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PROBLEMS OF FUTURE ENERGY MARKET PLANNING AND OPTIMIZATION

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Probable development of energy market is described in the article and special attention is devoted to the nuclear energy, which not only consume, but also produce raw material and how to proceed to avoid crises in supply.

Problems of future energy supply of heat, liquid fuel, electricity are described. Expected effect will be jump in prices or regulated supply to equalize supply and use. It can completely change our standard consideration of profit. The main profit will be to avoid losses and unemployment.

INTRODUCTION

Our dream is to have functional dependency of energy market demands and possibilities to fulfill it and further it will be some mathematics to evaluate the most profitable solution during the forthcoming century. There should be without troubles (at least principal) to evaluate optimal, in the sense of money, solution for any concrete time or maximized profit during the power-station lifetime. Contemporary existing simulations are analyzing supply of energy in such models and time is included via inflation rate only. Let us try to describe, what could be and very probably will be and what is destroying such traditional approaches.

If there is enough raw material, either solid fossil or liquid or gas fuel at the place you transmute it into electricity or oil for cars and produce goods and such a way ensure your life and rich, trying to work less and have more, and greater and greater part of the society is working as servants to others. The procedure is starting to be tough if there is no or less energy or servants or they are going to be too expensive. If there is no electricity – you will have no production, if there is no liquid fuel – you will not have south fruit on the north or at least in the greater distance from railway stations. There will be also consequences for all – if they do not sell, they will not be able to pay; if they do not have money they will not buy goods and there will be unemployment and fall down of living standard with probable social consequences. Market will react with the change of prices to equalize offer and demand.

What can you do? You say – no problem I shall accelerate my raw material production – here are the questions: do you have any? – yes, they are over there – obvious answer is that they are not mine they are privatized and I have open boundary and market, my sources from mines are through taxes and maybe my people (from my state) will not be able to pay so high price as the foreign ones and I shall have nothing. Such a way we are coming to the different possessors with different philosophy of profits. Private ones are maximizing profit, state (government) should try to avoid losses to repeatedly voted. What is the measure in money to stabilize market – probably degree of expected losses and their costs. Here we have recommendations how to survive: we must produce cheaper in the sense of energy demands. We can use temporary measures – formulate agreements or limitations for production or privileges to local consumers. Such features have time characteristics, this means time in which they could be introduced either from offer or from demand sides. What is the greatest demonstration of such considerations?

There is known feature called Hubert peak in the oil production – if we do not go into details it means that around 2016 there will be maximum of oil production, we reach about one half of all traditional oil resources and further production will be inevitably decreasing. Maybe for us no problem if we use existing amount and decrease will be smooth and slow. But it is surely not right – growing economies of developing countries like China and India are moving forward with the annual velocities reaching ten percent and this means, that they will need even more energy than developed countries for such grows (more than one half of the grows). Even if the production is decreasing slowly demand from developing countries will grow quickly. Therefore a significant outage of energy supply (primarily oil and liquid fuels) in developed countries can be expected in the period of primary energy shortage after Hubert peak. But oil is not a special example – any other resource if it is nearly exhausted is harder accessible and you are not able to keep too high production as before and also you are not ready to invest into the ending capacities. For our forecasts over the intervals several tens of years it is necessary to evaluate analogies for Hubert oil peak for coal and gas regions.

Question is – are we prepared to such phenomenon of future live – are we able to transform our cars for additional fuels and our technologies and living standards to new limitations? How much and how quickly are we able to produce additional car fuels? Are we able to limit our transport needs? Are we able to estimate resources needed to such transformations?

1 RESOURCES INVENTORY

Standard meaning of our (our means our state, our country – because state is the unit, we are at least trying to have some planning in it and maybe we can do some measures to correct forthcoming situation) resources is resources on our territory.

But let us analyze more deeply word our resource in our state. Our state is not closed system in the existing economy, we are open to external pressures and generally depends on the possibility to pay to whom we shall supply our resources. General rule is money and price. We (state) should take care about all our citizens and that is why, it is not question only about money but also about economic policy and overall balance of gain and losses (losses in the production using your resource). Just now we are not able to answer, where it will be possible to reach maximal prices and calculate balance – but it is clear if our people will not work, they will not have possibility to buy, and you as state will have to give them at least something to survive and organize due the sold resource new production or more effective production.

Characteristic of our resources should be their accessibility in the shortage period or in the scarcity period. Scarcity and shortage have special sense in the economy; scarcity is more near to our situation and means limiting resource, due to which it is not possible to fulfill all demands and the situation is still not stabilized in the market, and your policy is to avoid big troubles and quickly come to new stable curve of the at least comparable standard of living. Our task is to evaluate way of our steps and new technology needs.

Let us give examples of raw materials resources: they are either global – nearly the same price all over the world and relative small transport costs. Uranium is the typical example. Typical local resource could be geological thermal resource, which could be transported only via electricity production. In between there is coal, which is effective for energy production only in the surrounding of its mine. Concerning coal

there were consideration to transform it into liquid fuel and only then to transport it into the final user.

Different philosophy will be at suppliers of raw materials – to reach the highest prices as payments. But there should be thorough analyses, if the buyers go to the bankrupts, he will not be able to pay because he will not produce. Both must cooperate to avoid such consequences.

We hope that through such considerations we shall be able to estimate something like index of real possession, which could be used for estimation of period of deep scarcity with danger of losses in production due to it.

2 FUTURE ACTION PLANNING

The best example is also oil supply, which goes to supply troubles just now periodically, because there are too small reserves in supply and from time to time either people or weather brought troubles into production of oil products and consumers have fear from the stop of supply and in some sense proportionally to it, they are ready to pay more. But the troublesome situation is still temporal and after some time lost of reserves on the market is supplied.

Different situation will be if the lost of supply cannot be delivered later – we must do something to avoid losses in goods production and road movement and this is either save somewhere or to add something to the market – new technology either in production of energy or in production of goods. And question is: Do we know what and how? Do we have time to do it?

Let us compare influence of technology changes – first of all time needed to know, what to do; this means to have industrial project of factory either to produce oil from coal or another way of transport or anything else. To start big industrial project in nuclear branch is more than ten years (US estimation in current DoE studies is about twenty years, see [1]) – for us typical now is high temperature reactor at the first time to repeat old high temperature reactor with higher output temperature ~900°C, and connection with catalytic water splitting. Such technology has enough (at least for the first time) uranium, but must be realized in the vicinity of oil refineries or coal mines and to be able to repeat it on the regular basis needs experience; repeating is possible with low risks of economic losses only after some stage of such facility. Really twenty years is something like expected interval – it is too long to catch the first attack of scarcity.

Such a way we have an intermediate conclusion: use existing more or less known technology even if it is not sustainable to avoid losses of production due to the lack of energy source (in this case – liquid fuel) and prepare sustainable technological way.

Looking on this problem, already first comparison of energy needs gives us so much nuclear energy needs that it surely influence the overall uranium ore balance that fast reactors will be sooner needed and this is big demand.

3 NEIGHBORS

Mutually connected states and regions are giving complex economic and technical picture and we should understand, who are our partners and following it prepare ways of common steps.

There is special position given by the possibility of energy supply – in the case of neighbors it is the first possibility, to exchange energy – for the too long distance it is not possible due to transport losses. Just now fully global is only nuclear material

and oil. Limiting possibility has gas, but it could be changed, when liquefied gas will be fully introduced.

Practically fully transformable is technology – there should be only some degree of overall knowledge and education to introduce new technology – but if we want it, we must at least understand it to be able to expect, when it is introducible in our condition. The only way now is to take part in the development. Most of big energy production or transformation technologies are out of even big states possibilities and there should be some diversification of technology development and at the end ways of results exchange.

Anyway there is special position of geographical neighbors and the best and recommendable way is cooperate with them to reach the same or at least near understanding of future steps – neighbor's troubles or bankruptcy unavoidably come to us.

4 COMMON UNITS – MONEY

Existing Russian and American forecasts (and partially also French) are analyzing future energy situation without introducing concept of money and prices. They are based on supposed electricity demand and growing energy use and accessible raw materials resources. There are no special ways, how to separate nuclear energy from overall energy mix (coal, gas, oil, nuclear and others) – the curve of growing nuclear energy is based on different forecasts of "velocity" of nuclear power-stations realizations, population grows and industry needs. This not very precise formulation is coming to the conclusion that there will not be enough uranium from mines about 2040 and from that date we shall need breeders with as high as possible breeding ratio. [DESAE, DANESS]. Up to now there were no direct attempts to transform it into money and investments concepts. There are estimations, but without deeper explanation, in the works Hirsch, Bezdek, Wendling reports – [1], [2].

Because different energies are exchangeable (naturally with some losses, done by technologies), our measure should be optimal profit in comparable units, and it is under question mark, either in the given time or during some period of time. Part of our decision is moved by knowledge – to have knowledge, projects ready to build capacities. Such knowledge must be collected very soon – generally about ten years before the time supposed for realization – on the other side it could be practically done only one times all over the world and we can have, if we realize good technical policy. Immediate decision is motivated by raw material accessibility at the given site and optimization among different possibilities. Unfortunately realized capacities lifetimes are changing from 30 to 60 years and maybe even more. We shall have anyway great uncertainties in our decisions but we do not see any other way than to recalculate all our steps into one unit – money. Maybe step forward could be, if we subdivide money into some more invariant units like people works, amount of material needs for the capacity realization, independency in outer supply – long time guaranty of supply etc. But the final decision will be with our existing knowledge probably peace of art.

5 NUCLEAR ENERGY DURING TRANSFORMATION PROCESS

There are external influences into the technical policy and into nuclear energy specially. Market of European energy will be strongly influenced if for example Germany does not change its policy and really will close step by step nuclear capacities. We do not know how introduce such public influence into the technical consideration and how it will be realized in growing unification within European

Union. It is not possible to cancel only part of functional, because we know forward that too great part of wind energy is giving instability into the net and there are not enough ways, how to limit it, if we do not decide to limit it artificially or introduce special capacities to equalize net – it will be surely more expensive. Generally up to now it is not supposed to work with nuclear in the too frequently and too changing regimes and what will be price for it during the reactor lifetime and what will be new lifetime in such special ways of work. At the same time we cannot go into the too detailed description for the too far time intervals, because such a way we cannot be able to come to some conclusion.

It is without any doubt that just now we are able to construct in the industrial measure only PWR, WWER, BWR or PHWR reactors – their expecting lifetime will be sixty years; surely at the end there will be hardly uranium ore accessible. Price of uranium is growing – ten times during the last five years. Stop of price growing could be probably found, if we analyze demand, existing mining capacities, prices of nuclear and fossil energy and capital to open new mines. Internal analyses in the countries should be done to consider it and surely compare reprocessing prices and re-enrichment of the spent fuel. Our position was all the time that spent nuclear fuel is valuable raw material. Local country analyses should have as conclusion ways to ensure fuel during the whole reactor lifetimes and future transformation of all nuclear capacities to the sustainable regimes with fast breeders.

Even if there is not enough knowledge and experience how to transmute or spent minor actinides, starting fast breeders with plutonium fuel will put this problem much sharper and there will be enough actinides fuels to construct even the special reactor only for actinides fuel. Such technical steps cannot be realized in all existing planning units (our states) independently; it is one of the problems of technical policy how to do it and with whom to do it and where to do it and who and how to pay if we decide commonly to realize it and in this sense support common safety. Time interval, in which it is put is about 2040 (already in industrial operation) – this means that about ten years sooner massive reprocessing will start – plutonium will go into the fuel elements for fast breeders and actinides accumulation will start. We want all the time exclude such situation. There is the only solution – be prepared for minor actinides spending by fission. Extrapolation of existing public meaning and even the perception of general risks are avoiding possibility to give any subject too much dangerous material. There must be much deeper technical knowledge, if we want to support INPRO ideas of regional reprocessing and fuel elements supply centers. To be sure that it will be accepted, it must be conducted together with spending minor actins on site of fuel reprocessing. Even if we expect that from the point of view of energy it will not be necessary to add something, amount of such facilities will be very small and consequently their technical development will not bring too much profit – money sources should be collected by something like taxes from the customers and privilege to have exclusive possibility to reprocess fuel have to be supported by demonstration of ability to spent minor actinides. Taking into account technological complexity of such task, its R&D works already had to start in sufficiently great extends. Development of people's society is known for about several thousand years and it is more probable to extend not very positive past than to believe for idealistic global development.

Described procedures are technically inevitable and that is why they must be included into the commonly acceptable plan, respecting local feature and possibility.

Even if nobody wants to cast doubt on it, we suppose that our states will exist during the planning periods and will form planning units.

6 US DOE INFORMATION ABOUT THE FUTURE TRANSPORT

Accessible transport is nowadays ensured exclusively by liquid fuel from oil. The only complex studies of it from the long time perspectives, which we know, are from US and could be found on www.doe.gov pages, . Let us describe its main conclusions from our point of view and possibility of supply via nuclear energy.

The first analysis was done, to answer question: are we able to change our cars or to introduce do transport via railway and use electricity? Answer was negative – existing attempts of hydrogen cars are too expensive and there are no technical responsible believe to expect new technology development to bring prices on the existing level; even if we have it, time interval to exchange cars for new ones needs about twenty years. The only recommendable way now following that study is enlarge liquid fuel production.

New liquid fuel production is nothing new – artificial fuel was produced for German troop from brown coal in former Böhmen und Mähren during the Second World War. There is nothing special on it. Existing newer technologies are commercially working in South Africa today. But such classical technologies produce CO2 and using either additional coal or natural gas to produce hydrogen to change carbon for chemical molecules analogical to petrol. We do not have enough gas for it or maybe only for temporal period. More sustainable is high temperature reactor and water splitting.

There are several years information on www.doe.gov how to evaluate and compare various ways to produce additional liquid fuel, [10]. Each year it is about 1400 pages of technical survey text. Conclusion is that we shall need several ways to do it including production of fuel from crops, but from all production with wood or straw. How to use straw is not yet clear.

It is not clear also how to effectively use tar sands and oil shell.

The only what seems us clear that you can save lot of gas if you produce hydrogen from water. Problem is that you must now use thermal reactor with high enrichment about ten percent and temperatures, which you need are about 200°C higher that those you have experience with. Term, to build up the first facilities, is not yet specified, and there is indirect information that it will be about 2020. To suggest more or less sustainable solution you will need fast high temperature breeder – result could be expected even later. Intermediate solution or suggestion how to proceed to avoid transport bankruptcy or limitations are still looked for.

There is nothing better and we must at first read it and than to try to look about some decisions.

Market for hydrogen is even now without liquid fuel production huge and in US it is estimated for about hundred of 2000 MW thermal reactors.

7 INDICATIONS OF WAYS TO ANALYZE FUTURE

There was a very successful analysis of technology market penetrations, when one older technology is substituting with newer ones, [4]. Even if it is not analyzed new technology is cheaper and better – this is cover in coefficients of substitution – bright examples is change steam locomotives to oil ones. Generalization to several technologies was applied to energy in various forms: wood, coal, oil, gas and partially also nuclear.

Weakness of such approach is that you need to have at least ten percent of the market segment to calculate new distribution – to remove it we probably must be able to interpret parameters of the curves, which maybe enable us estimate them from the supposed technology analysis.

Second peculiarity is that beginning about 1990 it is not working. Probable reason is that world economy is splitted into developed and developing regions. When developed world is supplying developing part by not only technologies but also by investments, then velocity of growths is different and demands on energy in the developing part is much greater and quickly is moving to the corresponding technology level – the more advanced technology is put into the industry and its structure the more quick is energy demand in the sense of moving to the existing developed world. There is believe, if we go deeper into such analysis we can be able maybe more precisely forecast future energy demands and what is our main task future and existing technology development direction.

All our existing information show us that there is technology gap among liquid fuel demand and supply possibilities. Existing technology knowledge, using nuclear (produced via nuclear energy) hydrogen will not be sooner than around 2020 and some intermediate steps either in more massive technology development or into the intermediate supply ways would be needed.

All main nuclear countries are currently doing analysis when and how transform their own and world economy to sustainable future raw material base. There is in the visible future period of fast breeders (obviously started in 2040). Such conclusion is consequence of current understanding of uranium accessible resources. Program DESAE [11], [12] is available for the INPRO cooperation and for all participants. Its current version will need further development to catch effects mentioned in this proposition, even if we do not expect full understanding and parameter description of such complicated technical-economical future industry description.

8 STABLE AND VARIABLE SUPPLY OF ENERGY

It is known, that the energy supply (specially electricity) is not stable all the day. There are working days, weekends and during each day we have day and night and at least morning top of demands. The electricity mix from water, gas and coal traditionally ensured it. Nuclear was up to now supposed for stable work from fuel exchange to another fuel exchange. That is why the exchanges are obviously in summer, because electricity demand is lower than in winter. Coal, oil and gas are in storages and their use do not depends on daily even non-expected demand.

We have strongly different view on the situation if we want to use nuclear in different powers during the day. Basic part of nuclear electricity price is to cover investment into to the power station. There is no experience how to calculate lifetime of nuclear power plant during the change of power – if it is on the first guess without influence, nuclear electricity will cost more – proportionally to the power decrease.

The same even sharper effect is arising with different forms of “ecological” sources. Bio-fuel is added to coal, but wind and solar energy need the same capacity in gas or oil to be able to keep stable supply. So that is not acceptable (like in Czech vision up to 2030 and the same in EU) to have prescribed amount of ecological energies without compensation of variation supply. It is special task, to establish and simplify such connections, to be able to use it for future estimations, where we can

take into account only basic dependencies. Even if here we are not sure about effects, expected changes could be about twenty or more percents in supply and money estimations and will need materials in short supply. To have big wind energy park, could be very costly, mean exploitation is even on the best places less than twenty percent and you need the same maximal capacity in gas or oil which will go 4/5 of time. Huge wasting of gas or oil or greater nuclear energy prices is the consequence. More detailed description should be prepared or such study should be formulated and done by other specialists.

CONCLUSIONS

We hope that based on the suggested material, which is taken as open to further improvement, situation at each partner will be described and if we are successful – we shall prepare model, simulating market development and optimization of energy supply and technologies R&D works.

We cannot do anything; specially, we can hardly go into details of even classical new non-nuclear technologies. But we cannot successfully plan new nuclear capacities, if we do not understand market demands, technology possibilities and financial limitations.

We can and must study segment of nuclear market, its development and place in it, avoid home collapsing of energy supply, and at least try to cooperate with local partners, their knowledge, and at the parts where we can do or produce something for nuclear market also take part in the development.

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