# Operational Problems and Chalenges in Power System of Vietnam

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***Abstract* - The Vietnamese power system is growing rapidly both in terms of scale and complexity. The load growth rate averages to 14% for the last 10 years. The development of the Extra High Voltage network of 500kV and interconnections with neighboring grids are the main characteristic of such growths. However the fast growth rate also brings problems in operating the network, for instance the short-circuit current becomes too high or the difficulties in voltage regulation (Abstract).**

***Index Terms* – *500kV, Interconnection, Power market, Power system, Operation, 500kV, Short-circuit, Stability, Voltage regulation (keyword)***

## I. HISTORY OF VIETNAMESE POWER SYSTEM DEVELOPMENTS

### *A. Vietnames power system prior to 1994: before the construction of the 500kV North – South line.*

Before 1994, the Vietnamese power system was composed of separate sub-systems managed by regional power companies. These sub-systems are operated by system operators from respective regional power companies. Due to historical reasons, these systems utilized different types of equipments with diverse origins. Some areas in the South used two transmission voltage levels, 110kV and 66kV, with interchanging roles. The lack of interconnections leads to different operating problems, some areas have an excess of energy while others experience a deficit.

The maximum national and regional demands at the end of 1994 are National 2820MW – Northern region 1463 MW – Central Region 270 MW – Southern region 1151MW, respectively [1].

### *B. Vietnamese power system from 1994 to 2004: the introduction of the first 500kVNorth - South line*

In 1994, the first extra high voltage (EHV) 500kV North-South line went into operation and connected regional systems. Starting with an initial length of 1488km, the 500kV EHV North – South links regional systems of the North, Central and South areas through 5 substations (Hoa Binh, Ha Tinh, Da Nang, Pleiku, and Phu Lam). During the period of 1994 – 2000, the exchanged electricity among regions totaled to 40 billion kWh, equivalent to 13.8% of the national amount during this time.

By the end of 2004, the demand of the national system – North – Central – South regions were 8283MW – 3494MW – 853 MW – 4073MW respectively. The corresponding energy amounts were 46,790 – 17,603 – 4,435 – 24,407 billion kWh. The average load growth for this period is 13.89% [1].

### *C. Vietnamese power system after 2004*

After 10 years of operating 500kV lines, several projects constructing new lines and substations have been started from mid-2004. Among them, the most important one being the links of the second 500kV North – South line which went into operation in 2004 – 2005. The 500kV Phu Lam – Nha Be – Phu My connects Phu My power generation centre (installed capacity of 4000MW) to the 500kV network commenced operation in 2004.

To date, the 500kV system has grown to become the backbone of the whole system, connecting not only heavily loaded zones but also large generating power plants in Vietnam (hydro generators in Son La, Hoa Binh, coal generators in Quang Ninh, gas turbines centers in Phy My, O Mon). Outline of 500kV network is shown in the Figure 1.

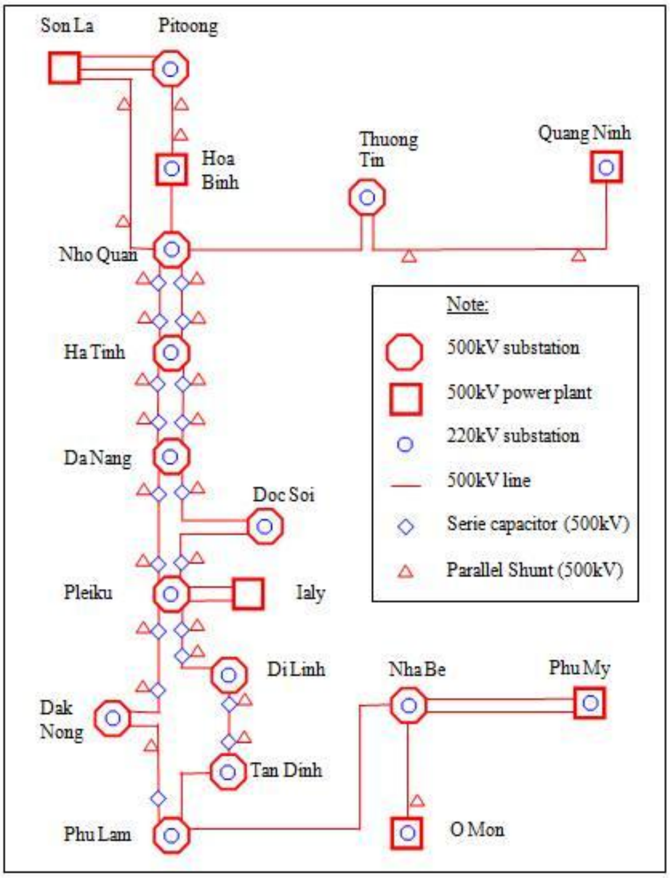


Fig. 1. Map of Vietnamese 500kV network – August, 2011
*(Source: National Load Dispatch Centre of Vietnam)*

The operation of the 500kV line not only facilitates transmissions and interconnections among regions but also helps unite regional sub-systems into a single national power network. Advanced technologies have been applied, such as: SCADA/EMS system, load shedding using F81 under frequency protection, special load shedding system, automatic reclosing system and other automation systems. The interconnection also enables a more economical load dispatching process, better utilization of hydro sources and more efficient consumptions of gas for electricity generation.

By the end of 2010, the 500kV system has a total length of 3890km and 18 substations (total capacity of 10650 MVA). The recorded load in 2010 is: national – 15,416MW; North – 6,547MW; Central 1,648MW; South – 7,566MW. The respective amount of energy generation are: national – 99,711 billion kWh; North – 38,499 billion kWh; Central 9,536 billion kWh; South – 50,073 billion kWh [1].

### *D. Power trading with neighboring countries*

Starting from 2004, Vietnam power system began buying power from China Southern Power Grid through 110kV lines. By the end of 2006, Vietnam purchased power from China through both 110kV and 220kV lines. By the end of 2010, the amount of energy purchased totaled to 16,939 billion kWh, the maximum power was 900 MW. In addition, from 2009, Vietnam began to operate the 220 kV line Chau Doc – Takeo selling power to Cambodia with maximum capacity of 120 MW. In the years of 2009 – 2010, 1,337 billion kWh was sold to Cambodia.

Power trading among neighboring countries is a new step in the international integration of Vietnam power industry. However it also carries problems for the operating process including: the difference in rules and procedures, in operating standards, the chain effects of faults from either sides, and difference in languages (to communicate during network operation). Currently, the section of the power grid of Vietnam that receives power from China is separated from the national grid to connect to the Chinese grid, hence causing various operating problems.

### *E. Establishment and development of the National Load Dispatch Centre (NLDC)*

Together with the event of the construction of the 500kV North – South line, the National Load Dispatch centre was established on April 11, 1994, and was responsible for the 500kV network operation, generation scheduling and generators dispatching. At the end of 1998, regional Load Dispatch Centres in the North, Central and South regions, previously under the supervision of Regional Power Companies, were merged into NLDC, forming a united system operator with two level of authority: national and regional, operating the transmission network at 110kV, 220kV and 500kV voltage levels; planning and dispatching generation orders.

In 2005, NLDC was given the responsibility of operating the internal pilot power market of Vietnam Electricity (EVN). This was an internal competitive generation market with 8 EVN power plants as participants: Ba Ria, Da Nhim – Ham Thuan – Da Mi, Ninh Binh, Pha Lai, Phu My, Thac Ba, Thac Mo, Uong Bi.

Beginning from July 1, 2011, NLDC takes a role of the market operator of the Vietnamese competitive generation market (VCGM) with 48 participating plants (61% of the system’s total installed capacity) [5]. This first phase of competitive generation market is to test the synchronism of the legal framework, the level of adaptation of the technical infrastructure and to familiarize participants as well as to assess the effects of the power market.

## II. OPERATING PROBLEMS OF VIETNAMESE POWER SYSTEM

### *A. EHV transmission stability at 500kV*

The 500kV line, as the backbone of the national power network, plays an important role in balancing the power supply and demand. The geographical characteristics of the country, long and narrow, have affected the distribution of generation sources in Vietnam. Main generation sources include hydro plants, coal plants, and gas turbine plants (single cycle and combined cycle). Large hydro plants mainly centered in the North and West areas of the Northern Region. Coal plants are constructed near primary energy sources in the East area of the Northern Region. Gas turbines are built in the Southern Region. Because of this uneven distribution and the diverse nature of primary sources as well as different operating modes, the 500kV North-South line frequently has to transmit a large amount of power between the North – South regions. Experience has proved that the power flow is often limited by the boundary values of: (1) Voltage stability, (2) Transient stability.

The voltage collapse limit of the 500kV line needs to be verified when the voltages of the busbars at receiving ends decreases. This can happen when the line is heavily loaded (around 1000 MW for a single line and 1500 MW for two parallel lines) provided that this happens during peak hours. Calculations show that the system becomes susceptible to instability when the voltage at the receiving end is lower than 0.9 pu.

The transient stability limit of the 500kV line is violated when the system becomes unstable after large disturbance such as the tripping of a 500kV circuit breaker. Internal simulations carried out in NLDC have shown that instability can happen when the line is heavily loaded (1200MW for a single line and 1700MW for two parallel lines). The risk of instability is especially higher when 500kV substations Da Nang, Pleiku operate with incomplete configurations (lacking one or more circuit breakers).

The Danang – Pleiku connection is the middle link of the 500kV system and the transmitted power is usually high. Real operation has experienced incidents where power swing happens, activating the distance relay (F21) on this line.

Many instability incidents have been recorded since the operation of the 500kV lines. Typical contingencies in the past that resulted in instability are: (1) One incident at 14h:43 on December 27, 2006 at 500kV Pleiku substation. A 500kV circuit breaker did not trip as commanded due to the loss of its DC source. A Breaker Failure relay acted upon the failure, tripping a busbar of Pleiku substation. Unfortunately, during that time, another circuit breaker connected to the other busbar of Pleiku was out of operation, causing the power to flow from Ialy to Phu Lam and back to Pleiku busbar and then to Da nang. The power swing happened in this case because of the weak interconnection. Network configuration at the time of the incident occurs is presented in the Figure 2. Simulation of power swing is recorded in Figure 3.

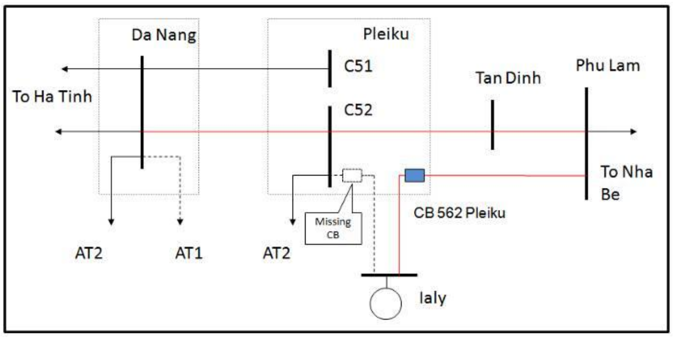


Fig. 2. Network configuration at the time of power swing, Dec 27th , 2006
*(Source: National Load Dispatch Centre of Vietnam)*

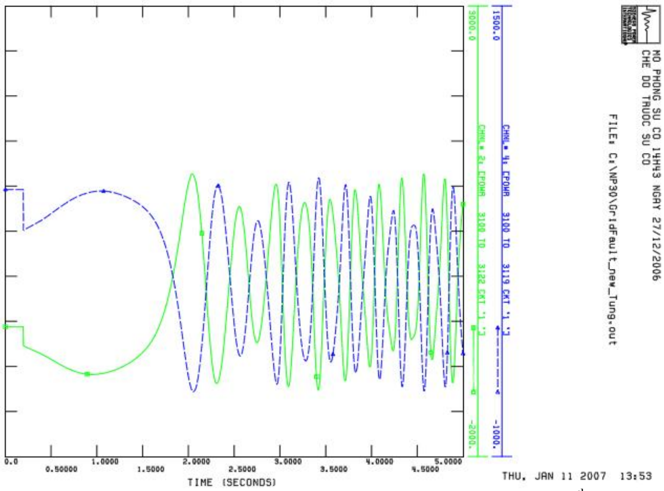


Fig. 3. Simulation of power swing in DaNang-Pleiku line, Dec 27th , 2006
*(Source: National Load Dispatch Centre of Vietnam)*

(2) Power swing at 500kV Da Nang substation: at 11h30 on April 24, 2008, there was power swing on the 500kV Pleiku – Da nang line. Distance relay F21 at Da nang station recognized the swing on the line. At this time, the 500kV Da Nang – Ha Tinh link was operating with a single circuit. The Pleiku – Da Nang was transmitting 1040MW, Da Nang – Ha Tinh was transmitting 690MW.

The swing caused the circuit breakers to trip the 500kV Da Nang – Ha Tinh, Da Nang – Pleuku lines. The system was separated at Ha Tinh – Da Nang. The over-voltage relay followed and tripped the Ha Tinh – Nho Quan line. Record of the swing is shown in Figure 4.

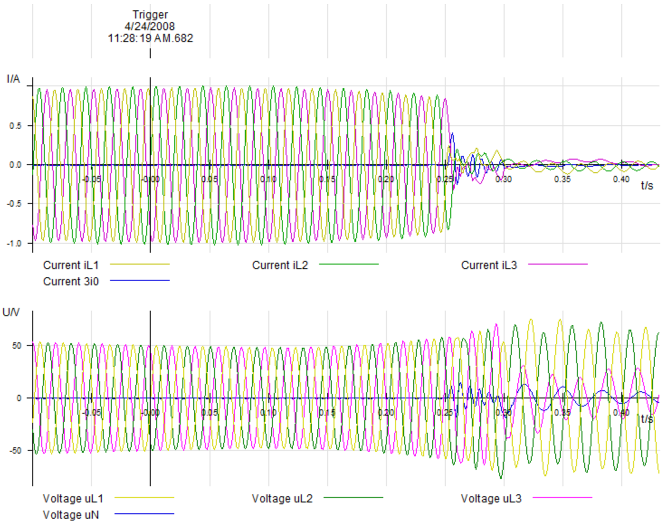


Fig. 4. Power swing recorded at Da nang 500kV Substation, Apr 24th , 2008
*(Source: National Load Dispatch Centre of Vietnam)*

The system's resistance to instability has increased significantly when most of the substations operate with transformers, especially when the link is operating with two complete parallel lines. With two parallel lines, the voltage and transient stability limits have both improved.

### *B. Voltage regulation of EHV 500kV network*

Voltage issues: voltage regulation of power system that includes 500kV faces many obstacles because of long lines and the load curve. Voltages on 500kV busbars normally range between 0.95 – 1.02 pu. However, in some cases, the voltage can fluctuate in a wider range of 0.9 – 1.04 pu. Operation in such conditions poses many risks such as: insulators ageing faster, reactive power pushed to 220kV causing transformer overload, etc.

Low voltage usually occurs at 500kV busbars at the receiving ends during peak hours plus the line is heavily loaded. Low voltage increases the loss and threatens the system stability.

High voltage usually occurs during holidays or at late night, early morning, when the system load is low. In some circumstances, operators have to trip one of the two parallel lines to reduce the voltage, lowering the system's supplying reliability.

Another difficulty for voltage regulation is that most of the shunt reactors are directly connected to the lines without circuit breakers, which causes inflexibility in operation of the system. Therefore, in the near future, Vietnam is promoting research and development of the application of switchable inductors and/or controllable compensators. At the present, Vietnam has already installed 500kV shunt reactors with circuit breakers at Nho Quan, Dak Nong, Tan Dinh, O Mon substations.

### *C. High fault current in 220kV network*

With a total of 10,015 km of line length and 102 substations where 220kV level is present (including 500/220kV and 220/110kV transformers), the 220kV lines are the main regional transmission link. The installed capacity of generators connected to 220kV network is 16,478 MW by the end of 2010 (63.7% of the national system's installed capacity). The short-circuit current at some busbars in the 220kV grid has exceeded the rated current of circuit breakers. Computation from NLDC proved that the fault current at large 220kV substations located near load centres and connected to a number of generators is higher than 40kA, which is the common rated current of most of 220kV circuit breakers. This causes the threat of fault spreading and in the worst case, might corrupt a part of the system.

Currently, in order to secure the operation, a temporary solution is applied, which separates the busbars to reduce the concentration of the fault current at busbars of Phu My, Phu Lam in the South. Most recent calculations (2011) have shown that others nodes also require the separation of busbars including Hoa Binh, Pha Lai (in the North) and Nam Sai Gon (in the South). Nonetheless, this temporary method also results in some negative consequences: (1) increased loss because the power flow is forced, (2) reduced flexibility in operations, (3) lower reliability, (4) less efficiency in economic operation.

Vietnam is looking into other solutions such as installing series reactors to reduce the fault current, requesting new generators not to worsening the fault current by installation of fault current limitation equipment at generator's sites and taking into account the problem of short-circuit current into power system planning. Among them, the idea of series reactors is an actual method which yields positive results in the short-term. Nevertheless, Vietnam is not experienced in this matter. Thus, the problem of short-circuit currents is not expected to be satisfactorily solved in the next few years. A complete solution to this problem is still being researched.

## III. CHALLENGES TO THE OPERATION OF VIETNAMES POWER SYSTEM IN THE NEAR FUTURE

### *A. Limiting the fault current*

Existing regulations, the Gird Code [3], set the maximum allowable fault currents for the corresponding 500kV/220kV/110kV voltage levels are 40kA/40kA/31.5kA, respectively. At the moment, NLDC's calculation shows that the fault currents at 220kV centre and near large generation sources have passed the limit of 40kA. Various solutions have been proposed in section II.C but only temporary.

The true challenges for the operation of the power system are exposed when the quantity of generators grow very quick with the total installed capacity almost doubles by the end of 2015. Preliminary calculation shows that the fault current at most of 500kV, 220kV busbars at load centres in Hanoi, Haiphong, Ho Chi Minh City, Dong nai and other generation centres such as Quang Ninh, O Mon, My Tho are all higher than the allowed current. A simultaneous comprehensive solution of both planning and operating to limit the fault current on the transmission network is urgently required for securing the operation. A number of these solutions are as follows:

(1) The planning solution: the transmission grid in large urban areas is 500kV ring circuit, each 500kV substation supply 2 to 4 220kV substations, 220kV network has ring configuration but operate as an open circuit. The method can be applied to city centres, which are heavily loaded areas, such as Hanoi, Hai Phong, Ho Chi Minh City, Dong Nai and surrounding areas.

(2) Imposing standard inductance values for step-up transformers within a sufficient range, together with supplementing Superconducting Fault Current Limiter that can be applied in a number of distribution or transmission areas to reduce the fault currents.

(3) Considering mandatory requirements for key locations that need circuit breakers with higher rated current.

### *B. Operating standards of a power system with interconections with other nations*

In the future, the cooperation and power exchange among neighboring countries are certain. The connection shall bring benefits similar to those of unifying regional sub-systems within a nation. Besides, this is also an opportunity to develop an inter-country power market (possibly among countries in the Indochina peninsula or even Asean countries). However, interconnection with outside system may create new challenges to the operating process. The first and foremost is the setting of technical standards (applying to connecting equipments, operating modes, fault responses, etc.). Between two electrically interconnected nations, there is usually a negotiation process to standardize all technical requirements. But for interconnections among more than two countries, there is a need for the establishment of a common system of technical standards for the whole area, at least for the parameters required during operation.

The idea of promoting interconnection between China southern grid and Vietnamese grid through HVDC at 500kV has been raised for few years. By using HVDC, Vietnam hopes to thoroughly resolve the current issue of operating separate systems. At the same time, the power exchange with the neighboring country will become safer.

Collaboration among system operators is also a key problem. It includes from dispatching authority and communicating languages. From previous experiences, since the current power trading is usually carried out in one direction, meaning one side is always the buyer – the other side is always the seller, the operation is fairly simple and the communicating language is the language of the selling partner. However, the progressing level of integration and more interconnections necessitate a more definite set of rules of collaboration among system operators. The communicating language should be English, since it is the most popular language in the area.

### *C. System operation in accordance with market-based rules*

Decision 26/2006/QD – TTg of the Prime Minister defines the three developing phases of a competitive power market [2]. The period of 2005 – 2014 employs the model of a competitive generation single buyer market. The period of 2015 – 2022 will be the competitive wholesaling phase and after 2022 is will be a retailing market. Figure 5 shows the roadmap for establishment and development of the electricity market in Vietnam. However, from the system operator's perspective, the transition from a centralized system to a deregulated system itself carries certain difficulties.

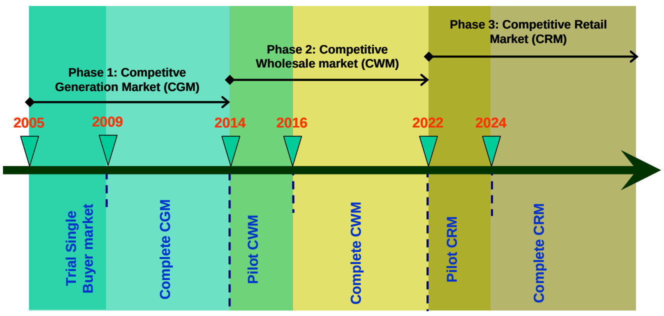


Fig. 5. Roadmap for electricity market development in Vietnam
*(Source: Decision No. 26/2006/QD-TTg dated January 26, issued by the Prime Minister, approving the development phases and establishing requirements of a power market in Vietnam)*

First of all, the load dispatch completely depends on the bids, which do not follow a preplanned schedule. This might cause overload, bottle-neck or local over-voltage, under-voltage at certain buses. The operator has to perform analysis of system security and reliability with extra measures to prevent such problems.

Secondly, the market payments based on metered values demands an accurate metering system as well as a high level of transparency and fairness.

Thirdly, the tight supply at the moment and the fact that many power plants are not used to the bid-based operation, the bids of participants will usually orients towards the high end of the bid caps. Consequently, it affects the economic target of the system.

Finally, previous experiences in constructing and operating power markets at some areas around the world (the Nordic countries [6], Singapore, New Zealand) have shown that the investment from non-government sector mostly goes into the generation sector, the investment for the transmission system usually depend on state companies (usually the Power Transmission Companies), resulting in pressures on the transmission network, which in general cause various problems in the actual operation. This condition can be resolved if the government can construct a reasonable transmission tariff, enough for reinvesting in the transmission system or encourages non-government sectors to invest in transmission system (the case of Australia [7]).

## IV. CONCLUSION

In this paper, operational problems in power system of Vietnam are presented. Many difficulties in operation has been identified since the introduction of the 500kV extra high voltage, in which three most critical ones are described in this paper that include stabilities, voltage regulation and high fault current. In the new environment of globalization and liberalization of the electricity industry, there are challenges that the operators have to face up to.

According to the Master Plan [4] regarding power sector development during the period of 2011 – 2015, the sum of the produced energy and the imported energy approximates to about 194 – 210 billion kWh by 2015, which is twice the current demand. Vietnam will also keep developing the EHV 500kV network. The total length of newly constructed lines is expected to be equal to the current length; the capacity of transformers will be 1.7 times that of the existing total capacity. Recognizing these challenges, NLDC has defined the operating strategies for the operation the power system including:

(1) Applying the State-of-the-art automation technology for power system operation such as a new SCADA/EMS (hardware, software, database, and telecommunication) to support the system and market operation.

(2) Staff training in specialized fields and foreign language for system analysis engineers, system operators as well as market operators.

(3) Constructing standard rules and procedures in operating system and market to comply with the laws, available capacity and actual ability (of the power system).

(4) Cooperating with domestic and international research centres and specialists, applying technical solutions to increase the reliability and stability of the transmission system such as installing new automatic systems including direct load control, fault recording on 500kV network, recognizing and suppressing outage spreading systems, etc.

(5) Strengthening the research of new issues in power system operation for short-term and mid-term periods such as direct current, hybrid AC/DC, reactive power control, effects of nuclear power plants to the grid, pumped storage hydro power plants, etc.

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## BIOGRAPHIES

**Ngo Son Hai** was born in Quang Ninh, Vietnam, in 1968. He received the B.E. degree in power electrical engineering from Hanoi University of Technology, Hanoi, Vietnam, in 1991, and the MEngSc degree in power electrical engineering from University of New South Wales, Sydney, Australia, in 1999, and the EMBA degree from Asian Institute of Technology, Bangkok, Thailand, in 2008.

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**Nguyen The Huu** was born in Vietnam, in 1979. He studied electrical engineering at Hanoi University of Technology in Vietnam, graduating with with a B.E. degree in 2001. He joined the National Load Dispatch Centre (NLDC), Hanoi, Vietnam in 2001 and working as power system analysis engineer. From May 2011, Huu became deputy manager of Power System Analysis and Planing Department, NLDC. His special field of interest include electric power systems operation and planing, power market operation.