacitors.[9]

However, most of these technologies are still in the development phase. Many pilot projects that make use of these technologies are currently being deployed and tested in electricity grids worldwide. When comparing different storage technologies, the economics tend to differ strongly in terms of operating and capital costs.

Some challenges:

- **Many alternative technologies are relatively new or are still being developed** and will require some time before they can be deployed on a mass scale.
- **The economics currently remain unfavorable** for large scale implementation in the electricity grid. This might change in the near future.
- **Not all technologies are able to provide sufficient balancing functionality** to TSOs given the required discharge times in order to meet TSOs requirements. Currently only flywheels, batteries and ultra-capacitors can meet these requirements[10].

9 http://www.greentechmedia.com/articles/read/VC-and-Entrepreneurs-Speak-on-Energy-Storage/
10 Ancillary Services, A Huge, Under The Radar Storage Market Opportunity, Cleantech, Nov 2010

3. No silver bullet for the balancing challenge

We have found no silver bullet to address the rising need for balancing services. Six dimensions enable us to compare the options at hand:

1. **Cost:** combines both operating expenditure as well as capital cost
2. **Time-to-build:** the time it takes to construct the solution and have it online
3. **CO2-emissions:** the carbon footprint of the solution
4. **Regulation maturity:** the 'readiness' of regulation for the roll-out of the solution
5. **Technical maturity:** the maturity of the technology used and ability to be rolled-out
6. **Reactivity:** the ability of the technology to react quickly to demand for balancing services.

When comparing the different tools along these lines, no single option comes out as a clear winner. TSOs will need to pursue a portfolio combining all of these options in order to have a strong and secure range of available balancing services at hand. This will allow them to deploy a balancing solution based upon the specific requirements of a situation. Only by analyzing and developing several options in parallel, can TSOs reap the benefits from competition and innovation amongst the different sources for balancing services.

Unfortunately, there's no silver bullet, so energy players will need to pursue all options and pursue them now

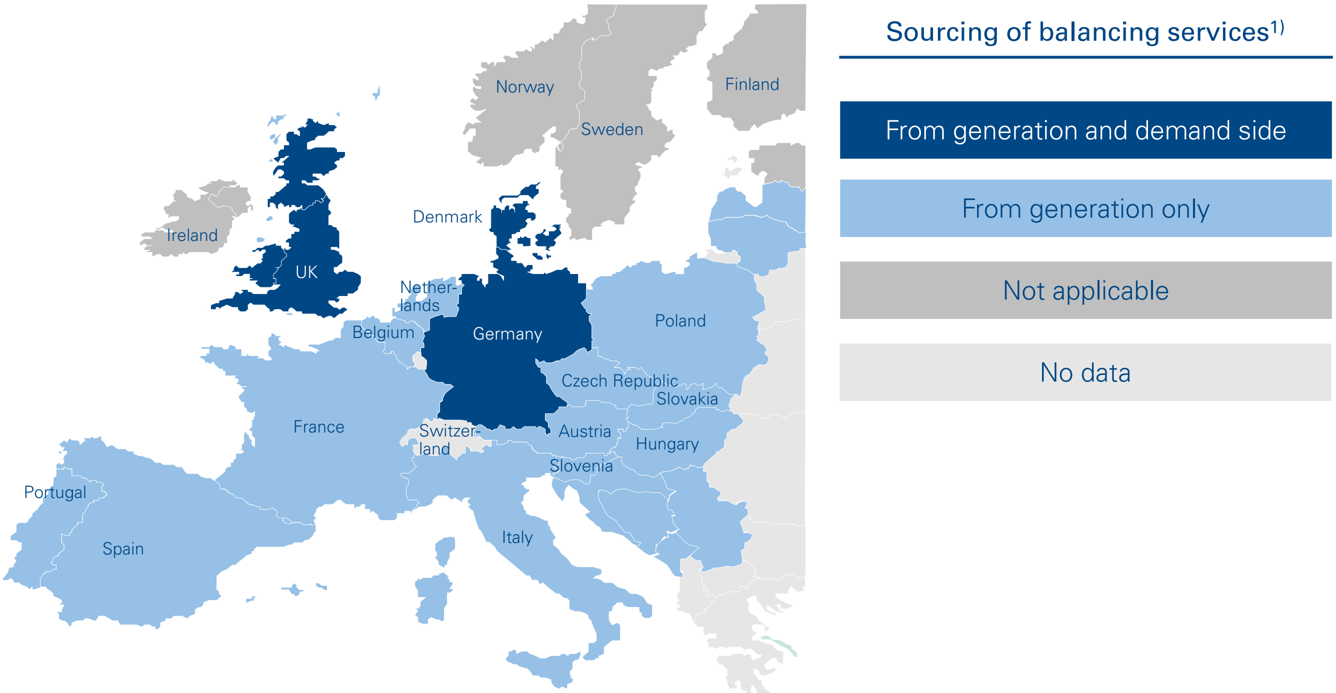
Figure 5: Sources of balancing services

		Cost	Time-to-build	CO_2-emissions	Regulation maturity	Technical maturity	Reactivity
1	Source from newly built, local "peaking" plants	Very high	Long	Very high	Mature	Mature	High
2	Source from existing "peaking" plants abroad	Low	Quick	Very high	Growing	Mature	High
3	Source from demand side	Medium	Quick	Very Low	Emerging	Growing	Very High
4	Source from alternative storage systems	High	Very Long	Low	Emerging	Emerging	High

Source: Arthur D. Little

4. Current state of play in the balancing market in the EU

Figure 6: Status of balancing services sourcing



1) View on secondary control reserves
Source: ENTSO-E, July 2011; Arthur D. Little Analysis

Some European countries are very advanced in developing a varied portfolio of options. Available sources for balancing services are quite diverse, but reveal some early movers (see figure 6).

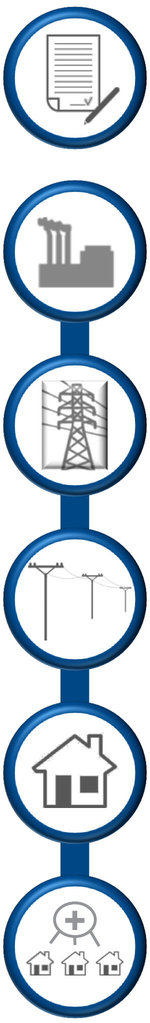
The UK, Germany and Denmark already allow the sourcing of balancing services from the demand side, next to the more traditional sources of generation-based ancillary services. Other countries are slower in opening their balancing services market to different sources. It will be key for these countries to learn from the early adopters and to leverage the best practice in the sector.[11]

11 Ancillary Services in Europe Contractual aspects, ENTSO-E, WG Ancillary Services, July 2011

5. Impact on current market players and beyond

The challenge of growing and diversifying the balancing solutions market impacts the entire value chain of the electricity system, from production through to consumption. This presents great opportunities for current market players. New business models will arise accordingly in order to "keep the lights on".

Simultaneously, new entrants may be triggered by the transformation of the balancing business: the Energy industry has, throughout its many business model transformations, attracted numerous new entrants in search of opportunities. Balancing may very well become yet another entry trigger.



Regulator

- Facilitate building of new 'peaking' plants (e.g. pricing mechanisms)
- Harmonize cross-border balancing services
- Broaden "balancing mix" by including demand response as balancing source
- Stimulate innovation in emerging technologies such as storage

Producer

- Reconsider investment decisions given current economic climate and balancing requirements
- Consider new business models on the horizon
  - Offering of demand response services & storage
  - Requiring a sound business plan & complementary competences

Transmission

- Address the short term requirements in balancing services
- Broaden "balancing mix" by including demand response & cross-borders balancing sources
- Identify optimal "balancing mix" in order to cover the needs in a cost effective way
- Upgrade sourcing process to allow for a diversified portfolio of balancing services

Distribution

- Leverage the roll out of smart meters, which can play a key role in the aggregation of consumer loads and decentralized generation for demand response purposes. May also done by Producers.
- Manage access to smart meters for third parties and data management
- Improve infrastructure to allow for 2-way flow electricity and incorporation of storage

Consumer

- Benefit from demand response, by allowing third parties to aggregate and control load within clearly defined boundaries
- Buy-in will need to be created in order to allow third parties to control loads and privacy concerns should be addressed

Aggregator

- Reap opportunities from the opening of the market towards demand side management
- Differentiate from other aggregators by developing innovative & efficient solutions
- Focus on improving delivery reliability – this is crucial for buyers of critical balancing services
- Role possibly taken up by players active elsewhere in the value chain (ESCOs and others)

Source: Arthur D. Little

6. Conclusion

We see opportunities to generate value and growth from the increasing need for balancing services in high-voltage electricity networks. Operators need to deploy new mechanisms to manage their networks, triggered by substantially higher volatility in both supply and demand. The trend is solid and driven by economic and political factors. To stay ahead, efficient and effective balancing service offerings are required. To answer the different challenges in this field a broad perspective and deep insight are key to success. Technical, economic, and competitive insights will also serve as a powerful vehicle for innovation of new features, services and business models. Arthur D. Little provides answers for your business and can help you design a winning strategy.

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Triggered by higher volatility in both supply and demand, the need for balancing services in high-voltage electricity networks is increasing. How can transmission system operators, traditional energy players and potential new entrants generate business value from this growing opportunity?

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