While not affecting the trend of GRP. Thus: with the increase of non-energy sectors (Agriculture and forestry, Transport and Communications, Building) from 2011 to 2020 and decreasing share of energy from 2018-2020 (mining, manufacturing, production quantity and distribution of EE), the share of GRP SFD continues to grow and the final year in comparable terms increased by 34%.

Also was approximate forecast electric capacity 2020 in comparable prices. So with due decrease of 18%, capacitance decreased by 13%.

Conclusion

The plan may include energy efficiency of the economy in my opinion:

1. Introduction of energy-saving technologies that will reduce the burden on the economy due to lower energy consumption and reduce the cost of production.

2. Qualitative and accurate planning and forecasting, power balances;.

3. Implementation of innovative programs, as well as the introduction of new energy facilities and replacement of the existing outdated equipment.

References:

1. Klimova G.N., Litvak V.V. Seven and seven key issues of energy conservation. Tomsk: Publishing "Red Flag", 2013. 148c.
2. Klimova G.N. The role of energy balance in the energy efficiency program Tomsk Oblast // Bulletin of the Tomsk Polytechnic University, 2005. T.308. № 7. With. 232-236.
3. Klimov G.N., Litvak V.V., Jaworski M. An estimate of the energy needs of the region's population / / Resources regions of Russia, in 2004. №5. With. 20-24. Federal State Statistics Service. Mode of access: http://gks.ru.

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HVDC transmission systems

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The application of HVDC transmission systems

The issue of application of HVDC transmission is very urgent nowadays since the use of power electronics in this system enables to reduce power losses and as a result increase its efficiency.

A high-voltage, direct current (HVDC) electric power transmission system uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current systems. For long-distance transmission, HVDC systems may be less expensive and suffer lower electrical losses. For underwater power cables, HVDC avoids the heavy currents required to charge and discharge the cable capacitance each cycle. HVDC allows power transmission between unsynchronized AC transmission systems. Since the power flow through an HVDC link can be controlled independently of the phase angle between source and load, it can stabilize a network against disturbances due to rapid changes in power. HVDC also allows transfer of power between grid systems running at different frequencies, such as 50 Hz and 60 Hz. This improves the stability and economy of each grid, by allowing exchange of power between incompatible networks.

Principle of operation

High voltage is used for electric power transmission to reduce power losses due to wire resistance. Unfortunately at present there is no method to vary DC voltage level without any power losses. The most effective device for changing the voltage level is transformer working on alternating current.

Therefore, transformers are installed at the input of high-voltage transmission lines to increase AC voltage. Equipment to convert alternating current to direct current is also installed at the input of high-voltage transmission lines while the equipment intended to convert DC to Ac is mounted in the output of these lines.

Practical conversion of power between AC and DC became possible with the development of power electronics devices such as mercury-arc valves and since 1970 semiconductor devices such as thyristors, integrated gate-commutated thyristors (IGCTs), MOS-controlled thyristors (MCTs) and insulated-gate bipolar transistors (IGBT) have also been widely implemented.

The components of an HVDC transmission system

The three main elements of an HVDC system are: the converter station at the transmission and receiving ends, the transmission medium, and the electrodes.

The converter station at each end is replicas of each other and therefore consists of all the needed equipment for going from AC to DC or vice versa. The main components of a converter station are:

- thyristor valves;
- voltage-source converters (VSC). The VSC converter consists of two level or multilevel converter, phase-reactors and AC filters;
- transformers. The converter transformers adapt the AC voltage level to the DC voltage level and they contribute to the commutation reactance;
- AC Filters and Capacitor Banks;
- DC filters.

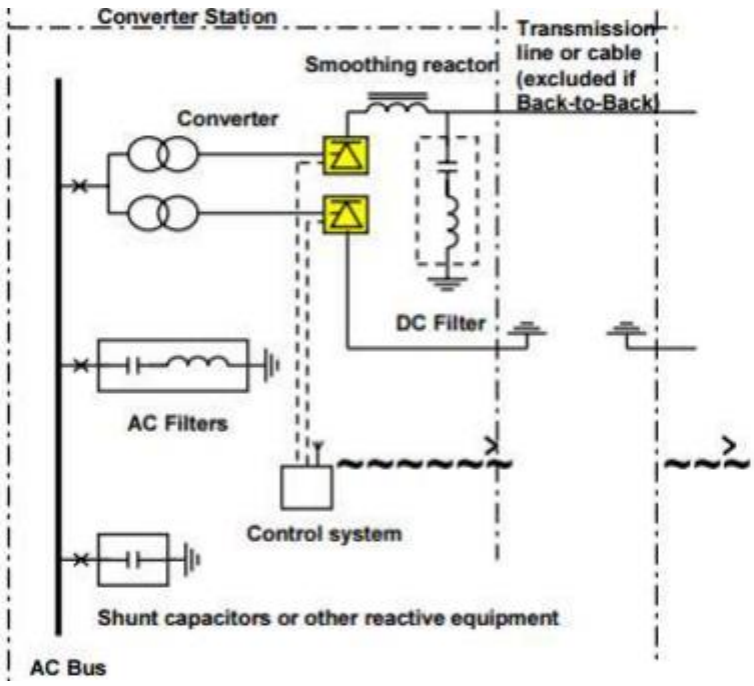

Figure 1. Components of HVDS transmission systems.

Comparison of AC and DC transmission

Advantages of DC are as follows:

- more power can be transmitted per conductor per circuit;
- use of ground return possible;
- smaller tower size. The DC insulation level for the same power transmission is likely to be lower than the corresponding AC level. Also the DC line will only need two conductors whereas three conductors are required for AC. Thus, both electrical and mechanical considerations dictate a smaller tower;
- higher capacity available for cables;
- no skin effect;
- lower short circuit fault levels.

However, there are some inherent problems associated with HVDC:

- expensive converters. Expensive Convertor Stations are required at each end of a DC transmission link, whereas only transformer stations are required in an AC link;
- reactive power requirement. Convertors require much reactive power, both in rectification as well as in inversion;
- generation of harmonics. Convertors generate a lot of harmonics both on the DC side and on the AC side. Filters are used on the AC side to reduce the amount of harmonics transferred to the AC system. On the DC system, smoothing reactors are used. These components add to the cost of the converter.
- difficulty of voltage transformation. Power is generally used at low voltage, but for reasons of efficiency must be transmitted at high voltage. The absence of the equivalent of DC transformers makes it necessary for voltage transformation to carried out on the AC side of the system and prevents a purely DC system being used;
- absence of overload capacity. Convertors have very little overload capacity unlike transformers.

Conclusion

The most common reason for choosing HVDC over AC transmission is that HVDC is more economic than AC for transmitting large amounts of power point-to-point over long distances. High power HVDC transmission scheme generally has lower capital costs and lower losses than an AC transmission link, when used over long distance router.

Even though HVDC conversion equipment at the terminal stations is costly, overall savings in capital cost may arise because of significantly reduced transmission line costs over long distance routes. HVDC needs fewer conductors than an AC line, as there is no need to support three phases. However, thinner conductors can be used since HVDC does not suffer from the skin effect. The above mentioned factors can lead to large reductions in transmission line cost for a long distance HVDC scheme.

Depending on voltage level and construction details, HVDC transmission losses are 3,5% per 1,000 km, which is less than typical losses in an AC transmission system.

References:

1. http://en.wikipedia.org.
2. http://www.cleanlineenergy.com/technology/hvdc/how.
3. Alfred Still, Overhead Electric Power Transmission, McGraw Hill, 1913 page 145.
4. Arrillaga, Jos; High Voltage Direct Current Transmission, second edition Institution of Electrical Engineers.

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Soft skills for successful professional career

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Sometimes the importance of human skills for every workplace is underestimated. Nowadays challenging economic situation means that it is no longer sufficient for new graduates to have knowledge of an academic subject and it is necessary for a student to gain the skills which will enhance their prospect of employment. And future engineers must learn and develop in the classroom some knowledge and skills during studying. Because undergraduates may not be aware of the importance of human skills for their future employment and professional development. They can meet the question like this: Beyond technical skills, what