Transport – Energy Water System of Eurasia and Its Top Priority Projects

With the current interest of legislative authorities to waterways, it would not take us long to see how the navigable rivers become connected in a united network

V. M. Lokhtin, 1914

1. Introduction: background and definitions

Railway monopoly in the post-Soviet Union territory is not natural. It was established on the basis of technical and economical ideology, beginning with GOELRO (Belyakov, 1998)\(^1\) (State Commission for Russia’s Electrification) plan. The railway transport originally strived to become a monopoly, and its main competitor is water transport. Therefore, in the middle of the XIX century, England witnessed railway companies buying shipping canals and reducing them to a size unfit for the passing of vessels.

Competition from water transport compels railways to cut traffic tariffs. Absence of competition encourages, overpricing. An observation of the American "automobile king" Henry Ford emphasises this point: “the railways were known for a good practice of not transporting goods by the most direct route. The goods were carried by the most circuitous routes possible for all the connecting lines could make some profit out of it. The losses, for sure, were passed customers". (Ford, 1989: 201).

The total transport expenditures, prior to Soviet Union fall, were exorbitant and starting from the 1960s were soaring. But the scientific and economic research of that time “proved” (with a reference to Friedrich Engels) that this fact should not be considered as a bad thing” (Mitaishvili, 1982: 46).

The strive of the USA and Western Europe railway companies for monopoly in the twentieth century was opposed by active state protectionism with regard to domestic water transport and waterways development (Agranat, Zhivilova, 1967).

Physical features determine the economic value of different transport modes. The main features of water transport are low energy-output ratio, low speed, high carrying capacity and seasonal fluctuation.

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\(^1\) The basis of GOELRO concept was “trunk railway”.

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Currently, the energy-output ratio of technological processes bears prevailing importance in technical-economic comparison, with energy saving becoming the top priority.

Relative energy intensity per thousand km of transportation by different transport modes comprise: 1 – for railway, 8-10 – for motor (on high quality roads; on low quality roads this ratio is 20-30 and over); 4-7 – for gas pipeline; 0.5 – for oil pipeline; 0.2-0.8 – for domestic water transport.

The energy intensity of water transport goes up with the accelerating speed of vessels and drops down with the growth of their load and draught. Energy intensity of consist of ships on the move is lower than that of a single ship. In other words, energy intensity depends on specific features of route (decreases with depth growth) and is subject to regulation (can be maintained at a required level) by managing load-draught and speed ratio.

Lower consumption of other resources is inherent for water transport, too (as opposed to different transport types).

Therefore, the low resources consumption of water transportation corresponds to its low speed.

But in the economic sense it is not the speed which is important but timely delivery of a certain amount of goods: early cargo delivery (at higher speed) causes additional costs (related to storage costs). It’s not a low speed of cargo transportation that ties up material resources, but late delivery that evokes the delay of goods realisation. Speed of movement is relative to the carrying capacity of the transport. We should remember the terms used by economists at the beginning of the current century: cargo has a head (first cargo batch) and tail (last batch). Physical transportation speed determines cargo’s head delivery terms to the customer, while the tail delivery terms are determined by the carrying capacity of used transport. The customer needs the whole cargo. Therefore, the terms of its delivery (speed in economic sense) are determined by terms of cargo tail arrival.

In 1914, due to the commencement of the “Volga-Siberia” waterway project, the study of both options of Siberian grain transportation by water and railway to Petersburg (in real volumes of that time) has shown, that the head of grain cargo would reach Petersburg by railway earlier than by water, and the tail later. In other words, the speed of the whole cargo by water is higher than that of by railway (Borkovskiy, 1914).

For instance, let’s assume that 4000 tons of cargo can be transported from point A to point B by water (500 km) or by motor (300 km) transport. In the case of the former, one would need the cargo motorship “Volgo-Don”, and the cargo would be delivered within 24 hours at one haul. In the latter case, it would take 400 rides of a KamAZ-53212 truck. He moves 3-4 times faster.
than "Volgo-Don" and the first cargo batch (10 tons) would be delivered to point B within 4-5 hours, i.e. 20 hours faster than by water. But if there is one vehicle, then even making two rides a day (which is 1200 km, which in turn exceeds operating standards) would take 200 days to deliver the cargo. If there were two vehicles – 100 days, 10 vehicles – 20 days, etc., i.e. it would be much slower than by water transport.

The high carrying capacity of water transport in shipping season surpasses its winter idleness. Therefore, the usage of motor or even railway transport entails its regular year-round work, whereas the usage of water transport sometimes requires just a couple of rides.

Artificial waterways include not only canals but also ("sluice") rivers supported by dams for deepening.

Prior to the twentieth century, people only resorted to river sluicing when creating a deep waterway. The economic benefit was secured by costs reduction for transportation resources as compared to alternative types of transport (horse-drawn, railway). The bigger cargo-traffic along the route meant faster coverage of sluicing costs on account of resources saving (in total for national economy).

But at the beginning of the 20th century, with proliferation and development of electric power, it became possible to use the energy generated by damming. The notion of economical efficiency has obviously obtained another setting: the sluicing, expenses for which could not be covered by improvement in shipping conditions, could be compensated through additional benefits from water fall energy (Nikol’skiy, 1917: 43).

In given circumstances, resource-saving in transportations is no longer economically determinative. Thanks to hydro energy utilisation, an artificial waterway acquires a distinctive feature distinguishing it from other means of communication: expenses for construction and operation of technical facilities are recovered neither through taxes nor by freight charges, but through usage of objectively free and inexhaustible natural productive force (the hydroelectric potential of the river).

This was the reason why, for instance, a new system Rhine-Main-Danube (through navigation opened in 1992) replaced the old waterway between the Rhine and the Danube ("the Ludwig Channel") when it could no longer stand competition from the railways. Revenues from energy sales generated by 57 hydropower plants’ which were part of the system, provided resources for this public-private construction project (Herboth, Kesseler, 1992).

And finally, owing to river flow regulation and other factors, the sluiced waterway, irrespective of cargo traffic, can solve various hydroeconomical, ecological and social tasks.
It is worth mentioning that among large-scale state projects in the USA in 1920-30s, which helped the country to overcome the Great Depression, were not only automobile roads and railways, but also projects on integrated (transport-energy) reconstruction of the Mississipi, Missouri, Ohio, Tennessee, Illinois and many other rivers. As a consequence by the beginning of the Second World War, the USA had a united deep waterways network. The output of the hydropower plants comprised 140-160 kWh per year. The number of large water reservoirs (volume – over 100 million m³) was over two hundred.²

2. Transport–Energy Water System (TEWS) of Eurasia

The concept of a “transport-energy water network (TEWN)” was put forward in 1990-91, relating to the USSR, as one would expect, and later to the Russian Federation (Belyakov, 1992).

The analysis of transport-energy complex as a united block in the economy had shown growth since the beginning of the 1960s of exceptionally unfavourable trends pointing at increase of complex resource intensity. Only the uniform development of deep waterways and hydroenergetics would allow it to be optimised.

Integration trends on Eurasian territory formulated the international willingness for the internal waterways of CIS rivers³ to join the United European system, resulting in the present time ideas and developments of TEWS gaining relevance in wider sense, which is applicable to the whole Eurasian continent (Kozlov, Belyakov, 2008) at the present time.

The transport-energy water system of Eurasia presupposes that:

• The main water transport arteries of the continent should be connected through canals in a network, and shipping conditions of rivers must be enhanced through their reconstruction into sluiced cascades (transport component);

• Hydropower plants on cascade steps (energy component) must introduce into operation the hydroelectric potential of rivers;

² At the end of the 20th century the number of such water reservoirs in USA comprised 702, in the RF – 104. Given that not all large-scale dams make large-scale water reservoirs and vice versa, statistics for water reservoirs is complemented by dams statistics: large-scale dams (over 15m in height) in 2000, China had 2411 (over 25 thousand nowadays), 6389 in USA, 2601 in India, 2467 in Japan, 871 in Spain, 820 in Canada, 554 in France, 540 in Mexico, 502 in Italy, 470 in Brazil, 427 in Turkey etc. The Russian Federation has 62 large-scale dams.

³ Resolution of Economic Commission for Europe #258 (Bucharest, 13-14.09.2006), has outlined “universal strategic policy in the area of internal water transport, which would include all interests of not only EC but also of third countries (Belarus, Kazakhstan, Moldova, Russian Federation, Serbia, Ukraine, Croatia)” and defined in particularly the necessity of the Dnepr–Vistula–Oder water route creation.
Besides transport and energy components in TEWS there are also hydroeconomic and ecologic components related to river flow regulating through water reservoirs and its territorial allocation over interbasin navigation channels.

3. United water transport networks

These networks – which are essentially transport–energy water systems, have been created and are being operated in America (USA and partly Canada) and in Eurasia: in the west of the continent (in Western Europe) and in the East (in China)\(^4\).

In the South of Eurasia, in Iranian territory, a shipping canal will be constructed between the Caspian Sea and the Arabian Gulf.

The development of the water transport network is carried through legislative support: for instance, dam construction in China without a navigation pass is prohibited by article 17, law on water usage.

Water transport networks appear to be indispensable components of united transport systems, constantly developing, receiving new parts and renewing old components.

Thus, as a result of opening a new through shipping route in the form of the Rein-Main-Danube system, the International Intercontinental Waterway had been formed. After the reunion of Germany, the territory of the former GDR is observing the reconstruction of old shipping systems (the Hanover-Berlin canal and other). The completion of waterworks facility construction “Three Gorges” in China on the Yangzi River, with unique navigation passes for crossing water level difference of 180 m (vertical ship’s lift and 2 strings of 5-chamber sluices) filling the originated by it water reservoir, would connect another 1.2 thousand km of waterways with this water reservoir.

In Russia, on its European territory, an active part of TVES is the Integrated Deep-Water System (IDWS): the Volga-Kama Cascade and its connecting systems (see Figure 14.1). It’s a complex project that was launched in the 1930s (but hasn’t been finished). It provides shipping with draught up to 3.5 m and electricity production around 40 billion kWh per year. It also solves issues related to river flow territorial allocation and adjustment, as well as irrigation, water supply and other factors.

\(^4\) “All economically developed countries of Europe, as well as the USA and China have united shipping systems. Our country’s falling behind time in this regard is clear and must be excluded”. (Zachesov, Ragulin, 2001: 361).
The Dnepropetrovsk cascade was a part of IDWS. Now it belongs to Ukraine. Yet, the connection of the Dnepr, Don and Oka, scheduled at the beginning of the twentieth century by state bodies, has not yet been implemented. The dimensions of IDWS waterways make “river-sea” shipping possible, allowing sending cargo from river ports of the RF to sea ports of Western Europe, while Western Europe waterways and former Soviet Union western waterways remain unconnected.

The Asian territory of Russia has no elements of TEWS. Large rivers have acceptable dimensions for shipping even without sluicing. The absence of navigable passes in hydrosystems of the Angar–Yenisey Cascade, Vilyui, Kolyma, Zeya, Bureya and others makes shipping through it impossible. Thus, in the west of the continent, although, shipping interrelations between Russian and Chinese waterways in the Amur basin are feasible, river basins are unconnected and the possibility of direct (without reload) water shipment in an east-west direction is unavailable.
The inland waterways connection of the whole continent in one interconnected network is needed for the establishment of Eurasian water transport network, i.e. TEWS formation in Russia, and substantially – connection of new deep-water lines (cascades on rivers, interbasin junctions) to functioning IDWS.

Creation of TEWS in Russia will enable in future up to one million km of deep waterways, connected with interbasin canals, of both latitudinal and longitudinal directions, to be put into operation.

3. Hydroenergy

The technical hydroenergy potential of the Russian Federation’s rivers comprises 1670 billion kWh per year. At the present time, the average long-term production of all hydropower plants of the Russian Federation makes 167 billion kWh per year.

Unused technically available hydroelectric potential comprises 1503 billion kWh per year, which is 1.4 times higher than the production of all RF hydropower plants’ production in peak 1990 (1082 billion kWh)

Establishment of TEWS in Russia will enable in future put into operation the river’s hydroelectric potential to the tune of 1.5 trillion kWh/year with relevant saving of non-renewable fuel recourses and atmospheric oxygen, as well as greenhouse gases emission reduction.

4. Water resources

The Russian Federation’s river water resources are huge. They comprise 9.5% of the world’s river flow. However, a significant territorial and seasonal inequality is inherent to large volumes.

So, 48% of Russia’s territory falls under high water supply sufficiency zone, and 27% – under low and very low water supply sufficiency zone. In a number of regions with extremely low-water periods, the vernal runoff (1-2 months) makes 80-95% of annual runoff.

The water deficit grows higher on the territories of Kazakhstan and Middle Asia adjacent to Russia. A number of regions in the Russian Federation’s natural regimes of water objects are of danger of population and husbandry due to possible floods, underflooding, riverbed instability, and other damaging effects, which entails protection measures.

Establishment of TEWS in Russia presupposes the creation of water reservoirs systems on rivers and interbasin junctions, which would allow the reallocation of river flow through time and territories, as well as effectively carrying out protection from waters’ damaging effects.
5. Principal Water Mains of Russia

As a basis for TEWS serve principal water mains initiated in 1909 by “Joint Committee for drawing out a plan on enhancing and development of the Empire’s water means of communication”. (1902-1912) (Belyakov, 1995). There are 8 mains: three latitudinal and five longitudinal. After the Joint Committee stopped its activity in project developments and state plan documents, the principal water mains targeted by it gained new names: the North-Russian Main was converted into the Middle-Union Main, the Middle-Russian Main was converted into the Middle Union Main, etc.

Since the beginning of the 1960s, when the USSR Ministry of river fleet obtained the Republican status, principal water mains directions have been forgotten. This brought about the realisation of paradoxically single-functional projects: the shipping function was excluded from the Dnepr and the Severski Donets junction project, which was planned to be a part of the South-Russian Main (and which is currently a functioning hydrologic system Dnepr-Donbass).

The following list of Russia’s principal mains network has been drawn up with a glance to the state plan documents, conceptual and design materials of the 1910-1970s, up-to-date socio-economic and political realias, as well as possibilities of “dispersed” water diversion of the Northern rivers and the Ob to the Volga Basin. The main names remain the same – latitudinal: the North-Russian, the Middle-Russian and the South-Russian, longitudinal: the Black Sea-Baltic, the Caspian-Baltic-White Sea, the Ob, the Yenisei, the Lena (see Figure 14.2).

Figure 14.2.
The Fundamental Scheme of Eurasia and Russia TEWS Principal Mains
The North-Russian Main was completed in its western part. One of its branches goes from the Baltic Sea over the Neva River (just one step of the Neva hydropower plant being absent), Ladoga Lake and the Svir River; the other branch goes from the White Sea to Onega Lake (the Belomor-Baltic canal); both branches get connected in the Vytegra estuary. The main then goes over the Volga-Balt up to the beginning of the Northern Dvina sluice system (NDSS) where the accomplished part of the main ends.

Then the main goes over NDSS (reconstruction needed; realignment whenever possible), the Sukhona, the Northern Dvina, and the Vychegda rivers, then over a canal (included in the planned Kama-Pechora-Vychegda Reservoir) across the Vychegda-Pechora watershed to the Pechora, then along it up to the Pechora-Ob watershed, and after it to the Severnaya Sosva and further to the Ob and the Gulf of Ob.

Currently, there are no grounds to select a place for the Pechora and the Northern Sosva junction. However, this junction might firstly have an important meaning for internal water transport access to the Yamal peninsula and, secondly, be in service for partial diversion of the Ob basin water over the Pechora, the Kama-Pechora-Vichegoda reservoir into the Volga basin (one of “dispersed” territorial flow redistribution directions).

The Middle-Russian Main on the territory of Russia begins on the west of the Oka river. The development of a main along the Dnepr and further along the Pripyat (pours into the Kiev reservoir, Ukraine), the Dnepr-Bug system⁵, the Bug and Vistula rivers must be a subject for international agreements.

The main might meet the Dnepr as per the South and the West schemes. According to the South scheme:

- From the planned Kaluga reservoir on the Oka river;
- Over the Zhizdra river and watershed canal;
- Into the Desna river and further into the Dnepr.

According to the West scheme:

- the Oka river (the Kaluga reservoir);
- the Ugra river;
- watershed canal;
- the Osma river;
- the Dnepr (the Dorogobuzh reservoir).

The West scheme might be preferred due to certain political factors.

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⁵At present time Belarus is carrying out reconstruction of the Dnepr–Bug system, navigable passes adapted to “Eurobarge” – new sluices chamber width reaches 12.9 m).
The Oka needs transport-energy reconstruction. The main line passes along it and falls into the Volga and further into the Kama (it is preferably to fill in to the design reference marks of Cheboksarsk and Nizhnekamsk (Lower Kama) Reservoirs).

From Kama Reservoir it is required to build the Transuralsk navigable waterway along the route: the Chusovaya, junction channel, the Iset, the Tobol and the Irtys.

It is expedient to implement the transition of the main line to the Ob in the following direction: the Om (Irtys affluent) – channel – the Chaya (Ob affluent).\(^6\) This is one of the directions of the “distributive” water diversion from Ob to Kazakhstan and Central Asia.

Then the main line passes along the Ob and Ob-Yenissey junction. The latter must be built anew; yet at the end of 1950s, the local administrative and party-economic bodies applied for its renewal. Earlier, the Ket-Kassk direction of this junction was considered preferable, but currently, in view of the KATEK development, the Chulymsk direction can become the preferred choice.

Then – the rivers Yenissey and Angara (hydrosystems of the Angarsk Cascade are to get navigable passes) and Lake Baikal.

From Baikal the main line passes along the rivers Selenga and Hilku. Then it must overpass the watershed (Yablonovy Range) and further – along the rivers Ingoda, Shilka and Amur. Against Khabarovsky the main line branches: one branch passes along the Amur towards Nikolayevsk; the other passes along the rivers Ussuri and Sungache and Lake Hanka, therefrom, having passed the watershed leading to the Razdolnaya river (Suyfun), must approach Vladivostok.

At present, the considerable part of the South-Russian main line is outwith the Russian Federation (in the territories of Moldavia and Ukraine)

On the way to the Russian Federation, the main line passes along Seversk Donets from the border of Ukraine to the Don. Then approaching as the branch to Rostov – up the Don and along Volga-Don navigable channel (VDNC) it flows into the Volga and Caspian Sea. In this regard it is expedient to proceed with the construction of “Volga-Don-2”.

The Eurasia Canal along the Kuma-Manych valley is planned to be the south branch of the main line, but in fact it will have an independent transport implication. Moreover, it will discharge the operating VDNC.

In the current political conditions it is expedient to connect the South-Russian main line with the Middle-Russian meridian line Oka – Don (as the Class B

\(^6\)This direction was offered by I.A. Volkov in the context of development of “Sibrechput” (“Siberian river way”) and complex water problems solving of Ob-Irtys interfluve – Volkov (1980).

The further development of the main line is possible too – in terms of the international project of Aral Sea recovery: the channel between Caspian Sea and Aral Sea (Akhmedov, Spitsyn, 1991) can be given two functions – water transmission from Caspian Sea to Aral Sea and navigation (further the navigable waterways could pass along Aral Sea, the Syr Darya and the Amu Darya).

At the present time, the state borders separate the Black Sea-Baltic Main Line. Its main part is the river Dnepr, which starts on the territory of Russia and passes along the territory of Belarus, while the optimal junction place of the river Dnepr with the river Zapadnaya Dvina (between Orshey and Vitebsk cities) is located in the same place, then as far as the estuary it passes along the territory of Ukraine. The junction of Zapadnaya Dvina and the river Lovatya is in the borderland between the Russian Federation and Belarus.

On the territory of the Russian Federation, it is expedient to implement the transport-energy reconstruction of the river Lovat (as the future part of the Black Sea-Baltic water main line). Further to the north the main line would pass along the Volhov river, the Ladozhskoye lake and the River Neva to St. Petersbourg. Prospectively, the reconstruction of the Dnepr on the territory of Belarus and RF, the construction of the junctions of Lovat with Zapadnaya Dvina and Zapadnaya Dvina with Dnepr and the completion of the main line, could become the interstate project (“Dneprovsk agreement” on multipurpose utilisation of water resources of Dnepr and Zapadnaya Dvina – Russia, Belarus, Ukraine).

A considerable part of the Caspian Sea-Baltic-White Sea Main Line (Volga and Volga-Baltic, Kama) is complete. It passes from the Caspian Sea up along Volga to the Kama estuary where it divides into two branches:

- One branch passes up the Volga, then along the Volga-Baltic;
- Further – North-Dvinsk Sluice System (NDSS – reconstruction is required), the rivers Suhona and Northern Dvina to the White Sea;

- The other branch of the main line passes up the Kama; transport-energy reconstruction of navigable waterways and construction of Kama-Pechorsky-Vychegodsk junction is required upward the Kama Reservoir. The main line passes along it to Pechora or Vychegda and further along the routes of the Northern-Russian main line.

Ob main line, as the Joint Committee planned in 1909, in its south part was to pass along Irtysh. At the present time, the considerable part of Irtysh is in the territory of Kazakhstan. Therefore, the Irtysh gradual reconstruction from the
estuary to the city of Omsk is expedient with perspective of the Kazakh part of Irtysh connection to the main line as well.

(“Irtysh agreement” on Irtysh transport-energy reconstruction and multipurpose utilisation of its water resources is expedient – China, Kazakhstan, Russia).

In this regard, on the RF territory, it is necessary to build the main line along the Ob itself together with the gradual reconstruction of Ob and its basin rivers (Ob is higher than the Novosibirsk reservoir, and it is also higher than Biya, Katun, Tom, Chulym), and the Ob main line in its south part would have two branches (Ob and Irtysh) in the long term.

The Yenisséy main line, as the Joint Committee planned in 1909, is to pass along the Yenisséy from its upper reaches to the Arctic Ocean. The existing hydrosystems are to be complemented by effective navigable passes and further Yenisséy reconstruction must have a complex, transport-energy character.

Lena main line. Taking into consideration recent design studies, and also the last decade’s socio-economic development on the territory of the Lena basin, the source of the Lena main line and its connection with the Middle-Russian main line is expedient to arrange by means of Angar-Lena connection between the rivers Ilim at the pressure head of Ust-Ilimsk reservoir and Kuta with the outlet to the Lena in Ust Kut. The problem with this connection is that it requires a complex decision: it is necessary to arrange the construction of navigable passes in the hydrosystems of the Angar Cascade, reconstruction of the Lena upward Ust Kut with subsequent cascade development down the Lena until it flows into the Laptev Sea.

6. Class B Main Lines, Access and Local Ways

Besides the main waterlines (Class A main lines) TEWS also includes secondary main lines (Class B Main Lines), access and local ways. In other words, TEWS must include all rivers, each river in prospect must become the waterway of relevant purpose, regulated by the reservoirs, and its hydraulic power must be put into operation.

The network of main waterlines and deep waterways of other classes can develop independently.

On the European territory of the RF, inasmuch as all regional centres are located along the rivers leading to Class A Main Line, these rivers must become Class B Main Lines. Class B Main Lines can be also considered as the connections of Suhona river (North-Russian main line) with the Volga.

In the Uralsk region, Class B Main Lines can be the rivers Pyshma, Miass from Chelyabinsk to the estuary, Tura, Tavda and also Ural, together with the channel Volga-Ural (perspective Russian-Kazakh project).
On the Asian territory of the RF, many rivers can acquire the significance of Class B Main Lines: Chulym (if it will not become a part of the Middle-Russian main line), Tom, Lower Tunguska and Vilyui with the construction of junction channel between them, Kolyma, etc.

All other rivers of the RF, depending on their transport-energy reconstructions, can become access and local ways.

7. TEWS and Other Transport Types

The transport system of the RF inherited from the USSR is characterized by the underdevelopment of the waterways system and, due to the lack of interbasin navigable connections, by consequential schemes of combined (water-railway) cargo transportation. The routes of the railways and highways and gas pipelines are laid everywhere, without regard to the perspectives of river reconstruction and transport use. In the course of TEWS development, the reconstruction and development of communications of all types must be implemented in a complex way:

- the development of water-railway-motor parallel guides is desirable. This will provide differential transportations according to the type of transport, cargo and passengers’ requirements, and on the whole it will provide the most efficient and economic transportation system;

- the location of river hydrosystems and bridge crossings of land communications must be interlinked: bridge crossings, as well as crossings of the pipelines across the river, must pass across the dams;

- in winter, it is possible to organise cargo transportation over the river’s (reservoir’s) ice: rolling-stock trains on the slips led by a hauler with the run adapted to movement on the snow;

- the appearance of new hydropower plants during TEWS development will require the development of power lines (“electron transport” of fuel-energy resources), which will become a factor of combined and local energy systems development.

8. The Primary Projects on TEWS setting up in Russia

Setting up TEWS in Russia must connect to the operating Integrated Deep Water System the following new deep-water lines, while the hydraulic power of the rivers, put into operation, is sufficient for providing investment attractiveness of the projects.

1. The River Oka from Nizhny Novgorod to Orel with the prospect of a connection with Dnepr and a further outlet into the waterways system of the Western Europe (part of the Middle-Russian main line).
The project involves the construction on the Oka of a cascade of complex hydrosystems: upward the Moskva River estuary with the regulating reservoirs (3 or 4 levels), below – the cascade of low-pressure hydrosystems.

The implementation of the project will connect about 1100 km of deep waterway to IDWS, and will provide electric power output of 1.6 billion kWh/year at hydropower plants. This will efficiently increase the Oka water quality and environmental situation on the whole.

The task of the Oka reconstruction and its connection with Dnepr has an international importance. In the West, the task of connecting the inland waterways of CIS and Western European countries has already been set by the Economic Commission for Europe: in particular, the task of opening transparent navigation between Dnepr and Visla, further leading to Oder. At the present time, Belarus is realizing the reconstruction of the Dnepr-Bugsky Canal, and, in addition, the project of a waterway from Riga to the Black Sea has been developed in Minsk.

Since the Dnepr joins the structure of the South-Russian, the Middle-Russian and the Black Sea-Baltic main lines with its different parts, it is necessary to
organize the transport-energy reconstruction of the Oka in Russian territory as a part of the Middle-Russian main line connecting the Volga (IDWS) with the Dnepr.

The activities connected with the Dnepr reconstruction and its basin rivers must be coordinated, and a “Dnepr agreement” between Russia, Belarus and Ukraine is advisable.

2. The Upper Volga from Tver city to the Upper Volga lakes and Seliger lake (Class B Main Line). It is proposed to continue the cascade upward the Ivankovo Reservoir (3-4 levels, including Tverskaya, Staritskaya, Rzhevskaya), which will extend the Integrated Deep Water System to this part of the Volga and will provide access for the ships to the Upper Volga Reservoir and Seliger lake. In order to achieve this, reconstruction of the Upper Volga hydrosystem, the pressure head of river Selizharovka and lake Seliger will be required. The navigable channel, forming one reservoir, connects the Upper Volga lakes and Seliger lake.

The project implementation will provide new opportunities for water tourism ("ecological" cruises) and will provide electricity production of 0.65 billion kWh/year at hydropower plant (HPP), will regulate the Volga flow upward Ivankovo Reservoir and enlarge its water resources, which is important for Moscow’s water supply.

3. Volga-Severodvinsk waterway from Volga-Balt to the estuary of the Vychegda river (a part of the North-Russian main line).
Presently, the North-Dvinsk Sluice System (NDSS) starts from Volga-Balt (Sheksninsk Reservoir) with Topornin Sluice and ends with the Suhona estuary from Lake Kubenskoye (the dam and the sluice “Znamenitye”). The wooden constructions of the system are physically and ethically out of date. During the system reconstruction, it would be expedient to reroute it by building a summit canal directly from Sheksninsk Reservoir to Lake Kubenskoye.

It is proposed that the project also includes the rivers Suhona (5-6 levels) and Northern Dvina up to the Vychegda estuary (1 level is to be higher than the city of Kotlas), the electricity production will comprise 1.7-1.9 billion kWh/year at HPP.

4. Kama–Pechora–Vychegodsk junction, Vychegda river (the parts of the Northern-Russian and the Caspian-Baltic-White Sea main lines). It is a large, capital-intensive project, where there will be marked stages; it should be correlated to the railway project “Belkomur”.

The project of connecting Pechora, Vychegda and Kama in their upper reaches has a long prehistory, in the latest developmental works (the end of 1960s) the project of uniting the Kama-Pechora-Vychegodsk Reservoir with channels was aimed at Vychegda and Pechora water diversion across the Kama into the Volga.

While implementing the project, besides the development of the deep waterways system, there can be received a considerable electricity production at HPP and the possibility of flow redistribution between the basins of Volga, Pechora and Northern Dvina. Without taking into consideration the flow redistribution the HPP output at hydrosystems of Ust-Kulomsk (r. Vychegda), Pokchinsk (r. Pechora) and the Upper-Kama (the Kama) will comprise 1.3-1.4 billion kWh/year, and the HPP cascade output at Vychegda river below the Ust-Kulomsk hydrosystem (3-4 levels) will comprise 2.6-2.8 billion kWh/year.
5. The Transuralsk waterway [navigable junction of the Volga and Ob basins from the Kama Reservoir (IDWS) to Irtysh – a part of the Middle-Russian main line]. The main route of the Transuralsk way: Chussovaya river, the junction channel, Isset and Tobol rivers.

The construction of the junctions of Volga with Ob between Chussovaya and Isset has been started many times. The first was in 1815, the last – within the Second five-year plan of 1933-37 years. The project implementation will allow for improving the efficiently the water quality in the rivers Chussovaya and Isset, providing electricity output 2.3-2.5 billion kWh/year at HPP.

The rivers adjacent to the Transuralsk line are subject to the transport-energy reconstruction as well.

These rivers are:

- the Tobol upward the Isset estuary (taking into consideration the necessity of solving a set of water problems, the reconstruction of Tobol can become a joint Russian-Kazakhstan project);
- Miass, the Isset estuary can become Class B Main Line from Chelyabinsk to the estuary; Tura and Tavda (the Tobol estuaries), Sylva, etc.

The Transuralsk waterway can possibly have additional branches. At the eastern slope, this branch is Pyshma river, along which cargo can be transported, whose initial station or terminal is Yekaterinburg. At the western slope, the additional branch of the main line can pass from the Upper Makarov Reservoir along the Chussovaya into the Nyazepetrovskoye Reservoir and along the rivers Ufa and Belaya.

7. The Rivers of the Upper Ob Basin: Tom, Chulym (Class B Main Lines), upper Ob up to the estuary of Tom river (a part of the Ob main line), Biya, Katun (local ways).

The Ob basin is characterized by a set of water problems: lack of water resources, floods, low water quality, etc. It is possible to solve these problems
only on the basis of flow regulation with reservoirs, which are most efficient in the basin upper reaches and can be created in connection with the transport-energy reconstruction of the above-mentioned rivers. The work can be performed independently as separate projects.

![Figure 14.7. The Upper Ob Basin Rivers Proposed for Transport-Energy Reconstruction](image)

- The river Tom from the city of Tomsk to the estuary of Mras-Su river can provide the deep-water outlet westward to the Kuzbas coal, solve water problems of Kuzbas (floods, lack of water, high water contamination rate). On completion of the Krapivinsk hydrosystem and construction of Tom and Kemerov hydrosystems (the Krapivinsk hydrosystem interrupts the continuity of the earlier-planned cascade and 1-2 additional levels may be required for recovery of the continuity) there will be received 643 km of deep waterways, electricity production of 6.6 billion kWh/year.

Besides Tom river, other Kuzbas rivers are subject to transport-energy reconstruction: affluent of Tom river, of the rivers Kondoma (0.6-0.7 billion kWh/year) and Mras-Su (0.6 billion kWh/year), as well as Inya river, which provides water outlet from Kuzbas directly to Novosibirsk (160-180 kWh/year).

- The river Chulym. The development of KATEK brought the considerable technogenic pollution of Chulym river; MPC of a number of harmful agents exceeds the norm tenfold. The Chulym Cascade (14-16 levels) with the Chulym-Yenissey junction will allow them to: create the deep waterway, which provides outlet to the Kansk-Achinsk coal in the western (Ob) and eastern (Yenissey) directions; get electricity production no less than 3.5 billion kWh/
year, arrange tankages for flood protection in the middle and the lower Ob; and increase the quality of water polluted by the operation of KATEK enterprises.

- The rivers Upper Ob, Biya, and Katun. For radical improvement of navigable conditions at the upper Ob (up to Tom river estuary), as well as for solving a set of the Ob problems (first of all, the problems of flood protection in the middle and the lower Ob) it is necessary, wherever possible, to implement the deep regulation of these rivers estuary. Earlier on the upper Ob it was proposed to create a cascade of 6 hydrosystems, among which only Novosibirsk Cascade alone has been built and is under operation.

At present time, a large project of Altay (Katun, Yelandinsk) HPP is again proposed for implementation. On Katun, it is necessary to create regulating reservoirs but they should be based on TEWS development. Therefore, there are four river reconstruction projects implemented sequentially or in parallel.

Project 1, Biya river. Taking into account the Biya river flow regulation by Teletskoye lake, the water-transport use of Biya river considerable part (225 km of the total length 301 km) and Teletskoylake (78 km) and their recreational attractiveness as well, the transport-energy reconstruction of Biya river must be of high priority (cascade of 5-10 levels, 5.2-5.5 billion kWh).

Project 2, the Ob from the source to the Novosibirsk Reservoir. A cascade of 3-4 levels (4.6-4.7 billion kWh/year), while the Upper Ob Reservoir would prop the lower reaches of Biya and Katun.

Project 3, Katun river. A cascade along Katun with bottom-up development: the deep water-way would pass along the whole lower 100 km reach of the river and further to mountains. On the Katun reach lower than the range of Chemal HPP (1.6 billion kWh/year), which has recently been offered as the counter-regulator of Altay (Katun, Yelandinsk) HPP, there can be received electricity production of no less than 2.2 billion kWh/year (1-2 levels).

Project 4. Baturin and Kireyevsk hydrosystems on the Ob river (lower than the Novosibirsk Reservoir) 2.2-2.3 billion kWh/year.

8. The Irtysh-Ob Deep Water Main from China to the Northern Sea Route can become an international project.

According to the “Scheme of Irtysh river Complex Use” developed in 1950-60s, it was proposed to reconstruct the river into continuous cascade of 16 levels, including 12 levels on the territory of Kazakhstan, 4 levels inside Russia. The total HPP cascade output is about 19 billion kWh/year.

Presently, on the territory of Kazakhstan, 3 cascade levels have been constructed and are under operation: Bukhtarminskaya (with reservoir of over-year regulation), Ust-Kamenogorskaya, as well as the new Shulbinskaya
(the first HPP started its operation in 1987). Their total output makes about 5.5 billion kWh/year.

There are some concerns that China’s water take-out from Black Irtysh river will lead to the impoverishment of Irtysh water resources. Besides, the quality of Irtysh water after crossing the borders of Kazakhstan and RF is low. These circumstances make the task of Irtysh Cascade development especially relevant.

9. The Yenissey-Lena Main is suggested as a special project, as the construction of Turukhansk hydro-system (Evenki HPP) on Lower Tunguska river is planned for 2010. It is proposed to include this project in the context of Yenissey-Lena Main Development (Class B Main Line): rivers Lower Tunguska, Vilyui, junctions of Lower Tunguska with Vilyui and Lena, Igarsk hydro-system on Yenissey river (a part of Yenissey Main).

This complex project will include 2 large HPP: Turukhanskaya (Evenki) and Igarskaya on Yenissey river with an electricity production of 46.0 and 30.6 billion kWh/year respectively.

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